INTERNATIONAL Society of Posture & Gait Research

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June 30 to July 4 Edinburgh Edinburgh International Conference Centre

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ABSTRACT BOOK 2019 ISPGR WORLD CONGRESS





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KEYNOTE ABSTRACTS

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K.1 Interventions to improve mobility after stroke: A journey from mechanisms and clinical trials to implementation science

Janice Eng¹

¹University of British Columbia

Stroke is a common condition with 1 in 5 persons having a stroke after age 55. Furthermore, there is an increasing stroke occurrence in younger adults due to the epidemic of obesity and diabetes. While stroke affects multiple domains of function, regaining and improving walking is high on the priority of stroke survivors. This presentation will first describe mechanistic research aimed at understanding how muscle function, balance and walking are altered by stroke. In addition, data quantifying the intensity of inpatient rehabilitation and physical activity in the community of individuals after stroke will be presented. The development and efficacy of interventions to improve postural reflexes, balance, mobility and reduce falls after stroke will then be discussed, including novel interventions utilizing wearable sensors, as well as robotic exoskeletons. In particular, the concept of repetitions and neuroplasticity, in addition to the importance of the time window of neurological recovery after stroke will be examined. Lastly, methods and theories to facilitate the implementation of complex stroke rehabilitation and exercise programs will illustrate translation of knowledge to real-world practice.

K.2 Studying human balance control by perturbations: Insights and applications for wearable robotics

Herman van der Kooij¹

¹University of Twente

We study human balance control during standing and walking by analysing the responses evoked by mechanical perturbations. We developed simple template models and more realistic neuromechanical models to interpreted and predict how humans respond to various mechanical perturbations and how they maintain balance. We translate these predictive models into human inspired controllers of wearable robots. We demonstrated that with this translational approach we can enhance standing balance and the walking speed of subjects with an incomplete spinal cord injury wearing an exoskeleton.



K.3 Gait - A step in the right direction?

Lynn Rochester¹

¹Newcastle University

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How do we keep people with neurodegenerative disease mobile and safe? This was the question we started with many years ago. It is a fundamental aim and the raison d'etre for myself and my research group as we directed a concerted, collaborative effort over the subsequent decade. Why is this important? People who develop age related neurodegenerative conditions such as Parkinson's have to cope with significant mobility problems. Walking (or gait) features at the top of their list of concerns. This is understandable as it reduces independence and leads to an increased risk of falls. As if this is not enough, becoming less active adds to the overall burden of disease. To date managing gait problems remains a significant challenge – not helped by the fact that an understanding of the causes is still evolving. Efforts to mitigate mobility loss by targeting gait impairments are therefore key and we need to start as early as possible.

Gait is complex and complex problems require complex solutions! Adopting a 360-degree perspective provides a platform to approach this, incorporating a multi-domain approach to include multiple contributing systems (including cognition and vision) and key pathological, neural and genetic substrates. We had two key objectives: to describe gait impairments from prodromal to late disease in PD; and to determine what drives them. Leveraging large and longitudinal datasets in well described patient cohorts was fundamental in combination with strategic collaboration and multidisciplinary input to help probe these objectives. We aimed to link our findings to novel measurement tools using wearable technology, and intervention development and this was coupled with a focus on the needs of our key stakeholders. Key insights demonstrated that gait impairments appear early even in the prodromal stages and drive early falls risk. They evolve selectively underpinned by multiple substrates enhancing our understanding of the mechanisms of gait impairment. Our findings promote an earlier, more preventative approach than previously recognised. Cognitive function, particularly attention, plays a significant early role and impacts on the visual control of gait. We showed this is driven by shared pathological substrates such as cholinergic disturbance and abnormal proteinopathy. These findings have informed therapeutic approaches utilising attention as a substrate to improve movement amongst others. Conversely, gait impairments also provide insights into cognitive function, demonstrating their symbiotic relationship. This has delivered other benefits such as tools to predict declining cognitive function along with insights for therapeutic development. Extending the remit of measurement, we showed that different features of gait appear sensitive to different dementia subtypes. Together our work suggests that discrete patterns or signatures of impairment may support enhanced diagnosis even in early/prodromal detection and a window of opportunity for neuroprotective therapy. Collectively our work has contributed to the role of gait as a clinical biomarker for enhanced diagnosis, disease monitoring and risk prediction and provided the basis for therapeutic development. We have linked our findings to develop the tools



to translate our work to the real-world using low cost wearable technology. Importantly this has addressed an unmet need for industry, clinicians and patients – the key stakeholders of our work. We set out with an ambitious aim. We have learnt a lot along the way, most important of all being that none of this is feasible without the collaborators and team to deliver it!

K.4 Visual control of posture

Adolfo Bronstein¹

¹Imperial College London,

In order to isolate the visual contribution to the control of postural balance, experiments in which subjects are exposed to large-field visual motion (optokinetic) stimuli are reviewed. In these situations, at motion onset, the visual stimulus signals subject self-motion, but inertial, vestibuloproprioceptive cues do not. Visually evoked postural responses (VEPR) thus induced can be guickly suppressed by cognitive status or simple repetition of the stimulus, if the inertial selfmotion cues available to the subject are reliable. In a conceptual model to be presented, the process of assessing the reliability, and degree of matching, of visual and inertial signals is carried out by a General comparator; in turn able to access the Gain control mechanism of the visuopostural system. Complexity and congruency in the visual stimulus itself are assessed by a Visual comparator, e.g. the presence of motion parallax in the visual stimulus can reverse the sway response direction. VEPR can also be re-oriented according to the position of the eyes in the head and the head on the trunk. This indicates that ocular and cervical proprioceptors must also access the Gain control mechanism so that visual stimuli can recruit and silence different postural muscles appropriately. The overall gain of the visuo-postural system is also influenced by less easily defined idiosyncratic factors, such as visual dependence and psychological traits; interestingly both these factors have been found to be associated with poor long term outcome in vestibular disorders. The experimental results and model presented illustrate that the visuopostural system is a wonderful example of interaction between physics (e.g. stimuli geometry, body dynamics), neuroscience and the border zone between neurology and psycho-somatic medicine.

K.5 A Cortical network for the planning and execution of visually-guided gait modifications

Trevor Drew¹

¹University of Montreal





Even in the most mundane of situations, we continually modify our gait to manoeuvre around natural and man-made obstacles, such as the curbs on each side of a street. In more exacting circumstances, for example, walking in the mountains or playing sports, such modifications of gait become more critical and more complex. Common to all such gait modifications in healthy subjects is the use of vision to evaluate the terrain and to anticipate changes to the normal gait pattern. Such anticipatory gait modifications are produced by a rich network of cortical and subcortical structures. In my presentation, I will discuss the cortical contribution to such visuallyguided gait modifications with a particular emphasis on the planning processes that are required to successfully negotiate a moving obstacle. These planning processes begin with the identification of the presence and the dimensions of an obstacle, together with the location of that obstacle with respect to the body. Subsequently, one must select the limb that will be the first to step over that obstacle and assure that the supporting (plant) limb is appropriately positioned in front of the obstacle. Studies in cats, from multiple laboratories, have shown the importance of the motor cortex for the production of the pattern of muscle activity in the limb as it steps over an obstacle. However, the available evidence suggests that the motor cortex does not participate in the planning of that step. Instead, our studies point to the posterior parietal and premotor cortices (PPC and PMC) as being involved in the planning. Results from lesion and single unit recording studies in cat suggest that the PPC is important in estimating the relative location of an obstacle with respect to the body. However, there is little evidence that the PPC is directly involved in specifying the changes in muscle activity in a given limb during the approach to the obstacle. Instead our recent studies suggest that heterogeneous populations of cells in the PMC contribute to this transformation of a global signal into one that specifies the precise spatiotemporal pattern of muscle activity required to step over a moving obstacle. In sum, the available evidence suggests a cortical network for the planning and execution of gait modifications that resembles that described in detail for the control of reaching in non-human primates. However, while reaching studies are generally made from a static position, the planning of gait modifications requires dynamic processes that must integrate and account for the movement of both the subject, and if necessary, objects in the environment. The studies summarized here, provide a starting point for understanding this complex behaviour. (Supported by the CIHR).





SYMPOSIA ABSTRACTS

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S.1: Virtual reality in motion: moving posture and gait research forward with do-it-yourself vs turnkey systems

S.1i Complex problems require complex solutions - Dynamic postural control in ecologically valid virtual environments

Nicoleta Bugnariu¹, Haylie Miller¹, Rita Patterson¹, Linda Thibodeau²

¹University of North Texas Health Science Center, ²University of Texas at Dallas

BACKGROUND: Clinical assessments of sensory, perceptual and cognitive elements that influence postural control are often conducted in a fragmented way, one at the time. Likewise, common clinical balance and mobility assessments often have low sensory and attentional demands. The disconnect between these discipline-specific findings obtained while patients are seated (e.g. hearing loss, cognitive impairment), and the impact of these findings in the real world where patients need to maintain balance and walk in complex environments, while attending to cognitive tasks and social interactions, represents a barrier in defining the true effect of a particular impairment on postural control. **METHODS:** We used a high-end immersive virtual reality (VR) system (CAREN; MotekforceLink) with motion capture, surround sound with integrated standardized audiological tests and eye-tracking, to investigate multisensory integration and postural control in adults and individuals with Autism Spectrum Disorder (ASD). In study 1, we tested dynamic postural control in 19 young (M=27.2), 20 old adults with normal hearing (M=68.7), and 20 old adults with hearing loss (M=71.2). Participants completed single- and dual- tasks of standardized audiology tests during surface perturbations in standing and walking. In study 2, we assessed dynamic balance of 6 age-matched pairs of adults with and without ASD aged 18-43. Participants wore eye-tracking glasses (ETG 2.5w; SensoMotoric Instruments) that allowed binocular eye tracking at 60 Hz during natural, unrestricted head movement. RESULTS: Centre of pressure variability in mediolateral direction increased (p<.05) in adults with hearing loss vs. controls when performing the dual postural/cognitive auditory task. Older adults with hearing loss had longer reaction time for initiating compensatory stepping responses compared to controls (p<.01) both in single- and dual-task conditions. Self-selected gait speed was slower (p<.05) in adults with hearing loss vs. controls, but only as long as they attended to the auditory task. In study 2, we observed a wider range of head-eye strategies used by participants to foveate targets compared to data generated using lower-end VR, and quantified differences in ASD vs. controls in the use of head and torso segments during stepping and leaning behaviors. The integration of



eye-tracking with the 180° surround VR revealed reduced fixation of static stimuli and less efficient tracking of moving stimuli that likely contribute to impairments in postural control in ASD individuals. **CONCLUSIONS:** When auditory or visual inputs are reduced or conflicting, perception of the environment is incomplete and the cognitive demands may be increased, potentially leading to maladaptive balance responses. High-end immersive VR systems are powerful tools for manipulating inputs in repeatable and scalable ways to parse the various sensory influences on static and dynamic postural control in different populations.

S.1ii VR for investigating perception and action during locomotion and for balance and gait rehabilitation

Desiderio Cano Porras¹, Gabriel Zeilig¹, Rivka Inzelberg², Meir Plotnik¹

¹Sheba Medical Center, ²Tel Aviv University

How do humans incorporate perception of gravity while walking? To what extent virtual reality (VR) technology contributes to engage neurological patients in balance and gait rehabilitation treatments? This presentation addresses this type of questions. The advent of VR, especially when combined with advanced motion capture that allows automated biofeedback, offers the unprecedented ability to manipulate visual perception and physical experience during balance and walking tasks. Mainly through this ability, VR has succeed to open new horizons for fundamental and applied research. First, we will present original research that introduces a paradigm in which participants walking on a treadmill are exposed to virtual inclinations (i.e. VR visual scenes simulating uphill and downhill walking). By testing conditions in which the inclination of the visual scene was either congruent or incongruent with the physical inclination of the treadmill, this paradigm allowed us to effectively interfere with perception-action coupling. Our findings contribute to unravel mechanisms of sensorimotor integration in the context of environmental transitions, and provide evidence for a visual perception of gravity during locomotion. Second, to assess the clinical impact of VR on the rehabilitation of balance and gait, we will discuss the results of a recent study reviewing the application of VR in clinical trials, and the conclusions from a recent report based on three years of experience using VR in routine clinical practice. Additionally, perspectives on the implementation and effects of different VR systems during rehabilitation of neurological patients will be presented. Although the systematic review identified studies with evidence that VR has advantages to promote motor learning and motivation, an overall poor methodological quality and a lack of theory-driven choices is a serious concern. Lastly, understanding the characteristics of VR is key for the design and planning of research (e.g. to dissociate the impact of visual cues vs. physical body-based cues) and for addressing specific sensory, motor and cognitive deficits during neurological rehabilitation. For example, to combine VR with other devices in order to, besides the visual input stimulation,



integrate other sources of sensory cues (e.g. vestibular, haptic). In terms of VR-based rehabilitation, an evidence-based framework to incorporate theories of neuroplasticity and motor learning is needed. In particular, considering that VR facilitates the incorporation of motor learning principles through task-oriented repetitive training. One challenge is to develop an efficient transition of VR-based rehabilitation as a tool for routine clinical practice.

S.1iii Characterization of pedestrian avoidance in a virtual environment using low-cost VR equipment.

Marco Buhler¹, Anouk Lamontagne¹

¹McGill University

BACKGROUND: In recent years, cutting-edge and affordable virtual reality (VR) systems developed by the games industry have become widely accessible. The extent to which such systems provide the required accuracy for research and elicit behaviours that are analogous to those observed in the real word, however, is yet to be determined. We used a low-cost VR system to examine pedestrian circumvention strategies as a complex locomotor task required for community walking in a virtual environment (VE) and contrasted the strategies with those observed in the physical environment (PE). AIM: (1) To estimate the extent to which circumvention strategies in response to static and moving pedestrians in the VE differ from those observed in the PE; (2) To estimate changes in circumvention strategies with repeated practice in the two environments and; (3) To contrast circumvention strategies obtained two head mounted displays (HMD) (gamers HMD vs. research type). **METHODS:** Twelve participants were assessed while walking towards a target and avoiding a collision with pedestrians in a PE and VE (random order). The VE, viewed with the HTC VIVE (gamers HMD), simulated the PE. In the static obstacle (SO) condition, participants avoided one interferer that remained static at 3 or 3.5 m from the participants' starting position. In the dynamic obstacle (DO) condition, one interferer randomly approached from the left, middle or right $(\pm 40^\circ, 0^\circ)$, towards a theoretical point of collision located 3.5 m ahead of the starting position. For the DO condition, 40 trials were recorded in 8 experimental blocks to estimate the effect of repeated practice. Two subjects repeated the experiment with the NVISOR SX60 (research HMD). RESULTS: Compared to the PE, circumventing static and moving pedestrians in the VE was characterized by slower walking speeds (SO: Δ =0.17±0.02m/s (mean ± 1SE); p<0.001, DO: Δ =0.13±0.04 m/s; p<0.01) and larger minimum clearances (SO: Δ =0.10±0.02; p<0.01, DO: Δ =0.10±0.02; p<0.01). No significant differences were observed between environments when contrasting the distance from the obstacle at onset of deviation (SO: p=0.17, DO: p=0.18). Similar behavior as a function of obstacle direction or location was observed in both environments. Furthermore, repeated practice caused a significant increase in average walking speed (p<0.05), which was similar between the VE and PE. In the participants who repeated the task with two HMDs, larger minimum distances, smaller distances at onset and slower walking speeds were qualitatively observed with the NVISOR vs. HTC VIVE. **CONCLUSIONS:** Although the enlarged obstacle clearances and slower walking speeds in the VE suggest the use of "safer" circumvention strategies, our results show that VR can reproduce similar adaptations as a function of obstacle condition and repeated practice. Furthermore, differences obtained with the two types of HMD suggest that the characteristics of VR equipment can modulate the user's responses.

S.1iv Low-cost virtual reality tools for gait assessment and rehabilitation

Anouk Lamontagne¹, Joyce Fung¹

¹McGill University

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BACKGROUND: Virtual reality (VR) allows creating ecological scenarios for assessment and training of complex motor tasks. While there is emerging evidence on VR effectiveness for gait rehabilitation, the complexity, high cost and poor accessibility of VR systems can limit its use in clinical settings. Our team is exploring the use of low-cost VR solutions made possible with advances in the games industry and their applicability to locomotor rehabilitation. More specifically, we: (1) developed a VR assessment to quantify goal-directed navigation deficits in post-stroke unilateral spatial neglect (USN); (2) identified barriers and facilitators to the use of VR for USN evaluation in the clinical setting; (3) examined the impact of a low-cost omnidirectional treadmill on locomotor adaptations and (4) developed a VR intervention protocol involving lowcost VR equipment to promote community ambulation after stroke. METHODS: Low-cost immersive VR technologies and open-source game engines were used. In study 1, stroke participants with and without USN were assessed while navigating towards virtual shopping items located in different locations. In study 2, barriers and facilitators were identified using focus groups involving clinicians. In study 3, body kinematics were contrasted between walking on an omnidirectional treadmill vs. overground in healthy young participants. In study 4, an integrated knowledge translation approach was used to develop a VR training toolkit for community ambulation rehabilitation after stroke. **RESULTS:** In study 1, the VR assessment revealed greater heading errors and navigation times in participants with USN. In study 2, several barriers and facilitators to using VR for USN assessment were identified, including personal, institutional, client suitability and equipment factors. In study 3, different strategies for speed adaptation (cadence and/or step length) and trajectory reorientation (temporal coordination of head, thorax, pelvis) were observed during treadmill vs. overground walking. In study 4, scenarios targeting different dimensions of community ambulation (e.g. endurance, speed, postural transitions, traffic, cognitive load) were developed, allowing participants to train according to individually-tailored goals while progressing through levels of increasing difficulty/complexity. CONCLUSIONS: Low-



cost VR tools show great potential for assessment and training of locomotor disorders. Notably, results show that VR can identify visual-perceptual deficits in post-stroke USN and their impact on goal-directed navigation. Addressing the identified barriers/facilitators could assist the adoption of VR assessment tools in clinical settings. Locomotor adaptations in VR, however, differ to some extent from those observed in the physical world. As the technology is rapidly evolving, future research should focus on not only the validation of VR tools but also on developing training paradigms exportable to different VR systems.

S.2: fNIRS data to understand cortical mechanisms underpinning exercise interventions

S.2i Effects of step training in older people and people with Parkinson's disease on haemodynamic changes in cognitive and motor cortical areas during stepping performance and gait adaptability

Paulo Pelicioni¹

¹Neuroscience Research Australia

BACKGROUND AND AIM: There is accumulating evidence from functional near-infrared spectroscopy (fNIRS)-based studies of increased Prefrontal Cortex (PFC) activation when older people walk and perform a secondary complex task versus simple walking. This increased reliance on cognitive-motor control resources to maintain balance under challenging situations is also apparent in people with Parkinson's Disease (PD), who display inherent motor impairments and executive functioning deficits. Impaired stepping and reduced cognitive functioning are wellestablished fall risk factors in older people and more so in people with PD. In pilot studies, homebased volitional step training while playing computer games significantly improved balance, dualtask ability and cognitive functions in older people; such training modality is likely to equally benefit people with PD providing sufficient training dose and adequate initial supervision are given. Yet the neural mechanisms underpinning the effectiveness of this training type have not been studied. As part of two ongoing randomized-controlled trials (RCTs), we aim to investigate the effects of the following in-home computerised game playing training interventions on haemodynamic changes in cognitive and motor cortical areas using fNIRS during stepping and gait tasks: (i) seated cognitive-only training using a touch pad versus cognitive-motor step training using a step mat versus usual care in older adults (smart+step RCT); (ii) combined cognitive-motor step mat training and reactive step training versus usual care in people with PD (SAFE-PD RCT). METHODS: The smart+step involves 75 older adults and its active interventions for 6 months (120min per week). The SAFE-PD involves 44 people with PD. The active intervention involves a 3-month home-based cognitive-motor stepping training programme (40-80min per week),





supplemented with two laboratory-based sessions of reactive step training. In both RCTs, participants are assessed at baseline prior to randomisation and then at three (SAFE-PD) or six months (smart+step). Haemodynamic changes are recorded with a 16-optode fNIRS system placed over the PFC and motor cortices while participants perform three cognitively-demanding stepping tasks on a computerised mat (both RCTs) and a gait adaptability test (SAFE-PD only). **RESULTS:** The trials are ongoing and full results will be presented at the ISPGR World Congress. **CONCLUSIONS:** We hypothesise that: (i) for the smart+step , the 6-month training programs will improve participants' cognitive performance in the cognitive training group and both cognitive and physical capacity in the cognitive-motor training group, and that such improved capacities will be associated with increased activity in the PFC region and motor cortices as applicable, (ii) for the SAFE-PD trial, the 3-month intervention will improve cognitive and physical capacities and increase PFC and motor cortices activity during the stepping and gait tests.

S.2ii fNIRS data to understand the effects of rhythmic auditory cueing and acute aerobic exercise on cortical activation during walking

Rodrigo Vitório¹

¹São Paulo State University (UNESP)

BACKGROUND AND AIM: The ability to cognitively process the environment and formulate appropriate locomotor plans for navigation can be compromised with ageing and in neurodegenerative pathologies such as Parkinson's disease (PD). Ageing- and PD-related walking impairments are associated with increased risk of falling and decreased independence. Therefore, effective interventions aimed to maintain safe mobility in older adults and people with PD are essential. Although recent studies confirmed the involvement of functional alterations of the brain cortex to walking impairments, less is known about the extent to which therapeutic interventions are able to modify cortical activation related to walking. Rhythmic auditory cueing and aerobic exercise are two of the most common interventions used for gait rehabilitation in older adults and people with PD. However, the underlying neural correlates are unclear. Functional near-infrared spectroscopy (fNIRS) devices, which assess cortical activity through the haemodynamic response of the brain, can be used to fill this gap in the literature. This symposium presentation will cover studies using fNIRS to examine the effects of rhythmic auditory cueing and acute aerobic exercise on cortical activation during walking in the context of ageing and PD. METHODS: Protocols combining fNIRS data and spatiotemporal parameters of gait were used in two different experiments. Experiment #1 tested the effects of rhythmic auditory cueing in older adults. Cues were delivered with a digital metronome at preferred stepping frequency and participants were instructed to step in time to the beats. Experiment #2 is designed to test the effects of a single 40minute session of aerobic exercise (65% to 70% of the maximum heart rate; performed in a



stationary bicycle ergometer) in people with PD. **RESULTS:** I will summarize findings from these two experiments and discuss them with those available in the literature. In short, findings from experiment #1 suggest that gait benefits (i.e. reduced gait variability) obtained with rhythmic auditory cueing were achieved through increased activity in multiple cortical areas. Although still preliminary, findings from experiment #2 suggest that prefrontal cortical activity slightly decreases after aerobic exercise in people with PD. **CONCLUSIONS:** fNIRS provides an innovative approach to assess brain cortical activity related to the control of human locomotion in interventional studies. fNIRS data can help researchers and health professionals to better understand the neural mechanisms underpinning the effectiveness of therapeutic interventions.

S.2iii Assessing human locomotion through mobile brain imaging techniques: Opportunities, pitfalls and future directions

Eling D. De Bruin¹, Federico Gennaro¹, Patrick Eggenberger²

¹ETH Zürich, ²EMPA

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BACKGROUND AND AIM: EEG and Functional near-infrared spectroscopy (fNIRS) have been involved in several studies related to human mobility. Both measurements hint towards promising opportunities, however, there are some pitfalls that need to be resolved before considering their routine clinical use in isolation or in combination. We discuss several pitfalls and propose research addressing them. Examples relate to validity, reliability and reproducibility of these methods in ecologically valid scenarios and in different populations. METHODS: Recent technological developments give rise to the expectation that EEG and movement artefacts related problems during human locomotion might be overcome. Several studies started using fNIRS for the assessment of functional brain activation during human bipedalism. fNIRS has the advantage being less prone to movement artefacts contamination. However, using fNIRS to study brain activity during locomotion has some limitations. Some of these disadvantages can be eluded with the help of a multimodal approach where fNIRS and EEG are used in combination. RESULTS: fNIRS measures concentration changes in both HbO2 and Hb simultaneously, which has shown useful to remove motion artefacts (Cui et al., 2010). Limitations of fNIRS technology include its limited penetration depth (1-2 cm) which only allows to assess changes in superficial cortical areas, as well as the limited spatial resolution of ~1 cm (Tong and Frederick, 2010). Additionally, strenuous physical tasks may affect fNIRS signals due to systemic vascular changes (Perrey, 2008). Currently no standardized fNIRS procedures and signal processing techniques exist to measure cortical activity during locomotion (Herold et al., 2017; Vitorio et al., 2017). To improve accuracy of fNIRS multi-distance measurement technique is recommended (Herold et al. (2017)), however, not many studies so far used this technique. The possibility of combining EEG and fNIRS measurement systems allows covering additional brain areas to assess effects in large-scale





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functional brain network connectivity, while providing greater spatial and temporal resolution. EEG detects very brief processes in the range of 100 ms but suffers related to spatial resolution. fNIRS provides good localization but the comparably slow vascular response limits temporal resolution. Hence, when both methods are simultaneously used they provide complementary information about neuronal and hemodynamic aspects of brain activation. Due to their tolerance to participants' motion artefacts and portability, experiments can be performed under real-life conditions. CONCLUSIONS: The last two decades have opened a new and fascinating "door" on the motor control research field investigating neuronal communication in human locomotion. This field of research is still in its fledgling state, however, is promising for revealing some aspects of the brain's role in human locomotion.

S.2iv The role of the prefrontal cortex in automaticity of movement in neurodegeneration - findings from fNIRS studies

Anat Mirelman¹

¹Tel Aviv Sourasky Medical Center

BACKGROUND AND AIM: It is now well accepted that gait and mobility are complex activities that are not solely automatic but rather rely on cognition resources, particularly in tasks that require more attention and faster processing speed, such as multitasking and gait adaptability. Traditionally, the role of cognition was assessed using dual-task paradigms (walking while performing a secondary cognitive task) which provided indications of the role of attention and executive function in the regulation of gait control. Functional near-infrared spectroscopy (fNIRS), an optical neuroimaging technique for investigating brain activation while participants move freely, enabled a direct investigation of cognitive resources during gait. This talk will focus on the contribution of prefrontal cortex to movement, its adaptation with task difficulty and changes in activation with age and neurodegeneration. METHODS: Data will be presented from several studies using FNIRS exploring mechanisms of motor-cognitive interactions in Parkisnon's disease and effects of intervention. RESULTS: Data from recent FNIRS studies will be discussed regarding the role of the frontal cortex in the control and automaticity of gait in Parkinson's disease and whether targeted interventions could reduce reliance on cognitive resources during walking. CONCLUSIONS: Points for discussion will be raised on automaticity of movement, potential interventions to enhance mobility and the use of FNIRS as an applicable clinical tool for assessment.



S.3: Balance, gait and falls post stroke: Steps towards a better future

S.3i Analysis of brain lesion impact on balance and gait after stroke

Shirley Handelzalts¹, Itshak Melzer¹, Nachum Soroker

¹Ben Gurion university

BACKGROUND: Falls are among the most common medical complications after stroke. About 70% of persons with stroke (PwS) fall during the first six months after discharge from hospital or rehabilitation setting and it remains a considerable health concern throughout their life span. In addition to physical consequences associated with fractures and related injuries, falls may have serious psychological and social consequences such as functional decline, poor quality of life, dependency, social isolation and depression. Reactive balance control is essential for fall prevention, however, only a few studies have explored the effects of lesion characteristics (location and extent) on balance control in PwS. Aim: To assess the impact of lesion characteristics on reactive and anticipatory balance capacity, gait, and hemiparetic lower limb function in PwS. METHODS: Forty-six subacute PwS were exposed to forward, backward, right and left unannounced horizontal surface translations in 6 increasing intensities, while standing. Fall threshold (i.e., perturbation intensity that results in a fall into the harness system) was measured. In addition, the Berg Balance Scale (BBS), 6 Minute Walk Test (6MWT) and Lower Extremity Fugl-Meyer (LEFM) were measured. Lesion effects were analyzed separately for leftand right-hemisphere damaged (LHD, RHD) patients, using voxel-based lesion-symptom mapping (VLSM). RESULTS: Voxel clusters where damage exerted a significant impact on balance, gait and lower-limb function were found in the corticospinal tract, in its passage in the corona radiata and in the posterior limb of the internal capsule. Additional significant impact was found to lesions affecting the putamen and the external capsule. Balance, gait, and hemiparetic lower limb function showed much overlap of the corresponding 'significant' voxel clusters. Test scores of RHD and LHD patients were affected largely by damage to homologous regions, with the LHD group showing a wider distribution of 'significant' voxels. CONCLUSIONS: The study corroborates and extends previous findings by demonstrating that balance control, gait, and lower limb function are all affected mainly by damage to essentially the same brain structures, namely - the corticospinal tract and adjacent structures in the capsular-putaminal region.





S.3ii Perturbation-based assessment and training for fall-risk reduction in people with chronic stroke: Effect of perturbation intensity and motor-impairment on behavioral outcomes

Tanvi Bhatt¹

¹University of Illinois at Chicago

The spectrum of motor impairments and deficits in reactive balance continue to persist on a longer-term in hemi-paretic stroke survivors even after recovering ambulatory ability; predisposing them to environmental falls. Previous work has established the significance of perturbation-based fall-risk assessment and training in prediction and reducing fall-risk in healthy older adults. This talk will focus on translation of work from the healthy older adults to people with chronic hemiparetic stroke (PwHS). We examined feasibility of using stance support surface perturbations (slip and trip) to assess reactive stability control, compensatory stepping and fallrisk in PwHS and examined contributions from paretic and non-paretic limbs for recovery. Results indicate that a ~50% fall rate during slip-stance perturbation with paretic compensatory stepping under unconstrained conditions and with paretic limb when explicit instructions were provided. Recovery from slips was more challenging with > falls and lack of step initiation than trip perturbations which yielded > compensatory stepping responses and very few falls. PwHS demonstrated impaired intensity-scaling of reactive stepping responses compared to healthy agesimilar adults. We subsequently also examined fall-risk in PwHS under both paretic and nonparetic limbs to overground gait-slips. The fall rate and stability control during overground slips was similar to stance-perturbations under both limbs when the perturbation intensity was small, however upon a longer slip, the falls under the paretic limb significantly increased, especially in those with greater lower limb motor impairment and gait abnormalities. We subsequently examined adaptation effects to a mixed slip-and-trip stance-perturbation training paradigm and effect of motor impairment on training-induced adaptations. Results indicated the ability of the high functioning, low impairment (HFLI) group to successfully tolerate large magnitude perturbations to rapidly improve stability control and lower fall incidence within 1st five trials. However the low functioning, high impairment group was able to demonstrate adaptation only after lowering perturbation intensity. Post-training both groups were able to demonstrate scaling to a higher intensity and shorter-term retention up to several weeks. Lastly, we examined the ability of training-induced adaptations to generalize to novel opposing trip perturbations and effect of mixed-slip-and trip training on fall-risk and stability control. Findings indicate a positive transfer of training effects within the compensatory stepping response achieved by a direction specific amplitude modulation of step length and further ability of PwHS to adapt to mixed perturbation training by achieving a stability state that would be resilient to both slips and trips. These findings could be leveraged for designing protocols to enhance inter-limb generalization of training effects.





S.3iii Sensorimotor adaptation post-stroke through the lens of muscle activity

Gelsy Torres-Oviedo¹, Pablo Iturralde¹, Digna de Kam¹

¹University of Pittsburgh

BACKGROUND AND AIM: Human movements are flexible as we continuously adapt to changes in the environment by recalibrating our motor commands and generating corrective actions. Sensorimotor recalibration occurs upon repeated exposure to predictable changes in the environment, whereas corrective actions serve as an immediate response to overcome sudden environmental changes. Corrective movements during walking are thought to simply reflect environmental transitions independently from sensorimotor recalibration (Morton and Bastian, 2006). However, recent studies suggest that corrective responses could be influenced by sensorimotor recalibration (Wagner and Smith, 2008). Thus, we asked if corrective motor commands are adapted and the extent to which this is a cerebral-dependent process. **METHODS**: We investigated cerebral involvement in adaptation of corrective actions using stroke as a disease model. We characterized changes in muscle activity in stroke survivors (n=15) and unimpaired individuals (n=15) before, during, and after walking on a split belt treadmill moving the legs at different speeds, which has been shown to induce sensorimotor recalibration (Reisman et al. 2005). Muscle activity was recorded bilaterally across 15 leg muscles. RESULTS: On the one hand, we found that corrective muscle responses in stroke survivors and controls were equally indicative of sensorimotor recalibration of gait. On the other hand, the steady state structure of muscle activity post-stroke in the novel split environment differed from that of controls. This indicates that stroke survivors have a limited ability to adjust movements to the new environmental demands. CONCLUSIONS: Corrective responses are indicative of sensorimotor recalibration of the motor system and this recalibration process does not require intact cerebral structures. This is the case even if muscle activity after cerebral damage is impaired in an altered environment. Taken together, our results suggest that the sensorimotor recalibration to generate motor commands and the execution of those commands are partially dissociable processes. The recalibration process does not require cerebral structures, whereas the execution process does. From a clinical perspective our results are interesting because they suggest that sensorimotor recalibration could be exploited to induce gait rehabilitation.

S.3iv Minor stroke, major balance problems?

Jolanda Roelofs¹, Ingrid Schut², Alfred Schouten², Alexander Geurts¹, Vivian Weerdesteyn¹

¹Radboud university medical center, ²Delft University of Technology

BACKGROUND AND AIM: Due to successful thrombolysis, an increasing part of the post-stroke population consists of individuals who have sustained a 'minor stroke'. Thus far, this group has



received very little attention, both clinically and scientifically, with regard to the possible motor consequences. Their usual care mainly focuses on prevention of a new stroke. Yet, persons after a minor stroke may still experience subtle balance and gait impairments, which are not always visible to the naked clinical eye. So far, the prevalence of these subtle impairments and their implications for daily life functioning are not clear. METHODS: This talk will summarize the evidence regarding the consequences of a minor stroke on physical capacity and functioning, with a particular emphasis on the results of two cohort studies we have recently conducted. Both studies included a (sub)group of people > 6 months after minor stroke with (almost) complete recovery of leg motor impairments (Fugl-Meyer assessment of the lower extremity >= 24). We will discuss the results of clinical and lab-based balance and gait tests, as well as data on falls and physical activity in daily life. RESULTS: Persons after minor stroke walked on average 0.5 km/h slower and scored 1.9 points lower on the mini-Balance Evaluation Systems Test (mini-BESTest; range: 0-28) compared to healthy age-matched controls. Thirteen percent of the persons after minor stroke scored near-maximal on the mini-BESTest, whereas this was the case for 61% of the controls. These impairments in dynamic balance capacity were also reflected by the lower perturbation intensities that persons after minor stroke could sustain with a single step and by the impaired reactive step quality after translational perturbations on a moving platform. During stepping from stance towards illuminated targets that sometimes moved during mid-step, minor stroke survivors placed their foot further from the new target position (i.e., made larger errors) than controls. Furthermore, 21% of the persons after minor stroke showed an asymmetric kinetic contribution of each leg to standing balance. With regard to daily life, persons after minor stroke fell twice as often as controls. In addition, the total intensity of daily physical activity (i.e., standing, walking, running, cycling) was lower for minor stroke participants compared to controls, whereas no significant differences were found in total time or volume (i.e., time x intensity) of physical activity. CONCLUSIONS: Individuals after minor stroke who present with (almost) complete clinical recovery of leg motor impairments may still show substantial balance and gait impairments. Given the double fall rates in this population, these balance and gait impairments appear to be clinically relevant. These results may point at an important unmet clinical need in the minor stroke population.

S.4: Going from here to there and beyond: Fundamental theories and applications from what we have learned about human navigation of cluttered environments

Bradford McFadyen¹



S.4i Meeting the brief history of human biped navigation research head on



¹CIRRIS-Université Laval

Human biped navigation, like all human movement, reveals a fusion between the person and the environment. We can only safely navigate when we properly attend to and anticipate the combined underlying personal and environmental aspects. Yet, effective and safe navigation is threatened by impaired personal capacity and precarious elements within the natural and built environment. While human biped navigation has evolved over millions of years, formal scientific study of it has only significantly progressed over the past few decades. This research has provided evidence of visual-locomotor coordination underlying anticipatory locomotor adjustments relative to environmental topography and social context. Different theories regarding the roles of anticipatory versus on-line control of bipedal navigation have been proposed along with control variables such as personal space and time to contact that drive our locomotor adaptations. In this talk, I will lay out some of the current evidence from our and other laboratories with respect to theories and the control variables for human biped navigation, as well as briefly discuss the evolution in protocols that have been used including both real and computer-generated environments. In addition, I will discuss some of the advantages and disadvantages of transferring current evidence and protocols to the clinic in relation to assessing and intervening in navigational capacity following acquired brain injury.

S.4ii Control laws that govern people's actions when interacting with other people and other objects in different environments

Michael Cinelli¹

¹Wilfrid Laurier University

Walking safely through a cluttered environment requires avoiding static and moving obstacles and, more specifically, other pedestrians. Fortunately, collisions between pedestrians or other objects rarely occur because vision plays a key role in safely and efficiently guiding routes away from collisions and towards open spaces. Visual information about an environment is gathered through eye movements, which allows individuals to appropriately adapt locomotion in response to obstacles. In this way, vision helps pedestrians to select pathways that will guide them towards openings and away from structures that would cause injury. Avoidance behaviours can be affected by fundamental differences in an object's movement (i.e., stationary vs. moving) and/or physical (i.e., human vs. nonhuman) characteristics. The ability to perceive an object's characteristics and make appropriate behavioural adjustments to avoid a collision is critical to safe locomotion in a dynamically changing environment. My research examines safe human locomotion in cluttered environments, which is affected by the dynamics between the person and the environment, such that changes to the person and/or the environment should result in a change in actions. My presentation will focus on manner in which people interact with other people in different





environments, how they use visual information to guide their avoidances, and whether visual information and avoidance behaviours are consistent regardless of the objects' physical or movement properties. The following control laws that govern pedestrians' actions will be discussed: 1) when passing through an aperture created by two people, pedestrians will account for the personal space requirements of both people resulting in more cautious behaviours compared to passing through similar sized poles; 2) Virtual Reality (VR) elicits behaviours that are not consistent with real world environments when constraining actions, however, when people are free to choose their own pathway, avoidance behaviours in VR match those in real world; 3) in situations in which a future collision is imminent (i.e., 180° collision course), pedestrians' will use time-to-contact to initiate a change pathway and maintain a consistent temporal distance only if the approaching human is moving along an uncertain path; 4) there are sex-differences in collision avoidance behaviours with an approaching female; and 5) gaze behaviours are directed mostly towards an approaching pedestrian's trunk when preparing an avoidance behaviour. This type of information will help expand crowd simulation models used in many industries (film, security, architecture) to accurately simulate person-person interactions in natural environments.

S.4iii Collision avoidance between two pedestrians: How future risk of collision can be used to describe motion adaptations? Is virtual reality relevant to study interactions between pedestrians?

Anne-Hélène Olivier¹

¹University of Rennes / MimeTic Team

Interactions between individuals and their environment represent the basic synergies of our daily life. In this context, this presentation will focus on the collision avoidance task between two pedestrians. Following the assumption that collision avoidance is a reciprocal task, we suggested a mutual variable named MPD to describe such an interaction. MPD is a continuous function of time that corresponds, for each instant of the interaction, to the future distance of closest approach based on pedestrians' current position, orientation and speed. Its value then represents the future risk of collision. Any change in MPD value in time corresponds to an adaptation of pedestrians' motion. We designed an experiment paradigm, where 30 pedestrians, by dyad having 90° crossing trajectories, were asked to walk to the opposite side of a gymnasium and avoid any collision on their path. Our results showed that pedestrians adapt their motion only when required, i.e., when MPD at the beginning of the interaction is too low (<1 m). Based on the temporal evolution of MPD during the interaction, the avoidance strategy can be described according to three successive phases: observation where MPD(t) is constant, reaction where MPD(t) increases to acceptable values by adapting locomotion and regulation where MPD(t) reaches a plateau. This regulation phase showed that the collision avoidance task is solved before the crossing. When studying





individual contributions to MPD evolution, results showed that both pedestrians contribute to the collision avoidance task. Nevertheless, the pedestrian crossing second contributes more than the one crossing first, suggesting asymmetric contribution depending on the role in the interaction. While these results are useful to understand interactions between pedestrians, the control of the experimental variables is complex. We therefore provided effort to validate Virtual Reality (VR) as a relevant tool to study interactions between pedestrians because it allows a strong experimental control and it offers safe situations that can be of interest when considering specific population. Reproducing the same experimental setup as in real conditions, we asked 17 participants to perform a collision avoidance task with a virtual walker. They can navigate in the virtual environment using several locomotion metaphors (including a joystick as well as full-body motions). Based on the evolution of MPD during the interaction, results showed that motion adaptations performed in VR are qualitatively similar as in real conditions, despite some quantitative differences. These results opens perspectives in the use of VR to develop new experimental paradigms, as well as to study specific populations where real conditions setup can be challenging.

S.4iv Modeling and simulation of human navigation

Julien Pettre¹

¹Inria

The simulation of human navigation, and by extension, crowd simulation, is a very active research field with a wide range of applications, including architecture design, autonomous vehicle control, crowd management and safety, visual effects for movies or video games. Research in Human Movement Science (HMS) is a great source of inspiration for the design of new simulation models and algorithms. This presentation will give an overview of the research questions addressed in the field of crowd simulation, and how they connect to HMS. A specific category of crowd simulation algorithms, called microscopic approaches, simulate a crowd as a set of agent moving independently, and interacting together. Each agent is equipped with a set of rules that reproduce the way humans navigate in their environment. More specifically, agent influence one another motion according to the a model of local interaction. The presentation will present several examples of such model of interaction, and explain their evolution in time. Crowd simulation started with most basic agents represented as charged particules, progressively moving toward more evolved agents equipped with simulated perception systems, and capable of controlling their motion to what they virtually perceive. The benefit of transdisciplinary approaches - including the role of HMS - will be highlighted and discussed. We will conclude the presentation by listing the questions remaining open in the field.



S.5: Falls prevention should start in middle age - Lessons on prevention from cardiology may advance fall prevention in old age

S.5i Is the middle-aged patient still a Jedi? Estimating declines in capacities required to successfully respond to a perturbation while walking

James Richardson¹

INTERNATIONAL SOCIETY OF

Posture & Gait

RESEARCH

ispgr

¹University of Michigan

BACKGROUND AND AIM: The ability to respond successfully to a perturbation while walking, during the approximate 350 ms available, requires near optimal neuromuscular and/or short latency neurocognitive functions. Clinicians and patients can be be falsely reassured that these essential neuromuscular and neurocognitive attributes are fully intact if the patient does not report falling. However, this is no more valid than concluding that a patient has no cardiac risk factors if s/he has not yet had a myocardial infarction. Therefore the aim of this presentation is to present one possible model of perturbation response, and to provide evidence that the essential neuromuscular and neurocognitive attributes upon which this response model depends (distal proprioceptive precision, short latency inhibitory processing, simple processing speed, and rate of torque generation in proximal muscles) decline in a sub-clinical manner during the middle years of life. We propose that this early decline can lead to falls later in life, analogous to the insidious progression of known cardiac risk factors which can lead to later life myocardial infarction. METHODS: Nerve conduction studies, the most objective measure of peripheral neuromuscular function, are known to decline during mid-life. These will be correlated with a laboratory-based means for determining frontal plane foot/ankle proprioceptive thresholds, with special reference to nerve conduction parameters in the fully normal range. Additionally, a novel means for determining short latency (400 ms) inhibitory processing accuracy and simple reaction time will be evaluated across mid-life age groups. RESULTS: Nerve conduction studies in healthy subjects without neuropathy demonstrate negative correlations with frontal plane foot/ankle proprioceptive precision, (R/p = -.737/.002 and -.494/.061 for fibular conduction velocity (m/s) and amplitude (mV), respectively). Additionally, short latency inhibitory processing accuracy and simple reaction time decline with age in healthy subjects younger than 50 years old (R/p = -.436/.004 and .338/.027, respectively). CONCLUSIONS: Clinicians and patients often do not detect subtle decrements in neuromuscular and neurocognitive functions which appear to begin before age 50, but appear to have functional relevance with regard to the deceptively athletic capacity to successfully respond to a perturbation while walking. However, the evidence presented suggests that with further prospective work we may be able to arm clinicians with tools sufficiently sensitive to detect these subtle declines, and in so doing track fall risk factors from mid-life on as is currently done for cardiac disease, allowing intervention before the "falling disease" becomes manifest.

BACK TO THE TOP



S.5ii Falls in middle age - A neglected issue?

Michele Callisaya¹

¹University of Tasmania

BACKGROUND AND AIMS: Falls are a major health issue causing considerable injury, morbidity and mortality. Most work to date on falls prevention has occurred in older adults (>65 years) with approximately 1 in 3 community-dwelling older people falling each year. We have shown a similar incidence of falls in both men (29.4%) and women (44.7%) of 'late' middle-age (60-64 years). Others have reported an incidence of falls in middle age (age 45-64 years) as high as 1 in 6 in a 3-month period. However this middle-aged group of women has largely been ignored in the context of falls prevention. This presentation will outline findings from the literature including from our longitudinal study of risk factors and circumstances of falls in middle aged women (PreFALL). We will also describe more novel methods (functional near infrared spectoscopy) currently being trialled to understand and assess falls risk in healthy populations. **METHODS:** PreFALL is a cohort of women who were assessed in 2011-12 on a number of factors including lower limb muscle strength and balance. In 2017, two hundred and eight one women returned (average age=55 years; range 42-63) for a comprehensive falls risk assessment including balance, mobility, strength, cognition, depression, physical activity, fear of falling and incontinence. Falls and their circumstances were ascertained prospectively via questionnaire over 12 months. RESULTS: We will present the results of the PreFALL study that shows balance and mobility begin attenuating in midlife. We will also present the incidence and circumstances of falls and the factors that predict them. The second half of this presentation will outline the role of functional near infrared spectroscopy and its potential in predicting falls in healthy populations. CONCLUSIONS: Our findings indicate that falls are not only a problem in older age, but also in middle age. Like in the fields of cardiology or even dementia, where factors in midlife are used in the prediction (and ultimately prevention) of future disease, a focus on falls prevention in midlife should be considered a key component of maintaining good health into older age.

S.5iii What people can do and what they actually do; self-efficacy in the self-management of falls prevention

Mirjam Pijnappels¹

¹Vrije Universiteit Amsterdam





BACKGROUND AND AIM: Gait characteristics on the quantity and quality daily life gait relate to falls and discriminate between people at risk of falls, already at late midlife. This relation between gait quality and falls appears modulated by self-perceived gait stability. An inadequate perception of one's own abilities may result in selecting inappropriate motor behaviour strategies and errors in daily life tasks could lead to falls. Age-related physical and cognitive decline might augment an inadequate self-efficacy. This presenation will focus on disparities between self-perceived and actual physcial abilities in stepping tasks and how a mismatch between what people can do and what they actually do can be derived from daily life gait characteristics; as well as on a new paradigm to detect such disparities in healthy older populations. **METHODS:** In the VIBE study, 284 relatively healthy older individuals (65 years and older) were tested on their physical abilities, self-perceived abilities and cognitive performance at baseline and after one year. They also wore an accelerometer on their lower back twice for one week, to monitor the amount of daily life physical activities, and to quantify daily life gait characteristics. During the 12 month follow-up period, the incidence of falls and participants' self-efficacy and health status was monitored monthly using questionnaires and telephone calls. A subsample of the VIBE cohort performed additional measurements in a stepping down paradigm, as to capture participants' self-perceived ability in their motor behaviour strategies when selecting either a heel or toe landing when stepping down level changes of different heights. RESULTS: Outcomes of measures of participants' actual and self-perceived abilities will be presented, as well as their daily life amount and quality of daily life gait. We observed disparities on the individual level between participants' actual abilities and their motor behaviour reflecting their self-perceived ability, as well as in their physical activity characteristics. CONCLUSIONS: People seem not all to select motor behavioral strategies and physical activities levels according to their actual abilities. Although these behavioral choices seem task and time-specific, they may indicate a higher risk of falling in the case of overestimation. Underestimation might induce a lower risk of falling due to inactivity and avoidance of exposure to challenging situations, at least on the stort term (commonly evaluated over one year). However, on the longer term, it may boost physical and functional decline and increase risk of falls as a consequence of unsuccessful ageing. Active ageing may be hard to achieve without an increase in fall risk. Yet, similar to cardiac risk factors, people should be aware of the their short and long term fall risk and be educated from early ages on how to monitor their self-efficacy in self-management of preventing falls.

S.5iv Modifiable fall risk factors and the application of personalized medicine

Kim Delbaere¹

¹Neuroscience Research Australia, UNSW





BACKGROUND AND AIM: Aging encompasses functional and structural changes in both central and peripheral sensorimotor systems, with substantial impacts on stability and falls. The ability to stay upright requires coordination of sensory and neuromuscular systems, as well as higher-level cognitive processing. Furthermore, certain affective parameters, such as depression and fear of falling, may also influence fall risk beyond the effects of neuromuscular and cognitive attributes. This talk will discuss how sub-optimal age-related changes in specific physical, affective and cognitive factors affect fall risk and preventative strategies. METHODS: 1,203 participants (71±13yrs; 6559), including 500 healthy older people and 703 people with balance disorders (dementia, N=175; multiple sclerosis, N=210; Parkinson's disease, N=318) have been tested on sensorimotor function, cognitive function and affect and were follwed up for falls. **RESULTS**: Concomittant deficiencies in physical, affective and cognitive function are common in normal ageing. An increased risk of falling is often the result of an accumulation of sub-clinical, nonsymptomatic processes that summate over time across this triad. At the same time, a range of diseases and age-related health conditions can also cause physical disability that increase fall risk. Our results confirm that deficits in cognition (executive function) and affect (depressive symptoms, fear of falling) are at least equally important as sensorimotor function for fall prediction and should therefore be included in fall-risk assessments. A suite of reliable and sensitive clinical measures have been identified that detect subtle changes in peripheral neuromuscular function, cognitive processing speed, and psychological distress; and guide a more tailored approach to fall prevention. CONCLUSIONS: Normal ageing is associated with changes in gait and increased risk of falling. Mental and physical capacities are even more strongly affected in people with Parkinson's disease, Alzheimer's disease, or a history of stroke, as their disease symptoms progress. Targeted fall prevention strategies are important in older people at high risk of falls; however, similar to 'healthy ageing', fall prevention should not abruptly start at the age of 65. Fall prevention strategies should be adopted at younger ages; for example by maintaining physically and mentally active lifestyles. Fall risk profiling should be used to identify long-term risk factors and offer guidance towards lifestyle changes (e.g. exercise), preventive medical treatments (e.g. cataract) and education. Crucially, the general public, as well as clinicians, need to recognize falls are not an inevitable consequence of old age and understand their risk factor profile in the same manner many people currently know their cardiac risk factors. The application of personalized medicine guided by basic principles for self-management should be the next frontier in fall risk management.

S.6: Turning as measure of functional mobility: When biomechanics, neural control, and technology come together





S.6i How is turning different from straight ahead gait, how we think it is structured, and how it can be enhanced.

Marco Schieppati1

¹International University of Health, Exercise and Sports, LUNEX University, Differdange

During our everyday activity, linear walking is intermingled with turns or steering courses when moving within the environment. The underlying biomechanical pattern requires adapted muscle activation for progression. Muscle-synergy studies suggest that rectilinear and curvilinear walking share a unique motor command and that fine-tuning of synergies during curvilinear conditions adapts the kinematic strategy to the biomechanical requirements. The strategy helps exploit gravity when steering, much as we do during gait initiation. Medio-lateral gravity torque is produced by appropriate foot placements that exploit gravity by letting-go and braking spells in order to produce the appropriate centripetal force. Turning implies trunk rotation over the stance leg. This can be studied by stepping in place on a rotating platform while maintaining a fixed body orientation in space. This procedure elicits a post-effect consisting in inadvertent turning while stepping in place eyes closed (podokinetic after-rotation, PKAR). Not surprisingly, voluntary turning while stepping in place also produces a post-effect similar to PKAR. The post-effect of voluntary turning shares all the features of PKAR, and both take place inadvertently, suggesting that the command to turn might share the same neural circuits underpinning the behaviour produced by podokinetic stimulation. Asymmetric axial muscle vibration also produces turning while stepping. PKAR is modulated by delivering asymmetric vibration to paravertebral muscles. Right-sided vibration reduces or reverses clockwise PKAR, whereas left-sided vibration increased PKAR velocity. Under all conditions, changes in foot step angle are coherent with body angular velocity. Hence, both PKAR and vibration effects and the post-effect of voluntary turning appear to depend on a common mechanism that possibly integrates effects on the straight ahead and inflow from proprioceptors. Curvilinear trajectories represent a challenge for patients affected by movement disorders. Freezing is not uncommon in patients with Parkinson's disease (PD) during turning. However, PD patients can learn to produce turning while stepping through appropriate training and this capacity translates into improved overground curved walking. Repeated sessions of podokinetic stimulation, requiring a progressively larger effort, favour the production of PKAR and curved walking in PD. Post-training, the velocity of walking increases, more so for the circular than the linear trajectory.

S.6ii The quality & quantity of real-world turns are poorer in prospective fallers

Lorenzo Chiari¹, Julia Leach¹, Pierpaolo Palumbo¹, Stefania Bandinelli², Sabato Mellone¹

¹Alma Mater Studiorum - Universita' di Bologna, ²Local Health Unit Tuscany Centre



BACKGROUND AND AIM: Although turning has been reported as one of the leading activities performed during a fall, and falls during turning result in 8-times more hip fractures than falls during linear gait, the quantity and quality of turns resulting in falls remain unknown since turns are rarely assessed during activities of daily living. Our hypothesis is that turning difficulty in real world activities is an early sign of balance instability and may be indicative of elevated fall risk. **METHODS:** We used in-home activity monitoring methods to investigate the relationship between turning strategies and fall risk in a high-functioning cohort of 160 community-dwelling older adults (a subsample of the InCHIANTI study) (Leach et al., 2018). Turn measures and activity rates were quantified. Fall incidence within 12 months from continuous monitoring defined fall status. **RESULTS:** Based on the analysis of 718,582 turns we found future recurrent fallers to exhibit both lower turn quantity and quality compared to the future non-/single fallers across a one-week monitoring period. Future recurrent fallers turned less often throughout their day and appeared to be less stable during one of the most common turn types (i.e., the 90° turn), as expressed by longer turn durations, lower turn velocities, and more steps utilized to complete the turn. Additionally, recurrent fallers walked slower, walked/turned less, and were more sedentary throughout their day. There was no difference in the overall active rate between the two groups, suggesting that impaired gait and turning ability, specifically, may have served as a significant contributing factor to the elevated fall risk within this cohort. CONCLUSIONS: Given the fact that 90° turn is the most unstable type of turn neurorehabilitation could focus on modifying turning strategies for 90° turns, with an emphasis on scaling turning speeds at different speeds of walking. Assessment tools targeting turning ability should also be adopted (e.g., the L-Test). If instrumented, as in the instrumented Timed Up and Go test, turn quality could be quantified and monitored throughout the duration of rehabilitation. Assessing turn quality via wearable sensors would indeed enable one to determine the efficacy of specific intervention strategies. Since directly impacting and improving turning ability lies in the forefront of our efforts to prevent future falls, adopting a neurorehabilitation approach with quantitative capabilities is essential.

S.6iii Turning deficits in patients with Parkinson's disease and the role of the prefrontal cortex during turning

Inbal Maidan¹, Anat Mirelman¹, Jeffrey Hausdorff¹

¹Tel aviv medical center

BACKGROUND AND AIM: Turning has been implicated as a complex task that requires both motor and cognitive resources. For patients with Parkinson's disease (PD), turning impairments are common features of gait disturbances, even in early stages of the disease, that are exacerbated with disease progression and can be a trigger for freezing of gait, falls, and reduced independence. Previous studies documented motor changes of turning in PD including impaired





axial coordination, reduction of spatial gait parameters, a greater number of steps, and more time to complete a turn. In contrast, the role of cognition in performing turns is more controversial. Intuitively, one could suggest that turning ability and the recruitment of the prefrontal region would be mediated by cognitive abilities mainly associated with motor planning and attention. Indeed, some evidence suggests that turns become slower and less efficient in the presence of a cognitive load, supporting the idea that turns demand attention and prefrontal activation, however, this evidence is indirect. Therefore, the aim of this work is to provide direct evidence on the role of prefrontal cortex during turns in PD patients. methods and RESULTS: Prefrontal activation during turns was investigated using functional near infra-red spectroscopy (fNIRS) in patients with PD. Interestingly, we found that PD patients use the prefrontal cortex during turning to a lesser extent than during straight-line walking. In addition, the degree of prefrontal activation during turning was related to background motor abilities, in particular ambulation function, showing that patients with better mobility reduced activation more than patients with worse mobility. Moreover, in another study that included patients with freezing of gait (FOG), we observed that during turns with freezing, i.e., unsuccessful turns, prefrontal cortex activation increased, compared to straight-line walking. In contrast, during turns without freezing, i.e., successful turns, prefrontal activation decreased, compared to straight-line walking. CONCLUSIONS: These findings demonstrate that during turning the prefrontal cortex plays a different role from straight line walking that may depend on the motor abilities of the patient. Higher prefrontal activation during turning in patients with relatively worse ambulation and FOG may reflect a compensatory attempt at improving turning performance. This possibility is consistent with a proposed model of gait failures in PD which posits that in the presence of reduced motor automaticity and poor gait, cognitive resources, in particular prefrontal regions, are called into play in attempt to compensate for these motor deficits. These findings suggest that improving ambulation in patients may increase the efficiency of brain activation by reducing prefrontal activation. Futures studies should examine activation in other brain regions and in response to specific interventions that target motor abilities.

S.6iv Rehabilitation treatment for turning: Role of wearable technology

Martina Mancini¹, Martina Mancini¹, Samuel Stuart¹, Fay Horak¹, Laurie King¹

¹Oregon Health & Science University

Nearly every task performed during the day requires some amount of turning [1]. Difficulty in turning during gait is a major contributor to mobility limitations, falls and reduced quality of life in older people and people with movement disorders (e.g. Parkinson's disease). Moreover, falls during turning are particularly dangerous because they usually result in contact of the femur with the ground, which results in eight times more hip fractures compared with falls during straight walking [2,3]. Turning gradually becomes more difficult as we age due to increasing sensorimotor





impairments. The ability to modify our locomotor trajectory by turning safely is important for functional independence but, surprisingly, turning is much more difficult for the nervous system to control than straight-ahead walking. It has been suggested that neural systems related with turning may be more vulnerable to impairments than those related with straight-ahead gait since turning involves more inter-limb coordination, more coupling between posture and gait, and modifications of locomotor patterns requiring frontal lobe cognitive and executive function that plays a role in postural transitions. Based on those impairments, a rehabilitation program for turning should include components of: coordination (inter-limb, temporal, spatial), consistency (reducing variability), challenge (speed, direction, sensory input, cognitive challenges). This guided discussion will review rehabilitation programs that target different aspects, such as muscle flexibility, weight shifting, coordination, and open-loop external cueing to improve turning outcomes. In parallel, we will also review the potential of wearable technology to improve rehabilitation programs outcomes by 1) providing objective measures at the impairment level, 2) providing a greater sensitivity to detect subtle changes in turning and 3) providing data on turning during regular daily function (home monitoring). Lastly, wearable technology could also be of help in providing patients with feedback about their performance during the rehabilitation session (closed-loop cueing). References [1] Glaister BC, Bernatz GC, Klute GK, Orendurff MS. Gait Posture, 2007. [2]. Cummings SR, Nevitt MC. Osteoporosis international, 1994. [3]. Feldman F, Robinovitch SN. Journal of biomechanics, 2007.

S.7: From basic science to clinical practice: Anxiety, attentional focus and the control of posture and gait

S.7i The role of movement specific reinvestment in attention focus and gait behaviour by older adults

Liis Uiga1

¹University of Waikato

BACKGROUND AND AIM: The Theory of Reinvestment (Masters, 1992; Masters & Maxwell, 2008) argues that using conscious step-by-step movement processes to control the movement mechanics online can disrupt performance of relatively automated motor skills. Conscious movement processing (i.e., movement specific reinvestment) is a function of personality, specific context of the task and a variety of psychological, physiological and environmental contingent triggers. As such, the propensity for movement specific reinvestment varies from one person to another and from one context to the next. The aim of this presentation is to provide the theoretical underpinnings of movement specific reinvestment and its association with gait behaviour in older adults. **METHODS:** Empirical research conducted in our laboratory examining gait behaviour by





older adults will be introduced. **RESULTS:** We have shown that older adults with a high propensity for movement specific reinvestment are more aware of their limb movements and less aware of the external environment when walking on ground level and/or navigating obstacles, whereas, older adults with a low propensity for movement specific reinvestment are less aware of their limb movements and more aware of the external environment. High inclination for movement specific reinvestment has been further associated with less accurate stepping, despite increased preparation and planning times. **CONCLUSIONS:** As conscious processes are slow and attention demanding, it is possible that older adults with a high inclination for movement specific reinvestment need more time to 'plan' their movements; however, this inefficient information processing leads to worse stepping accuracy that might lead to future falls. The findings of these studies have implications for practitioners (e.g., rehabilitation) and signal that caution should be taken when providing detailed verbal instructions that cause conscious movement processing.

S.7ii Postural threat and standing balance control: Do changes in attention play a role?

Martin Zaback¹

ispgr

¹University of British Columbia

Postural threat, manipulated through changes in surface elevation, has been used to examine how fear of falling influences balance control. When standing at the edge of an elevated surface, individuals typically lean away from the platform edge and demonstrate higher frequency and smaller amplitude postural adjustments [1]. While these threat-related changes in standing behaviour have been consistently replicated, the underlying mechanisms are not well understood. One theory is that emotionally-evoked neurophysiological changes are responsible. Support for this theory comes from research that has demonstrated facilitation of balance relevant vestibular and proprioceptive reflexes when standing under conditions of height-related postural threat [2-4], as well as increased cortical processing of balance relevant sensory inputs [5]. Such changes in sensorimotor set could contribute to the tighter regulation of standing balance typically observed when threatened. Alternatively, threat-related changes in standing balance may be influenced by changes in cognitive strategy. Recent work has demonstrated that there are broad changes in attention when standing under conditions of postural threat; individuals tend to dwell on threat-related stimuli, employ various self-regulatory strategies, and engage in greater conscious movement processing [6-8]. The latter is of particular interest, as redirecting attention toward one's movements may interfere with otherwise automatic postural control processes, potentially influencing standing behaviour [9]. This presentation will discuss recent work from our lab that has examined associations between threat-related changes in conscious movement processing and standing balance control, along with existing work that has examined how the manipulation of attention influences standing balance under non-threatening as well as





threatening conditions. Discussion will also focus on how known neurophysiological and attentional changes associated with threat may interact to influence standing behaviour. The overall aim of this presentation will be to provide insight into whether changes in attention represent an important mechanism underlying the relationship between postural threat and standing balance control. [1] Adkin and Carpenter (2018), Front. Neurol. 9:789; [2] Horslen et al. (2013), J. Neurophysiol. 110:899-906; [3] Horslen et al. (2014), J Physiol.592:3671-3685; [4] Naranjo et al. (2016), J. Neurophysiol. 115:833-842; [5] Adkin et al. (2008), Neurosci. Lett. 435:120-125; [6] Huffman et al. (2009), Gait Posture 30:528-532; [7] Zaback et al. (2016), Gait Posture 45:19-24; [8] Johnson et al. (in press), Psych. Res.; [9] Young and Williams, (2015), Gait Posture 41:7-12.

S.7iii Anxiety, attentional focus and the visuomotor control of adaptive locomotion

Toby Ellmers¹

¹Brunel University

A growing body of research has sought to understand how emotion and attention influence the control of posture and gait. This presentation will describe how fall-related anxiety, and associated changes in attention (e.g., an internal focus/conscious movement processing), influence how young and older adults control locomotion. Specific focus will be directed towards discussing how anxiety can disrupt the visuomotor processes necessary for adaptive gait, such as the proactive feedforward planning required to effectively avoid an obstacle. Previous research highlights marked differences, based on fall-risk, in the visuomotor control of adaptive locomotion. For example, older adults deemed to be at a high risk of falling often display both reduced feedforward planning and impaired on-line visual control of stepping movements (e.g., Chapman & Hollands, 2006; Young et al., 2012) - behaviours associated with increased stepping errors and, therefore, reduced safety. Young and Williams (2015) identified heightened fall-related anxiety as one potential mechanism underlying these 'high-risk' visual-search behaviours. Specifically, these authors proposed that anxiety-induced internal focus (and subsequent attempts to consciously control movement) mediates the relationship between fear of falling and altered patterns of visual search. This presentation describes a series of experiments conducted in our laboratory, which have directly manipulated fall-related anxiety and attentional focus in order to evaluate the impact of fall-related anxiety (and associated changes in attention) on visual-search during locomotion. The results from this research highlight a causal relationship between increased anxiety and disrupted visuomotor control of locomotion, and identify conscious movement processing/control as one possible underlying factor. This presentation will conclude by attempting to conceptualise these findings within previously presented psychological frameworks, such as Attentional Control Theory (Eysenck et al., 2007) and Reinvestment Theory (Masters & Maxwell, 2008).





S.7iv Attentional control strategies for retraining gait and balance control in rehabilitation: One size fits all?

Elmar Kal¹

¹VU University

BACKGROUND AND AIM: Considerable evidence from basic science suggests that conscious movement processing can disrupt motor performance in healthy adults and elderly. This finding could have important ramifications for clinical practice, as it implies that therapists should try to discourage their patients from using conscious control while moving. This may be especially appropriate for patients with stroke or Parkinson's, and elderly fallers. These clinical groups often report a particularly strong tendency to rely on conscious movement processing in daily life. **METHODS:** Focusing specifically on stroke rehabilitation, this presentation will try to answer whether (and how) the negative effects of conscious movement processing on motor performance translate to the clinical setting. For a comprehensive assessment, the presentation will first describe the results of observations regarding how physical therapists currently use internal focus strategies (which promote conscious control) when treating patients with stroke. Second, experimental studies will be discussed that have investigated the immediate and long-term effects of learning using internal focus strategies across a range of motor tasks (e.g., stepping, balancing, reaching). RESULTS: Combined, results of these studies challenge the notion that conscious motor processing is fundamentally maladaptive per se. Rather, converging evidence shows that an individual's motor skill, proprioception, and attentional capacity can partially determine whether an internal, conscious strategy will benefit or disrupt motor performance. For example, a recent randomised trial suggests that conscious processing may only disrupt balance when patients have relatively intact proprioceptive and motor control, and might actually be beneficial in individuals with impairments in these areas. CONCLUSIONS: To conclude, anxiety-induced changes in attentional control may sometimes be adaptive in people with movement difficulties. It may be appropriate for therapists to screen their patients' motor, proprioceptive and cognitive skills to be better able to adapt their use of instructions to the individual patient.

S.8: Data analytics in the wild: Translating emerging wearable inertial and camera methods to fall prevention intervention strategies





S.8i Digital gait biomarkers beyond the laboratory: advantages and challenges

Silvia Del Din¹

¹Newcastle University

Digital gait biomarkers are emerging as a powerful tool to detect early disease and monitor progression across a number of conditions. Typically, quantitative gait assessment has been limited to specialised laboratory facilities. However, measuring gait in home and freeliving/community settings may provide a more accurate reflection of gait performance as it allows walking activity to be captured over time in habitual contexts. Modern accelerometer-based wearable technology allows objective measurement of digital gait biomarkers, comprising metrics of free-living walking activity/behaviour as well as discrete gait characteristics. This presentation will address the feasibility, advantages and challenges of measuring digital gait outcomes during free-living activity for discriminating pathology and detecting early risk. The use of traditional digital gait outcomes and novel metrics as a measurement tool for characterising patient populations, discriminating disease (e.g. Parkinson's disease) and detecting risk (e.g. prodromal stage of disease) will also be discussed. Data driven approaches for disease classification and progression will also be presented. Quantification of digital gait outcomes in freeliving/unsupervised environments presents considerable challenges due to: sensor limitations; lack of standardised protocols, definitions and outcomes; engineering challenges; and contextual recognition. However our preliminary results are encouraging regarding the use of digital gait biomarkers for application in large multi-centre clinical trials, for supporting diagnosis and guiding clinical decision making.

S.8ii Fall risk assessment with wearables in the wild: Towards recommended free-living outcomes

Mina Nouredanesh¹, Alan Godfrey², James Tung¹

¹University of Waterloo, ²Northumbria University

Current wearables, largely inertial measurement unit-based devices (IMUs, e.g. accelerometer, gyroscope) have been used to quantify a range of physical functioning/capability related tasks. Most notable are gait related activities such as intermittent and continuous (predefined timed, e.g. 2 minutes) walking during clinical/laboratory observational-based testing. Other examples include transitions, turns and composite measures of physical capability such as timed-up-and-go (TUG). Utilising IMUs to objectively quantify outcomes during those tasks adopts an instrumented approach which have shown promise for fall risk assessment (FRA) during laboratory-based protocols. Yet, true IMU value resides beyond the laboratory while monitoring more natural, habitual activities. Discrete, high resolution IMUs can gather data continuously in any environment.




Current state of the art has primarily focused on gait assessment during 3 to 7 day studies but notable challenges remain which are also evident during gathering free-living turning, transition and composite related data. Despite the growing body of literature focusing on the development of novel IMU-based free-living FRA methods, there is little consensus on use of language (e.g. quantity vs macro) and outcomes (e.g. spatiotemporal gait, sedentary duration, quantity of missteps). Moreover, this is complicated by the (i) inconsistent inclusion and description of gait outcomes within discrete domains associated with fall prediction (e.g. postural control, pace); (ii) methodological and algorithm descriptions of how gait and other activities are defined from freeliving IMU bout segmentation; and (iii) dearth of contextual analysis surrounding IMU captured free-living gait and fall related events. From a detailed narrative literature review, we highlight inconsistencies within the literature while providing recommendations towards the harmonisation and standardization of outcomes for free-living FRA by: (a) proposing a new conceptual framework to map free-living IMU-based outcomes; and (b) identifying outcomes with strong predictive power for falls. Furthermore, current limitations associated with collecting and analyzing free-living IMUbased data only are discussed. Consequently, we introduce the potential of body-worn egocentric cameras to complement IMU data with contextual information (to detect fall-related environmental hazards, circumstance and location) while proposing new approaches to complement existing gait models with outcomes from video data.

S.8iii Video capture of falls in long-term care from cameras mounted to ceilings and walls: Lessons from an 11 year cohort study

Stephen Robinovitch¹, Natalie Shishov¹, Vicki Komisar¹

¹Simon Fraser University

For the past 11 years, we have partnered with two long-term care facilities in the Vancouver area in a cohort study of falls. The study involves the collection of video footage of real-life falls collected from networks of cameras mounted to ceilings and walls in common areas (dining rooms, hallways and lounges). To date, we have analyzed over 2400 falls experienced by over 650 residents, using structured questionnaires to explore the characteristics of fall initiation, descent, impact and recovery. These validated tools allow us to quantify the activities that older adults were attempting at the time of the fall, the characteristics of the environment, the nature of balance recovery attempts, the direction of the fall, and the body parts experiencing impact during the fall. The size of the database allows us to narrow our focus to examining falls in specific patient subgroups, situational or environmental contexts, or injury outcomes including hip fracture (see Figure). We are now sharing a database of 105 falls for reuse by researchers through the NYU-based Databrary network. Environmental cameras have specific strengths and weaknesses for video capture of falls. Once installed, they do not rely on the user to adopt or wear the technology. They





can provide extensive coverage (at a cost) and high resolution images. The external view of the fall facilitates analysis of the time-varying kinematics of the body during falls with video digitization or modelling software. However, each camera only captures movements in it's field-of-view, and occlusions are common. In contrast, body-mounted cameras can provide continuous footage regardless of location. For any type of video system, the range of feasible outcomes is limited to what can be reliably observed from the video. For example, our questionnaire quantifies the biomechanical nature of imbalance (slip, trip, loss of support, etc), but we cannot determine from the video the physiological factors underlying imbalance. Challenges arise in extracting the intent or thoughts of the individual from video. Body-centric cameras may provide complementary information on head orientation or gaze. Another challenge is automatic detection of events of interest, such as falls (a process that is facilitated in long-term care through incident reports, and the ability to capture weeks or even months of video footage on large hard drives). The development of computer vision techniques to automatically extract a range of useful outcomes from video footage is a worthwhile but challenging goal. Preliminary attempts to detect falls from video footage with machine learning algorithms show about 70% accuracy in detecting falls, but may be higher for body-centric cameras.

S.8iv Daily-life gait analysis to evaluate fall risk and mobility decline

Kim van Schooten¹

¹Neuroscience Research Australia/University of New South Wales

Wearables are becoming ubiguitous for activity tracking and can provide insight into quality of movement. These devices can be used to unobtrusively assess the amount and quality of gait someone engages in during daily life, which has been linked to fall risk. This presentation will provide an overview of the opportunities, challenges and limitations of using wearable sensors in large-scale studies to assess fall risk and mobility decline. It will also discuss how video-based approaches may advance the field. The first part of the presentation will focus on sensitivity of daily-life gait to change, which is essential for use beyond screening. We collected repeated assessments in 169 older people, 2 weeks apart, to assess stability of daily-life gait quality characteristics. Our results show that gait characteristics were comparable (all $p \ge 0.11$) and strongly correlated between the two assessments (r = 0.77 to 0.97). Recent work on sensitivity to change over a year as a result of time or a balance exercise intervention will also be discussed. Whilst initial results are promising, the field is still in its infancy. Future work should address standardisation of daily-life gait analysis and rigorous testing of methodology. Video observation might assist in validating some of the underlying assumptions of daily-life gait analysis, as well as provide insight into contextual influences, which cannot readily be assessed with accelerometers. Hence, the second part of the presentation will focus on how wearable and video-based



approaches may complement and enrich each other to discuss the future of these techniques to improve efficient use in clinical-based studies.

S.9: Spinal cord stimulation for gait dysfunction and postural instability in Parkinson's disease

S.9i Effects of spinal cord stimulation on mobility and cortical activity in Parkinson's disease patients with severe gait dysfunction and ON-freezing

Olivia Samotus¹, Andrew Parrent², Mandar Jog²

¹Western University, Ontario, ²London Health Sciences Centre

BACKGROUND AND AIM: Axial motor symptoms such as gait dysfunction and freezing of gait (FOG) are highly disabling and result in injuries, and loss of independence and quality of life in Parkinson's disease (PD) patients. The response of axial symptoms to dopaminergic therapy and deep brain stimulation is limited and unpredictable. Individualized programming of epidural spinal cord stimulation (SCS) has been shown to reduce the number of FOG episodes and improve spatiotemporal gait features over 6-months. We investigated how motor cortical excitability is modulated by SCS therapy for PD gait dysfunction over a 12-month period. METHODS: Midthoracic SCS was implanted in 10 PD patients with levodopa-resistant FOG and gait dysfunction. Primary motor intracortical facilitation and inhibition activities were assessed using paired-pulse transcranial magnetic stimulation (pp-TMS) protocols targeting the first dorsal interosseous (FDI) and tibialis anterior (TA) muscles. SCS programming was individualized to each participant's spatiotemporal gait metrics within the first month post-SCS implantation. Ambulatory and turning gait tasks and pp-TMS measures were collected pre-SCS implantation and at 3-, 6-, and 12months of SCS use while participants were OFF and ON dopaminergic medication. RESULTS: SCS significantly reduced the number of FOG episodes and improved dynamic postural balance, stride velocity, step length, single support and swing times acutely (1-hour in the lab with SCS ON) and with chronic SCS use (participants on medication with the SCS turned OFF and ON) compared to pre-SCS. At baseline, impaired intracortical facilitation (ICF) levels in the lower limb cortical areas were correlated to stride length and velocity gait parameters while participants were off medication. ICF levels increased with chronic SCS use while participants were off and on medication. With SCS, short afferent inhibition levels in the upper limb were improved and correlated to improvements in spatiotemporal gait dynamics. CONCLUSIONS: Observed gait improvements by SCS in PD participants may be governed by enhancing motor cortical activity.





S.9ii Subthalamic neural signatures of gait impairment and FOG in Parkinson's disease and the response to 60 Hz and 140 Hz deep brain stimulation

Helen Bronte-Stewart¹, Chioma Anidi¹, Johanna O'Day¹, Ross Anderson¹, Muhammad Furqan Afzal¹, Judy Syrkin-Nikolau¹, Anca Velisar¹

¹Stanford University Medical Center

BACKGROUND AND AIM: Freezing of Gait (FOG) is a devastating axial motor symptom in Parkinson's disease (PD) leading to falls, injury and loss of independent living. The response of FOG to dopaminergic medication and deep brain stimulation (DBS) is complex, variable and yet to be optimized. Fundamental gaps in the knowledge of the underlying neuro-biomechanical mechanisms of FOG render this symptom one of the unsolved problems in the treatment of PD. Subcortical neural features of gait impairment and FOG in PD are largely unknown due to the challenge of accessing deep brain circuitry in freely moving human subjects, and due to the difficulty of eliciting FOG. Since FOG is episodic we hypothesized that dynamic features of subthalamic (STN) beta oscillations (beta bursts) may contribute to the freezer phenotype during gait tasks that elicited FOG. We also investigated whether STN DBS at 60 Hz or 140 Hz affected beta burst dynamics and gait impairment differently in Freezers and Non-Freezers. **METHODS**: Synchronized STN local field potentials from an investigative implanted sensing neurostimulator (Activa® PC+S, Medtronic Inc, FDA IDE, Stanford IRB approved), and gait kinematics/kinetics were recorded in 12 PD subjects, off medication, during forward walking and stepping in place (SIP on dual force plates) tasks under the following randomly presented conditions: NO, 60 Hz, and 140 HZ STN DBS. RESULTS: Prolonged movement band beta burst durations differentiated Freezers from Non-Freezers during gait without FOG, and were longer during periods of FOG in Freezers. In Freezers, both 60 Hz and 140 Hz DBS improved gait arrhythmicity and shortened burst durations during gait without FOG, reduced the percent time of FOG and shortened burst durations during FOG. In contrast STN DBS at either frequency left unchanged the normal gait parameters and short burst durations in Non-Freezers. CONCLUSIONS: This study demonstrates that prolonged periods of excessive beta oscillations and synchrony (longer beta burs durations) are important neural markers for freezing behavior and FOG in PD and that STN DBS modulates longer not shorter beta burst durations while improving gait arrhythmicity and FOG, thereby acting to restore physiological signaling in sensorimotor networks.

S.9iii Behavioral and electrophysiological effects of spinal cord stimulation Parkinson's disease animal models

Rómulo Fuentes¹, Aquiles Martínez¹, María Florencia Alamos²

¹Universidad de Chile, ²Pontificia Universidad Católica de Chile





BACKGROUND AND AIM: Dopamine replacement therapy is effective for treating appendicular symptoms of Parkinson's disease (PD), but is less effective for axial symptoms like posture and gait impairments. For the first time, we applied the novel use of thoracic spinal cord stimulation (SCS) to restore locomotion and improve freezing, bradykinesia and rigidity symptoms in rodent and primate parkinsonian animal models. The objective is to discuss the possible mechanisms of action of SCS for treating gait in parkinsonian disorders. METHODS: In several studies involving different PD animal models, acute pharmacologically induced dopamine-depleted mice, chronic 6- hydroxydopamine (6-OHDA) lesioned rats, rats with alpha-synuclein over expression, and marmosets with 6-OHDA lesion we measured behavioural and electrophysiological responses to SCS. In vivo electrophysiological recordings within the brain motor circuit using local field potential and single neuron were measured before and after SCS was applied. RESULTS: The functional recovery was paralleled by the disruption of the pathological low-frequency synchronous oscillatory activity, leading to an electrophysiological state normally preceding spontaneous initiation of locomotion. Neuronal activity patterns of dorsolateral striatum and primary motor cortex (MI) were also significantly altered. CONCLUSIONS: These studies suggest that SCS effect is not just due to a local effect on the spinal cord. It seems that SCS can interfere with brain dynamics, leading to states that allow movement. SCS should be considered as an additional treatment option for PD-patients.

S.10: Virtual reality as a tool to alter multisensory perception and human motor learning

S.10i Limitations and opportunities for virtual reality sensorimotor training

Daniel Ferris¹

¹University of Florida

BACKGROUND AND AIM: Previous research using virtual reality for motor skills training has failed to demonstrate it can accelerate or improve training outcomes relative to training in the real world. Sensorimotor training seems to inhibit motor learning compared to practicing the real world task. Potential reasons for the inhibited motor learning are the slow refresh rate of visual displays, disconnect between visual display and vestibular feedback, reduction in peripheral vision, and/or added cognitive load. As a result, many attempts at improving sensorimotor training with virtual reality have not fared well in comparison to real world training. Although there appear to be drawbacks to virtual reality training, there are advantages to using virtual reality that allow for perturbations or manipulations to training that cannot be done in the real world. For example, virtual reality can induce added stress safely in a human by modifying the training environment. Walking on a balance beam four stories off the ground is safer and easier to accomplish in virtual





reality than in the real world. Another example of training modifications that can be more easily accomplished with virtual reality compared to the real world are visual perturbation. Introducing transient changes to the visual field with virtual reality can cause individuals to downgrade their dependence on visual feedback and increase their dependence on proprioceptive feedback. These types of virtual reality modifications enable researchers to enhance motor learning outcomes during sensorimotor training. METHODS: My laboratory has studied how electrocortical brain activity (i.e. high-density electroencephalography) and whole body biomechanics change in regard to virtual reality modifications during sensorimotor training. We often use an experimental paradigm of subjects walking on a treadmill-mounted balance beam as it is a functional locomotor task that requires active lateral balancing. With virtual reality, we have been able to modify the sensory feedback to individuals as they practice the sensorimotor locomotor task. **RESULTS:** Virtual reality modifications can modify physiological parameters during training along with motor learning outcomes after practice. The electrocortical data indicates that the choice in virtual reality modifications can have distinct effects on brain network activity, providing insight into the neurophysiological mechanisms for modified motor learning outcomes. CONCLUSIONS: Combining biomechanical and electrocortical measurements during experimental modifications of sensorimotor training with virtual reality can greatly enhance the design of new training approaches. In addition to providing new insight into how the brain controls human movement, the techniques can also inform computer scientists and engineers how they might improve virtual reality systems for enhanced sensorimotor training outcomes.

S.10ii Using simulation technologies to study multisensory self-motion perception and mobility: Effects of age-related changes to sensory and cognitive functions

Jennifer Campos¹, M. Kathleen Pichora-Fuller², Karen Li³, Natalie Phillips³, Laurence Harris⁴

¹Toronto Rehabilitation Institute - University Health Network, ²University of Toronto, ³Concordia University, ⁴York University

Background As we move though our environment, our brain integrates visual, auditory, proprioceptive and vestibular inputs. Optimally integrating these inputs allows us to perceive self-movement parameters (e.g. heading direction) with greater certainty. However, much remains to be understood regarding how sensory inputs are integrated in the brain to support mobility and how age-related changes to sensory and cognitive functions affect these processes. Virtual Reality (VR) and simulation technologies are unique tools for multisensory research given the ability to strategically manipulate individually sensory inputs. Further, these technologies can be used to mimic everyday conditions, which is informative when applying fundamental knowledge in multisensory and sensory-cognitive integrative processes to real world mobility-related challenges. First, I will describe Toronto Rehab's Challenging Environment Assessment





Laboratory (CEAL) which houses a motion platform, advanced driving simulator and immersive projection-based VR system with treadmill. Second, I will describe studies evaluating sensorymotor-cognitive interactions during tasks of standing balance, walking, and passive motion. methods and **RESULTS:** 1. We evaluated age-related changes to visual-vestibular integration using the motion platform and a head-mounted display to perform psychophysical heading estimation tasks. Results indicate that older and younger adults both demonstrate increased estimate precision from congruent bimodal inputs (visual+vestibular) compared to unimodal inputs (visual or vestibular alone); however, during sensory conflicts (conflicting visual and vestibular heading angles), older adults do not demonstrate reliability-based sensory weighting as would be predicted by optimal integration. 2. We used the projection-based VR simulator to evaluate standing balance and walking performance during multisensory, multitasking conditions. Specifically, participants either walked or stood within a simulated city scene while either performing an auditory divided attention task or no secondary task. Dual-task costs were evaluated and suggest that mobility-related functions were prioritized; particularly in older individuals with and without hearing loss and older adults at risk of cognitive decline. Conclusions Understanding how sensory inputs are integrated to support mobility helps extend traditional approaches of studying sensory systems independently. Reproducing realistic and challenging conditions can provide novel insights into sensory and cognitive interactions. These processes may change with age-related sensory and cognitive declines. Simulators can provide novel methods of systematically studying the fundamentals of multisensory integration and can provide an important middle ground between traditional labs/clinics (controlled/safe) and the real world (uncontrolled/dangerous). FUNDING: NSERC, CIHR, Alzheimer's Association.

S.10iii Development of low-cost virtual reality applications to assess sensorimotor function and improve real-world mobility

James Finley¹, Aram Kim¹, Beth Fisher¹, Marientina Gotsis¹, Vangelis Lympouridis¹

¹University of Southern California

BACKGROUND AND AIM: Recent advances in consumer-level virtual reality (VR) have opened the door for the development of low-cost, fully-immersive systems for interactive mobility training. The promise of VR for improving mobility lies in its ability to mimic real-world challenges such as obstacles and crowds while providing systematic control over the environment and augmented performance feedback. However, creating effective training applications requires an understanding of how sensory feedback provided in VR is integrated with ongoing locomotor commands and how the practice of locomotor skills in VR transfers to the real world. Here, I will share recent work from our lab exploring sensorimotor integration and locomotor skill learning in virtual reality, and conclude with a description of how we use this information to develop





interactive mobility training experiences. **METHODS:** We first investigated how visual feedback about the lower extremities influenced the coordination between head orientation and foot placement during a treadmill-based virtual obstacle negotiation task. During the task, participants received one of three types of visual feedback about the lower extremities: no feedback, end-point feedback, and a link-segment model. In a second study, we examined how people acquired a novel obstacle negotiation skill in VR and evaluated how this skill transferred to the real-world. Transfer of learning was assessed by measuring how VR-based training influenced participants' foot clearance during over-ground negotiation of a physical obstacle. We also assessed retention of the learned skill on the treadmill and over-ground 24 hours after the initial session. RESULTS: The presence of a visual representation of the lower extremities led to greater downward head pitch during the approach to and subsequent crossing of an obstacle. Moreover, this strategy was associated with increased safety margins during trailing limb crossing. In our study of skill learning, we found that participants systematically learned to reduce foot clearance during the VR trials, and this reduction in foot clearance transferred to over-ground walking. Moreover, this skill was retained in VR and over-ground on Day 2. Lastly, we found that retention in each environment was associated with the final level of performance in the same environment on Day 1. CONCLUSIONS: These results demonstrate that the quality of visual information about the lower extremities influences visuomotor coordination during virtual obstacle negotiation. Moreover, we showed that locomotor skills can be learned in VR and the retention of these skills is associated with performance during skill acquisition in a context-dependent manner. Ultimately, gaining a deeper understanding of sensorimotor control and learning in the context of VR is critical for informing the development of effective VR-based clinical interventions to improve mobility.

S.11: Balance training using perturbations to prevent falls: Is it feasible and effective?

S.11i Perturbation training for fall-prevention: Inception, evolution, translation

Tanvi Bhatt¹

¹University of Illinois at Chicago

Despite the commonality of falls within the community-dwelling aging and disabled population, little is known about their mechanism or their contributing factors, with limited tools assessing this crucial aspect. Further, there are limited evidence-based treatment approaches for fall reduction in these populations. Perturbation training is an emerging, task-specific intervention that exposes individuals to self- or externally-generated perturbations, entraining proactive and reactive control mechanisms for fall prevention. We examined the adaptation and training effects to repeated laboratory-induced perturbations and the ability to generalize their effects to different contexts.





Healthy subjects were exposed to repeated moveable platform slip perturbations induced under their right limb and were subsequently exposed to slips under the non-trained limb, non-trained surface (oil contaminated vinyl floor) and non-trained tasks perturbation (trips). We observed that the perturbation-training induced adaptations could be significantly generalized across limbs, functional tasks, and training devices, resulting in reduced fall outcomes on exposure to these novel, non-training environments. Preliminary results indicate that older adults are able to demonstrate similar adaptations and generalizations. Findings from systematic large scale clinical trials indicate in older adults indicate that single-session, training-induced adaptations can be retained in a laboratory setting for up to 12 months with maximum retention at 3 months with a gradual motor memory decay from 6 to 9 to 12 months. To facilitate translation of such training into clinical environments, we subsequently conducted an RCT to examine adaptation effects induced from treadmill-slip-perturbation training in older adults and their generalization to overground slips. Results indicated that treadmill-slip-perturbation training though effective in inducing reactive adaptations in stability control and reducing fall-risk to novel overground slips was less effective than the task-specific overground slip training. Conversely overground tripperturbation training though resulted in significant adaptations within a single-session in terms of stability control and obstacle hit, shorter-term retention was not as robust as slip-induced. Further, considerations of optimal dosage for perturbation training will be discussed. Lastly we examined if the adaptive effects observed within a healthy nervous system would be impacted by a neurological insult such as a stroke. Results indicated that upon exposure to overground slips people with hemi-paretic chronic stroke could acquire adaptations in stability control similar to healthy older adults both under affected and non-affected limbs (albeit at different rates) for preventing fall-risk. Given these positive results, perturbation-based assessment and training could be used as an adjunct to current rehabilitation paradigms to target fall-prevention.

S.11ii Adaptation and retention of reactive gait stability to trip perturbations in older adults

Kiros Karamanidis¹, Epro Gaspar¹, Chris McCrum², Matthias König¹

¹London South Bank University, ²Maastricht University Medical Centre+

Gait stability declines and falls incidence increases with age. Most falls among older people occur during gait, often due to tripping or slipping. Thus, the ability to respond appropriately to unexpected external disturbances in the mechanical environment during gait, and to improve and retain such fall-resisting skills are important for preventing falls. Task-specific assessment of gait stability and adaptability, in addition to potential training-induced improvements in the recovery stepping behaviour of older adults, comprise an interesting experimental approach to assess and influence mechanisms that may affect the safety of human gait. In a series of laboratory-based





studies, we investigated how gait stability and adaptability during walking with trip-like perturbations are affected by age and muscle-tendon unit mechanical properties, in order to better understand the underlying mechanisms of the decline in locomotor function across the adult lifespan. We demonstrated that the ability to control dynamic stability in response to a novel trip-like perturbation during walking has already begun to deteriorate by middle age, however, even in old age the ability to adapt gait and improve stability following repeated perturbations is preserved. In subsequent studies we showed that leg-extensor muscle strength and tendon stiffness limit gait stability during unexpected, untrained perturbations, but that the potential for adaptive improvement after repeated perturbations during walking seems not to be related to the age-related degeneration in muscle-tendon unit capacities. Concerning the long-term retention of acquired gait stability improvements, we found that the neuro-motor system of older adults is capable of retaining the improved fall-resisting skills over a prolonged time period (years) with minimal decay over time. In summary, our findings support the hypothesis that the aged neuromotor system can facilitate reactive balance responses by upgrading its neuromuscular coordination and retaining those balance improvements over several years and may thereby reduce the risk of falling. Whether training effects are also translated to other balance tasks will be discussed.

S.11iii Pursuit of ecological validity in perturbations used for reactive balance training: Studies using the trip and slip walkway in young and older adults

Yoshiro Okubo¹, Matthew Brodie¹, Daina Sturnieks¹, Stephen Lord¹

¹Neuroscience Research Australia

The greater fall reduction effect shown by balance training using perturbations, compared to general exercises, are likely related to the greater task-specificity of the trained movements (Okubo et al., 2017). Ecologically valid perturbations (i.e. similar to real life hazards) may be crucial for training balance to prevent falls. The most common causes of falls among community-dwelling older adults are trips and slips (Berg et al., 1997). Therefore, we developed a walkway that provides unpredictable trips and slips while walking at usual gait speed. We will present results from two pilot experiments and a randomised controlled trial (RCT) using this trip and slip walkway. Our first pilot study with 10 young participants indicated (i) rapid adaptations (in a few trials) are related to prediction of the perturbation type and location, (ii) gait adaptations based on prediction do not transfer to trips and slips that occur in new, unexpected locations, and (iii) improvement of reactive responses occurs more slowly. The second pilot study with 10 young and 10 older participants indicated that increasingly unpredictable perturbations (i.e. less prediction and more reactive response) resulted in increased anxiety and a 30% dropout in older adults. This indicates training reactive balance in a single session is not optimal and older adults



require more staged progression in learning appropriate responses to unpredictable trips and slips. This informed a RCT which involved 44 older adults taking part in three sessions of trips, slips and mixed training (intervention) and sham step training (control). At post-assessment, relative to the control group, the intervention group experienced -60% fewer total falls (rate ratio [RR]=0.40, 95% confidence interval [CI]=0.22-0.76), -67% fewer slip falls (RR=0.33, 95% CI=0.12-0.90) and -51% fewer trip falls (RR=0.49, 95% CI=0.21-1.12) in the laboratory (Figure 1). These findings indicate older adults can improve reactive responses to trips and slips with high unpredictability. Further research is required to examine its effects in reducing real-life falls and improve clinical feasibility of the training paradigm while maintaining its efficacy and ecological validity.

S.11iv Can balance training with perturbations actually be implemented in rehabilitation practice?

Avril Mansfield¹, Elizabeth Inness¹

¹University Health Network

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Reactive balance training (RBT) with perturbations is a relatively new treatment approach, and lack of awareness and knowledge of new interventions is often the primary barrier to clinical implementation of new practices. Furthermore, specific characteristics of RBT pose challenges for implementation into clinical practice. Most notably, previous studies of RBT usually use custom equipment (e.g., walkways, moving platforms) or programmable treadmills to deliver the perturbations. Lack of time, lack of equipment, poor equipment reliability, and knowledge and skills required to use the equipment are some common barriers to using new treatments in rehabilitation practice when new devices are involved. Therefore, relying on equipment to provide the perturbations may pose a significant challenge to implementing RBT into clinical practice. Additionally, reactive balance control is not assessed routinely in clinical practice, which presents a challenge for identifying client-specific reactive balance dyscontrol that can be targeted with training. We have developed task-oriented RBT methods that do not require specialized equipment, and have implemented these methods into neurorehabilitation practice at our institution for individuals with stroke, acquired brain injury, and spinal cord injury. This presentation will discuss our experiences implementing RBT, results of studies we have conducted evaluating the effect of RBT on reactive balance control and falls in daily life, and results of a survey of healthcare professionals' use of RBT in clinical practice. Using an integrated knowledge translation approach, working collaboratively with clinical partners, we iteratively developed an approach to outline principles of training (e.g., motor learning and 'FITT' principles), inclusion/exclusion criteria and safety considerations, and potential training strategies based on underlying dyscontrol. Our work demonstrates that low-tech RBT is feasible in neurorehabilitation



practice, can improve reactive balance control, and has the potential to prevent falls in daily life. With an aim to translate this practice to other settings, we undertook a Canadian-wide survey to understand current practices. Results of our survey suggest that RBT is used frequently in clinical practice (used by >75% of respondents). Lack of knowledge of RBT is the most significant barrier for those who do not use this method in their practices. Healthcare professionals who were familiar with RBT and open to using it in practice reported barriers related to training, knowledge, human resources, client characteristics, and the practice setting. While low-tech RBT methods are feasible and effective, a question remains as to which perturbations methods are most effective. Our ongoing and future work aims to further develop and evaluate knowledge translation tools to support clinical uptake of RBT in other rehabilitation settings.

S.12: The challenge of preventing stair falls: Understanding the individual contributions of, and interplay between, environmental and intrinsic factors

S.12i The challenges and opportunities of simulating stair falls in a laboratory environment to inform stair and handrail design

Alison Novak¹

INTERNATIONAL SOCIETY OF

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ispgr

¹Toronto Rehabilitation Institute-UHN

Falls can be prevented on a population-level through environmental changes. This is because these extrinsic risk factors are amenable to correction and do not require modifications in individual behaviour or physical function. In the case of stairs, environmental changes can effectively occur through modifications to building codes and standards. However, to affect policy change considerable empirical evidence is needed. When evaluating changes in stair and handrail design parameters there are two aspects of prevention to consider. Firstly, we must understand the effectiveness of the environmental parameter to prevent the unexpected occurrence of a slip, trip, misstep, or other event which may lead to a fall (i.e. to prevent the balance loss from occurring in the first place). In addition to preventing the balance loss from occurring, we must also understand the effectiveness of the environmental parameter to prevent a fall from occurring when an unexpected event occurs and an appropriate balance recovery reaction is required. In general, this component of addressing stair falls has been much more difficult to evaluate in a laboratory environment given concerns with safely simulating stair falls. Adding to this challenge, ~ 40% of falls on stairs result in backward rotation of the body, while 50% of falls result in forward rotation. These distinct forms of balance loss on stairs place different demands on whole-body control to generate sufficient recovery reactions and should be uniquely simulated in the





laboratory environment. To date, several methods to simulate stair falls have been employed in our lab, including support surface removal, support surface rotations and translations, and induced slips. While some of these methods produced the intended type of balance loss, there was significant variability in global recovery responses between participants. In the case of handrail usage specifically, evaluation of size and shape parameters on comprehensive biomechanical measures is a challenge given the lack of repeatability. To address this, a maximum withstood perturbation protocol (MWP) has been implemented; perturbations are delivered via support surface translations demanding participants to reach and grasp for a nearby handrail without stepping. The perturbations increase in magnitude until the participant fails. The MWP permits us to create a repeatable testing protocol where full handrail reliance is required and systematic modifications in design parameters can be assessed. The external validity of this testing paradigm, however, remains unknown. Moving forward, this research will comprehensively evaluate parameters of stair and handrail design to support effective balance recovery reactions, including more detailed analyses of stepping and grasping responses considering age and impairment. Ongoing work is actively being translated to policy makers in Canada and internationally to inform stair and handrail codes and standards.

S.12ii Stair biomechanics in ageing and diabetic neuropathy: Personal factors underpinning fall risk

Neil Reeves¹

¹Manchester Metropolitan University

Stair negotiation is one of the most physically challenging activities performed on a daily basis with evidence from studies in both young and older adults measuring joint moments on stairs of standard dimensions. The challenging nature of stair negotiation is particularly evident at the ankle joint where older adults need to employ biomechanical strategies to remain within the limits of their maximum joint moment capacity. On standard rise stairs (170mm), older adults are able to control their descent through increased co-contraction of knee and ankle extensor muscles in a way that reduces their downward centre of mass (CoM) velocity and acceleration compared to young adults. This 'conservative strategy' likely compensates for their reduced lower limb strength, since upon landing, older adults are much slower at arresting downwards CoM velocity compared to young adults. Slower attenuation of the landing impact stems from a reduced ability to generate adequately high eccentric ankle moments at high angular velocities and necessitates using the lowering leg to minimise the loads on the outstretched landing leg. Older adults adopting a sideways stepping strategy (facing sideways, two feet on each step) minimise the elevated joint moment demands at an increased rise height (170mm to 220mm) compared to a typical 'step-over-step' strategy (facing forwards, one foot on each step) and a step-by-step strategy (facing





forwards, two feet on each step). Notably, there was minimal increase in ankle joint moment with this sideways stepping strategy and even a slight reduction in the landing limb. Sideways stepping may therefore be considered as a useful strategy to minimise ankle joint moment demands in high fall-risk groups on stairs. The response of the landing limb during stair descent is particularly important in arresting the CoM velocity and ensuring a controlled landing. Whilst ageing reduces ankle strength capacity, diabetic peripheral neuropathy (DPN) not only reduces ankle strength but involves a complete absence of foot sensation affecting knowledge of foot-ground contact. People with DPN pre-activate plantar flexor muscles earlier while the landing limb is being lowered onto the step during descent to compensate for absent sensation. Despite earlier pre-activation, this clinical population shows a much slower rate of ankle joint moment development after contacting the step compared to matched-controls without diabetes and a group with diabetes but no neuropathy. This has implications for limb instability and unsteadiness. Overall, marked impairments to balance control on stairs have been observed in patients with DPN compared to controls and a group with diabetes but no neuropathy. Impaired sensory perception and motor control in the lower limb with DPN is therefore a key factor influencing joint moment development and balance control, placing this clinical group at particularly high risk for falls.

S.12iii Using visual markings to enhance the visual environment on stairs and reduce stair fall-risk

Richard Foster¹

¹Liverpool John Moores University

Ambiguous visual properties of stair surfaces are important contributing factors to risky behaviour which can lead to stair falls. Age-related declining visual function or onset of visual impairment contribute to older adults being more susceptible to stair falls. Additional environmental visual factors that contribute to stair negotiation being so challenging include low lighting levels, patterned surfaces and surfaces that are uniform in colour (e.g. Fig. 1A). Locating a stair edge may therefore be easier with the presence of visually contrasting strips (edge highlighters), placed across the stair tread to clearly delineate the edge from the rest of the tread. However, incorrect positioning of edge highlighters on stair treads can also be dangerous. Our previous work has shown that when misleading edge highlighters are set back from the tread edge (e.g. by up to 30 mm), as commonly seen on public stairwells, foot clearances in young and older adults are significantly closer to the tread-edge. Furthermore, for stairs that are uniform in colour or with misleading edge highlighters, accidental foot contacts increase, especially for those with visual impairment. We suggest that an edge highlighter placed flush with the tread-edge clearly delineates the tread from the step below, enabling adequate and less variable foot clearance. Visual markings on surfaces may also alter visual perception or create an illusory effect (e.g.





exposure to patterned surfaces on carpets in the home or tiled pavements/sidewalks). Our computer-based perception tests were previously developed to assess perceptual responses to various visual cue configurations on stairs in young adults. The visual cues appeared as black and white vertical stripes arranged at varying spatial frequencies on a stair riser with an abutting edge highlighter on the stair tread (Fig. 1B), representing a version of the horizontal-vertical illusion (Fig. 1C). Young adults significantly overestimated (up to 25%) the true height of stair risers (190 mm) compared to a plain riser, and the magnitude of overestimation tended to increase with increasing spatial frequencies. When the striped visual cue was superimposed on to physical steps and stairs, there was a significant increase in foot clearance (approximately 1 cm; 17.5%) for older adults during stair ascent, with no accompanying destabilizing effects on postural stability. This suggests there may be a link between what participants visually perceive and their corresponding stepping action. Ongoing research is focused on determining if there is an explicit perception and action link in older adults in response to the visual cue on stairs, and whether the striped visual cue can be simplified in appearance (reduced spatial frequency) and remain effective. Understanding this could help in determining visual cues suitable to place on home or public stairs to help improve stair safety for older adults.

S.12iv Studying the interplay between cognitive factors and stairwell illumination to better understand falls risk during stair descent

Mark Hollands¹, Neil Thomas¹

¹Liverpool John Moores University

BACKGROUND AND AIM: Our previous work has shown how cognitive factors such as selfconfidence and anxiety can influence where individuals look during adaptive locomotor tasks. For example, when walking on targets and stepping over obstacles anxious older adults tend to look away early from imminent obstacles to look at future hazards which, paradoxically, results in reduced stepping accuracy and increased risk of tripping on the imminent obstacle. Stair walking represents a particularly hazardous locomotor activity which can evoke strong feelings of anxiety and fear of falling in older adults especially when illumination levels are low or stair dimensions are challenging or irregular. Cognitive factors such as anxiety and fear of falling influence where and when individuals look on stairs, especially at low light levels, which has repercussions for their walking safety. For example, older adults tend to look less far ahead (i.e. closer to their feet) during stair descent resulting in altered head posture and associated destabilizing changes to centre of mass behaviour. Adequate illumination is important for stair safety. Lighting has become particularly pertinent since incandescent bulbs were banned in many countries, resulting in households using energy saving compact fluorescent lamp (CFL) bulbs. These can take minutes to reach full brightness, which may leave stairwells poorly lit during initial use. Light emitting diode





(LED) bulbs are also energy efficient, but reach full brightness immediately and may offer a better alternative. Our own analysis of light bulb characteristics has clearly demonstrated that "Low" and "high" power CFL bulbs only produced illumination of 10 and 20 lux respectively averaged over the time taken to descend the stairs. This compared to 35 and 112 instantaneous lux from the low and high power LED bulbs. In order to determine the extent to which stair walking safety was affected by these varying levels of illumination (together with a very bright 300Lux illumination representing optimal lighting), whole-body 3D kinematics (Vicon motion analysis system) and force platform kinetics (3 Kistler force platforms) were recorded to quantify various biomechanical markers of stepping safety and postural stability. RESULTS: During low illumination conditions both younger and older adults report lower self-confidence in their ability to descend stairs safely (Figure 1A) yet only younger adults appear to compensate by adjusting their walking strategies to increase postural stability e.g. by reducing the variability in their trunk vertical acceleration during weight transfer from one step to another (Figure 1B). CONCLUSIONS: The implication of these results, (together with those from ongoing analyses of biomechanics and gaze behaviour), for falls risk assessment, individualised falls prevention interventions and built environment design will be discussed.

S.13: Early development of human locomotion and its functional consequences

S.13i What does newborn skateboarding tell us about the ontogeny of human locomotion?

Marianne Barbu-Roth¹, David Anderson², Vincent Forma¹, Joëlle Provasi³

¹Paris Descartes University- CNRS, ²San Francisco State University, ³Ecole Pratique des Hautes Etudes

BACKGROUND AND AIM: The acquisition of bipedal locomotion is a celebrated milestone in infant development. However, most human infants start to crawl long before they walk and even without practice, adults retain remarkable crawling capacities. This common observation raises important questions about the connection between bipedal and quadrupedal locomotion and the development of both forms of locomotion during early infancy. Even adult upright bipedal locomotion is not free of quadrupedal mechanisms, with the arms mirroring the motions of the legs, but perhaps more surprising and puzzling are recent reports of a functional quadrupedal organization of the spinal networks underlying walking. When and how does this quadrupedal organization emerge during infant development? Extensive studies of upright bipedal stepping in the newborn have created the impression that humans are born bipeds. In our current study, we challenge this notion by showing that 2-day-old newborns are functional quadrupeds. **METHOD**: The existence of this independent quadrupedal locomotion was revealed by using a mini





skateboard that supported the newborn's head and trunk and freed the arms to move. We tested 60 at-term typical newborns in two one-minute randomly-ordered conditions: (i) crawling in a prone position on a Mattress (Mattress condition) and (ii) crawling on the mattress with the mini skateboard (Crawli condition). The number and characteristics of the infant's leg and arm locomotor movements were captured using synchronized video and infra-red motion capture cameras. **RESULTS:** In the Crawli condition, the analyses of the number and types of limb movements and their characteristics, the coactivation of limb pairs, and the displacement across the surface, revealed that newborns are able to use arms and legs to crawl with locomotor patterns similar to those documented during quadrupedal locomotion in animals and human adults. In the Mattress condition, newborns were not able to move their arms and propel themselves, as they were impeded by the weight of their head and trunk. CONCLUSIONS: This discovery questions the well-established bias toward studying newborns as bipeds and lends credence to the idea that all forms of locomotion, including bipedal gait, could be organized quadrupedally in humans and represented biologically in spinal neuromotor networks from birth. We propose that humans are born as quadrupeds and develop bipedal competencies later, in concert with maturationally- and experience-driven anatomical changes and practice locomoting in a variety of different contexts. This proposition has very important, though yet to be experimentally verified, implications for the design of interventions for infants at risk for locomotor delays. It suggests these interventions may be more efficacious at hastening the onset of independent walking if they promote guadrupedal locomotion in the early months of life.

S.13ii Development of spinal locomotor output

Yury Ivanenko¹

¹IRCCS Fondazione Santa Lucia

INTRODUCTION. In this presentation, various findings, ideas and approaches will be considered that represent important conceptual frameworks for characterizing and understanding human locomotor development, with a particular emphasis on the first years of life. The spinal cord does not simply transmit information to and from the brain and its maturation and physiologic state determines reflex, postural and locomotor control. We will discuss recent advances in understanding how motor commands are expressed at different stages of human development. methods. The spinal locomotor output can be assessed by identifying the basic patterns of lumbosacral motoneuron activity from multimuscle recordings. The idea that the CNS may control complex interactions by modular decomposition has received considerable attention. Each human lower limb contains over 50 muscles, comprising many intrinsic foot muscles, that are coordinated during locomotion. It has been argued that the nervous system may control numerous muscles through modularity, using neural patterns to activate muscles in groups. We explored this idea for





human locomotion by examining the spinal locomotor output during early development along with maturation of coordinated patterns of limb motion. **Results.** The development of human locomotion from the neonate to the adult starts from a rostrocaudal excitability gradient in the spinal motor output and involves a progressive reduction of EMG burst durations and a functional reorganization of the pattern generation circuitry with increasing age. Furthermore, the accomplishment of mature locomotor movements relies upon the integrated coordination of the lower and upper limbs and the trunk, as well as integration of proper load-related proprioceptive feedback. Foot placement patterns in human neonates and the episodes of alternating arm-leg oscillations suggest the potential contribution of load-related proprioceptive feedback and/or the expression of variations in the locomotor program already during early manifestations of stepping on ground in human babies. We will also present data on how early injuries to developing motor regions of the brain in children with cerebral palsy substantially affect maturation of the spinal locomotor output and consequently the future locomotor behavior. **CONCLUSIONS**. The complexity and flexibility of the spinal locomotor output changes with age. We discuss the precursor of the mature locomotor pattern in infants also in comparison with other animals.

S.13iii Does balance help explain why infant crawling & walking induce changes in visual proprioception?

David Anderson¹, Minxuan He¹, Joseph Campos²

¹San Francisco State University, ²University of California, Berkeley

INTRODUCTION: Visual proprioception is the sense of self-movement produced by patterns of optic flow. Prior research has shown a dramatic shift in infants' responsiveness to peripheral lamellar optic flow (PLOF) following the onset of hands-and-knees crawling, evidenced by their robust postural compensation to movements of the side-walls of a moving room. This shift in visual proprioception may be driven by the visual system's need to regulate multiple tasks during crawling. If balance control can be relegated to the periphery, then central vision is freed to monitor the environment to ensure the surface affords locomotion and obstacles and apertures are negotiated successfully. This explanation predicts that changes in visual proprioception would be less obvious for infants who initially crawl on their bellies because belly-crawling places limited demands on balance control. It is also possible that the onset of walking induces further changes in visual proprioception because walking demands a different type of balance control than crawling. We tested these predictions in three experiments. **METHOD**: Experiment 1 involved comparisons among 64 8-month-old infants categorized as pre-crawlers (n = 25), belly-crawlers (n = 15), and hand-and-knees crawlers (n = 24). Experiment 2 examined 7 infants with spina bifida across the transition to independent belly crawling. Experiment 3 examined 77 11.5-13.5 monthold infants who were categorized as: 1) proficient crawlers (n = 31), 2) less proficient walkers (n



= 22), and 3) proficient walkers (n = 24). All infants were tested for responsiveness to PLOF from side-wall motion in a moving room. **RESULTS:** Experiment 1 revealed that hands-and-knees crawlers were significantly more responsive to PLOF than pre-crawlers (p = .04) and marginally more responsive than belly-crawlers (p = .06), whereas pre-crawlers and belly-crawlers did not differ from each other. Omnibus ANOVA: F (2, 61) = 3.93, p < .05. A Wilcoxon signed-ranks test on the spina bifida infants from Experiment 2 revealed no significant changes in responsiveness to PLOF across the transition from pre-crawling to belly crawling, Z = -.34, p = .81. The Experiment 3 results showed that the less proficient walkers were more responsive to PLOF than the proficient crawlers (p = .04) but not the more proficient walkers (p = .23), Omnibus ANOVA: F (2, 75) = 3.10, p < .05. **DISCUSSION:** These findings support the idea that the balance demands associated with new forms of locomotion drive important changes in visual proprioception. The acquisition of skills that place new demands on balance control appears to heighten responsiveness to visual input and facilitate the differentiation of information contained in patterns of optic flow and the subsequent mapping of this information onto motor control strategies.

S.13iv The internal body representation in a developing brain

Christine Assaiante¹

¹CNRS

BACKGROUND AND AIM: In order to perceive and act in its environment, the individual's body and its interactions with the environment are represented in the brain. The precise knowledge about how our body is involved in action allows us to act or to interact with our social and nonsocial environment. At the cerebral level, this knowledge is stored in an internal representation labelled the body schema (BS). The BS is built through ontogenesis and is constantly updated using sensory information. Nevertheless, proprioception that encompasses the perception of positional changes and movements of body parts appears to be the most essential sensory modality to build and to update the BS. BS must be updated during development due to many factors such as morphological changes, acquisition of motor skills, and cognitive practice (Assaiante et al, 2014). METHODS: Using a neurosensory approach, the aim of our studies was to highlight the building of the BS through childhood (7-12 years old) and adolescence (13-17 years old) by exploring through proprioceptive integration the maturation of its cerebral basis and its link with behavioural improvement during development. To this end, brain imaging and behavioural performance requiring proprioceptive information were associated to explore the different processes (i.e. perception-action coupling, sensory integration) leading to the elaboration and to the update of an internal body representation in a developing brain. RESULTS: Our results reveal that the neural basis subtending the BS was already well established as early as the age of 7, although still immature in some aspects. This included a lower level of somatosensory and





posterior parietal regions activation, and the exclusive activation of the frontopolar cortex in children compared to adults (Fontan et al, 2017). We also found that proprioceptive network is still undergoing refinement during adolescence, including a shift from diffuse to focal Functional Connectivity (FC) and a decreased FC strength. This developmental effect was particularly pronounced for frontostriatal connections. Furthermore, changes in FC features continued beyond adolescence, although to a much lower extent. (Cignetti et al, 2016). CONCLUSION: Altogether, these findings support the slow maturation of the proprioceptive integration and point to a protracted developmental time course for the BS network, which breaks with the relatively with early functional maturation often associated sensorimotor networks. REFERENCES: Assaiante, C., Barlaam, F., Cignetti, F., Vaugoyeau M. (2014). Building of body schema during childhood and adolescence: a neurosensory approach. Neurophysiologie Clinique / Clinical Neurophysiology, (2014) Cignetti, F., Fontan, A., Menant, J., Nazarian, B., Roth, M., Anton, JL., Vaugoyeau, M., Assaiante, C. (2016). Early adolescence as a main time window of plasticity in organization of the proprioceptive brain network. Cerebral Cortex, 27: 1285-1296.

S.14: Maximising interdisciplinary methods to assess falls risk in clinical groups

S.14.iii Addressing misconceptions relating to fear of falling and the control of adaptive gait

William Young¹

¹Brunel University London

BACKGROUND AND AIMS: The problem of how to predict and prevent falls is a major concern for governments and health services dealing with the wide-ranging economic and social consequences of falls and related injuries. Over recent decades much research has been carried out to identify physical, social and environmental risk-factors for falls. Factors within each of these categories can serve as strong predictors of fall-risk, particularly concerning measures of functional balance. However, some researchers argue that too much emphasis is placed on simple clinical outcome measures, in part, because such tests are generally considered to encompass physiological status along with numerous trait and state factors relating to individual differences in disposition etc. This being the case, such assessments are not sensitive to certain specific dispositions and associated behaviours that might have an independent role in influencing balance in specific tasks/contexts. Being fearful of falling is an example of such a disposition. Much research has demonstrated the impact that fear of falling (or concern about one's balance ability) can have on functional outcomes associated with fall-risk. However, researchers have only recently started to evaluate how fear of falling (and related state anxiety) can influence attentional





processes/biases and associated prioritisation strategies during movement planning and execution. METHODS AND RESULTS: This presentation will cover examples of potential misinterpretations evident in the literature, relating specifically to how fear of falling influences the control of balance and adaptive gait. In particular, the talk will focus on mechanisms suggested to underpin conservative movement strategies observed in fearful older adults (including increased muscle co-contractions and reduced visual search behaviour). Examples will be given from my own laboratory where we applied extant anxiety-related psychological theories (e.g., Reinvestment and Attentional Control Theory) to the context of ageing and falls, only to establish through incremental studies that the perspectives set out by such theories do not always readily translate and, in some cases, can lead to misconceptions that cause fundamental problems with our capacity to interpret findings. The objective of this presentation is, therefore, to promote discussion about how we can be vigilant to potential misconceptions so that we might best-inform the selection of specific outcome measures used in future research. CONCLUSIONS: The presentation will conclude with a summary of what 'we think we know now' in the context of anxiety-related changes in attention during gait, along with recommendations for how current knowledge can be utilised by future cross-sectional and prospective studies evaluating fall-risk in older adults.

S.14.iv Automatic recognition of gait patterns with machine learning

Yuhan Zhou¹, Tibor Hortobágyi¹, Claudine Lamoth¹

¹University Medical Center Groningen

PURPOSE AND BACKGROUND: Physical, emotional, cognitive, behavioral and social factors and their interactions underlie gait and balance abilities and fall risk in older adults. The International Classification of Functioning, Disability and Health (ICF) model can be used as a framework to examine the multifactorial nature of gait and balance decline and fall risk. For machine learning to contribute significantly and meaningfully to the understanding and prevention of fall risk and the estimation of movement related disorders, the collaboration between different disciplines (clinicians, physiotherapists, data scientists,) is necessary. Here, we present a model using an aggregate analysis of gait accelerometer data from healthy adults and geriatric patients. The first purpose of this study was to identify the most accurate machine learning method to automatically classify gait patterns in groups of participants; the final purpose of the model is to early identify at-risk gait and evaluate treatment outcomes. **METHODS:** Healthy young and middle-aged adults (n=58, age: 42.7±16.60), healthy old adults (n=54, age: 74.6±5.71), and geriatric patients without cognitive impairment (n=126, age: 79.3±5.81) participated in this study. Trunk accelerations were measured with 3D accelerometers (DynaPort® MiniMod, McRoberts BV & iPod touch 4G, iOS 6, Apple Inc.; sample frequency±100 Hz) during three minutes of walking. From the 3D





accelerometer signals, we extracted 23 dynamic gait variables quantifying gait pace, stability, regularity, variability. A Kernel Principal Component Analysis (KPCA) was applied to extract underlying gait features and reduce the dimensionality of the data for Support Vector Machine (SVM) classification, compared other machine learning methods Random Forest (RF) and Artificial Neural Network (ANN) with raw features. These methods also can be extended for other kinds of variables to predict different labels, such as fall risk and Parkinson's disease. RESULTS: KPCA reduced gait data dimensions efficiently from 23 dimensions to five dimensions, explaining97% of the variance, and representing gait features of pace, synchronization, regularity, and variability. Preliminary analyses showed that both SVM (accuracy=89%, AUC=0.91) and ANN (accuracy=90%, AUC=0.87) could differentiate gait patterns between the three age-based groups. RF was sensitive to parameter selection and results in worse classification performance (accuracy=73% and AUC=0.86). CONCLUSIONS: Aging affects specific gait features that can be identified by non-linear approaches such as KPCA followed by SVM or ANN classifiers. Both of these classifier methods reveal differences in temporal gait characteristics between age groups. Future analyses will add data on person's objective and subjective measures at the different levels of the ICF model. In addition, different machine learning models will be added to investigate labelled disorders, to finally predict the risk of falling.

S.14i An interdisciplinary approach to assess the electrophysiological, kinematic and gaze factors related to gait and fall risk in older adults

Chesney Craig¹, Paul Holmes¹, John-Stuart Brittain², Will Young³, Zoe Franklin¹, Nicola Ray¹

¹Manchester Metropolitan University, ²University of Birmingham, ³Brunel University London

PURPOSE AND BACKGROUND: Early identification of individuals at high risk of falls is essential to ensure efficient fall prevention interventions. Given the heterogeneity of fall accidents that are experienced by some older adults, it is important to utilize a multifactorial approach to assess fall risk. Although multifactorial approaches have successfully identified a number of functional and behavioral outcome measures that can predict subsequent falls, less is known about the neural profile associated with fall risk. The advent of mobile electroencephalography (EEG) technology and advanced signal processing algorithms have enabled remote online measurement of neural activity during active gait, which may provide unique insights into the neural control of asymptomatic and clinically-impaired gait. The field is, however, still in its infancy and we are unaware of any publication to date that has used mobile EEG in a clinical population during natural gait. This talk will outline how we have employed an interdisciplinary approach to provide a comprehensive characterization of the neural, kinematic, muscle, gaze and psychological factors that may discriminate fallers from non-fallers during naturalistic gait, adaptive gait and obstacle avoidance. **METHODS:** We present a novel experimental method that combines mobile 64-





channel EEG, wireless electromyography (EMG), motion tracking and mobile eye-tracking, to assess naturalistic gait and obstacle avoidance in older people with (N = 20, Mage = 72.32 ± 5.58) and without identified fall risk (N = 20, Mage = 73.32 ± 4.55), compared to young adults (N = 20, Mage = 27.75 ± 4.96). These variables were assessed simultaneously during a 2-minute looped walk, followed by a walking and turning 'on cue' task, which assessed adaptive gait and obstacle avoidance. Participants walked either straight towards the end of a 6.5m walkway or turned right or left at an intersection depending on a visual cue presented during the walk. During half of the walking trials, an obstacle was present in one of the pathways. Independent Component Analysis was used to remove movement-related artifact from the EEG signals. Ongoing data analysis (at the time of writing) will analyze group differences in gait variables, lower-limb muscle activity, taskrelevant gaze fixations and EEG â band oscillations during each gait condition. DISCUSSION: This complex multi-modality experimental protocol considered interactions between related disciplines for a more valid study design, implementation, analysis and interpretation. The interdisciplinary approach, its implementation and current results highlight important implications for assessing fall risk in older adults. In addition, we will outline how the strengths and limitations of our experimental approach provide insights for future research. Recommendations based on this study are currently being implemented in a similar protocol investigating fall risk in Parkinson's Disease.

S.14ii Sensorimotor, neuropsychological and daily-life gait assessments to identify people at high risk for falls

Kim van Schooten¹

¹Neuroscience Research Australia/University of New South Wales

Purpose and background Falls are a multifactorial problem with causes amongst sensorimotor, cognitive and affective domains. Whilst there is a range of tools for assessing fall risk, few encompass all these domains. Moreover, recent studies suggest that not only one's balance abilities but also their activity behaviour affect the probability of experiencing a fall. This presentation will address the utility of clinical tests and daily-life gait to identify people at high risk for falls. It will draw upon multidisciplinary studies to discuss the strengths and weaknesses of these approaches and presents results of an interdisciplinary study combining these techniques to assess fall risk. **Methods** The first part of the presentation will consider recent observations on multifactorial risk factors for falls in general and clinical ageing populations. We pooled data of 1,230 participants (74±10yrs; 640⁽²⁾), including 500 community-dwelling older people and four clinical groups with balance disorders (Parkinson's disease, N=312; dementia, N=175; stroke survivors, N=140; multiple sclerosis, N=111), to characterise similarity in risk factors for falls. Our results confirm that deficits in cognition (executive function) and affect (depressive symptoms, concern about falling) are at least equally important as sensorimotor function in fall-risk prediction





and should therefore be included in routine clinical assessment. The second part of the presentation will review current evidence for using daily-life gait characteristics to identify people at risk for falls. This part will touch upon dependency on activity recognition, estimation of characteristics, models used to predict risk and fall-risk definitions. Recent work on the predictive ability for falls of daily-life gait characteristics combined with clinical tests of sensorimotor, cognitive and affective function in older people will be presented and compared to previous work. **Discussion** Taken together, the studies will provide an overview of interdisciplinary approaches, combining sensorimotor, neuropsychological and daily-life gait assessments, to assess fall risk in various populations. Transdisciplinary collaboration is needed to implement these assessments into clinical practice.

S.15: STOP! Age-related changes in sensorimotor inhibition and the associated implications for impaired gait and balance control

S.15i Age-related reductions in tactile and motor inhibitory function start early: Implications for gait and balance

Rachael Seidler¹, Marit Ruitenberg, Kaitlin Cassady, Kathleen Hupfeld¹

¹University of Florida

BACKGROUND AND AIM: Previous work documents that surround inhibition and intra-/interhemispheric inhibition in the somatosensory and motor systems are mediated by gammaaminobutyric acid (GABA). Surround inhibition describes cortical lateral inhibition of surrounding receptive fields upon skin contact or muscle activity, resulting in a sharper neural representation of stimuli. Surround inhibition has also been shown to extend to contralateral homologous representations and to the motor system. The effects of healthy aging on these inhibitory functions and their underlying mechanisms are neither well characterized nor understood. Thus, in the current study we determined tactile thresholds for a given finger while either a neighboring or the contralateral digit were simultaneously stimulated; this allowed us to test tactile surround inhibition in individuals across a wide range of ages. We also used bimanual motor tasks to assess motor intra- and inter-hemispheric inhibition to illustrate the trajectory of decline and to test for associations between age differences in the two systems. METHODS: Participants ranging from 18 to 76 years old performed assessments of tactile and motor inhibitory function. To evaluate tactile surround inhibition, we determined tactile thresholds for a given finger while either a neighboring or the contralateral digit were simultaneously stimulated. Typically, this results in higher (i.e., less sensitive) tactile thresholds, due to surround inhibition. Since inhibitory function





declines with age, however, we predicted that low amplitude stimulation on a neighboring finger would decrease tactile thresholds for older adults due to "spillover" effects. Participants also performed motor tapping tasks requiring asynchronous movements of two neighboring digits or of two homologous digits (i.e. bimanual actions), which we have previously linked to inhibitory function. RESULTS: Older age associated with greater decreases in tactile detection threshold when a stimulus was simultaneously applied to a neighboring or the contralateral homologous finger. These findings are indicative of age-related declines in surround inhibition. Additionally, increasing age was significantly associated with poorer performance on the motor task requiring asynchronous actions of neighboring fingers on the same hand, again supporting reduced intrahemispheric inhibition with age. Declines in inhibitory function were evident starting in the fifth decade of life, but were not correlated between tactile and motor systems. CONCLUSIONS: Our findings demonstrate that aging impacts tactile and motor inhibitory function, particularly for behaviors that are mediated by GABA neurotransmission. In ongoing work we are evaluating whether similar age declines in inhibitory function are evident for the lower limbs, are associated with magnetic resonance spectroscopy measures of GABA, and are associated with age declines in gait performance. NIH 1R56AG043402.

S.15ii The effects of age and task difficulty on the neural control of standing balance

Tibor Hortobagyi¹, Tulika Nandi¹, Selma Papegaaij²

¹University Medical Center Groningen, University of Groningen, ²MOTEK

BACKGROUND AND AIM: We examined the hypothesis that when guiescent standing is challenged by reductions in base of support, sensory perturbations, or old age, motor cortical (M1) supervision of standing balance becomes necessary with a putative role assigned to the GABAergic inhibitory system. METHODS: We collected transcranial magnetic stimulation data while healthy adults stood in a wide, narrow, tandem, and one-legged stance and healthy young and old adults stood with and without support at the chest, stood on a rigid and foam surface with eyes open or closed, and sat or leaned forward with and without a support at the chest. We also examined the effects of a simulated balance task on dual-task costs while lying in an MRI scanner. **RESULTS:** While the net corticospinal input to biomechanically relevant leg muscles increases with reductions in base of support in the mediolateral direction and GABAergic inhibition decreases, these outcomes do not correlate with sway magnitude (1,2). Likewise, M1's involvement became more prominent in free vs. supported standing (3). There also was disinhibition of M1 in standing independent of age but an age-specific reduction in GABAergic intracortical inhibition that correlated with center of pressure velocity when subjects stood on foam, a proprioceptive perturbation (4). When healthy young and old adults sat and voluntarily leaned forward with and without a chest support, the area of EMG suppression produced by brain





stimulation, i.e., GABAergic intracortical inhibition, was ~60% smaller in unsupported vs. supported leaning and sitting, with no difference between these latter two conditions (5). Leaning closer to the maximum without support correlated with less M1 inhibition. While age did not affect the motor control strategy as quantified by the modulation of M1 activity, the modulation appeared at a lower task difficulty with increasing age. The critical factor in modulating M1 activity is postural challenge instead of contraction aim (voluntary, postural) or posture. When standing difficulty was simulated in an MRI scanner by keeping a forward or backward falling avatar vertical by plantarflexing toward a load cell in combination with a calculation task, the age-related increase in brain activation and dual-task costs did not correlate, suggesting that the dual-task costs were not due to increased structural interference (6). **CONCLUSION:** When quiet standing is challenged by reductions in base of support, sensory perturbations, or old age, motor cortical supervision of standing balance becomes evident. Future experiments will clarify if age- and task-differences in M1 activation underlie impaired postural control and postural instability. 1.Nandi GP 60:135-140, 2018. 2.Nandi FHN12:303, 2018. 3.Papegaaij EJAP 116:959-967, 2016. 4.Papegaaij FAN 6:28, 2014. 5.Papegaaij EG 73:78-85, 2016. 6.Papegaaij PONE 12(12):e0189025, 2017.

S.15iii Effects of age and mental fatigue on dynamic postural control

Anita Christie¹, Amanda Morris²

¹The University of Western Ontario, ²The University of Oregon

BACKGROUND AND AIM: Mental fatigue is a psychophysiological state that occurs after or during prolonged periods of cognitive activity. Older adults report higher levels of fatigue than young adults, which is associated with impaired motor performance. Despite these important associations, little is known about the direct impact of mental fatigue on physical function. The reduction in attentional resources that occurs with mental fatigue may exacerbate compromises in balance control in older adults. The aim of this work is to examine the impact of mental fatigue on postural control in older adults and to identify neural contributions to reduced function. METHODS: We examined the impact of mental fatigue on responses to postural perturbations in young and older adults. Participants stood on two force platforms that were anteriorly translated at random intervals before, during and following a mentally fatiguing task. Postural responses to the perturbations and assessments of neuromuscular properties, including transcranial magnetic stimulation measures of corticospinal excitability and intracortical inhibition were assessed before, during and after the mentally-fatiguing task. In a sub-group of young individuals with reported high levels of mental fatigue and measured impairments in gait balance control, magnetic resonance spectroscopy was used to assess concentrations of glutamate and gamma-aminobutyric acid (GABA) in the primary motor cortex (M1) and the dorsolateral prefrontal cortex (DLPFC). **RESULTS:** Older adults had slower reaction times and greater postural responses to



perturbations than young. Mental fatigue did not differentially affect the magnitude of the postural responses in young and older adults. However, the velocity of the postural responses to perturbations was slower in older adults compared with young, during conditions of mental fatigue. Older adults had a greater reduction in overall muscle activity during the postural response following mental fatigue than young. Relative to young, older adults showed a similar change in corticospinal excitability in response to mental fatigue, but a greater change in intracortical inhibition. In a population of individuals who report high levels of mental fatigue, and demonstrate impaired dynamic balance control, we have shown a lower glutamate:GABA ratio in M1, but a higher Glutamate:GABA ratio in the DLPFC. **CONCLUSION:** The condition of mental fatigue may impact some aspects of dynamic balance control, particularly in older adults. Concurrent changes in muscle activation and intracortical inhibition suggest central factors involving inhibition are likely involved in the observed alterations in postural control. The region-specific imbalances in neurotransmitters in a sub-group of young individuals may help to inform observed changes with mental fatigue in older adults.

S.15iv Age-related differences in associations between dynamic gait characteristics and motor cortex inhibition

Brett Fling¹, Clayton Swanson¹

¹Colorado State University

BACKGROUND AND AIM: Healthy aging is associated with structural and functional alterations in the brain and declines in multiple facets of motor performance including gait, balance, and motor coordination. For example, interlimb coordination and performance during turning both diminish with age, posing a risk for gait-related injuries. Cortical inhibitory processes are essential for optimal motor control and undergo age-related alterations that may account, at least in part, for these behavioral deficits. In this regard, a key role is played by gamma-aminobutyric acid (GABA), the principal inhibitory neurotransmitter within the nervous system. Recent studies demonstrate that levels of motor inhibition are related to GABAergic function and that levels of GABA diminish with advancing age. In fact, levels of inhibition within the motor cortex are significantly associated with coordination of the upper extremities, however, it is unknown if this same association exists for dynamic lower extremity control required for daily tasks such as coordinating the legs while walking and turning. **METHODS:** Our results are from a current sample of nearly 50 healthy adults, comprised of younger (18-30 years old) and older adults (65-80 years old). Cortical inhibition is assessed via the cortical and ipsilateral silent period within the dominant and non-dominant cortical hemisphere, both of which are elicited by TMS within muscles of the lower extremities. Dynamic measures of gait, including the phase coordination index and multiple measures of turning performance, are collected and analyzed through the use of six, wireless





inertial sensors during 2- or 6-minute over-ground walking trials at a self-selected pace. **RESULTS:** We report that older adults demonstrate significantly reduced performance during turning coupled with reduced coordination and increased variability during over-ground walking, compared to a younger cohort. In addition, we report reduced cortical inhibition within the non-dominant (right) motor cortex of these older adults. Interestingly, measures of gait coordination and variability demonstrated a positive relationship with cortical inhibition in the younger adults, while there was a negative correlation between inhibition and these same behavioral measures in older adults. Furthermore, motor cortex inhibition was significantly associated with multiple turning characteristics. **CONCLUSIONS:** Taken together, these results propose a fundamental difference in the relationship between motor cortex inhibition and lower extremity control with age; younger adults are better able to maintain lower extremity coordination and variability with reduced cortical inhibition, whereas older adults with increased cortical inhibition demonstrate better mobility performance. Importantly, these findings are complimentary to previous work demonstrating age-related differences in the association between motor cortex inhibition with bimanual control.





POSTER ABSTRACTS

Poster session 1: Monday July 1, 2019

A - Activity monitoring

P1-A-1 Monitoring walking activity with wearable technology in rural-dwelling older adults in Tanzania: a feasibility study nested within a frailty prevalence study

Silvia Del Din¹, Emma Grace Lewis², William Gray², Harry Collin¹, John Kissima³, Lynn Rochester⁴, Catherine Dotchin², Sarah Urasa⁵, Richard Walker²

¹Newcastle University, ²Northumbria Healthcare NHS Foundation Trust, North Tyneside General Hospital, ³Hai District Hospital, ⁴Institute of Neuroscience, Newcastle University, ⁵Kilimajaro Christian Medical Centre

BACKGROUND AND AIM: Older adults (OA) with low levels of activity can be at risk of poor health outcomes. In low-income countries (LIC), objective measures of physical activity can be difficult and often subjective (e.g. completion of activity questionnaires or diaries). Wearable technology has improved acceptability, accuracy and objectivity of measuring activity for OA in high-income countries. Nevertheless, the technology is under-utilised in LIC [1]. As part of a larger study (Hai District Ageing and Frailty Study), the aim of this work was to explore feasibility, acceptability and compliance of utilising wearable technology and an automatic online pipeline for data transfer and analysis of walking activity, in a group of rural-dwelling, frail OA in Tanzania. METHODS: 65 OA (age: 73.9±11.2 years, 39 (60%) female), including 36 non-frail and 29 frail, were assessed. Participants were tested at baseline; free-living data were recorded for 7 days with an accelerometer (Axivity AX3) placed on the lower back. Data were uploaded and analysed via a validated automatic cloud-based pipeline: macro gait outcomes representing the volume (total walking time per day), pattern (alpha), and variability of free-living walking activity were extracted [2, 3]. Acceptability questionnaires were completed. T-tests were used for preliminary comparison of macro gait characteristics between the 2 sub-groups. RESULTS: Of the 65 datasets uploaded, 59 were analysed. Data loss (9%) was due to 5 OA who were unable to stand or bed-bound (no analysis performed) and 1 dataset was lost due to sensor battery issues. Results showed that frail OA walked significantly less, were less variable and had a greater proportion of shorter walking bouts (higher alpha) compared to non-frail OA, Figure 1. Qualitative analysis showed that 15 OA reported experiencing or expecting some therapeutic benefit from wearing the accelerometer, while 16 OA expected some diagnostic benefit. Eighteen OA experienced symptoms attributed to wearing the accelerometer. The most common was itching, while other symptoms were pain, discomfort and diarrhoea. Five experienced worries about wearing the device for example one raised concerns that he may be accused of witchcraft. **CONCLUSIONS**: INTERNATIONAL SOCIETY OF ISpgr Posture & Gait Research

Despite some technical and practical issues, the AX3 sensor was tolerated by the majority of the participants. Preliminary results show that macro gait outcomes look promising in discriminating between frail and non-frail OA. This feasibility study is encouraging in terms of using wearable technology in rural-dwelling OA in LIC, although cultural issues became evident in this cohort. This raises questions about implementation in different geographical/cultural contexts and the need for education and evaluation for participants when setting up new studies. **ACKNOWLEDGEMENTS AND FUNDING:** We thank the Hai District Ageing and Frailty Study participants for their time and commitment to the study. **REFERENCES:**[1] Hallal PC et al, 2012, Lancet;380(9838):247-57 [2] Del Din S et al, 2016, IEEE SSP;1-5 [3] Del Din S et al, 2017, J Gerontol A;glx254

P1-A-2 The impact of freezing of gait in daily life: a wearable sensors approach

Martina Mancini¹, Vrutangkumar Shah¹, Carolin Curtze², Samuel Stuart¹, Mahmoud El-Gohary³, James McNames⁴, Fay Horak¹, John Nutt¹

¹Oregon Health & Science University, ²University of Nebraska Omaha, ³APDM, ⁴Portland State University

BACKGROUND AND AIM. Although a growing number of studies focus on the measurement and detection of freezing of gait (FoG) in laboratory settings, few studies have attempted to measure FoG during usual daily life. Moreover, the impact of FoG and percentage of time spent freezing during community-living have not yet been reported. This pilot study investigated the impact of FoG, objectively measured with inertial sensors, on balance confidence and on mobility function during community-living in people with Parkinson's disease (PD). Methods. Twenty-four subjects with PD (67±7 years, UPDRS III: 36±3.8), 14 withFoG (new FoG Questionnaire (nFoG-Q) score >1), wore 3 inertial sensors attached to the feet and lumbar region for 7 days of continuous monitoring with an average recording of 8 hours per day. Walking bouts, of at least 10s, were first identified, and features of FoG, derived by the percentage of high to low power frequency (3.5-8Hz vs 0.5-3Hz) of the acceleration signals of the foot sensors were calculated. Our primary outcome measure for freezing was the cumulative sum of such percentage normalized to the total hours of recording (average time spent freezing per hour). Also, the variability of percentage of time spent freezing was reported. In addition, overall quantity and quality of gait and turning were extracted and averaged across the week. Results. Time and variability of time spent freezing were associated with the nFoG-Q (r=0.56, p=0.03 and r=0.62, p=0.01, respectively), and to subject perception of balance (ABC: r=-0.44, p<0.05). Results showed significantly reduced balance confidence and impaired quality of mobility in freezers compared to non-freezers (variability of pitch angle 0.51°±0.05 vs 0.95°±0.15, average turning angle 97.2°±1.9 vs 90.1°±1.2). Gait speed (0.85m/s±0.04 vs 0.77m/s±0.06) and quantity of mobility (# gait bouts/30min: 8.2±0.9 vs 8.8±0.7, # turns/30min: 28±5 vs 30±6) were similar across groups. Conclusion. These pilot findings showed that objective measurement of freezing in PD using inertial sensors on the feet during





community-living monitoring for 7 days differentiated those who reported FoG and those who did not report FoG. Objective measures also related to self-reported freezing severity perception and balance perception. These findings are important, as an objective measure of time spent freezing with wearable technology during community-living should relate to clinical, mobility and patientrelated outcomes to be useful for managing this distressing feature of mobility disability in PD. ACKNOWLEDGMENTS: Research supported by NIH, R00 HD07849201, R43 AG044863-02, and R41NS076088-0

B - Adaptation, learning, plasticity and compensation

P1-B-3 Targeted familiarization based on user feedback and motor control principles to optimize positive adaptation strategies for learning to walk with a passive load-bearing exoskeleton: a feasibility study

Laurent Bouyer¹, Krista Best², Thomas Karakolis³, Gabriel Diamond-Ouellette⁴, Etienne Lamoureux⁴, Kurt Modie⁵

¹Université Laval, ²CIRRIS-Universite Laval, ³Defence Research and Development Canada, ⁴Mawashi Science & Technology, ⁵Defence Science and Technology Australia

BACKGROUND AND AIM: When learning to use a new assistive device, learners can adopt adaptive or maladaptive strategies. Adaptive strategies occur with optimal muscle activation that minimizes energy cost and reduces musculoskeletal stress. Maladaptive strategies commonly result from movement changes associated with discomfort or fear of injury and vary depending on the device and intent of use. Repeated use of maladaptive strategies can limit the effectiveness of device use and may increase risk of musculoskeletal injuries and pain. It is therefore critical to prevent the development of maladaptive strategies during familiarization periods with new devices. The aim of this work was to promote adaptive strategies for using a passive load-bearing exoskeleton through the design of a familiarization protocol using an iterative approach that integrated principles of motor control and learners' feedback. METHODS: Canadian soldiers (n=3) who were naïve to the device completed four consecutive 6-minute walk tests (6MWT) in a controlled experimental design. Upon completion of each 6MWT participants described the location and sensation of discomfort. Anatomical location of discomfort was considered and movement strategies for optimizing muscle activations were integrated into the development of a 3-hour familiarization period (i.e., warm-up, walking tasks, and an obstacle course). After familiarization, participants completed 3 usability questionnaires (modified Technology Acceptance; modified LEAP subjective rating; Evaluation of Satisfaction with Assistive Devices) and a semi-structured interview. Analysis consisted of assessing location and level of perceived discomfort and change in device acceptance post familiarization. RESULTS: Naïve users perceived discomfort in both feet, anterior tibia and hip joint during the walking trials. Muscle activations of the core, hips, knees, ankles and feet were therefore included in the familiarization



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protocol. Upon completion of familiarization, users felt less discomfort when using the device, but were still not at complete device acceptance (e.g., 'slightly likely' or 'neither unlikely nor likely to accept the technology'). Soldiers confirmed that targeted familiarization assisted in their learning process, but suggested that more than 3 hours was needed to optimize familiarization periods. Consideration and integration of movement strategies relevant to tactical operations was also recommended. **CONCLUSIONS:** As technology evolves, it is critical to understand user experiences to improve uptake and satisfaction with device use to optimize meaningful use. Obtaining user feedback through subjective approaches can inform development of familiarization protocols, thus improving the likelihood of positive adaptation and reducing the risk of maladaptive compensation strategies during learning. **ACKNOWLEDGEMENTS AND FUNDING:** this work was supported by a grant from the Department of National Defense-NSERC partnership program and Mawashi Science & Technology.

P1-B-4 The moving platform illusion in older adults: Effects of the duration of adaptation to a sway-referenced environment on perceptual delays and postural aftereffects

Mihalis Doumas¹, Laura Coulter¹

¹Queen's University Belfast

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BACKGROUND AND AIM: Postural control relies on sensory information from visual, vestibular and proprioceptive channels, utilised by an adaptive sensory reweighting process to maintain upright stance. For example when stepping into a dark room visual information is down-weighted and information from the other two channels is up-weighted. In a series of experiments we investigated age-related decline in sensory reweighting and showed age equivalence in the rate of adaptation when inaccurate proprioceptive information was introduced, but larger and longer aftereffects in older adults when the accurate environment was restored (Doumas & Krampe, 2010). In a recent study (Craig & Doumas, 2019) we also showed that older adults took 30-40s to perceive that the platform had stopped which is a similar duration with the postural sway aftereffect. The aim of this study was to assess the relationship between the perceptual delay and the postural aftereffect using a short and a long adaptation phase to induce longer and shorter aftereffects. METHODS: Eleven healthy young (age range: 18-28 years, 10 female) and 14 healthy older adults (age range: 63-80years, 12 female) participated in the study. Participants were asked to stand on a surface which was either fixed or tilted in the anterior-posterior direction (toes updown) in proportion to body sway (support-surface sway reference). The sway referenced surface was more compliant for young (gain=1.6) compared with older adults (gain=1) in order to match postural sway in the two groups during Adaptation. Participants stood on a fixed surface for 2 min (Baseline) immediately followed by adaptation to a sway-referenced surface for 1 min (short Adaptation) or 3 min (long Adaptation) and again on the fixed surface for 2 min (Reintegration). They were not informed about when the platform started or stopped moving, and they were asked to press a hand-held push button when they perceived that the platform had stopped moving.





RESULTS: In the short condition, no age differences in postural sway in any of the three phases were observed. Young and older adults adapted to the sway referenced environment at the same rate and they both showed a short (20-40s) aftereffect. However, in the long condition, even though there were no baseline differences and the two groups adapted in the same rate, the aftereffect was larger and longer in older compared with young adults, suggesting that longer adaptation exacerbates age differences in the aftereffect. Perception of the time the platform stopped showed large age effects: young short=7.2s, long= 8.1s, older short= 39.1s, long=27s. Differences between perception of platform stop between the short and long conditions were not significant in neither group. **CONCLUSIONS:** Our results show that increasing the duration of the adaptation phase causes an increase in the magnitude and duration of the aftereffect especially in older adults. However, this increase is not accompanied by a change in the duration of the perceptual illusion suggesting that the illusion may be independent of the sensory reweighting process. Further research is needed to assess the association between purely perceptual and postural aspects of this illusion.

P1-B-5 Foot speed perception during split-belt treadmill adaptation in adults with Parkinson's disease.

Dorelle Hinton¹, Roger Wei¹, David Conradsson², Caroline Paquette¹

¹McGill University, ²Karolinska Institutet

BACKGROUND AND AIM: Parkinson's disease (PD) leads to a decrease in gait automaticity and difficulty in perceiving gait speed differences between legs. Accordingly, adults with PD often show exacerbated gait changes when alterations are made to each leg separately, such as during turning. In the lab, a split-belt (SB) treadmill, capable of driving each leg at a different speed, has however, highlighted the ability of adults with PD to adapt their gait pattern to walking with each belt at a different speed. It is not known if and how a PD-related change in the perception of each leg's speed affects this adaptation process. The current study examined the effect of PD on the perception of gait symmetry throughout SB treadmill adaptation and upon returning to typical treadmill walking. METHODS: Perception of gait speed asymmetry during SB treadmill adaptation was assessed in 12 adults with PD (63±7y) and 14 healthy older adults (67±8y). Participants' typical walking speed was assessed during 2 minutes of steady-state over ground walking and their slow walking was deemed 70% of typical speed. On the SB treadmill, participants completed a single 19-minute walking trial: Tied-belt baseline (2 minutes slow, 2 minutes typical speed), Adaptation (10 minutes, 1 belt slow, 1 belt typical speed), Post-Adaptation (5 minutes slow speed). Participants wore over-ear headphones playing white-noise with audio prompts each minute to verbally indicate their perception of the belt speed asymmetry. Participant's perception was based on a confidence scale with 1 being completely confident belts were moving a different speed and 5 being completely confident belts were moving at the same speed. Dual support symmetry (DSS) and perception of foot speed asymmetry were compared across Adaptation and Post-Adaptation





and between groups (Older Adults vs PD). **RESULTS:** Adults with PD did not differ from healthy older adults in their ability to adapt gait symmetry to split belts during Adaptation and Post-Adaptation (p>0.05). Both groups had a significant negative DSS early in Adaptation that returned to baseline by the end of Adaptation. There was no difference in rate of DSS adaptation between groups. Initially, both groups had a large positive DSS upon returning to tied-belt walking. Finally, there were no significant differences between groups for perception of foot speed asymmetry during Adaptation or Post-Adaptation periods. Both groups properly determined a large speed asymmetry between their feet early in Adaptation. Over the course of adaptation, their perception of foot speeds gradually became more symmetrical. This same trend was present during Post-Adaptation (tied-belts), where participants initially believed foot speeds to be asymmetrical before gradually perceiving their foot speeds to be symmetrical. CONCLUSIONS: Participants with PD had similar perceptions of gait speed symmetry to their healthy counterparts on a split-belt treadmill. Although adults with PD experience more difficulty with perception of speed asymmetry compared to healthy older adults during overground walking, this difference did not translate to the SB adaptation walking protocol. ACKNOWLEDGEMENTS AND FUNDING: Parkinson Canada New Investigator Award (CP) and Graduate Student Award (DH).

P1-B-6 Influence of smartphone use while walking: the relationship between obstacle avoidance and adaptive walking caused by smartphone use

Sato Ren¹, Kotaro Shimizu¹, Koyuki Nishikawa², Yuriko Kihara³, Kazunari Itou^₄, Keita Tai^₅, Taketo Furuna¹

¹Sapporo Medical University, ²Goryokaku Hospital, ³Japan Health Care College, ⁴Asahikawa Rehabilitation Hospital, ⁵Houseikai Motomachi Himawari Clinic

BACKGROUND AND AIM: Walking while using a phone is considered dangerous, because of the risk of stumbling or bumping into other people. A previous study reported that 33.7% of participants almost bumped into another pedestrian when walking while using a phone. Moreover, an increasing number of patients have been hospitalized because of accidents caused by walking while using phones. Thus, it may be useful to investigate how phone use affects the safety of walking. To this end, we investigated how visual restriction and dual task performance involving smartphone use affected the strategy used for stepping over an obstacle while walking.**METHODS:** Ten subjects stepped over an obstacle under three conditions: without any task (Normal condition), while gazing at a phone display (Look condition), and while reading text displayed on a smartphone aloud (Read condition). Infrared reflective markers were attached to participants' toe and heel, and spatial data for each marker were collected using a three-dimensional motion analysis system. Dependent measures were step length one and two steps before stepping over the obstacle, and toe clearance of the leading leg and following leg, respectively. One-way repeated analysis of variance (ANOVA) was performed on step length. Two-way repeated ANOVA was performed on toe clearance. If a main effect was found, post hoc





testing was performed using Sidak's test to identify significant differences between conditions. **RESULTS**: Toe clearance showed a significant main effect (F 2, 18 = 10.409, $p \le 0.005$). Post hoc analysis revealed differences between the Normal condition and the Look condition (p = 0.05), as well as the Read condition (p = 0.005). However, no significant effect was found between the leading leg and following leg (F 1,9 = 0.808, p = 0.392), and no interaction was found between conditions and legs (F 2,18 = 1.594, p = 0.231). In addition, the length of the one step before stepping over the obstacle significantly decreased under dual task conditions, and showed a significant main effect (F 1,10 = 0.976, $p \le 0.05$). Post hoc analysis revealed a significant difference between the Normal and Read conditions (p ≤ 0.05). No significant effect was found on step length two steps before stepping over the obstacle (F 1,10 = 0.976, p = 0.365). This result suggests that the preceding steps before stepping over the obstacle were substantially modified by dual task performance. **CONCLUSIONS:** In the current study, toe clearance increased, and the step just before stepping over the obstacle was adjusted when using a smartphone, compared with stepping over the obstacle while performing no task. The findings suggested that subjects maintained too safer spatial margin during obstacle avoidance. Determining the risk of walking while using a phone may inform measures for the prevention of falling and bumping into pedestrians, or the development of dual-task training methods. Further studies are needed to clarify this issue.

P1-B-7 Gait adaptations in response to perturbation treadmill training in Parkinson's disease: Time-course, sustainability and transfer

Simon Steib¹, Sarah Klamroth¹, Gassner Heiko¹, Cristian Pasluosta², Bjoern Eskofier¹, Juergen Winkler¹, Jochen Klucken¹, Klaus Pfeifer¹

¹Friedrich-Alexander University (FAU) Erlangen-Nürnberg, ²University of Freiburg

BACKGROUND AND AIM: Gait impairment is a major motor symptom in Parkinson's disease (PD), and treadmill training is an effective non-pharmacological treatment option. Recent findings suggest that perturbation training is a particularly promising approach to prevent falls in PD. In this study, we explored the time-course, sustainability and transferability of gait adaptations to perturbation treadmill training. **METHODS:** 38 PD patients (Hoehn & Yahr 1 - 3.5) were randomly allocated to eight weeks of treadmill training, performed twice-weekly for 40 minutes either with (perturbation treadmill training [PTT], n = 18) or without (conventional treadmill training [CTT], n = 20) additional perturbations to the treadmill surface. Spatiotemporal gait parameters and their stride-to-stride variability were assessed during treadmill walking (treadmill-integrated pressure sensor matrix) on a weekly basis (T0 - T8), and after three months follow-up (T9). Additional overground gait analyses (shoe-worn inertial sensors, SHIMMER 2), assessing the same dependent variables as on the treadmill, were performed at T0 and T8 to investigate transfer effects. Separate two-level linear mixed models were used to analyze within- and between-group differences in treadmill gait parameters (T0 - T8). Sustainability from posttest (T8) to follow up

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(T9) was assessed using nonparametric tests, and transfer was evaluated by calculating the proportion of patients improving in overground gait characteristics. RESULTS: Treadmill gait variability reduced linearly over the course of 8 weeks in both groups (p<.001; d (range): -0.53 to -0.84). Only the PTT group significantly improved in other gait parameters (stride length/ time, stance-/ swing time), with stride time showing a significant between-group interaction effect (d = 0.33; p = .05). At T9, significant between-group interactions indicated more sustained improvements in stance (d = 0.85; p = .02) and swing time variability (d = 0.82; p = .03) in the PTT group. Transfer effects to overground walking varied substantially between gait parameters (PTT range: 5.6% - 77.8%; CTT group range: 10.0% - 55.0%) but appeared to be limited in most variables. CONCLUSIONS: Stride-to-stride variability on the treadmill reduced substantially and linearly in both experimental groups, providing valuable insight into potential adaptation mechanisms. Importantly, transfer to overground walking was limited, suggesting that gait adaptations might at least partially be task specific. Training with additional postural perturbations lead to increased efficacy and sustainability in selected treadmill gait characteristics. This pilot work provides valuable directions for future studies. ACKNOWLEDGEMENTS AND FUNDING: This work was funded by the German Foundation Neurology (DSN) and the Emerging Fields Initiative of the FAU.

P1-B-8 Task-specific modulation of the soleus H-reflex following a single balance training session

Craig Tokuno¹, Louis-Solal Giboin², Andreas Kramer², Markus Gruber²

¹Brock University, ²University of Konstanz

BACKGROUND AND AIM: Previous studies have found that long-term balance training programs induce task-specific changes in the soleus (SOL) H-reflex amplitude [1, 2]. However, it is still unknown whether similar training-induced changes in neural excitability occur following a single balance training session. METHODS: Eighteen young adults (8 men; 26±8 y) were tested on two consecutive days. On the first day, participants completed a balance training protocol, where they performed 90 acquisition trials of stepping onto a wobble board with their dominant leg and maintaining balance for as long as possible. On the first and last 15 of these trials (baseline and acquisition, respectively), SOL H-reflexes were elicited from the participant's stepping limb when the foot made initial contact with the wobble board (UNSTABLE). Prior to and after the 90 balance acquisition trials, H-reflexes were also evoked while participants sat relaxed on a chair with their knee extended (REST), or stepped down onto the ground (STABLE) in an identical manner as the UNSTABLE condition. 24 h later, 15 SOL H-reflexes were again elicited under the same three tasks (REST, STABLE, UNSTABLE) as the previous day (retention). To facilitate comparisons of SOL H-reflexes between tasks and time points, the stimulation intensity was set to elicit a constant M-wave response [~10% of maximal M-wave response (Mmax)]. Balance performance on each balance trial was quantified by the amount of time spent on the wobble board while the H-reflex




size was determined as the peak-to-peak EMG amplitude in response to each electrical stimulus. **RESULTS:** The balance training protocol resulted in an 130% increase in performance on the wobble board, from 1.7±0.2 s (baseline) to 4.0±0.8 s (acquisition) (p=0.006). This improved performance was maintained at retention (3.5±0.6 s; p=0.003). H-reflex amplitude was influenced by a task x time interaction effect (p<0.001). Post-hoc analyses revealed that during the UNSTABLE task, SOL H-reflexes decreased by 27±13% at retention compared to baseline (p=0.004). In contrast, during the REST task, H-reflexes were depressed by 37±10% at acquisition compared to baseline (p=0.006). Both of these changes in H-reflex amplitudes were observed despite no differences in SOL M-wave amplitude or background EMG activity across the three test time points. No differences in SOL H-reflex amplitude were observed between any of the three time points during the STABLE task. CONCLUSIONS: A single balance training session evoked a persistent depression of SOL H-reflex amplitude 24 h after training. Since this effect was limited to the trained balance task, it is suggested that this task-specific modulation is a reflection of synaptic consolidation occurring via the repeated activation of specific neuronal circuits involved during balance training [3]. REFERENCES:[1] Gruber et al. (2007) J Motor Behav. [2] Taube et al. (2007) Int J Sports Med. [3] Dudai (2004) Annu Rev Psychol.

P1-B-9 Large errors upon Introduction vs. removal of the training environment have distinct effect on the generalization of locomotor adaptation.

Gelsy Torres-Oviedo¹, Digna de Kam¹, Wouter Staring²

¹University of Pittsburgh, ²Radboud University Medical Center

Large errors upon Introduction vs. removal of the training environment have distinct effect on the generalization of locomotor adaptation. BACKGROUND AND AIM: Movement patterns that are adapted through interactions with the world partly carryover to untrained contexts. Such carryover is limited by contextual cues, such as performance errors, that promote the linking of adapted motor patterns to the context in which they were adapted (Torres-Oviedo and Bastian 2012). We aimed to determine the effect of performance errors during and after experiencing a novel walking environment on the carryover of movements across contexts (e.g. from treadmill to overground). METHODS: Performance errors (i.e., step length asymmetry) were modulated during split-belt treadmill walking. Subjects adapted their gait on split-belt treadmill with 1) large performance errors upon Introduction of the perturbation, 2) small errors due to implicit corrections (i.e. gradual adaptation), 3) small errors due to explicit corrections (i.e. visual feedback) and 4) large errors upon removal of the split perturbation. Step length asymmetry aftereffects were assessed in both the trained and untrained context to quantify adaptation and carryover of movement patterns respectively. RESULTS: The groups with larger performance errors exhibited more adaptation and carryover compared to those with reduced errors. Implicit and explicit strategies to reduce errors mitigated carryover of motor adaptation to the same extent. The association between error size and aftereffects was non-linear, since errors that were too





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large did not further increase aftereffects. Lastly, the group that experienced errors in the same direction as aftereffects (i.e. upon perturbation removal during the catch trial) exhibited less aftereffects on the treadmill and overground. CONCLUSIONS: Errors experienced when the perturbation is introduced (positive errors) or removed (negative errors) have opposite effects on carryover of motor adaptation across contexts. Large positive errors upon Introduction of the perturbation facilitate carryover of motor adaptation across contexts, presumably because they induce more adaptation. On the other hand, large negative errors experienced upon perturbation removal limit the carryover of walking patterns across contexts. Note that these negative errors are in the same direction as aftereffects. Thus, they most likely facilitate switching between motor patterns tied to split vs. regular walking environment.

P1-B-10 Changes in muscle activation patterns underlie split-belt gait adaptation

Danique Vervoort¹, Rob den Otter¹, Tom Buurke¹, Nicolas Vuillerme², Tibor Hortobágyi¹, Claudine Lamoth¹

¹University of Groningen, University Medical Center Groningen, ²University Grenoble-Alpes

BACKGROUND AND AIM: With increasing age, gait adaptability decreases, which can contribute to falls. The mechanism of how age reduces gait adaptability, however remains unclear. A popular paradigm to study gait adaptation is split-belt walking. The changing belt speed evokes initial asymmetries in step length and modifies stance and swing timing. Changes in muscle activation may underlie the previously found age-related differences in swing time. To better understand the mechanisms, and the onset of deterioration of gait adaptation, we examined muscle activation patterns associated with the stride adaptations induced by split-belt walking. More specifically, the aim of the study was to examine changes in muscle activation patterns during split-belt adaptation. METHODS: Young (23±3.1 y, n=11) and middle-aged adults (55±2.9 y, n=10) walked on an instrumented split-belt treadmill, starting with 6 min tied-belt walking (1.4 & 0.7 m/s; baseline), then 10 min split-belt walking with a fast (1.4 m/s) and slow belt (0.7 m/s; adaptation), and finally 6 min tied-belt walking (0.7 m/s; post-adaptation). Surface EMG was recorded from 8 bilateral leg muscles: Gluteus Medius (GM), Biceps Femoris (BF), Semitendinosus (ST), Rectus Femoris (RF), Vastus Medialis, Medial Gastrocnemius (MG), Soleus (SOL) and Tibialis Anterior (TA). Using PCA analyses, we extracted common muscle activation patterns for the fast and slow leg separately, resulting in sets of muscle contributions and temporal projections. To assess changes in muscle activation patterns, the temporal projections were compared across phases and age groups with a SPM RM ANOVA. **RESULTS:** The PCA for the fast and slow leg resulted in 3 PCs, explaining ±77% of the variance. PC1 of the fast leg, representing all muscles except TA, showed an increase in activation and a change in timing during early adaptation and early post-adaptation vs. baseline (p<0.001). The magnitude of activation decreased over the gait cycle in late vs. early adaptation (p<0.001-0.009). PC1 of the slow leg, describing all muscles except MG and SOL, showed similar changes across the phases (p<0.001). PC2 showed significant changes for specific parts of the

stance and swing phase related to the activation of the contributing muscles (TA, SOL, MG, RF (slow: +ST)). PC3 only changed for the fast leg, describing BF, ST, RF and GM. Age did not significantly affect the temporal projections. **CONCLUSIONS:** Muscle activation patterns increased in the early periods of adaptation and post-adaptation during split-belt walking. These increases are likely necessary to respond to the perturbation created by the change in belt speeds. Age however did not affect muscle activation patterns, indicating that the level of neuromuscular function at midlife does not affect gait adaptability. We conclude that the changes in muscle activation patterns underlie the changes in gait adaptation during split-belt walking, but are not affected at midlife.

P1-B-11 Prolonged exposure to height-related threat: adaptation and retention of standing balance outcomes

Martin Zaback¹, Minh Luu¹, Allan Adkin², Mark Carpenter¹

¹University of British Columbia, ²Brock University

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BACKGROUND AND AIM: Individuals' emotional response to height-related postural threat is attenuated following a short period of repeated threat exposure, yet threat-related changes in standing balance are largely preserved [1]. This suggests that some changes in standing balance are adopted irrespective of one's emotional response to threat. Alternatively, standing balance adaptations may only manifest after near complete emotional adaptation. This study used an extended threat exposure protocol to determine if threat-related changes in standing balance remain unchanged following near complete adaptation of one's emotional response to threat. **METHODS:** Eighteen healthy young adults completed 90-s standing trials at LOW (0.8m above ground, away from edge) and HIGH (3.2m above ground, at edge) threat conditions on two days separated by 2-4 weeks. On day 1, a block of 20 consecutive HIGH trials were completed to examine adaptation, while a block of 5 consecutive HIGH trials were completed on day 2 to assess retention of adapted behaviours. On both days, 2 LOW trials were completed before and after the blocks of HIGH trials. To assess emotional and cognitive state, self-reports of confidence, anxiety, fear, and attention were obtained and electrodermal activity was recorded. To assess standing behaviour, force plate and surface EMG from bilateral soleus (SOL) and tibialis anterior (TA) were recorded. From force plate data, mean position (MPOS), root mean square, and mean power frequency (MPF) of the anterior-posterior centre of pressure (COP) time series were calculated. Comparison of spectra were performed to examine changes in COP frequency content. From EMG data, SOL-TA co-activation was calculated. **RESULTS:** When threatened, participants were less confident, more aroused, anxious, and fearful, and directed more attention to their movement, threat stimuli, coping strategies, and task objectives, and less attention to task-irrelevant information. These changes were accompanied by a backward shift in MPOS and an increase in MPF, COP power between 0.7 and 5Hz, and SOL-TA co-activation. Following repeated threat exposure, participants showed substantial emotional adaptation, with 60-108% decreases in the



effect of threat across all cognitive and emotional outcomes. However, threat-related changes in MPOS and MPF did not significantly change; only COP power greater than 2Hz and SOL-TA coactivation showed adaptation. On day 2, participants' emotional response to threat partially reemerged and adaptations of higher frequency COP power and SOL-TA co-activation were not retained. **CONCLUSIONS:** Despite substantial adaptation of the emotional response to threat, only some behavioural outcomes showed adaptation. This suggests that some threat-related changes in standing balance are closely linked with one's emotional response to threat, while others may be regulated in a context-dependent manner. **ACKNOWLEDGEMENTS AND FUNDING:** NSERC [1] Zaback et al. 2017, ISPGR

C - Aging

P1-C-12 Two-year change in gait variability in community-living older adults

Bård Bogen¹, Mona Aaslund¹, Anette Ranhoff¹, Rolf Moe-Nilssen¹

¹University of Bergen

Backround and aim Gait in older adults is often characterized by increased stride-to-stride fluctuations, or gait variability. Gait variability may be an important marker of fall risk, frailty and of cognitive decline, but to be able to ascertain whether changes in gait variability are signs of pathology, knowledge about how gait variability changes in typical aging is needed. In this study, we therefore examine how gait variability changes over two-years in a non-clinical sample of community-living older adults. Methods Potential participants were specified to be 33 percent male and between 70-81 years, and selected randomly from the electoral roll. They were tested at a movement lab twice, with a two-year interval between tests. For examination of gait variability, the participants walked back and forth over a distance of 6.5 meters wearing an inertial motion unit (IMU) at their lower backs. Trunk accelerations in the anteroposterior (AP), mediolateral (ML) and vertical (V) directions were captured, and gait variability was estimated using an autocorrelation procedure, where results tending towards 0.0 mean high variability and towards 1.0 mean low variability. Participants walked under four conditions: At preferred speed, at fast speed, during dual task and across an uneven surface. Changes were investigated using a paired samples t-test. Results 85 older adults were tested at baseline and 56 of these were available for analysis of two-year change. During preferred speed walking, there were significant changes in the AP (p=.001) and V (p=.018) directions. During fast speed walking, there was a significant change in the V direction (p=.007). During dual task walking, there was a significant change in the V direction (p=.017) and during uneven surface walking there were significant changes in the AP (p=.003) and V (p=.016) directions. Conclusion To our knowledge, no studies have examined longitudinal change in gait variability in typically aging older adults with IMUs. These findings may be helpful for determining whether increased gait variability is normal or a sign of pathology. This study was funded by the Norwegian fund for postgraduate training in physiotherapy



P1-C-13 The effects of mechanical and cognitive constraints on beam walking in older adults

Andréia Abud da Silva Costa¹, Tibor Hortobágyi², Andrew Sawers³, Renato Moraes⁴

¹Ribeirão Preto School of Medicine - FMRP-USP, ²University Medical Center Groningen, ³The University of Illinois at Chicago, ⁴University of São Paulo

BACKGROUND AND AIM: Dynamic balance is a determinant of walking ability, but it is difficult to measure. Clinical tests currently in use have poor sensitivity and specificity to identify those with inferior dynamic balance. Beam walking could detect subclinical impairments in dynamic balance because it reduces the base of support, challenges foot placement, increases the magnitude and variability of trunk movements, and the height of the beam, albeit small, perpetuates fear of losing one's balance. Beam width, arm position, and cognitive load are factors that could further increase the ecological validity of beam walking to assess dynamic balance and evolve into a test that is sensitive to subtle clinical impairments. Therefore, we determined the effects of beam width, arm use, and cognitive task on healthy older adults' dynamic balance indexed by beam walking distance and speed. METHODS: Healthy older adults (n = 20) walked on 6, 8, and 10-cm wide, 2-cm high and 4-m-long beams with three arm positions (free, chest folded, akimbo) with and without a cognitive task (sequential subtraction by 3, starting at a number between 300 and 900) 3 times in each condition. Video recordings were used to determine the instant of balance loss (i.e., taking the hands off the hips, unfolding the arms, or stepping off the beam). Beam walking performance was quantified as the normalized distance traveled over the three trials by the maximum possible distance (3 trials x 4 m/trial = 12 m = 1.0) and the total time over the beam to calculate the walking speed. Cognitive errors were computed as the sum of errors over the total distance traveled. RESULTS: For the normalized distance, a 3-way ANOVA identified main effects of beam width (p = 0.001) and arm position (p = 0.036), but the post-hoc tests identified differences only between beam widths (all 3 different, $p \le 0.005$). The distance traveled increased with beam width (Figure 1). The ANOVA for walking speed revealed main effects for beam width (p = 0.001), arm position (p = 0.001) and cognitive task (p = 0.037). Walking speed was slower on the 6-cm compared to the 10-cm beam (p = 0.003); walking speed was slower for the arms at the chest and akimbo compared to the free arm condition (p = 0.006), and walking speed was slower during cognitive dual-tasking (p = 0.037, Figure 1). Beam width and arm position did not affect the number of cognitive errors (cognitive error: 0.16 ± 0.04 errors/m). **CONCLUSIONS:** In contrast to the traditionally used outcome, i.e., beam-walking distance, beamwalking speed could be more sensitive to subtle dysfunctions in dynamic balance. These preliminary data suggest that beam walking performance, speed in particular, could evolve into a sensitive test to identify subtle dysfunction in dynamic balance. FUNDING: FAPESP/Brazil (Grant 2018/18081-0).



P1-C-14 Low function based on spatio-temporal gait variables and disability

Takehiko Doi¹, Sho Nakakubo¹, Kota Tsutsumimoto¹, Minji Kim¹, Satoshi Kurita¹, Hideaki Ishii¹, Hiroyuki Shimada¹

¹National Center for Geriatrics and Gerontology

BACKGROUND AND AIM: Disability is a condition required any support to overcome difficulty or dependency in daily activities. However, whether low gait functions represented in spatio-temporal parameters had culminative effects on risk assessment of disability were still unclear. **METHODS:** A prospective study was conducted. Subjects participated in National Center for Geriatrics and Gerontology-Study of Geriatric Syndromes (NCGG-SGS) and 4,212 subjects were analyzed. The procedure to evaluate gait were to walk along WalkWay (WalkWay MW-1000, Anima Co., Tokyo, Japan) at usual pace, and gait speed, cadence, stride length and stride length variability were measured. All gait variables was measured over 2.4 m, with 2 m allowed for acceleration and deceleration. Disability was prospectively confirmed from monthly updated Long-term care insurance in Japan. **RESULTS:** The cut-off value of each gait variables for incident disability during follow-up duration was detected using the Youden index. Cox proportional hazard analysis adjusted for covariates showed numbers of gait variables regarded as low function was accumulatively related disability compared to no low function (p < .001). **CONCLUSIONS:** This study revealed that spatio-temporal gait variables had a significant culminative effects on risk of disability.

P1-C-15 Age-related differences in lower limb joint moments during turning gait

Yuto Fukuda¹, Takeshi Yamaguchi¹

¹Tohoku University

BACKGROUND AND AIM: Fall-related injuries are a serious public health issue among elderly adults (approximately ages 65 years and above). Walking trajectories such as turns, straight steps, and irregular steps are commonly seen in everyday life. However, research concerning falls among elderly adults occurring as a results of irregular steps, in addition to lower limb joint motion and muscle activity during a turning gait remains to be seen. Due to losses in muscle strength, it is hypothesized that there are age-related differences in the generated lower limb joint moments and powers between young and elderly adults. Thus, the current study aimed to investigate the generated lower limb joint moments and powers during 90 degree turning for young and elderly adults. **METHODS:** Sixteen healthy young adults (8 males and 8 females, 21.4 ± 1.2 years) and sixteen elderly adults (8 males and 8 females, 71.8 ± 4.5 years) participated in this study. The subjects were instructed to execute 90° step ad spin turns to the right at their personal normal walking speed. The lower limb joint (ankle, knee, and hip joints) moments in each anatomical plane (sagittal, frontal, and transverse plane) were calculated from ground reaction forces measured





with force plates along with joint marker positions measured with a three-dimensional motion capture system using inverse dynamics. Joint power was calculated from joint moment and joint angular velocity parameters. Each anatomical plane during turning was defined using the orientation of the pelvis to construct a body-fixed reference frame. **RESULTS:** In both step and spin turns, there were significant differences in the hip joint moment and power in the sagittal plane among young and elderly adults. Hip extension moment in the sagittal plane for elderly adults was significantly larger than that seen in young adults (p < 0.05). The duration of the hip extension moment for elderly adults was longer than that of young adults (p < 0.05). The positive hip joint power and corresponding duration seen among elderly adults were larger and longer than those of young adults (p < 0.05) exhibited in both turning methods. This difference can be attributed to an elderly adult's increased hip extension associated with a weak psoas major muscle. **CONCLUSIONS:** This study demonstrated that elderly adults turn with a larger hip extension moment and positive hip power compared to young adults. These results may ultimately be used as a basis for developing new strategies to prevent falls during turning for elderly adults. ACKNOWLEDGEMENTS: This work was partially supported by JSPS KAKENHI Grant Number 16K06038

P1-C-16 "COgnitive and Motor interaction in Older populatioNs (ComOn)" - A prospective multi-center study for quantitative evaluation of treatment effectiveness in 1000 geriatric patients with cognitive and motor deficits

Johanna Geritz¹, Sara Maetzold¹, Andrea Pilotto², Marta Corrà³, Mariana Morscovich⁴, Maria Rizzetti⁵, Barbara Borroni², Alessandro Padovani², Annekathrin Alpes¹, Corinna Bang¹, Igor Barcellos⁴, Ralf Baron¹, Thorsten Bartsch¹, Jos Becktepe¹, Daniela Berg¹, Lu Bergeest¹, Philipp Bergmann¹, Raquel Bouça-Machado⁶, Michael Drey⁷, Christin Ehlers¹, Morad Elshehabi¹, Susan Farahmandi¹, Johanna Geritz¹, Andre Franke¹, Anja Friederich¹, Corinna Geisler¹, Janne Gierthmühlen¹, Oliver Granert¹, Sebastian Heinzel¹, Maren Heller¹, Markus Hobert¹, Marc Hofmann⁸, Philipp Hüllemann¹, Björn Jemlich⁹, Laura Kerkmann¹, Stephanie Knüpfer¹, Katharina Krause¹, Maximilian Kress¹, Sonja Krupp¹⁰, Jennifer Kudelka¹, Gregor Kuhlenbäumer¹, Roland Kurth¹¹, Frank Leypoldt¹, Corina Maetzler¹, Luis Maia³, Patricia Neumann¹², Katharina Niemann¹, Christian Ortlieb¹, Steffen Paschen¹, Hoang Pham¹, Thomas Puehler¹³, Franziska Radloff¹, Christian Riedel¹, Simone Sablowsky¹, Elena Schanz¹, Linda Schebesta¹, Andreas Schicketmüller⁸, Simone Studt¹¹, Martina Thieves⁹, Sebastian Ullrich⁹, Paul Urban¹², Nuno Vila-Chã³, Elke Warmerdam¹, Tobias Warnecke¹⁴, Michael Weiss¹, Anna Wiegard¹, Clint Hansen¹, Walter Maetzler¹

¹Christian-Allbrechts-University of Kiel, ²University of Brescia, ³Centro Hospitalar do Porto, ⁴Federal University of Paraná, ⁵FERB ONLUS-S. Isidoro Hospital, ⁶University of Lisbon, ⁷Ludwig-Maximillians Universität München, ⁸Hasomed GmbH, ⁹Städtisches Krankenhaus Kiel, ¹⁰Red Cross





Hospital Geriatric Centre, ¹¹ZIP, Centre for Integrative Psychiatry, ¹²Asklepios Klinik Barmbek, ¹³Universitätsklinikum Schleswig-Holstein Campus Kiel, ¹⁴University Hospital Muenster

BACKGROUND: Reduced mobility and motor impairment are main factors for decreased quality of life in older people. Recent research indicates strong associations between reduced mobility, motor impairment and at least some cognitive functions. Geriatric patients are particularly affected by these symptoms. METHODS: The ongoing ComOn study will include 1000 geriatric inpatients from academic and non-academic hospitals until the end of 2019. Recruitment centers are Kiel, Hamburg, Brescia, Lisbon, Porto and Curitiba. We will evaluate mobility deficits and motor impairment quantitatively using inertial measurement units (IMUs), and cognitive deficits both at referral and discharge of an inpatient stay. Moreover, a follow-up will be performed three to six months after discharge. Besides IMU-based assessment, we collect detailed information about medical history, perform a clinical examination, a neuropsychological test battery, and evaluate autonomic functions, nutritional aspects, sarcopenia, frailty health-related quality of life, behavioral aspects, activities of daily living, physical activity, fear of falling, pain and dysphagia. Moreover, biofluid material is collected. A subsample undergoes structural MRI imaging and unsupervised home-based assessment with wearables (7-day assessments). RESULTS: Currently, 300 patients have been included and progress of recruitment meets our expectations. No serious events occurred, and the assessments are well accepted. **DISCUSSION:** This paper aims at presenting, to potential collaboration partners, the study protocol of a large prospective observational multicenter study to evaluate mobility and cognitive parameters on a quantitative level. Results will provide an entirely novel view on mobility and motor impairment as well as cognitive deficits in this vulnerable and, from the medical point of view, highly relevant cohort.

P1-C-17 Specific gait measures predict cognitive decline in highly educated older adults

Elissa Ash¹, Tali Ben Porat², Odelia Elkana¹, Natalie Ganz¹, Jeff Hausdorff¹

¹Tel-Aviv Sourasky Medical Center, ²Academic College of Tel Aviv-Yaffo

BACKGROUND AND AIM: Highly educated older adults are at risk of being under diagnosed in the early stages of cognitive decline. The Cognitive Reserve hypothesis suggests that these individuals have a greater premorbid reserve that helps them mask cognitive deficits. This problem is exaggerated by the widespread use of standardized norms of cognitive tests that often do not take into consideration both age and education. To avoid under-diagnosis and to aid in the early detection of individuals who have an increased risk of cognitive decline, it is necessary to find sensitive tests that can "bypass" the cognitive reserve effect seen in highly educated older adults. Longitudinal studies have demonstrated that older adults with gait abnormalities at baseline had a significantly increased risk of developing dementia years later. Further, gait impairment and falls are associated with the severity of cognitive impairment among patients with dementia. Based on that, here we aimed to evaluate whether gait measure scan predict cognitive decline in healthy,





highly educated older adults. Participants and **METHODS:** 27 healthy participants (12 men and 15 women) ages 66-80 (Mean \pm SD = 72.6 \pm 4.5 yrs) with a high education level (17.14 \pm 3.21 yrs) completed a cognitive assessment once at baseline and then again 3 years later. The cognitive assessments included: Montreal Cognitive Assessment test (MoCA); Rey Auditory Verbal Learning Test (RAVLT); Rey Osterrieth Complex Figure test (ROCF); Wechsler Adult Intelligence Scale (WAIS-III) Information Subtest (IS); WAIS-III Digit Span Forward and Backward Subtest; Trail Making Test (TMT), Parts A and B; Verbal Fluency Test: Phonetic Fluency (PF) and Semantic Fluency (SF). Gait measures were assessed at baseline using an inertial measurement unit placed on the lower back. **RESULTS:** Measures in several domains declined significantly over the 3 years of follow-up. Significant correlations were found between baseline gait measures and cognitive decline in the ROCF-copy [stride time variability (r=0.55, p<0.01) and with stride regularity (r=-0.40, p<0.05)]. Gait speed, stride length, stride time, and gait asymmetry were not significantly associated with changes in RAVLT, SF, TMT and MoCA (p>0.2). CONCLUSION: Gait measures were associated with the earliest stages of cognitive decline in highly educated older adults. In particular, gait measures that reflect within-subject stride-to-stride fluctuations were correlated with future decline in performance on the ROCF-copy. This is a test of visual cognition that requires the integration of visual information processed by separate regions in visual association cortex, and also reflects attention, planning, working memory and executive functions, possibly due to common neural networks. These findings suggest that specific gait features may help to identify highly educated older adults who are at risk of cognitive decline.

P1-C-18 Medical, sensorimotor and cognitive factors associated with gait variability: a longitudinal population-based study

Oshadi Jayakody¹, Monique Breslin¹, Velandai Srikanth², Michele Callisaya¹

¹University of Tasmania, ²Peninsula Health, Monash University

BACKGROUND AND AIMS: Greater gait variability is associated with a multitude of adverse health outcomes in older people including risk of falls. However, there is limited understanding as to how gait variability changes in older age and what factors are associated with gait variability. This study aimed to examine 1) change in gait variability across time and 2) factors that predict overall mean gait variability and change in gait variability over time. **METHODS:** Participants (n=410; mean age 72 years) were assessed at baseline and during follow up visits at an average of 2.6 and 4.6 years. Step time, step length, step width and double support time (DST) were measured using a GAITRite walkway. Intra individual variability was calculated as the standard deviation of all steps for each individual. Baseline covariates included demographic, medical [cardiovascular diseases (CVD), arthritis, depression, body mass index (BMI)], sensorimotor [postural sway eyes open (EO) and closed (EC), quadriceps strength, edge contrast sensitivity, proprioception and grip strength] and cognitive factors [executive function, processing speed, memory and visuospatial function]. Linear mixed effect models were used to determine 1) change





in gait variability over time 2) factors that predicted or modified any change in gait variability over time. **RESULTS:** Step length variability (β 0.028 95%CI 0.004 to 0.052; p=0.02) and DST (β 0.223) 95%CI 0.091 to 0.355; p=0.001) variability significantly increased each year independent of baseline age, sex and education. Greater increases were seen for step length variability in people with CVD (p value for interaction=0.04) and for DST variability in people with lower education levels (p=0.04). Although step width variability did not increase over time on average, increased variability was observed in people with lower quadriceps strength (p value for interaction=0.01). Several factors predicted greater mean variability across the 3 phases. Greater postural sway (EC) predicted greater variability in all measures (p<0.05). Arthritis, a higher BMI, slower processing speed and lower quadriceps strength predicted greater mean step time variability (p<0.05). Arthritis and a higher BMI predicted greater mean step length variability, whereas slower processing speed and a higher BMI predicted greater mean DST variability (p<0.05). **CONCLUSION** Variability in different gait measures may not necessarily show uniform changes over time. The factors that modify change in variability, or predict overall greater variability, also appear specific to each variability measure. These findings add to the knowledge on potential targets for future trials to prevent mobility loss and maintain independence in older age.

P1-C-19 Power spectral changes in ankle plantar flexors in people with Parkinson's during walking - implications for gait?

Annette Pantall¹, Othello Cope¹, Shu En Lee¹, Silvia Del Din¹, Lisa Alcock¹

¹Newcastle University

BACKGROUND AND AIM: Ageing and neurodegenerative conditions are associated with abnormal gait which is linked to increased risk of falls and decreased guality of life. Dual task walking (DTW) heightens the risk of falling. Another feature of ageing is skeletal muscle atrophy with type II (fast) fibres impacted more than type I (slow) fibres. The relationship between change in muscle and effect on gait in ageing and neurodegenerative disease is not known. A non-invasive method which may indicate motor unit recruitment strategies is spectral analysis of the electromyographic (EMG) signal. The aim of this study was to investigate the effect of Parkinson's disease (PD) and ageing on the EMG spectrum of ankle plantar flexor muscles during walking tasks. A further aim was to examine the effect of DTW compared to usual walking (UW) on the EMG spectrum. METHODS: The study involved three groups: 1) 30 people with PD; 2) YA- 15 vounger adults (18- 40 years) and 3) OA -15 older adults (60 years plus). Participants walked overground for 300 s, alternating 30 s of UW with 30 s of DTW Muscle activity was recorded bilaterally from medial gastrocnemius (MG), lateral gastrocnemius (LG) and soleus (SO) using a wireless EMG system (Zerowire, Aurion, Italy). Power spectral density was estimated using a nonlinearly scaled wavelet transform with a bank of 11 wavelets (central frequencies 7 - 395 Hz). Signals were bandpass filtered and mean frequency (MF) was estimated. Gait parameters were determined from an accelerometer attached to the low back. Statistical analysis was performed





using a linear mixed model with walking task, participant group and muscles as main factors and significance at p<0.05. **RESULTS:** There was a significant effect for muscle and for interaction effect of muscle and group (p<0.001). The MF of SO was greater in the PD group compared to both the YA and OA. The PD group had a higher MF for LG compared to the OA group and the MF of LG was greater in the YA compared to OA. There was no significant difference between groups in MF for MG. Separate analyses of walking tasks revealed differences between groups in DTW for LG and SO whereas for UW only SO was different. There was a decrease in step velocity and step length between groups with an incremental reduction in these parameters from YA to OA to PD. **CONCLUSIONS:** These novel findings indicate that synergistic plantar flexors are impacted differently in PD and ageing during walking which may relate to the observed changes in gait parameters. SO showed the greatest change which may be explained by higher type I fibre composition compared to the gastrocnemii. Additionally, there are different motor control mechanisms for 1-joint muscles such as SO compared to the 2-joint gastrocnemii. Greater differences were observed during DTW indicating different locomotor control systems when both motor and cognitive networks are active.

P1-C-20 Fat mass index and the performance of older people in the 6-minute walking test

Tatiane Pontes¹, Fernanda Pessanha², Renato Freire Júnior¹, Natália Alves², Karina Pfrimer³, Priscila Fassini³, Eduardo Ferriolli²

¹University of São Paulo, ²Ribeirão Preto Medical School, University of São Paulo, ³Faculty of Medicine of Ribeirão Preto

BACKGROUND AND AIM: Body characteristics as lower muscle mass and higher fat mass affect the physical function of older people. Physical function is a fundamental component for the performance of daily activities and for the maintenance of the independence of older adults. However, the relationship between body composition and physical function is still unclear. This study aimed to investigate the association of fat mass index (FMI) determined by Dual-energy Xray Absorptiometry (DXA) with physical function in Brazilian community-dwelling older adults. METHODS: A cross-sectional study with a sample of 55 participants living in Ribeirão Preto -Brazil, aged 60 years and older, including both men and women was conducted. FM was measured by DXA and FMI was calculated as fat mass/height2 (kg/m²). The physical function was assessed by the 6-minute walk test, and walking distance was recorded as the main parameter, considering the distance predicted by sex. The Kolmogorov-Smirnov test was used to verify the normality of data distribution. The association of physical function and FMI was analyzed using the Pearson's correlation test and statistical significance was set at $p \le .05$ (two-sided). **RESULTS:** The participants were aged 70.13±6.3 years, FMI was 9.88±3.1 kg/m2 and distance walked was $454.6\pm83.2m$. There was a significant negative association (r = - 277, p = 0.040) between FMI and distance walked, showing that higher fat mass index is associated with worse performance in the





6-minute walk test. **CONCLUSION:** Higher fat mass concentration impair the functional performance of Brazilian older adults. **ACKNOWLEDGEMENTS AND FUNDING:** processo nº 2016/15735-4, Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP).

P1-C-21 Postural stability during reaching-to-grasping while standing in young adults and older adults with and without a history of falls

Natalia Rinaldi¹, Renato Moraes²

¹Federal University of Espirito Santo, ²University of São Paulo

BACKGROUND AND AIM: By performing a functional task like reach-to-grasp, we can investigate the postural stability in a more dynamic context. In addition, the level of difficulty of the manual task may influence the postural stability. We aimed to investigate the postural stability, by using the margin of dynamic stability (MDS), while reaching-to-grasping an object with increasing levels of difficulty in young and older adults with and without a history of falls. METHODS: Forty-five individuals distributed into three groups (n=15) participated in this study: young adults (YA), older adults with no history of falls (OA), and older adults who experienced at least one fall in the 12 months before data collection (FOA). They stood upright and reached-to-grasp a dowel located at a distance of 30% of their right upper limb length. We placed the dowel on a table adjusted to the greater trochanter height and tested six different conditions combining the stability of the dowel's base and obstacles close to the dowel to characterize different levels of difficulty: stable and unstable bases without obstacles, stable base with obstacles at short and long distances, and unstable base with obstacles at short and long distances. We computed the whole body center of mass, and, subsequently, the extrapolated center of mass to obtain the MDS in both anteriorposterior (AP) and medial-lateral (ML) directions in the interval between reaching onset and dowel contact. The variables analyzed were: minimum, maximum and range. RESULTS: The MANOVA revealed a main effect for group (p=0.002) and obstacle (p<0.0001) for the minimum MDS in both directions. It was larger for the YA than for the OA in both directions (Fig. 1A). In the ML direction, it was larger for the YA than for the FOA. For the effect of obstacle, the minimum MDS was larger without the obstacles than with the obstacle at the long and short distances, and with the obstacles at the long than with the obstacles at the short distance in the ML direction (Fig. 1B). In the AP direction, the minimum MDS was smaller without the obstacles than with long and short obstacles (Fig. 1B). For the maximum MDS, the MANOVA revealed only a main effect for group. In both directions, the YA presented a larger maximum MDS than the OA (Fig. 1C). For the MDS range, the MANOVA revealed a main effect of obstacle (p<0.001) in both directions. The MDS range was smaller without the obstacles than with the obstacles at long distance in the ML direction, and it was greater without the obstacles than with the obstacles at the short distance in the AP direction (Fig. 1D). CONCLUSIONS: OA and FOA decreased the MDS while reaching-to-grasping in an upright posture compared to YA. The presence of the obstacles made the reaching task more



challenging for the dynamic stability, especially at the short distance, but the level of difficulty did not interact with the groups.

P1-C-22 Changes in Achilles tendon reflex strength during quiet standing with age

Margot Schmidt¹, Robyn Mildren¹, Gregg Eschelmuller¹, Jean-Sebastien Blouin¹, Mark Carpenter¹, J. Timothy Inglis¹

¹University of British Columbia

BACKGROUND AND AIM: There are a number of age-related changes in the sensorimotor system that could adversely affect the control of standing balance in older adults. It has been shown that the amplitude of the Hoffman reflex (H-reflex) decreases with age, but these effects are inconsistent in a standing posture [1,2]. Furthermore, the H-reflex may have limited physiological relevance, as it relies on transient electrical activation of the afferent axon and bypasses the mechanotransduction process. Conversely, mechanical stimuli applied to the tendon evoke responses that rely on mechanotransduction, and when using a broad band noisy stimulus, it allows for the examination of reflexes across a physiological range of frequencies encoded by muscle spindles. The purpose of the current study was to characterize aging-related changes in the frequency between Achilles noisy tendon vibration (NTV) and Triceps Surae EMG. **METHODS:** Participants (n = 6, 62-75 years old) stood quietly on a force plate for two minutes, while surface EMG was recorded from the Soleus, Tibialis Anterior, Medial Gastrocnemius, and Lateral Gastrocnemius. Following this, two more standing trials were conducted while Achilles NTV (10 - 115 Hz) was applied with 1 N tendon preload force and an amplitude of 15 m/s2. Vibration acceleration was recorded using an accelerometer, and preload force was recorded with a force transducer. We estimated coherence and cross-covariance between the vibration acceleration and rectified surface EMG. To assess how vibration-evoked reflexes change with age, Pearson product moment correlation coefficients between age and peak-to-peak crosscovariance (a measure of reflex strength in the time domain) were calculated. **RESULTS:** The bandwidth of vibration-evoked Soleus reflex during standing was decreased in comparison to previous findings in young adults. Peak-to-peak cross-covariance between NTV and Soleus was negatively associated with age (r = 0.85). CONCLUSIONS: These preliminary results suggest that there is a decline in vibration-evoked Soleus reflex with age during standing. We postulate that this could be due to changes in the mechanotransduction of continuous stimuli across a broad frequency band. Importantly, these age-related changes in lower-limb sensorimotor pathways may contribute to the risk of falls. Therefore, our findings will enhance our understanding of agerelated declines in the sensorimotor system, as well as impairments in mobility and increased risk of falls and injury that occur with aging. REFERENCES:[1] Baudry et al. 2014, Acta Physiol. 210(3):667-677. [2] Obata et al. 2012, J Electromyogr Kinesiol. 22(1):31-36. ACKNOWLEDGEMENTS AND FUNDING: Funded by NSERC



P1-C-23 Biomechanical balance control in older adults: a systematic review and metaanalysis

Pieter Meyns¹, Lotte Palmers¹, Sander Verbeek¹, Joke Spildooren¹

¹Hasselt University

BACKGROUND AND AIM: The ability to maintain postural balance decreases with age, resulting in an increased fall risk. The aim of the current systematic review is to investigate the differences in static postural balance between healthy older and young adults, and to determine the effect of increasing age on the biomechanical mechanisms (i.e. moving the centre of pressure (CoP) using muscle action or counter-rotating segments around the center of mass [Hof 2007 J Biomech]) to maintain postural balance. Based on these findings it may be possible to design balance interventions that specifically target the most affected balance mechanisms in older adults. METHODS: A literature search was conducted in Pubmed and Web Of Science. A combination of the following search terms was used: Aged OR aging OR older adults OR elderly OR agerelated; Young adults; Static OR quiet stance OR quiet standing OR stationary standing OR sensory organisation test; Centre (center) of mass OR centre (center) of gravity OR centre (center) of pressure OR postural changes OR postural sway OR postural balance OR biomechanical phenomena. Articles were included if they met following criteria: 1) investigating the difference in postural balance during quiet stance between older (mean age > 65y/o) and younger adults (mean age < 35y/o), 2) written in the past ten years 3) written in Dutch or English. Quality of the included studies was assessed by two authors (LP and SV) separately using the Critical Appraisal Skills Programme (CASP) checklist. RESULTS: Literature search on Pubmed and Web Of Science identified 272 articles with a final inclusion of 46 articles. Quality assessment resulted in an average of nine out of ten points and a minimum score of seven. The meta-analysis of the first 10 articles showed an increased mean displacement of the center of pressure or COP (Z=2.74,p<0.006), specifically in anterior-posterior (AP) direction (Z=2.78,p=0.005) but not in mediolateral (ML) direction (Z=0.01,p=0.99) in older adults compared to younger adults. The mean velocity of the COP during quiet standing was also significantly higher (Z=13.69,p<0.0001) in older adults in comparison to younger adults. Specifically, there was an increase in ML velocity (Z=8.91,p<0.0001) in older adults compared to young adults but not in AP velocity (Z=1.75,p=0.08). The other 36 articles will be included in the final poster or oral presentation. **CONCLUSIONS:** Previous studies have suggested that proprioceptive efficiency is decreased in older adults compared to young adults [Maitre et al. 2013 JRRD]. As such they may rely less on consistent proprioceptive information around the ankle to move the COP using muscle action during standing. This hypothesis can be supported by the current findings, as older adults were found to have altered AP COP displacement and ML COP velocity compared to young adults during quiet standing. Findings from the other 36 articles may help to determine the cause of the





differences in results between AP and ML COP amplitude and velocity in the comparison between older and young adults.

P1-C-24 PreventIT feasibility RCT: Improving physical function in older age by changing people's habits in daily life

Kristin Taraldsen¹, A.Stefanie Mikolaizak², Andrea Maier³, Elisabeth Boulton⁴, Kamiar Aminian⁵, Clemens Becker², Sabato Mellone⁶, Chris Todd⁴, Mirjam Pijnappels³, Beatrix Vereijken¹, Jorunn Helbostad¹

¹Norwegian University of Science and Technology, ²Robert-Bosch-Krankenhaus, ³Vrije Universiteit Amsterdam, ⁴University of Manchester, ⁵Ecole Polytechnique Fédérale de Lausanne (EPFL), ⁶University of Bologna

BACKGROUND AND AIM: Lifestyle factors and diseases put older people at risk of functional decline, which can lead to reduced balance, impaired gait and falls, with concomitant negative impact on guality of life. The PreventIT project has adapted the Lifestyle-integrated Functional Exercise programme (LiFE) and developed an intervention for healthy young older adults at risk of accelerated functional decline. The intervention targets balance, muscle strength and physical activity, and is delivered either via a smartphone application (eLiFE) or by use of face-to-face support and paper manuals (aLiFE). The primary aim of the RCT was to assess the feasibility and usability of the interventions, and to assess changes in daily life function. METHODS: A multicentre, three-armed feasibility RCT was conducted in Norway, Germany, and the Netherlands, comparing eLiFE and aLiFE against a control group (given general physical activity advice). We included men and women between 61-70 years of age, randomly drawn from regional registries and screened for risk of functional decline. Daily life function was assessed by the Late-Life Function and Disability Instrument (LLFDI) and a physical behavior complexity metric. Participants were assessed at baseline, after the six months intervention period, and at one year postrandomisation. RESULTS: 180 participants (66.3 ±2.5 years, 99 females) were included. Baseline functional lower extremity LLFDI scaled scores were 84.0±14.3 (basic) and 70.9±15.9 (advanced) and the weekly mean complexity value was 0.105±0.011. Mean gait speed was 1.4 m/sec (±0.2). In total, 156 were re-assessed after six months, with 12-month follow-up data on 138 participants. Data analyses are ongoing, and results from the PreventIT interventions will be presented at the ISPGR conference. CONCLUSIONS: Perspectives will be discussed on the lessons learned from completing this trial in order to improve lifestyle-integrated activities targeting balance, muscle strength and physical activity for young older adults.

D - Biomechanics

P1-D-25 The role of limb length and stature in the transition from walking to running





Niamh Gill¹, Kristen Hollands¹, Anmin Liu¹, Dale Walker¹, Andrew Roberts², Thomas O'Leary², Julie Greeves², Richard Jones¹

¹University of Salford, ²Army Personnel Research Capability

BACKGROUND AND AIM: Military personnel are often required to march at a fixed speed (approximately 1.8 ms-1) and step length for prolonged periods, often whist carrying heavy loads. Marching is potentially an injurious activity, particularly for women marching within a group of men, as preferred walking speed, step length and step frequency are related to stature. Both stature and limb length are positively correlated with the preferred walk-to-run transition speed (PTS) in a mixed group of men and women; however, it is not known whether this relationship is the same for men and women. Walking at step lengths greater than the preferred step length, or at speeds markedly different to the PTS, may be energetically less efficient and increase joint loading, which could increase the risk of lower limb and lower back injuries. The aim of this study is to evaluate the PTS and preferred step length during normal walking for both men and women of different statures. The results from this study will further our understanding of the dynamics of walking and potential injury risks. METHODS: Sixteen (6 male), out of an intended total of 42 (21 male), participants have so far been recruited for this study. Stature, body mass, and anthropometric measurements of the lower limbs were obtained prior to a transition protocol on an instrumented treadmill. Treadmill speed was increased every two minutes from 1.2 to 2.2 ms-1 in 0.1 ms-1 increments. Participants were asked to walk until they felt it would be more comfortable to run. The speed at which participants transitioned from walking to running was recorded. **RESULTS:** There was a strong correlation between stature and limb length with PTS (r=0.90 and 0.86, respectively; Figure 1). The correlation between stature and PTS was strong for women (r=0.90, p<0.01), but weak for men (r=0.27, p=0.61), which could be due to the narrower stature range for men, or the current low sample size. There was a strong correlation between limb length and PTS for both women (r=0.84, p<0.01) and men (r=0.83, p<0.05). CONCLUSION: These data support previous findings confirming PTS is directly related to stature and limb length, especially for women. Our data also indicate that women may transition earlier than men, but that limb length rather than stature may have a bigger influence on the PTS. These findings could have implications for injury risk, for both men and women, when marching at fixed speeds, whereby shorter individuals may prefer to run whereas taller individuals may prefer to walk.

P1-D-26 Virtual reality training affects joint angle strategies which correlate with safer real-world obstacle crossing

Chanel LoJacono¹, Michael Kress¹, Christopher Rhea¹

¹University of North Carolina, Greensboro

BACKGROUND AND AIM: Obstacle crossing is a critical part of safe ambulation. A reduced ability to safely negotiate obstacles may lead to an increased risk of foot-obstacle contact, which





can lead to an increased risk of injury from a fall. Our previous work showed that training participants to more safely walk over obstacles presented in virtual reality (VR) was transferred to a real-world obstacle crossing task. However, it is unknown what joint angle strategies were adopted to produce these safer obstacle crossings. The purpose of this study was to examine the hip and knee angle changes within both the leading and trailing limb that contribute to safer realworld obstacle crossing. It was hypothesized that changes in hip and knee angles as a result of VR training would correlate with higher clearance and peak elevation values within the real-world regardless of limb. METHODS: Young healthy adults (N=38; 21.6±2.7 yrs) crossed 10 real environment obstacles (pre-training), completed 2 sessions of 10 virtual reality obstacle crossings, and then crossed 10 more real environment obstacles (post-training). Full body kinematic data were recorded at 100 Hz. The obstacle crossing variables examined in the real environment were knee and hip angles (degrees), and radial clearance (closest distance) to the obstacle and peak elevation during crossing (meters). Delta scores (Δ =post-training - pre-training) were calculated for radial clearance (RC), peak elevation (PE), knee angle (KA), and hip angle (HA). Bivariate correlations were run with the delta scores for each the lead and trail limbs. RESULTS: Lead HA was significantly correlated with Lead RC (r= -.554; p<.0001) and Lead PE (r= -.483; p<.001). Lead KA was significantly correlated with Lead RC (r= -.617; p<.0001) and Lead PE (r= -.888; p<.0001). Trail KA was significantly correlated with Trail RC (r= -.510; p=.001) and Trail PE (r= -.893; p<.0001). However, Trail HA was not significantly correlated with Trail RC (r= .023; p=.89) and Trail PE (r= -.277; p=.09). CONCLUSIONS: This study indicates virtual reality training may produce safer real-world obstacle crossing strategies through changes in lead limb hip and knee angles and trail limb knee angles. As hip and knee angles decreased and became more flexed, RC and PE increased in the lead limb. For the trail limb, as knee angle decreased, RC and PE increased as well; however, the trail hip angle did not. The lead limb may increase flexion of both the hip and knee as the lead limb is farther away from the obstacle during initiation of crossing, thus giving more time for the foot to elevate as a result and increase obstacle clearance. The trail limb is closer during initiation, thus may only increase knee flexion in order to clear the obstacle because if the trail limb increases hip flexion, the foot would be closer to the obstacle and increase risk of obstacle contact.

P1-D-27 Excessive arm swings and asymmetric walking lead to more variability in the trunk kinematics

Cézar Mezher¹, Allen Hill¹, Tarique Siragy¹, Julie Nantel¹

¹University of Ottawa

BACKGROUND AND AIM: Stable posture is a primary characteristic of efficient gait. Different strategies such as increasing the base of support and gait speed or decreasing step length can be used to improve postural control during human locomotion. However, few studies have looked into the role of arm motion in normal walking on gait stability. The aim of this study is to compare





the effect of different arm motions on postural stability in symmetric and asymmetric walking conditions. We expect active arm swing to increase walking stability and asymmetric walking to decrease it. METHODS: Fifteen healthy volunteers (18-30 years old) walked on a dual-belt treadmill (CAREN-Extended, Motek Medical, Amsterdam, Netherlands). Participants completed 3minute walking trials in three arm conditions (held, normal and active arm swing) while walking symmetrically (both belts at 1.2 m/s) or asymmetrically (left foot: 1.2 m/s, right foot: 0.96 m/s). Trunk linear (LV) and angular velocity (AV) mean, standard deviation (SD), root mean squared (RMS) and average maximal (max) and minimal peaks (min) in all 3 axes were compared between conditions. Two-way repeated measures ANOVAs were performed to determine the effect of arm motion and gait symmetry. This was followed by a Bonferroni correction for multiple comparisons. **RESULTS:** Statistical analyses showed an effect for arm swing, with active arm swing leading to larger LV SD (p<0.001), RMS (p<0.001), max (p=0.01) and min (p<0.05) in the anteroposterior (AP) direction as well as LV SD (p<<0.001), RMS (p<0.001), max (p<0.001) and min (p<0.001) in the mediolateral (ML) direction. Similarly, active arms swing showed larger AV min (p<0.001) in the AP direction. While the ANOVA showed an effect for arms in the SD and RMS, the post hoc showed no significant differences. Likewise, active arm swing led to larger AV SD (p<0.001), RMS (p<0.01), max (p=0.001) and min (p<0.01) in the ML direction. Around the vertical axis, AV SD (p<0.001), RMS (p<0.001), max (p<0.001) and min (p<0.01) were larger using active arm swing. As for the treadmill condition, in the AP direction, asymmetric walking showed larger LV SD (p<0.001), RMS (p<0.001) and max (p<0.001) when compared to symmetric walking. Similarly, in the ML direction, results showed larger mean AV (p<0.01), SD (p<0.05), RMS (p<0.05), and max (p<0.05) in asymmetrical walking compared to symmetrical walking. However, symmetric walking lead to higher LV SD (p<0.001), RMS (p<0.001) and min (p<0.001) than asymmetric walking on the vertical axis. CONCLUSION: Both asymmetrical walking and active arm swing led to higher variability in the linear and angular velocity of the torso, which suggests a decrease in overall stability. This is only partially in line with our hypotheses, as active arm swing was expected to improve postural stability. It is possible that the active arm motion interfered with other aspects of gait such as interlimb coordination and therefore modified postural stability.

P1-D-28 Plantar pressures and muscle activity of normal and pes planus foot postures wearing different footwear during treadmill walking

Katrina Protopapas¹, Stephen Perry¹

¹Wilfrid Laurier University

BACKGROUND: Different foot postures influence the mechanics of the foot and have been associated with greater risk of lower limb injuries. Measuring biomechanical function of different foot postures is important to understanding the properties that may predispose individuals to these injuries. Previous research has demonstrated there may be an association between foot postures and plantar pressures[1], and foot posture and lower limb muscle activity[2]. However,





there is a paucity of research demonstrating how foot postures and external environmental factors (i.e. footwear) together influence these biomechanical properties. The aim of this study is to compare plantar pressures and lower limb muscle activity of healthy subjects with normal and pes planus foot postures during treadmill walking with three different footwear conditions. METHODS: Eighteen healthy young adults aged 20-35 participated in the study. Individuals were classified into either normal (N= 10) or pes planus (N= 8) groups with the Foot Posture Index and normalized navicular height truncated. Two types of standardized foot wear (high-support and low support shoes), as well as each participants own footwear were worn during the three walking trials. Participants were required to walk on a treadmill set at their normal walking pace for a total of two minutes per footwear condition. Total peak pressure (TPP) and total pressure-time integral (TPTI) were measured using the Pedar® Novel in-shoe system. Additionally, surface electromyography (sEMG) was used to measure average EMG magnitude of tibialis anterior (TA), peroneus longus (PL), and medial gastrocnemius (MG) lower limb muscles. Repeated measures ANOVA were used to test for the significance in the measures mentioned above. **RESULTS:** There was a significant interaction of footwear and foot posture for TPP and TPTI (p<0.001). Individuals with pes planus had greater TPP for low support shoes (5.4%, p=0.001) and high support shoes (3.6%, p<0.001) compared to normal foot posture. Additionally pes planus had greater TPI for own shoes (7.5%, p<0.001), low support shoes (8.6%, p=0.001), and high support shoes (5.9%, p<0.001) compared to normal. No significant difference of the average EMG magnitude between the three different footwear for TA, PL and MG for either normal and pes planus. CONCLUSION: Overall, plantar pressures are slightly greater with pes planus foot posture when individuals experience an acute change in footwear compared to the normal foot posture. The findings of this study is consistent with previous findings with variation in foot postures having associated changes in plantar pressures. Additionally, this study confirms that both foot posture and footwear influence plantar pressures. REFERENCES:[1] Buldt, A. K., et al. (2018). Foot posture is associated with plantar pressure during gait: A comparison of normal, planus and cavus feet. Gait & posture. [2] Murley, G. S., Menz, H. B., & Landorf, K. B.(2009)

P1-D-29 Sagittal balance control during perturbed walking

Maud van den Bogaart¹, Sjoerd Bruijn², Jaap van Dieën², Pieter Meyns³

¹UHasselt, ²Vrije Universiteit Amsterdam, ³Hasselt University

BACKGROUND AND AIM Frontal stability during walking can be controlled through appropriate foot placement and the mediolateral ankle strategy, by moving the Center of Pressure (CoP), to keep the Center of Mass (CoM) within the Base of Support (BoS) (1-2). However, it is not clear how sagittal balance is controlled during perturbed walking. The aim of this study is to identify the effect of a sagittal perturbation on the sagittal ankle joint torque, stance duration and foot placement during the first recovery step in healthy adults. **Methods** Ten healthy subjects (5 male,5 female, mean age 25±2.0 years) performed 5 trials of unperturbed and perturbed walking at fixed





speed (1.2ms⁻¹) on a Gait Real-time Analysis Interactive Lab (GRAIL;Motek bv). All trials contained 15 perturbations (belt acceleration with 5 possible magnitudes, ranging from 0.1-0.5 m/s², P1-P5) and number of steps between subsequent perturbations were randomly varied. Perturbations were applied immediately after right heel strike and finished within the right stance phase. Stance duration, foot placement relative to the pelvis and sagittal ankle joint torgue during the first recovery step after perturbation and during an unperturbed step were calculated from the full body kinematics (using Vicon camera 3D motion analysis system[Oxford]) and kinetics. Repeated measures ANOVA was performed to determine the effect of perturbation magnitude (none-0.5m/s²) Post-hoc analyses using Bonferroni-correction were performed to determine differences between conditions. Statistical analyses were performed with SPSS(v23) at α <0.05. **Results** The dorsiflexion ankle joint torque was greater at 5-10% of the gait cycle during the first recovery step after P3 and P5 compared to an unperturbed step(U) (p < 0.01, Figure 1). The stance duration was increased during the first recovery step after P2,P3 and P5 compared to U. The foot was placed closer to the pelvis during the first recovery step after P4 and P5 compared to U. Conclusions Balance during the first recovery step is controlled by a greater stance duration, foot placement closer to the pelvis and a greater dorsiflexion ankle torque at 5-10% of the gait cycle. Looking into the influence of the counter-rotation mechanism to maintain balance after perturbation could be relevant (1). ACKNOWLEDGEMENTS AND FUNDING VIDI grant no. (016.Vidi.178.014) from the Dutch Organization for Scientific Research (NWO).) References 1. Hof AL. The equations of motion for a standing human reveal three mechanisms for balance. J Biomech. 2007;40(2):451-7. 2. Vlutters M, van Asseldonk EHF, van der Kooij H. Reduced center of pressure modulation elicits foot placement adjustments, but no additional trunk motion during anteroposterior-perturbed walking. J Biomech. 2018;68:93-8.

E - Brain imaging/activation during posture and gait

P1-E-30 Mapping the cortical representation of lower-limb muscles using transcranial magnetic stimulation

Jennifer Davies¹

¹Cardiff University

BACKGROUND AND AIM: Transcranial magnetic stimulation can be used to explore the cortical representation of skeletal muscles, and any changes in this representation that may occur with pathology. However, the majority of motor mapping studies are of the upper-limb muscles, or only one lower-limb muscle. The aim of this study was to map the cortical representation of multiple lower-limb muscles in healthy individuals. **METHODS:** Sixteen young healthy adults (12 women, four men; mean [SD] age 23.0 [2.6] years) completed a single testing session. Neuronavigated TMS was delivered through a 110-mm double-cone coil. Surface electromyography was recorded from rectus femoris and medial and lateral quadriceps, hamstring and gastrocnemius muscles





according to SENIAM guidelines. Stimuli were delivered at 63 locations arranged in a 9x7-cm grid covering from 1 cm to the right and 5 cm anterior to the vertex to 5 cm to the left and 3 cm posterior to the vertex. Each site was stimulated five times. Stimuli were delivered while muscles were guiescent. For each muscle, amplitude of the motor evoked potential was used to calculate medial-lateral and anterior-posterior coordinates of the centre of gravity (CoG). Within each muscle group, medial-lateral and anterior-posterior CoG were compared across muscles using a one-way repeated-measures analysis of variance (quadriceps) or paired t-test (hamstrings, gastrocnemius). RESULTS: The mean (SD) stimulation intensity was 52 (9.3)% maximum stimulator output (range, 38-65%). Medial-lateral CoG significantly differed across muscles within the quadriceps muscle group (p = 0.001) but not the hamstring (p = 0.07) or gastrocnemius (p = 0.07) 0.67) muscle groups. Anterior-posterior CoG was similar across muscles within the quadriceps (p = 0.60), hamstring (p = 0.44) and gastrocnemius (p = 0.70) muscle groups. There was interindividual variation in the motor maps, and some instances where multiple sites of peak response (i.e., hot spots) could be observed. CONCLUSIONS: It may be possible to distinguish the cortical representation of the medial and lateral quadriceps muscles, but not hamstring and gastrocnemius muscles, in healthy individuals using transcranial magnetic stimulation. However, attention must be paid to the qualitative characteristics of the motor maps. These data from healthy individuals will inform the interpretation of motor maps from individuals with lower-limb or gait pathology.

P1-E-31 Reduced weight-shifting skills during single- and dual-task conditions are accompanied by altered neural activation in ageing

Veerle de Rond¹, Diego Orcioli-Silva², Lynn Rochester³, Jean-Jacques Orban de Xivry¹, Annette Pantall⁴, Alice Nieuwboer¹

¹KU Leuven, ²São Paulo State University (UNESP), ³Institute of Neuroscience, Newcastle University, ⁴Newcastle University

BACKGROUND AND AIM: The ability to transfer bodyweight deteriorates with ageing and may be mediated by attention. These problems likely contribute to imbalance and falls. Until now, the neural basis of whole body movements, assessed by mobile systems was mostly studied during gait and involved the prefrontal cortex (PFC) only. This study aimed to probe the effects of ageing and dual tasking on 3 brain regions during mediolateral (ML) weight shifting by means of high-density functional Near Infrared Spectroscopy (fNIRS). **METHODS:** To date, 8 young and 7 older participants performed a wasp-task (WT) measured with the VICON-system. The WT required making ML weight-shifts scaled to 80% of individuals' stability limits in order to obliterate virtual wasps projected on a computer screen. A tethered fNIRS system (LABNIRS, Shimadzu, Japan) with 32 optodes recorded cerebral oxyhaemoglobin (HbO2) and deoxy-haemoglobin (HHb) levels in the PFC, the somatosensory cortex (SSC) as well as in the motor cortices (MC). Each participant performed two blocks of 5 min and 50sec (five trials), alternating between 30s in stance while





watching the screen with wasps only and 40s of actual weight-shifting. The WT was executed during both single (ST) and dual-task (DT) conditions, consisting of a non-verbal serial subtraction task of sevens for young and threes for older adults. Outcome measures included the number of wasps hit (WT score) and the changes in normalized cerebral HbO2 and HHb between stance and WT. Exploratory non-parametric statistics were used. Data collection is ongoing. RESULTS: Older adults (age range 65-81) showed a lower WT score compared to young adults (age range 18-21) during ST and DT conditions (ST: 9.89 (2.71) old and 14.63 (3.13) young, p=0.009); DT: 6.89 (2.95) old and 13.33 (1.76) young, p=0.002). Adding the DT resulted in a lower WT score compared to ST in older adults only (ST: 9.89 (2.71); DT: 6.89 (2.95) p=0.028). None of the fNIRS changes between or within groups were statistically different. Descriptively, the HbO2 changes showed a consistent pattern. During ST, older adults had higher PFC, SSC and particularly MC levels than young adults. During DT, older adults decreased PFC and SSC activation compared to ST, while MC HbO2 levels remained high. Young adults increased MC and SSC activity, a pattern not seen in older adults. The negative HHb values largely mirrored these results. CONCLUSIONS: Weight-shifting ability deteriorated with ageing, even when performance was scaled to individual stability limits. In older adults, weight-shifting required increased activation in PFC, SSC and particularly in MC compared to the young, suggesting that with age a broader cortical network was recruited. Weight-shifting accuracy decreased when adding a cognitive task in both age groups, but showed different age-related brain activity changes across regions. Future analysis on a larger sample is needed for precise interpretation of these patterns. ACKNOWLEDGEMENTS AND FUNDING This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 721577.

P1-E-32 Postural state modulation of reactive balance control

Mark Laylor¹, Paula Polastri², Jessy Varghese¹, William McIlroy¹

¹University of Waterloo, ²São Paulo State University (UNESP)

BACKGROUND AND AIM: Walking poses a challenge to the nervous system with concurrent control of progression and stability. Phasic modulation of stability may explain cortical involvement in walking. In the current study we used measures of cortical excitability to reveal changes in postural state. Specifically, we explored state modulation of cortical activity time-locked to the onset of a balance perturbation (N1 response). The study aims to describe cortical excitability through the N1 during changes in posture that mimic gait. We hypothesize that N1 peak amplitude will be greater during lateral weight shifts where the center of mass (COM) is at the limits of the base of support (BOS). We also hypothesize that N1 peak amplitude will be greater for perturbations incongruent with weight shift direction where participants will reach the limits of their BOS faster. **METHODS:** Young healthy adults stood on a platform used to induce unpredictable perturbations to stability. Subjects performed 2 task conditions: 1) standing equal





weight distribution (NORMAL) and 2) standing with 90% weight on left leg (LEAN). Subjects were instructed to stand quietly. Perturbations were delivered in a randomized and counterbalanced order with left (congruent) and right (incongruent) directions and high or low amplitude based on an acceleration threshold to evoke stepping. Thirty trials per condition were collected. Timing of perturbation varied 5-10 seconds after the start of a trial. Measures were collected for brain activity (EEG), muscle activity (EMG), kinetics (force plates) and autonomic activity (GSR). EEG, EMG and GSR was collected using mobile systems (ANT Neuro eegosports; TMSi Porti) sampled at 1024 Hz. 32 channels of EEG were collected and muscular activity from tibialis anterior and peroneus longue to measure reactive balance control after a perturbation. **RESULTS:** Initial results demonstrate an increase in N1 peak amplitude during LEAN versus NORMAL and high amplitude versus low amplitude. An interaction of posture and direction is found with increases in the N1 peak amplitude during right perturbations when leaning. Muscle activity time-locked to the perturbation revealed a difference in amplitude associated with perturbation magnitude and direction with respect to lean position. Larger amplitude responses were recorded when perturbation created instability towards the limits of the BOS (i.e. right perturbation when leaning). **CONCLUSIONS:** Cortical excitability reflected through the N1 reveals an association of current posture as a modifier of reactive balance control processes. While this study uses static conditions, one might expect similar modulation of cortical activity during walking where the relationship between the COM and the lateral BOS limits are constantly changing. Ongoing analysis will focus on the relationship between cortical, reactive response and autonomic activity to determine the network connectivity underlying this modulation.

P1-E-33 Functional interplay between body sway and parieto-premotor network revealed by somatosensory potentials evoked by foot sole stimulation and microneurography

Laurence Mouchnino¹, Marie Fabre¹, Edith Ribot-Ciscar², Rochelle Ackerley², Jean-Marc Aimonetti², Pascale Chavet¹, Jean Blouin², Martin Simoneau³

¹Aix-Marseille University CNRS, ²Aix Marseille Université, ³Université Laval

BACKGROUND AND AIM: During standing, activation of the foot sole receptors largely depends on the speed and amplitude of the body oscillations. We hypothesized that during natural standing, small body sways may not generate sufficient somatosensory transmission to the cortex, due to continued skin compression (i.e. depressed signal transmission). Under such circumstances, central mechanisms would trigger a large sway to gather plantar tactile information. **METHODS:** To test this hypothesis, we compared the amplitude of the P50N90 somatosensory cortical potentials evoked by electric stimulations of the foot sole during either small and large sways produced in 16 young adults that were standing still with the eyes closed. **RESULTS:** Our results showed greater P50N90 SEP amplitude during large sways as compared to small sways, consistent with an increased sensory transmission in the former case. The depressed sensory transmission observed during small sways is coherent with our microneurographic recordings



showing adaptation/suppression of tactile fibres discharge during continuous pressure applied to the mechanoreceptors. **CONCLUSION:** Our hypothesis that large sways during standing correspond to a self-generated functional behaviour to release skin compression is supported by cortical source and EMG analyses showing respectively that large sways were preceded by activation of cortical areas known to be engaged in motor planning (superior parietal cortex, supplementary motor area, and the dorsolateral prefrontal cortex) and by ankle muscle activations. The present findings provide evidence for an important sensory function of large body sways for maintaining equilibrium.

P1-E-34 An exploratory in vivo voxel-based PET analysis of cholinergic correlates of postural sway variability in Parkinson disease

Martijn Muller¹, Uros Marusic², Prabesh Kanel¹, Nicolaas Bohnen¹

¹University of Michigan, ²Science and Research Centre Koper

BACKGROUND AND AIM: Parkinson disease (PD) is often complicated by postural instability. Our previous study has shown that, in the context of severe nigrostriatal dopaminergic loss, decrease in cholinergic innervation of the thalamus was associated with impaired postural sensory integration functions. A disadvantage of our acetylcholinesterase radioligand was that it would not allow for detailed assessment of cholinergic innervation in cortical areas and the inability to quantify cholinergic activity in high binding areas such as striatum and cerebellum, regions that are critical for postural control. The purpose of this study was to explore cholinergic correlates of postural control using in vivo positron emission tomography (PET) with the vesicular acetylcholine transporter (VAChT) ligand [18F]FEOBV. METHODS: A total of 84 PD subjects (63M/21F; 67.0±6.7 years old; median modified Hoehn & Yahr stage of 2.5; motor disease duration of 5.6±4.4 years; MDS-UPDRS part III total score: 33.2±12.2) underwent postural control assessments in the dopaminergic "off" state as well as in vivo VAChT [18F]FEOBV brain PET imaging to quantify brain cholinergic innervation. Participants stood with eyes open (EO) and eyes closed (EC) on a firm and foam surface and inertial sensor-based vendor-provided parameters reflecting variability in postural sway (sway RMS) were extracted from the Mobility Lab system (APDM). Whole brain correlation between [18F]FEOBV binding and sway RMS was analyzed using a voxel-based multiple-regression analysis with the SPM12 toolbox in Matlab (MathWorks) at an uncorrected threshold of p<0.01 with a voxel cluster size \geq 5. **RESULTS:** Whole brain voxel-based correlation analyses of [18F]FEOBV PET showed predominantly negative correlation between sway RMS with EO on foam surface and cholinergic activity in the bilateral caudate nuclei, thalamus, and lateral geniculate nuclei (LGN), and to a lesser extent hippocampal fimbria. Additional bilateral negative correlations appeared for prefrontal cortex, temporal pole, hippocampal fimbria, mid cingulate, and right insula for the EC condition on foam surface. There were no strong correlations between [18F]FEOBV PET binding and sway RMS while standing on a firm surface for neither visual condition. CONCLUSIONS: Cholinergic system involvement in postural sway becomes especially

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important in conditions requiring increased somatosensory control (foam surface) and is further modulated by vision. There appears to be a cholinergic network involving subcortical structures (caudate, thalamus, and LGN) that is associated with somatosensory aspects of postural control with additional involvement of cortical structures (prefrontal cortex, temporal pole, mid cingulate, and right insula) when vision is absent. These novel findings confirm and expand on our previous findings suggesting a distinct cholinergic network for sensory control mechanisms of postural sway in PD. **FUNDING:** NIH P50 NS091856.

P1-E-35 Neural correlates of body dynamics

Nicholas Murray¹, Gustavo Sandri Heidner¹, Caitlin O'Connell¹, Chris Mizelle¹, Zac Domire¹

¹East Carolina University

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BACKGROUND AND AIM: Neural correlates of body dynamics and balance control are still a vastly underexplored area within human movement research and neuroscience. A few studies have identified beta- and gamma-band corticomuscular coherence between the brain and lowerextremity muscles. However, these studies typically do not investigate frequencies above 40 Hz (i.e. low- and high-gamma). This is particularly important because, while beta-range corticomuscular synchronization has been extensively investigated during steady-state motor output, a significant shift from beta- to gamma-range synchronization occurs when the force output is dynamic. Our purpose was to develop a novel approach using surface Laplacian technique to extract corticomuscular coherence during postural control. Further, we investigated corticomuscular communication due to optical flow changes within a virtual reality environment. **METHODS:** Thirteen participants performed an average of 5 trials of guiet standing each on four conditions: eyes open, eyes closed, virtual reality baseline, and virtual reality perturbation. Surface EMG data were recorded on the left and right tibialis anterior, and lateral gastrocnemius using a bipolar Ag/AgCl electrode configuration. The EMG and EEG data were sampled at 1000 Hz, and bandpass filtered between 2-200 Hz. A notch filter was applied at 60, 120, and 180 Hz. Data was then cleaned, and problematic channels were interpolated with a spherical configuration. A Laplacian transform was used to correct for current source density. A MATLAB script was used to identify EMG peaks that were greater than the mean plus two times the baseline standard deviation. The peaks time points were then used to extract epochs of -300 ms in each channel of the corresponding trial EEG data. Magnitude-squared coherence was then calculated for each channel, in each trial, compared to each one of the four target muscles, and averaged across conditions for each muscle. **RESULTS:** Using a whole brain analysis, left gastrocnemius lateralis mean coherence was much lower than right gastrocnemius lateralis in balance tasks. Also, both left and right tibialis anterior demonstrated similar corticomuscular coherence, while right gastrocnemius lateralis had higher coherence values during dynamic postural control. CONCLUSIONS: Our findings demonstrated cortical and muscular communication within low and high gamma frequency bands and determined the contribution of dominate cortical areas in



balance control. Further, this approach has the potential to differentiate neural correlates of typical and impaired balance.

P1-E-36 Evidence for an alternate neural control in freezing of gait during complex walking

Trina Mitchell¹, Trina Mitchell¹, Alexandra Potvin-Desrochers¹, Anne-Louise Lafontaine¹, Oury Monchi², Alexander Thiel¹, Caroline Paquette¹

¹McGill University, ²University of Calgary

AUTHORS (in correct order): Mitchell T, Potvin-Desrochers A, Lafontaine AL, Monchi O, Thiel A, Paquette C BACKGROUND AND AIM: Freezing of gait is characterized by a transient inability to produce effective steps despite the intention to walk. It is a common motor symptom in Parkinson's disease (PD) leading to severe disability and falls. Turning while walking (i.e., steering of gait) is an important trigger of freezing episodes. This type of complex gait is believed to be problematic due to an increased demand for voluntary control compared to steady state forward walking. Fronto-striatal impairment in freezing of gait is associated with decreased automaticity of locomotion and impaired compensatory mechanisms involving cognitive circuits. It is not well understood however, what role these mechanisms have during complex gait known to induce freezing episodes. Therefore, our aim thesis was to determine if complex walking promotes the use of alternate neural circuits during an upright gait paradigm comparing steering of gait (i.e., complex locomotion) to straight walking (i.e., simple locomotion) in PD with and without freezing of gait. METHODS: Eighteen participants with PD, OFF-medication, were recruited and allocated to a FOG group for those experiencing freezing of gait (n=9, aged 68 ± 6) or to a FOG- group for those not experiencing freezing (n=9, aged 65 ± 5). All subjects underwent [18F]-fluoro-deoxyglucose positron emission tomography ([18F]-FDG PET) imaging during two gait tasks: steering and straight walking. Cerebral glucose metabolism and spatiotemporal gait measures (i.e., stride length, stride velocity) were obtained. Region-of-interest and whole-brain voxel-wise analysis were used to determine task-related change (steering vs. straight walking) in cerebral glucose metabolism between groups. Regions with significant change in activation between groups were correlated with severity of freezing and gait impairment (i.e., stride length). RESULTS: During steering, FOG had reduced modulation of locomotor centers within the cognitive cortico-thalamic circuit (i.e., posterior parietal cortex, dorsolateral prefrontal cortex, and thalamus). More specifically, those with freezing of gait had less activation of the posterior parietal cortex, less deactivation of the dorsolateral prefrontal cortex and thalamus, and increased activation in the supplementary motor area. Activity in the dorsolateral prefrontal cortex was related to gait impairment in FOG (i.e., reduced stride length). CONCLUSIONS: FOG participants have reduced activity of parietal regions involved in cognitive control and increased activity of prefrontal and supplementary motor areas compared to FOG- during upright complex walking. These findings provide evidence for alternate neural control during complex gait in PD with freezing of gait and



provide a better understanding of the mechanisms underlying freezing of gait. **ACKNOWLEDGEMENTS AND FUNDING:** The authors thank the MRI and PET units of the McConnell Brain Imaging Centre. This work was supported by Parkinson Canada.

P1-E-37 A brainstem, subcortical and cortical network for dynamic balance control in healthy older adults

Elizabeth Pasman¹, Martin McKeown¹, Saurabh Garg¹, Taylor Cleworth², Bastiaan Bloem³, J Timothy Inglis¹, Mark Carpenter¹

¹University of British Columbia, ²University of Waterloo, ³Radboud University Medical Center

BACKGROUND AND AIMS: While newer technologies (e.g., fNIRS) allow for limited cortical assessment, studying brainstem and subcortical involvement in balance control requires functional MRI (fMRI) scanners which are almost exclusively horizontally-based. Some studies have had subjects perform balance-related tasks while supine, but none of the tasks involved maintaining equilibrium of a free-standing balance system [1-3]. Similarly, motor imagery may be limited when studying non-volitional sensorimotor tasks such as balance. Recently, we developed and validated an MRI-compatible balance simulator that allows subjects to perform tasks resembling free-standing balance using postural leg muscles while supine [4]. In this study, the novel simulator was used to examine effective brain connectivity during static and dynamic balance control in healthy older adults (HOA). METHODS: 17 HOA (mean ± SE age = 68.1 ± 1.3 years) performed 4 tasks within an fMRI scanner (3T, Philips) with eyes closed: resting (R), proprioception (P), static balancing of the simulator (SB), and dynamic balancing (responding to random perturbations) of the simulator (DB). The reference task was a combination of R/P. The connectivity network between 57 regions of interest (ROIs) was computed using a Bayesian Network learning approach with false discovery rate set to 5%. Analysis was performed in each subjects' native space to prevent misregistration, particularly of subcortical and brainstem regions. The first 12 principal components (PCs) of detected connections were entered into a multiple binomial logistic regression to identify connections predicting the SB and DB tasks. Leave-oneout cross validation was used to evaluate the ability of the models to correctly predict the outcome category of observed cases. RESULTS: 164 significant connections were detected between ROIs. The 12 PCs accounted for 75% of the total variability of the data. The SB model was not statistically significant. The DB model was statistically significant with an overall prediction success rate of 73% during cross validation. Four PCs made a significant contribution to predicting DB. The connections with the largest effect on these 4 PCs are displayed in Figure 1. In particular, there was an increase in strength of connections from brainstem to subcortical and limbic areas (cerebellum, thalamus, insula) and connections received by basal ganglia from frontal and limbic areas. **CONCLUSION:** This study provides novel evidence of an effective brain connectivity network used in healthy older adults during a dynamic balancing task that involves connections between brainstem, subcortical and cortical areas. The current methods can be used to

investigate deficits in cortical and subcortical neural substrates associated with postural instability in clinical populations such as patients with Parkinson's disease. ACKNOWLEDGEMENTS: Funding by Parkinson Canada and NSERC **REFERENCES**:[1] Karim et al, 2014, Brain Res; [2] De Lima-Pardini et al, 2017, Sci Rep; [3] Buettner et al, 2017, Front Neurosci; [4] Pasman et al, 2018, SfN

P1-E-38 Functional near-infrared imaging of the temporo-parietal junction during vestibular rotational stimulation

Patrick Sparto¹, Theodore Huppert¹, Helmet Karim¹, Joseph Furman¹

¹University of Pittsburgh

BACKGROUND AND AIM: Functional near-infrared spectroscopy (fNIRS) is a non-invasive neuroimaging technique for measuring evoked cerebral hemodynamic responses that uses low levels of light to measure optical absorption due to blood oxygenation and/or volume changes in the brain. In this descriptive study, fNIRS was used to record cerebral blood volume changes in the temporo-parietal junction (i.e. vestibular cortical) region during Earth Vertical Axis Rotation (EVAR) vestibular stimulation. METHODS: Ten young (6M/4F, aged 29 +/- 8yrs) and eight older (5M/3F, aged 77 +/- 5yrs) participants underwent fNIRS brain imaging during rotational testing. We examined the magnitude of blood volume changes during three conditions using seated 0.05 Hz EVAR--rotation in the dark (VOR), rotation with earth-fixed vertical stripes (visually-augmented VOR, AVOR), and rotation with a head-yoked visual fixation point (visually-suppressed VOR, SVOR). Hemodynamic responses were recorded at 4 Hz using four 808 nm light sources and four detectors placed over a single lateral temporal-parietal region, resulting in 10 channels of data. Each condition was performed separately for each hemisphere. The light intensity was transformed to total hemoglobin concentration via the modified Beer-Lambert law. After reviewing the data from each trial, four channels were judged to have a consistently high signal-to-noise ratio (SNR). A transfer function analysis was used to estimate the magnitude and phase of the mean response averaged across the four high SNR channels at the 0.05 Hz stimulation frequency. A statistical procedure was used to determine if a significant fNIRS response occurred at the stimulation frequency. **RESULTS:** The figure demonstrates the best example of cortical responses to EVAR stimulation, with fNIRS responses at the stimulation frequency. The magnitude and phase of the responses varied considerably across the subjects; seven of the young adults and one of the older adults had at least one trial in which no response was detected. The presence of a 0.05 Hz cortical hemodynamic response was detected in 36% of the trials for young adults and 56% of the trials for older adults. A significant response was detected more frequently in the AVOR condition compared with the VOR and SVOR conditions. Considering only the trials in which a response was detected, the magnitude of the response was about twice as great in the older adults (0.29 + 0.30 micromolar) compared with younger adults (0.16 + 0.13 micromolar), and slightly larger in the VOR condition compared with the AVOR and SVOR conditions. The phase

values for the trials in which a response was detected varied widely, and thus a measure of central tendency was not computed. **CONCLUSION:** This study demonstrates evidence for cortical hemodynamic responses in the temporo-parietal region during sinusoidal stimulation of the horizontal semicircular canals. Responses were not consistently produced in all subjects, particularly younger adults. Future investigations should assess which technical and personal factors affect the presence, magnitude, timing and reliability of responses. In addition, the influence of visual-vestibular interactions on the cortical responses needs to be characterized in more detail.

P1-E-39 Understanding the hemodynamic response and sensory contribution to automatic postural control

Gabrielle St-Amant¹, Tabassum Rahman¹, Nadia Polskaia¹, Sarah Fraser¹, Yves Lajoie¹

¹University of Ottawa

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BACKGROUND AND AIM: Trough the examination of multiple kinetics and kinematics measure such as area and standard deviation of center-of-pressure (SD of COP), postural control has been suggested to be automatic under a dual-task paradigm (Woollacott & Shumway-Cook, 2002). Recently, a wavelet analysis of COP data during dual-tasking revealed a shift towards an increased contribution from the cerebellar and vestibular systems, suggesting a more automatic mode of control. In order to understand the cortical component of postural control, functional near-infrared spectroscopy (fNIRS) has been used to identify cortical activation under postural control conditions (Pinti et al., 2018). However, the neural correlates of automatic postural control have yet to be fully investigated. Therefore, the purpose of this study is to determine if there is a corresponding change in cortical activation (i.e. changes in levels of oxyhemoglobin (HbO)) in the prefrontal cortex (PFC) following the shift in contribution of the sensory systems, which would indicate a change from conscious to automatic postural control. METHODS: Eighteen healthy young adults between the ages of 18 to 35 years old with no balance deficits were recruited. Participants were instructed to either quietly stand on a force platform (SM), perform three cognitive tasks while seated (SC) or perform both aforementioned tasks concurrently (DT). The condition were repeated four times for each of the cognitive tasks and were 45-seconds in duration. The cognitive tasks consisted of the following: simple reaction time (SRT), n-back, and the double-number sequence (DNS). The SD of COP in anterior-posterior (AP) and medial-lateral (ML) directions and the area of 95% confidence ellipse were collected. RESULTS: Results identified a significant main effect of condition for area (F (3,42) = 6.50, p < 0.001). The post-hoc test revealed that the n-back promoted the greatest reduction in area compared to the other cognitive tasks (p = 0.0013). As for SD of COP in the AP direction, a main effect of condition was also found (F (3,42) = 5.01, p < 0.005). The post-hoc test revealed that the n-back resulted in higher stability as evident by a decrease in SD (p = 0.0007). The wavelet analysis identified a task x bands interaction effect (F (3,27) = 10.13, p < 0.0001). The post-hoc test revealed a significant



decrease in the contribution of the visual system (p = 0.0004), and a significant increase of the cerebellum's contribution (p = 0.002) in the DT condition when compared to quiet standing. Cortical activation in the right PFC was significantly lower when compared to the left hemisphere under the DNS task (F (17) = 5.18, p < 0.05) when comparing the DT condition to quiet standing. **CONCLUSION:** Thus, the decrease in cortical activation in the right PFC, and the increased contribution of the cerebellum further suggests that dual-tasking promotes a more automatic mode of postural control.

P1-E-40 Structural neural correlates of independent gait characteristics in Parkinson's disease

Joanna Wilson¹, Brook Galna¹, Sue Lord², Alison Yarnall¹, Rachael Lawson¹, Gordon Duncan³, Tien Khoo⁴, David Burn¹, Lynn Rochester⁵, John-Paul Taylor¹

¹Newcastle University, ²Auckland University of Technology, ³University of Edinburgh, ⁴Griffith University, ⁵Institute of Neuroscience, Newcastle University

BACKGROUND AND AIM: Gait disturbance is a cardinal feature of Parkinson's disease (PD). However, the mechanisms underlying gait are poorly understood, limiting its therapeutic management. Associations have been reported between quantitative gait measures and regional brain structures in healthy ageing; few have assessed the relationship between gait and structural brain imaging parameters in PD, or assessed gait characteristics from a robust gait model within the same protocol. It is postulated that different subcortical regions are responsible for unique gait characteristics, and that these associations differ in PD compared to healthy ageing. Here, we aimed to assess the subcortical brain structures associated with independent gait characteristics from a validated model of gait, in PD patients and healthy age-matched controls. METHODS: 100 newly diagnosed PD participants and 47 healthy controls underwent quantitative gait and 3T magnetic resonance imaging (MRI) assessments through the ICICLE-PD and ICICLE-GAIT studies. From T1-weighted brain images, subcortical volumes related to motor and cognitive functions were measured with Freesurfer image processing software. For gait assessment, participants walked continuously for 2 minutes around a 25m circuit at their comfortable pace, with gait repeatedly sampled as participants walked over a 7m X 0.6m instrumented walkway included in the circuit. Sixteen spatiotemporal gait characteristics were derived. Participant's heights were recorded; motor function of PD patients was also assessed through the MDS-UPDRS III. Correlations were made between subcortical structures and gait characteristics, with the additional inclusion of age, gender, height, UPDRS score, disease and total intracranial volume as covariates. **RESULTS:** Preliminary results indicate that, after correcting for multiple comparisons, a reduced volume of the brainstem was associated with a larger step width, from the postural control domain of gait, in PD patients but not in controls (p<0.01). This relationship remained when controlling for all covariates; no other associations reached statistical significance once all covariates were included. **CONCLUSIONS:** This study gives evidence that the brainstem may

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play a more significant role in postural control in Parkinson's disease compared to healthy ageing. Assessments of cortical volumes and structural integrity of white matter tracts may give further insight in to the roles of different neural networks during gait. **ACKNOWLEDGEMENTS AND FUNDING:** This research was funded by Parkinson's UK and supported by the National Institute for Health Research (NIHR) Newcastle Biomedical Research Unit and Newcastle Biomedical Research Centre based at Newcastle upon Tyne Hospitals NHS Foundation Trust and Newcastle University.

F - Cognitive impairments

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P1-F-41 Step-length changes caused by a dual-task test among individuals undergoing memory assessment - a pilot study

Anna Cristina Åberg¹, Fredrik Tinmark², Lars Berglund¹, Kjartan Halvorsen¹, Vilmantas Giedraitis¹

¹Uppsala University, ²The Swedish School of Sport and Health Sciences, GIH

BACKGROUND: Dementia disorders are a growing global public health challenge. Research has shown that gait changes occur early in the development of dementia, already before impairment can be identified by cognitive tests. Gait tests combined with a simultaneous verbal task have been suggested as a 'brain stress test', which may reveal the degree of cognitive impairment, but more research is needed. Aim: To investigate if and how the performance of a well-established gait test (Timed Up-and-Go, TUG) combined with a dual verbal task (TUG dual-task, TUGdt) among individuals undergoing memory assessment causes changes in step length (SL). **METHODS:** A sample of 22 participants, 12 men and 10 women, with a mean age of 73 years (range of 58-87), undergoing memory assessment at a specialist clinic was consecutively included. Ten had a dementia disorder diagnosis and 12 were under investigation due to cognitive impairment. The TUG testing was initiated by the single task TUG test, which consists of one movement sequence: starting from a sitting position in an armchair, standing up and walking 3 meters, turning around, walking back to the chair and sitting down again. This was followed by a TUGdt test involving TUG with the addition of the verbal task of naming different animals. All TUG tests were video-recorded by two synchronised cameras in a room marked with references for measures of length. The data collection also included measuring body height and a battery of established clinical motor and cognitive tests, including the Mini Mental State Examination (MMSE). Data processing involved the digitalisation of the positions of the right and left heel and toe, respectively, derived from video-data of the camera with a sagittal view. 2D reconstruction was performed using Direct Linear Transformation in the software SkillSpector Version 1.3.2 (Video4Coach, Odense, Denmark). For statistical analyses, Spearman's correlation, as well as the Wilcoxon's two-sample test adjusted for age, gender, and body height with Willett's residual method, were used. **RESULTS:** Individuals with a dementia diagnosis showed significantly lower MMSE scores; M=21.3 vs. M=26.5, (p=0.04). In the whole group, age was negatively correlated



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with SL in both TUG and TUGdt tests (R=0.63-0.68, p<0.003). In general, SL for TUG appeared longer than TUGdt in both groups. It was also observed that a majority of participants took shorter steps after turning in both TUG and TUGdt. Interestingly, all individuals without dementia shortened their SL after turning in TUGdt, whereas results varied in the group with dementia (see Fig. 1). Significant differences were found between the groups concerning change of SL before vs. after turning in TUGdt, but not in TUG (p=0.031). **CONCLUSION:** This study indicates that changes in SL during dual-task testing may be a relevant parameter to investigate for the differentiation of individuals with different degrees of cognitive impairment.

P1-F-42 Comparison in postural sway between healthy control and mild cognitive impaired group with dual tasks

Junggil Kim¹, Jinsoo Lee¹, Jeongwoo Seo¹, Jinseong Choi¹, Gyerae Tack¹

¹Konkuk University

BACKGROUND AND AIM: As incidence and prevalence rates of dementia patients are increasing every year, the interest in MCI (Mild Cognitive Impairment) which is recognized as a pre-stage of dementia is increasing. It is generally known that there is a correlation between balance and cognitive ability such as orientation and memory. And in the case of gait, it is reported that the difference between health group and cognitive impairment group are more evident when difficulty of task increases [1]. On the other hand, in the case of static balance, it is reported that the difference between the cognitive decline group and the normal person is not observed regardless of the task difficulty [2]. However, in the literature analyzing the static balance, quantitative analysis of kinematic variables was insufficient. Thus, the purpose of this study was to analyze the difference in the kinematic characteristics between healthy control and mild cognitive impaired group during standing posture and with increasing difficulty of task. Method: The elderly aged over 60 were classified into two groups based on the degree of cognitive impairment using MMSE-KC (Korea Version of Mini Mental State Examination). Based on cutoff score 24, total 122 participants were divided into two groups, 58 Healthy Control (MMSE-KC: 26.72 ± 2.00) and 64 MCI group (MMSE-KC: 21.09 ± 3.64). One-minute standing with eye open as single task (ST) and eye open with backward counting from 50 to 1 as dual task (DT) were performed. IMU (Inertia Measurement Unit, APDM Inc., Portland, OR, USA) were attached at the subject's thorax, lumbar, thigh and ankle, and the movement of the Center of Mass (COM) was recorded and the 6 kinds of variables(Sway area, RMS (Root Mean Square) sway, Mean velocity, Mean Distance, Path Length, Range of Acceleration) related sway were calculated. Result: For ST, there were no significant differences between HC and MCI. However, for DT, the values of 4 kinds of variables (Sway area, RMS sway, Mean Distance, Range of Acceleration) of MCI were significantly larger than HC (p<0.05). CONCLUSION: By adding Dual task, the variables related sway were shown significantly different between HC and MCI. Thus, in the case of the static balance with Dual Task, the characteristics of the cognitive impaired group can be confirmed. REFERENCE [1] G. Allali.





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P1-F-43 Is gait variability a biomarker of neurodegenerative disorders?

Manuel Montero Odasso¹, Yanina Sarquis-Adamson¹, Natalie Ravid², Quincy Almeida³, Frederico Pieruccini-Faria¹, Kerry Howell², Richard Camicioli²

¹University of Western Ontario, ²University of Alberta, ³Wilfrid Laurier University

BACKGROUND AND AIM: Gait variability has been proposed to be a sensitive marker of central neurological control of mobility in general, and gait dynamics and navigation, in particular. Gait variability is altered in motor disorders including Parkinson's disease and, recently, it has also been associated with cognitive disorders such as mild cognitive impairment (MCI) and Alzheimer's disease (AD). However, there is a lack of studies comparing these different neurodegenerative conditions, specifically addressing the role of cognitive impairment in each disorder and their association with gait variability. Our aim was to evaluate gait variability in the spectrum of normal cognition (Controls), subjective cognitive impairment (SCI), Parkinson's Disease (PD), MCI, PD-MCI, mild-AD, Lewy body dementia (DLB) and Parkinson's disease dementia (PDD). METHODS: Two hundred and ninety six older adults (mean age 78±9, 56% women) across the cognitive spectrum were recruited from two sites in Canada: London (ON) and Edmonton (AB). Participants had to walk 6 meters on an electronic mat at a self-selected comfortable and safe pace. From this walk, stride length was extracted for each participant and its coefficient of variation (CoV; variability) was calculated as CoV= Standard deviation/Mean. Comparisons of the stride length variability across the cognitive spectrum were completed with mean and standard deviation, and statistical significance was calculated with a one-way ANOVA. RESULTS: Stride length variability was significantly different across groups (F7, 288= 8.37; p< 0.001), where participants had increasing variability with increasing cognitive impairment (Figure 1). The mean (SD) for each cognitive group was: Control: 2.50 (1.24), SCI: 2.98 (1.60), PD: 2.87 (1.18), MCI: 3.20 (1.87), PD-MCI: 4.46 (1.82), Mild-AD: 4.20 (1.58), DLB: 6.03 (5.32), and PDD: 8.31 (5.46). CONCLUSIONS: Stride length variability, calculated as CoV, increased across the cognitive spectrum and may be a sensitive marker of cognitive disorders in neurodegeneration.





P1-F-44 The association between spatial navigation and physical function in memory clinic patients.

Gro Tangen¹, Anne-Brita Knapskog², Elisabeth Telenius¹, Geir Selbæk¹, Kristin Taraldsen³

¹Norwegian National Advisory Unit on Ageing and Health, ²Oslo University Hospital, ³Norwegian University of Science and Technology

BACKGROUND AND AIM: Getting lost and impairments in spatial navigation are common in persons with dementia. The first impairments in navigational abilities may even occur in the predementia stages. Impaired abilities in spatial navigation may reduce the amount of daily physical activity and influence gait and balance performance. The aim of this study was to explore the associations between performance-based navigational abilities and physical function in memory clinic patients. **METHODS:** We included patients from the memory clinic at the Oslo University Hospital who were home-dwelling, able to walk without a walking device, could perform the testing in Norwegian and who did not have severe psychiatric comorbidity. Physical function was assessed using the Mini-BESTest for dynamic balance, Short Physical Performance Battery (SPPB) for general physical function, and 4-meter walking at comfortable speed for gait function. Spatial navigation was assessed using the Floor Maze Test (FMT), and we used error-free vs. witherror performance as outcome. Group differences were examined using Mann-Whitney U tests, and Multiple linear regression analyses were performed to examine the association between the Mini-BESTest and FMT, adjusted for age, gender, Mini Mental Status Examination (MMSE) and musculo-skeletal comorbidity. **RESULTS:** We included 71 patients that performed the FMT (mean age 67.9, ±8.2, years, 57.7 % men), where 37 (52.1 %) had error-free performance. In total, 25 (36.7 %) patients had cognitive impairment without dementia, 32 (47.1 %) had Alzheimer's dementia (AD), and 11 (16.2 %) had other dementias (OD). Median (IQR) values for Mini-BESTest score was 24.5 (6) points, for gait speed 0.94 (0.3) m/s, and for the SPPB score 12.0 (2.0) points. Patients with error-free performance on the FMT performed better than patients with-errors on the Mini-BESTest (25.5 (7) points vs. 23.0 (7) points, p=0.007) and on gait speed (0.99 (0.3) vs 0.91 (0.3) m/s, p=0.013), but not on the SPPB (11.0 (1) vs 12.0 (2), p=0.62). In multiple linear regression analyses, comorbidity and FMT were significantly associated with Mini-BESTest as the dependent variable, while age, gender and MMSE were not (all p>0.05). This model explained 32 % of the variance in the Mini-BESTest. Data collection is ongoing and final results will be presented at the ISPGR. ACKNOWLEDGEMENTS AND FUNDING: The authors thank all the patients who participated in this study. The study was funded by South-Eastern Norway Regional Health Authority.

G - Cognitive, attentional, and emotional influences

P1-G-45 Effects of concussion history on centre of pressure during static dual-tasking in collegiate athletes





Kelsey Bryk¹, Jaclyn Caccese¹, Katherine Hunzinger¹, Thomas Buckley¹

¹University of Delaware

BACKGROUND AND AIM: Dual task is a critical component when assessing neurologically impaired individuals including concussed athletes. Executive function is a cortically demanding brain function, assessed with the Trail-Making Test (TMT), and tests attention, cognitive processing, and shifting. The effect of concussion history on the TMT has been assessed, the motor output has not been identified. The purpose of this study was to examine the effects of concussion history on centre-of-pressure (COP) metrics while performing TMT on an iPad. **METHODS:** Seventy-four NCAA Division I collegiate student-athletes from a variety of sports (e.g., football, baseball) completed a baseline concussion assessment prior to the beginning of their season. Subjects completed 3 tasks on a force plate; 1 single-task (quiet stance only) and 2 dualtasks (TMT-A, TMT-B) and data was sampled at 50 Hz. The single task had the subject stand with eyes open, feet together for 2 minutes. The dual-task had subjects complete the TMT on an iPad with their finger. The COP outcome measures were 95% area, sway velocity, and approximate entropy (medial-lateral; ApEnX & anterior-posterior; ApEnY). Concussion history was selfreported. A 2 (Concussion history: Yes vs No) x 3 (Task: 2min, TMT-A, TMT-B) repeated-measures ANOVA was used to analyze the differences between concussion history groups and tasks. **RESULTS:** Of the 74 athletes (28 females, 46 males), 60 athletes self-reported no history of concussion (age: 18.7±1.1; height: 177.5±11.9cm; weight: 78.6±19.7kg) and 14 reported a history of concussion (age: 18.9±1.7; height: 181.3±13.7cm; weight: 86.2±28.5kg). There was a significant interaction between task and concussion history for ApEnY (p=.044, $\eta^2=.046$), whereby those with \geq 1 concussion had greater ApEnY decrease from 2min to TMT-A (Δ : -.22) than those with no history (Δ :-.11). Both displayed a similar increase in ApEnY from TMT-A to TMT-B (Δ :+.11), however ApEnY during TMT-B was greater for those with no history than with a history. There were significant main effects of task for 95% area (2min: 3.5±2.6 cm; TMT-A: 4.2±2.6 cm; TMT-B: 4.6±3.3 cm; p<.001, n²=.131), sway velocity (2min: 1.2±0.4 cm/sec; TMT-A: 1.5±0.5 cm/sec; TMT-B:1.5±0.5 cm/sec; p<.001, n²=.413), ApEnX (2min: 1.0±0.2; TMT-A: 0.7±0.1; TMT-B: 0.9±0.1, p<.001, η²=.487), ApEnY (2min: 0.9±0.2; TMT-A: 0.7±0.1; TMT-B: 0.9±0.1, p<.001, η²=.246). There was a significant main effect of concussion history for 95% area (p=.02, n²=.073). CONCLUSIONS: Concussion history does not affect most postural control variables. Lower entropy for TMT-A in those with a history means their sway followed a more predictable pattern and continued to do so for TMT-B than during a 2-min guiet stance. This result suggests that athletes with a history of concussion appear to use an altered strategy for postural control.

P1-G-46 Does it matter where you look during obstacle crossing?

HyeYoung Cho¹, Nathaniel Romine¹, Fabio Barbieri², Shirley Rietdyk¹

¹Purdue University, ²São Paulo State University (UNESP)





BACKGROUND AND AIM: Visual information of an obstacle allows a person to step over it safely [1]. However, while walking, gaze is frequently diverted to other regions such as traffic or pedestrians, which may impair the ability to gather visual information about an upcoming obstacle since the same perceptual mechanism (vision) is being used, called structural interference. For example, during stair descent, when the location of a visual reaction time (RT) task restricted the view of a staircase, impaired performance was observed in RT and gait measures [2]. Gaze diversion should only affect performance if the location of the gaze restricts or facilitates the gathering of visual information relevant to the task. For example, diverting gaze to or away from an obstacle will likely affect cognitive and/or motor performance when required to step over the obstacle, but gaze diversion should not affect cognitive performance when standing in front of the obstacle. The purpose of this study was to determine how gaze diversion affects young adults while standing versus during obstacle crossing. METHODS: Seventeen adults (20.9 ±1.9 yrs; 14 females) completed a simple RT task while standing or approaching an obstacle on an 8 m walkway. RT task was to press a remote switch following a light cue. Two light locations were either (1) on the obstacle or (2) at eye level at the end of the walkway. Two tasks were (1) standing and (2) stepping over the obstacle. A baseline obstacle crossing task without a RT task was also included. The five conditions were block-randomized with 20 trials for each condition (100 trials). RT, RT variability, and standard gait measures were calculated. RESULTS: An interaction of task by location was observed for RT (p=0.01). The location of the RT task did not affect the standing conditions, but did affect the walking task [Figure 1]. RT variability was greater in gait task (p<0.001). The trail foot to obstacle horizontal distance was significantly affected by the RT task (p=0.002). When the gaze was diverted away from the obstacle, the trail foot placement was closer to the obstacle compared to the gaze diverted to the obstacle. Closer foot placement increases risk of tripping [3]. CONCLUSION: Impaired performance in the gait task likely resulted from structural interference as the same perceptional mechanism, vision of the obstacle, was used for both the cognitive and gait task. Conversely, in the standing task, vision of the obstacle was only relevant for the cognitive task, so no structural interference was evident. The findings provide evidence that the role of vision is critical for young adults while obstacle crossing, and future studies should explore how diverted gaze affects older adults during adaptive gait. REFERENCES [1] Hollands et al. In Locomotion and Posture in Older Adults (pp. 55-72). Springer, 2017. [2] Miyasike-daSilva McIlroy, Exp Brain Res, 234(11), 3233-43, 2016. [3] Heijnen et al, Exp Brain Res, 223(2), 219-31, 2012.

P1-G-47 The influence of social anxiety on balance and walking task assessment in older women

Diego Orcioli-Silva¹, Elizabeth Pasman², Lilian Gobbi¹, Mark Beauchamp², Mark Carpenter²

¹São Paulo State University (UNESP), ²University of British Columbia




BACKGROUND: Social anxiety caused by the presence of an evaluator has been shown to influence balance performance in older women [1]. Based on evidence that the presence of a partner can offer social support and help improve health behaviour [2,3], we hypothesized that co-performing balance tasks with a spouse/friend would reduce the effect an evaluator has on an individual's perceived social anxiety and changes in balance control. METHODS: 21 older women (mean±SD age=66.5±5.17 years) participated in this study. Participants performed seven balance tasks while standing on a forceplate (Bertec, USA): standing with feet together on firm or foam surfaces with eyes open (EO) or eyes closed (EC) for 60s, reaching forward with outstretched arms, standing with feet in tandem with EO for 30s, one leg stance with EO for 20s; and 2 tandem walking tasks: 8 steps heel-to-toe with EO and EC (Swaystar, CH). All tasks were performed under three conditions: (a) Alone (no evaluator present); (b) Evaluator (male evaluator present); (c) Partner (evaluator + performing tasks in parallel with partner). Participants were split into two groups post-hoc: Affected (n=10) and Unaffected (n=11), based on their emotional response to the presence of the evaluator (increased self-reported anxiety and fear). All measures were analyzed using a 2 (group)×3 (condition) mixed design analysis of variance ($p \le 0.05$). **RESULTS:** Interaction effects were observed for root mean square (RMS) of centre of pressure displacement in anterior-posterior (p=0.045) and medial-lateral (p=0.055, trend) directions during one leg stance, with significantly increased RMS in the Affected group during the Evaluator vs. Alone condition, but not in the Partner condition. A significant interaction for duration during tandem walking with EO (p=0.007) revealed a significantly longer duration for the Affected group during the Evaluator vs. Alone condition, but not in the Partner condition. In contrast, the Unaffected group had a shorter duration in the Evaluator vs. Alone condition. A main effect of condition was found for pitch trunk angular velocity during tandem walking EC (p=0.012), with both groups increasing velocity in the Evaluator vs. Alone condition, but not during the Partner condition (Fig 1). CONCLUSION: Social anxiety influenced balance and gait performance of older women, particularly in those most affected by the evaluator. However, co-performing with a partner reduced the effects of social anxiety and the balance and gait changes observed compared to when subjects were evaluated alone. These results suggest social support may help to mitigate some of the potential white coat effects experienced during clinical balance assessments, particularly for anxious individuals. FUNDING SOURCE: Funding received from the Sao Paulo Research Foundation (FAPESP #2014/16503-4) and NSERC. REFERENCES:[1] Geh et al J Psychosom Res 2011 [2] Gellert et al Eur J Ageing 2011 [3] Ranby & Aiken Br J Health Psychol 2016

P1-G-48 Lateropulsion is common after right hemisphere stroke, strongly related to spatial neglect, and the primary cause of mobility limitation

Dominic Pérennou¹, Shenhao Dai², Emmauelle Clarac², Andréa Kistner², Patrice Davoine², Anne Chripin², Marie Jaeger², Olivier Detante², Marc Hommel², Monica Baciu², Céline Piscicelli¹





INTERNATIONAL SOCIETY OF POSTURE & GAIT RESEARCH

¹University Hospital Grenoble-Alpes, ²Grenoble Alpes University Hospital

BACKGROUND AND AIM: After a hemisphere stroke, contralesional lateropulsion has been empirically described as part of pusher syndrome (PS), which is caused by a wrong internal model of verticality. Here we investigated the existence of lateropulsion and its association with other deficits, and analyzed its role in balance and gait disorders. METHODS: Cohort study of consecutive participants admitted to neurorehabilitation ward after first hemisphere stroke from 2012 to 2018. Retrospective analysis of data collected at around one month post-stroke. Lateropulsion was assessed with the Scale for Contraversive Pushing (SCP), then classified into 3 classes: upright, lateropulsion without pushing and lateropulsion with pushing. Other deficits assessed were: spatial neglect, aphasia, apraxia, motor weakness, spasticity, sensory loss, hemianopia, and depression. Balance and gait disorders were assessed with the Postural Assessment Scale for Stroke (PASS), and modified Fugl-Meyer Assessment (mFMA). Factors associated with lateropulsion severity, balance and gait disorders were statistically evaluated with uni- and multivariate analyses. RESULTS: 220 persons met inclusion criteria. Lateropulsion prevalence was 28% (15% without and 14% with additional pushing), predominant in right hemisphere stroke (RHS, 48%) and influenced by the gradient of laterality. Ninety-eight % individuals after RHS who showed lateropulsion were right-handers. Spatial neglect was the strongest factor independently associated with lateropulsion severity. All individuals showing lateropulsion had spatial neglect, regardless the existence of PS. Lateropulsion was the primary deficit explaining balance and gait disorders, particularly after RHS determining 90% of balance and 66% gait disabilities. CONCLUSIONS: The strong association with spatial neglect and the exclusive presence of lateropulsion in right-handers indicated that lateropulsion has to do with a high order cognitive process related to spatial cognition, highly lateralized in the brain. This contradicts the initial and long lasting interpretation of lateropulsion in terms of elementary sensory-motor deficits. From a heuristic point of view, this study shows that, at the subacute phase after stroke, the impaired body orientation is the primary cause of balance disorders, much over impaired body stabilization. This should guide future rehabilitation programs dedicated to poststroke postural disorders.

P1-G-49 Using virtual reality to safely increase mobility-related anxiety when turning in simulated environments

Tiphanie Raffegeau¹, Mindie Clark¹, Bradley Fawver¹, William Young², Mark Williams¹, Keith Lohse¹, Peter Fino¹

¹University of Utah, ²Brunel University

BACKGROUND AND AIM: The fear of falling profoundly impacts postural control and walking behavior. However, mobility-related anxiety is often investigated in laboratory settings using simple postural tasks (e.g., standing or straight walking) to safely manipulate threat. As a result,





existing approaches offer limited understanding of the effects of anxiety during more complex locomotor tasks typical of daily life (e.g., turning). The purpose of this pilot study was to determine the effectiveness of using virtual reality (VR) to induce mobility-related anxiety during turning. **METHODS:** Six healthy participants (25.5 years) wore a head-mounted display (Sony HTC Vive) presenting a 0.40 x 2.2 m virtual path in two types of immersive environments: simulated at ground level (low elevation), and at 15 m above ground to induce anxiety (high elevation). A real-world path aligned with the VR path dimensions but with a 3.6 cm high platform. Participants walked to the end of the path and turned around 180° at a self-selected speed and at their 'fastest comfortable pace' in both VR environments. Inertial sensors were placed on the lumbar spine and both feet to measure peak turning velocities. Between blocks of five trials, participants completed the Mental Readiness Form 3 (MRF-3) to evaluate cognitive and somatic components of anxiety and confidence (1-11 Likert-scales) while turning. Participants also reported the level of mental effort required to walk in each condition using the Rating Scale of Mental Effort (RSME). General linear models were used to compare standardized effect sizes (ES), mean differences (mDiff), and 95% confidence intervals (CI) for self-report and kinematic measures as a function of VR height and walking speed. RESULTS: Participants reported greater cognitive (ES=0.59, mDiff=0.8, CI=-1.6, 3.2) and somatic anxiety (ES=0.64, mDiff=1.6, CI=-2.4, 5.6), reduced confidence (ES=0.66, mDiff=1.0, CI=-0.8, 2.8), and greater levels of mental effort (ES=0.82, mDiff=10.6, CI=-8.3, 29.5) when turning at high elevation compared to low elevation. Participants successfully increased speed to complete turns during the faster pace condition, evidenced by a large effect for peak turning velocity (ES=3.10, mDiff=80.38, CI=35.79, 101.35). Walkway height showed a moderate effect on peak turning velocity (ES=0.58, mDiff=13.70, CI=-6.34, 31.11), confirming that participants turned at a slower speed when an environmental threat was present. However, the effect of height at preferred speed (ES=0.63, mDiff=18.42, CI=-1.01, 37.85) was larger than at faster speeds (ES=0.34, mDiff= 8.97, CI=-9.01, 26.95). CONCLUSION: The elevated VR pathway induced anxiety in the sample, evidenced by higher ratings of worry, tension, and mental effort, and the effect of mobility-related anxiety was associated with changes in turning behavior. This approach shows promise for investigating anxiety-induced changes to perceptual, cognitive, and motor performance in future studies.

P1-G-50 Does postural threat influence the StartReact effect in a lateral stepping task?

Vivian Weerdesteyn¹, Milou Coppens², Tim Inglis³, Mark Carpenter³

¹Donders Institute, Radboud University Medical Centre, ²Radboud University Medical Center, ³University of British Columbia

BACKGROUND AND AIM: The StartReact (SR) effect is the accelerated release of a prepared movement when a startling acoustic stimulus is presented at the time of the imperative stimulus (IS). SR paradigms have been used to study defective control of balance and gait in people with neurological conditions, but differences in emotional state (e.g. fear of falling) may be a potential





confound when comparing between patients and healthy subjects. In this study, we aimed to gain insight in the effects of emotional state on the SR effect by manipulating postural threat (by elevating surface height to 3.2m) during a lateral step task and a wrist extension task. **METHODS**: Eleven young healthy participants performed a lateral step perpendicular to the edge of a platform, and 17 participants performed a wrist extension task while standing at the surface edge. Participants had to initiate the movement as fast as possible in response to an IS that varied in intensity across trials (80dB, and 8 intensities from 103 to 121dB) in low and high surface height blocks. We determined APA and step onset latencies from center of pressure data for the lateral step task, and EMG onset latencies from extensor carpi radialis recordings for the wrist extension task. We first verified the presence of the SR effect by comparing onset latencies between 80 and 121dB stimuli. We then tested whether the SR effect occurred at different IS intensities between surface heights. We used simple planned contrasts (separately for each height) to identify up to which IS intensity the onset latencies significantly differed from those to 121dB stimuli. If this occurred at different intensities between the low and high surface heights, post-hoc tests were used to test for height effects at those IS intensities. RESULTS: For both tasks, onset latencies were significantly accelerated at 121dB compared to 80dB (p<0.001), regardless of height. In the lateral step task, the SR effect occurred from 112dB onwards on the low height, but from 115 dB onwards (p<0.025) on high height. Post-hoc testing confirmed delayed APA and step onset latencies when standing on the high compared to the low surface height at 112dB (p=0.022). In the wrist extension task, no differential effects of height could be demonstrated across IS intensities. CONCLUSIONS: Postural threat had a significant, yet modest effect on the occurrence of the StartReact effect, with a mere 3 dB difference between standing on the high versus the low surface height. Interestingly, this effect of height was specific to the postural (i.e. lateral stepping) task, as no such differences could be demonstrated in the wrist extension task. This presumably reflects more cautious execution of the lateral step task when standing on height. The present findings show that applying stimuli of sufficiently high intensity (iY115dB) appears to neutralize potential differences in emotional state when studying SR effects.

P1-G-51 Dual task gait interference in Parkinson's disease: the impact of baseline cognitive capacity

Rosie Morris¹, Ellen Lirani-Silva², Rachael Lawson³, Alison Yarnall³, Brook Galna³, Sue Lord⁴, Lynn Rochester⁵

¹Oregon Health & Science University, ²São Paulo State University (UNESP), ³Newcastle University, ⁴Auckland University of Technology, ⁵Institute of Neuroscience, Newcastle University

BACKGROUND AND AIM Gait and cognitive deficits are common in Parkinson's disease (PD) and are strongly interrelated. Their interrelationship is commonly assessed through dual task (DT) paradigms, where concurrent cognitive tasks are carried out while walking to expose DT interference (DTI). DTI may be disproportionately affected in PD, but ultimately increases falls risk.





Understanding the nature of DTI is important to accurately measure and effectively address it. Importantly for PD, there is reduced cognitive capacity, resource allocation and difficulties with task prioritization, all of which may independently explain DTI. Controlling for baseline cognitive performance suggests that DTI is related more to cognitive capacity than the ability to switch attention between tasks. However, no comparisons between normalized and fixed protocols have been carried out to understand the deficit underlying DTI in PD. We aimed to examine DTI under two different conditions: normalized to individual capacity and fixed across all participants in idiopathic PD and older adults (OA). We hypothesized greater detrimental effects on gait in PD under the fixed paradigm compared to a normalized paradigm; furthermore, this would be exacerbated compared to OA. Methods Forty-two OA and 36 people with idiopathic PD were recruited from the ICICLE-GAIT study. Gait was assessed during three, two-minute continuous walks at a comfortable pace under three different conditions 1) single task (ST) gait, 2) DT under a titrated paradigm (forward digit span normalized to individual capacity), and 3) DT under a fixed paradigm (serial seven subtraction). Sixteen gait characteristics were measured representing five domains (pace, rhythm, variability, asymmetry and postural control) using a pressure sensor walkway (GaitRite?). DTI (DT -ST performance) was compared under the different conditions controlling for age and gender. Results Participants were matched for age, gender and global cognition. Under DT conditions there were significant group*task interactions for pace (step velocity (p=.017) and step length (p=.012)), rhythm (stance time p=.042) and postural control (step length asymmetry (p=.038)). For step velocity and stance time both groups demonstrated greater DTI under the fixed paradigm compared to the titrated, but this was to a greater extent in PD (step velocity: OA p=.042; PD p=<.01; stance time OA p=.012; PD p <.01). Only the PD group showed significantly greater DTI under the fixed compared to titrated paradigm for step length (p<.01) and step length asymmetry (p<.01). Conclusions The fixed DT paradigm led to significantly greater DTI in PD, rather than OA, compared to normalizing to individual capacity. These findings suggest that paradigms requiring greater cognitive ability produce greater DTI in PD. Therefore, selection of DT paradigm is critical in order to design optimal testing protocols and target the underlying nature of DTI in PD.

P1-G-52 The multiscale dynamics of resting-state brain activity is associated with the performance of dual task standing postural control in older adults

Junhong Zhou¹, Laura Dubreuil Vall², Brad Manor¹, Giulio Ruffini²

¹Harvard Medical School, ²Neuroelectrics

BACKGROUND: The physiologic control system that regulates standing posture depends upon numerous interconnected brain regions that interact with one another over multiple temporal scales. Considerable research indicates that the dynamics of a given physiologic system during basal or "free-running" conditions are "complex;" that is, they contain meaningful information over multiple scales of time and space. Importantly, such complexity in free-running system output is





believed to give rise to the capacity of that system to adapt to stressors. Here, we tested the hypothesis that the algorithmic complexity of brain electrical activity, as measured by electroencephalogram (EEG) during quiet sitting and estimated using LZW compression, would predict the ability of older adults to maintain standing posture when the control system was stressed by concurrent performance of an unrelated cognitive task. METHODS: Thirty-eight older adults (aged 74±7 years; 25 women) without overt illness or disease completed this study. A 32channel EEG system (Enobio?, Neuroelectrics Co.) was used to record the brain electrical activity during six minutes of sitting quietly with eyes open. Participants then completed a postural control assessment consisting of three 60-second standing trials of standing in two separate conditions: standing quietly with eyes open (i.e., single task) and standing with eyes open while performing verbalized serial subtraction of three from a random 3-digit number (i.e., dual task). Standing postural "sway" was recorded by a wearable sensor system (Mobility Lab, APDM Inc) and both average sway speed and area in each condition were computed. Spectrograms frames from twenty-second EEG time-series windows of each channel were computed to create a spectrogram stack of frames. The stacks where then flattened and binarized using the median of the data, and the Lempel-Ziv-Welch (LZW) compression technique was used to quantify the complexity of EEG time-series globally (i.e., across all the channels), with greater values indicating less compressibility and therefore, greater complexity. RESULTS: The averaged dual task cost (i.e., the percent change from single task to dual task condition) of sway speed was 38±61% and the cost to sway area was 97±87%. Older adults with greater complexity of resting-state global brain activity exhibited smaller dual task costs of sway speed (r2 =0.23, p=0.03). Similarly, those with greater complexity of resting-state global brain activity exhibited less sway area specifically within the dual task condition (r2=0.46, p=0.01). This relationship was independent of participant age. No association was observed between the complexity and the sway metrics in single task condition. CONCLUSION: In older adults, the dynamics of resting-state global brain activity, as measured by the LZW metric of complexity from EEG spectrograms obtained during quiet sitting correlates with the ability to maintain standing postural control specifically when engaged in a cognitive dual task stressor. Future studies are thus warranted to examine the relationship between LZW and other metrics of complexity, as well as to determine the sensitivity of such metrics to cognitive-motor decline and falls in aging and disease.

H - Coordination of posture and gait

P1-H-53 Combined diabetes and arthritis are associated with declined gait speed

Bader Alqahtani¹, Aqeel Alenazi¹, Mohammed Alshehri²

¹Prince Sattam Bin Abdualziz University, ²Jazan University

BACKGROUND: Gait speed is considered a sixth vital sign. Decreased gait speed has been linked to poor health outcomes and mortality Evidence has shown that gait speed decline is associated



with diabetes and arthritis, independently. However, combined comorbidities (diabetes and arthritis) may negatively affect gait speed, but there is a lack of evidence to understand this association. Therefore, the aim was to investigate the association between combined diabetes and arthritis on gait speed compared to diabetes only, arthritis only or neither. METHODS: A cross sectional analysis was performed for Midlife in the United States-2 (MIDUS 2): Biomarker Project, 2004-2009, a multisite longitudinal study, for 1227 individuals aged between 34-84 years (mean age 54.52[11.71). Participants were grouped into four categories; combined arthritis and diabetes, arthritis only, diabetes only or neither. Walking speed was measured using the average gait speed of two 50 foot walk tests. Diabetes and arthritis were assessed via self-reported questionnaire. Covariates included age, gender, BMI and depression symptoms using Center for Epidemiologic Studies Depression Scale. ANOVA and multiple linear regression analysis were performed at 0.05 alpha level. RESULTS: A total of 77 participants had combined arthritis and diabetes, 435 participants had Arthritis only, 70 participants had diabetes only, and 645 had neither arthritis nor diabetes. A total of 690 (56.2%) participants were females. Mean gait speed for combined arthritis and diabetes was 0.90 m/s, for arthritis only was 0.98 m/s, for diabetes only was 0.99, and for neither arthritis nor diabetes was 1.10 m/s. ANOVA results showed that there were statistically significant differences between gait speed in all groups when compared to neither arthritis nor diabetes group, p<0.001. There was no significant difference in gait speed between arthritis only group and diabetes only group, p= 0.96. When compared diabetes only group to combined arthritis and diabetes group, there was no significant difference in gait speed, p=0.051. When compare arthritis only group to combined arthritis and diabetes group, there was a significant difference in gait speed, p=0.018. Results from linear regression analyses showed that after controlling the covariates, combined arthritis and diabetes was significantly associated with decreased gait speed (B= -0.125, 95% Confidence Interval (CI) [-.178 to -0.73], p<.001). Arthritis only was significantly associated with decreased gait speed (B= -0.078, 95% CI [-.11 to -0.051], p<.001). Finally, diabetes only was significantly associated with decreased gait speed (B= -0.064, 95% CI [-.11 to -0.012], p=.016) CONCLUSION: This study found that combined arthritis and diabetes were associated with slow gait speed. The decline in gait speed was -0.125 m/s, and this is exceeded the clinically meaningful difference, which is -0.10 m/s. The limitation of this study includes self-reported diabetes and arthritis that may underestimate those burdens. Although there are different mechanisms for each type of arthritis, this was not specified in this study. Future research may investigate the complex relationship between these factors on gait speed to understand the underlining mechanisms.

P1-H-54 Healthy young adults use vision for postural control similarly at low and high virtual heights

Eric Anson¹, Nicole Kuznetsov¹, Raul Rodriguez¹, Kyle Critelli¹, Benjamin Crane¹

¹University of Rochester





BACKGROUND AND AIM: Many studies demonstrate changes in postural control when standing at a height compared to ground level. Specifically, an increase in stiffness corresponds to reduction in sway and increased physiological arousal. Recent studies also reported increased vestibular and ocular reflexive responses when standing at heights. Despite increased ocular reflexes at heights, it is unclear whether optic flow is used differently for postural control when standing at heights. This question has relevance to rehabilitation given the proliferation of virtual reality applications for balance rehabilitation, including high height scenarios to address balance related anxiety. METHODS: Seven healthy young adults (mean age 26.3 (5.8) years, range 19-35) consented to participate in a virtual reality balance experiment and completed a visual height intolerance questionnaire. Subjects completed 3 standing trials lasting 8 minutes for both low and high virtual height conditions. The virtual environment was a warehouse with an elevating catwalk (Vizard, Inc) and presented by using an HTC Vive head mounted display. During minutes 3-5, the virtual environment oscillated in pitch about an axis through the ankles at 0.6 degrees at 0.2 Hz. Body sway velocity and electromyography (EMG) was measured using 9 degree of freedom IMUs (Delsys, Inc) at the lower back, tibialis anterior (TA) and medial gastroc (MG). A co-contraction index was calculated using root mean square TA and MG EMG in 30 second bins during the visual motion. Gain and phase were calculated from visual scene velocity and pitch body sway velocity. Mixed models were used to determine whether postural gain to vision or CCI differed across virtual heights. RESULTS: In the mixed models accounting for within subject variability across trials, there was no significant effect of virtual height condition on the magnitude of postural sway in response to the visual scene motion (z = 0.0, p = 0.997). A significant repetition effect indicated that sway gain to vision decreased with repeated exposure (z = -2.57, p = 0.01). Sway gain to vision did not differ based on reported visual height sensitivity (n = 2, z = 0.67, p = 0.501). EMG CCI did not differ across conditions for any time bin (p's > 0.05); however, males had significantly lower CCI compared to females for each of the last 4 optic flow time bins (p's < 0.01). **CONCLUSIONS:** In healthy young adults, despite some inter-individual differences, visually induced postural sway and muscle activity patterns were the same regardless of virtual height. These preliminary data suggest that balance responses to optic flow when presented at a virtual height will not be more intense than when presented at a low virtual height. Future work is needed to determine whether older fallers or individuals with balance disorders follow a similar pattern.

P1-H-55 Body sway is mediated by vestibular cortical dominance

Adolfo Bronstein¹, Patricia Castro¹, Diego Kaski², Hussein Al-Fazly¹, Deniz Ak¹, Liam Oktay¹, Qadeer Arshad¹

¹Imperial College London, ²University College London

BACKGROUND AND AIM: The involvement of the posterior parietal cortex in vestibulo-cortical processing has been observed in the literature, and functionally, is connected with maintaining spatial orientation and postural control. Recent imaging data suggests a right-hemispheric





dominance for vestibular processing, but to-date the influence of this hemispheric dominance on postural control remains unknown. METHODS: 24 right-handed healthy individuals underwent either cathodal or anodal transcranial Direct Current Stimulation (tDCS) for 15min over the left Posterior Parietal Cortex (PPC). Vestibulo-cortical hemispheric dominance was quantified using the, "nystagmus suppression index" calculated as the change (i.e. before/after tDCS) in the peak Slow Phase Velocity in response to cold-water caloric irrigations. A larger nystagmus suppression implies a higher right vestibulo-cortical dominance. To assess postural control, subjects performed a postural task before and after tDCS which required them to maintain balance whilst they stood on a moving platform and were exposed to left-right perturbation. Objective and subjective measures of instability were recorded. RESULTS: Increased right vestibulo-cortical dominance (i.e. larger nystagmus suppression) was negatively correlated with the sway path and sway velocity change (r:-0.7, p<0.05 and r:-0.65 p<0.05 respectively) only in the cathodal group. No relationship between the degree of hemispheric dominance and postural performance was observed following anodal stimulation. No relationship was observed with the subjective measures of instability on any of the stimulation conditions. Conclusions The degree of right hemispheric vestibulo-cortical dominance influences postural control. That is, greater right hemispheric dominance is associated with increasingly stable postural control presumably attributable to preferential sensory weighting upon vestibular cues.

P1-H-56 Postural balance at children survived after posterior fossa tumor

Dmitry Skvortsov¹, Anna Dreneva², Vladimir Kasatkin³, Alexander Karelin³

¹Pirogov's Medical University of Moscow, ²Rehabilitation center "Russcoe Pole", ³Dmitry Rogachev National Research Center of Pediatric Hematology, Oncology and Immunology

Tumors arising in the brain's posterior fossa are the most common type of pediatric brain tumors. methods of treatment, such as surgical rejection, radiotherapy and chemotherapy, have provided substantial increase in patients' survival rates. Nevertheless, the disease itself as well as late effects of therapy can impair motor functions and specifically postural balance. The most frequently observed deficits include motor skills decrease due to the cerebellum pathology involvement. The aim of the trial was to evaluate the state of postural balance in posterior fossa tumor (PFT) survivors comparatively to healthy controls, as well as its changes before and after training sessions. We used Stabilan-01-2® stabilometric platform device (Russia) for postural assessment. The sampling frequency of the platform was 25 Hz. The participants were instructed to stand straight with heels together and toes apart (Europe standard position). The participants completed the Romberg test with eyes open and eyes closed during 20 sec each probe. After the first assessment, they were divided into two groups equal by sex, age and diagnosis. Then one of the group performed conventional therapy and 2-week training consisted of 6 sessions using devices for postural balance, gross motor functions and visual-motor integration enhancement. The other group got only the conventional therapy. After two weeks, the Romberg test was carried





out in all participants once again, and then two groups were changed over: the second one received intervention, and the first one did not. The assessment of postural functions was conducted once again. The following groups participated in the trial: 30 PFT survivors (20 females, 10 males, mean age was 10.83 ± 3.34) and 25 healthy controls (14 females, 11 males; mean age was 12.6 \pm 2.1. The patients had the following diagnoses: medulloblastoma (n = 17), pilocytic astrocytoma (n = 8), ganglioglioma (n = 2), malignant neoplasm of cerebellum (n = 2) and anaplastic ependymoma (n = 1) (Diagnosis code C71.6). The mean period of remission was 42 months. The findings have revealed the decreased postural balance in PFT survivors comparatively to healthy controls: in the condition with open eyes most observed parameters ('ellipse area', 'mean velocity of center of pressure', 'mean root square oscillations in frontal and sagittal plane') are worse in the group of patients. Comparison of training and control weeks have shown significant changes of the parameter '60% Spectral Power in Frontal plane' in intervention condition. The results reveal the impairments of balance control, such as increased amplitude and velocity of pressure center oscillations, in patients who survived posterior fossa tumors. After intervention, postural function insignificantly changes comparatively to the baseline, hence visual system tends more to interfere rather than to assist in maintaining postural stability.

P1-H-57 Full body responses in visually perturbed quiet stance

David Engel¹, Adrian Schütz¹, Frank Bremmer¹

¹Philipps-Universität Marburg

BACKGROUND AND AIM: To maintain balance, humans heavily rely on vision. When subjects perceive their body as moving, they trigger counter movements, resulting in body sway. This sway is typically investigated by monitoring the body's center of pressure (COP). Here, we induced body sway by visually simulated self-motion in virtual reality (VR) and complemented COPmeasurements by full body tracking. Our aims were (i) to find whether there are ambiguities regarding postural configurations when only the COP is tracked and (ii) to develop an analysis which allows for identification of subjects according to their postural characteristics, using a highdimensional body-sway related parameter space. METHODS: We induced sinusoidal perturbations of a virtual environment (3D-cloud of random dots) and measured the trajectory of the subjects' COP and 25 joint positions in 3D-space over time. Visual stimuli were presented through a head mounted display (Oculus Rift DK2). Subjects stood on a force plate (AMTI Accusway) to track their COP. Body tracking was performed using a 3D-video system (Microsoft Kinect v2). Data of each participant were collected in several sessions over the course of several days. We transformed the allocentric coordinates of subjects' body joints into body-centered joint angles, spanning a 14-dimensional parameter space. Using these parameters, we aimed to distinguish between subjects when their COP was at a similar position, using hierarchical clustering. To quantify the separation of the postural data according to the resulting clusters, we introduced a COP-resolved Subject Separability Index (SSI). RESULTS: The clusters revealed a



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high degree of separability between individual subject data. This suggests that subjects were distinguishable by their posture, even when their COP remained in a similar area. Calculation of SSI confirmed separability of subjects for most of the COP coordinates. Moreover, this separability between subjects remained stable over several days. CONCLUSIONS: Our findings suggest sole COP tracking to be insufficient for adequate body sway analysis, as similar COP positions might be achieved through various body configurations. Even during guiet stance, humans seem to achieve positioning of their COP through different strategies, varying across subjects. These strategies might be unique to the subject and stable over time. Overall, this stability appears to allow for reliable classifications according to postural characteristics. ACKNOWLEDGEMENTS AND FUNDING: Deutsche Forschungsgemeinschaft: IRTG-1901; EU: PLATYPUS

P1-H-58 Balance mechanisms differ across cadences on a self-paced treadmill

Tyler Fettrow¹, David Grenet¹, Hendrik Reimann¹, Ian Sotnek¹, Elizabeth Kaye¹, Maelyn Arcodia¹, John Jeka¹

¹University of Delaware

BACKGROUND: In previous work, we identified three basic mechanisms that are used to respond to a perceived fall to the side; the lateral ankle mechanism, the foot placement mechanism, and the pushoff mechanism. The lateral ankle mechanism is an active modulation of the ankle inversion/eversion angle that shifts the center of pressure (CoP) in the direction of the perceived fall. The foot placement mechanism is an active modulation of the swing foot in the direction of the perceived fall. The pushoff mechanism is an active modulation of the ankle plantarflexion/dorsiflexion angle that modulates the pushoff force depending on the direction of the perceived fall. Here we quantify the balance response in healthy young adults (18-35 years) while walking at different cadences, and consequently different walking speeds. METHODS: Subjects (16F 5M; 23.65±4.43yrs; 64.23±14.97kg; 1.68±0.11m) walked on a self-paced, instrumented treadmill surrounded by a virtual environment matched to the speed of the treadmill and the position of the subject. Subjects were asked to step to a metronome, either 80bpm (SLOW) or 110bpm (FAST), alternating every two minutes. A balance perturbation, initiated every 12-15 heel-strikes, consisted of 1mA galvanic vestibular stimulation over 1000ms. Bilateral electromyography, ground reaction forces, and kinematics allow for quantifying the balance mechanisms in response to the balance perturbations. We calculate balance response variables with respect to control steps or non-perturbed steps (Δ). Positive values indicate a shift in the direction of the perceived fall. **RESULTS:** At the end of the second double stance following the onset of the balance perturbation the Δ CoM position was -0.027 m for SLOW and -0.0026 m for FAST and the ∆ CoM velocity was -0.047 m/s for SLOW and -0.030 m/s for FAST. Subjects used the lateral ankle mechanism more in SLOW, 0.004 m s, than in FAST, 0.001 m s. Subjects used more foot placement in FAST, 0.02 m, than in SLOW, -0.007 m. Subjects did not alter the use of the pushoff mechanism between cadences. DISCUSSION: The major findings are 1) lateral ankle

mechanism is used substantially more in the SLOW condition, 2) the foot placement mechanism is used substantially more in the FAST condition, and 3) the pushoff mechanism does not differ across conditions. The role of walking speed or cadence in balance is contentious. We do not attempt to address the issue of whether one condition is more stable than another, but merely observe how the control of the available biomechanics associated with balance changes across conditions. This data may provide some insight into why certain populations tend towards slower walking speeds in the case of older adults, or higher cadences in the case of people with Parkinson's.

P1-H-59 The ability to switch from a trail limb avoidance to a lead limb accommodation strategy

Félix Fiset¹, Bradford McFadyen¹

¹Université Laval

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BACKGROUND AND AIM: The leading limb during obstacle avoidance (OA) is mostly guided by vision whereas the trailing limb depends of visuomotor memory and proprioception. We recently showed that the leading limb knee strategy for OA can be switched to a leading hip flexor strategy for a level change during the planning phase, but not when beginning execution. Given the bilateral difference in OA control, the present study focused on the ability to switch from trailing limb OA to leading limb level change accommodation during both latter planning and early execution. METHODS: Ten healthy, young adults (24.2 ± 3.1 years; 5 males) were immersed in a virtual environment (VE) within a head mounted display (Oculus Rift V1) recreating the laboratory. Participants were told to walk towards and step over an obstacle that could randomly change to a platform (PI) positioned 71 cm further ahead. Trials were presented in two counterbalanced blocks related respectively to the possibility of an early environmental perturbation at trail foot contact (latter planning) and a later change at trail foot toe-off (start of execution). The final VE always corresponded to the real environment. Trailing limb kinematics (Vicon) were used to calculate minimal obstacle foot clearance (MFC) and maximal relative joint angle (MRJA) and synchronized to force plate data to estimate net muscle work related to ankle push-off, and knee flexor generation, hip flexor generation and hip hiking around toe-off and into the swing phase. Repeated measures ANOVAs were used to compare across conditions. RESULTS: Ankle pushoff remained unchanged across conditions (p=0.755). Knee flexion generation and trail MFC were decreased when the obstacle switched to a PI early (both p<0.001), but not late (both p=1.000). Hip flexor generation was adapted in an early perturbation (p<0.001) and not for a late one (p=0.408). However, a delayed hip flexor generation increased hip flexion during mid-swing (p=0.037). The hip hiking power burst only increased for a late perturbation (p<0.001), but was not changed for an early one (p=519). MRJA at the ankle only increased during late perturbation (p<0.001) while MRJA at the knee only increased for an early perturbation and hip MRJA increased for both PI changes (p<0.001 for both). CONCLUSION: The trailing limb OA strategy

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appears to be adjustable in the latter planning phase, but not at the beginning of execution. Despite the differences in the control of the leading and trailing limbs for OA, this concurs with previously work for leading limb perturbations and suggests that regardless of the sensory mode of control, the chosen strategy at initial execution cannot be immediately switched. However, the trailing limb tended to optimize an already delayed hip flexor generation used for OA to assure limb advancement and final foot placement. **ACKNOWLEDGEMENTS AND FUNDING:** We thank N. Robitaille, F. Dumont, G. St-Vincent and S. Forest for valuable technical assistance and NSERC for funding.

P1-H-60 Specificity of trunk postural responses to three-dimensional surface stimuli

Adam Goodworth¹, Cody Barrett², Jonathan Rylander², Brian Garner²

¹University of Hartford, ²Baylor University

BACKGROUND AND AIM: Perturbation testing and training is becoming more popular. Perturbations are often delivered in a single plane of motion (e.g., backward surface translation or lateral push). But complex stimuli across multiple planes more accurately simulate daily life and are used in some therapies such as hippotherapy. In this study, we quantified the specificity of trunk postural responses to three-dimensional (3D) surface stimuli across stimulus frequency and direction. If postural responses are highly specific to 3D stimuli, then researchers and clinicians can select complex motion profiles to trigger desired postural responses at specific frequencies and directions. However, there is the possibility for sizable interactions across frequency and planes of motion (e.g., stimuli in the transverse plane may produce responses in all three planes of motion). Interactions could occur because trunk muscles cross many spinal joints and are oriented across different planes of motion, such that a single muscle may be used to simultaneously respond across all three planes of motion. Also, non-linear neural processes may degrade frequency-specific responses to stimuli. METHODS: We tested nine healthy individuals on a mechanical horse-riding simulator that moved in a complex 3D pattern. We measured trunk and head kinematics in the frontal, sagittal, and transverse planes. To quantify specificity, kinematics were related to the stimuli in the time domain (RMS and angle-angle diagrams) and frequency domain (amplitude spectra). In the frequency domain, we calculated the ratio of trunk amplitude to simulator amplitude across the two frequencies with the largest simulator motion in each plane. When this ratio was calculated within the same plane, it was termed the "main response" and is equivalent to the average gain between the two frequencies. When this ratio was calculated between planes, it is termed the "interaction response". RESULTS: When horse simulator and postural responses were decomposed into planes of motion, there was high specificity to the stimuli. Trunk angle-angle diagrams were nearly symmetrical. Amplitude spectra showed that the simulator moved at distinct frequencies in each plane of motion. Main responses in the sagittal, frontal, and transverse plane were similar at 1.26, 1.28, and 1.36, respectively. Trunk responses in the sagittal plane relative to simulator tilts in the sagittal plane (main response)

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were approximately 6.5 times larger than interaction responses. Similarly, the main response in the frontal plane was about 9.8 times larger than interaction responses. **CONCLUSIONS:** Results suggest high specificity between complex 3D stimuli and postural responses in healthy adults. This specificity may be used to elicit specific movement patterns in research or clinical settings, such as hippotherapy or simulated hippotherapy. Moreover, this specificity approach can be considered as an evaluation metric, where significant interaction across planes may indicate abnormal neural control which could be tracked over time with perturbation training. **ACKNOWLEDGEMENTS AND FUNDING:** NIH R03 DC013858

P1-H-61 The effects of intensive balance training in individuals with chronic spinal cord injury on quiet standing centre of pressure measures

Olinda Habib Perez¹, Janelle Unger², Katherine Chan¹, Jae Lee², Kei Masani², Kristin Musselman²

¹Toronto Rehabilitation Institute, ²University of Toronto

BACKGROUND AND AIM: Incomplete spinal cord injury (iSCI) compromises the neurologic pathways that influence balance control and coordination, resulting in balance instability and an increased risk for falls. Balance training after iSCI has focused on task-specific, goal-oriented, or locomotor training. Perturbation-based balance training (PBT), which has shown effectiveness in improving balance and preventing falls in other populations, is currently being studied in individuals with iSCI. The aim of the current study was to investigate the effects of two intensive balance training protocol on quiet standing centre of pressure measures in individuals with chronic iSCI. METHODS: As part of a larger study, individuals with iSCI were randomly assigned to conventional intensive balance training (CIBT) or PBT. Both training programs involved taskspecific, goal-oriented practice of challenging balance tasks while standing and walking. PBT also included external perturbations (i.e. pushes and pulls) elicited by a trainer. Each training protocol lasted 8 weeks, with three 1-hour sessions/week. Standing balance measures were collected from participants at three time points: baseline, mid-training (Week 4 (W4)) and post-training (Week 8 (W8)). Participants stood for 60 seconds in a standardized position with each foot on adjacent force plates in eyes open and eyes closed conditions. Net centre of pressure root mean square (COP RMS), and the cross-correlation coefficient at zero phase (Rxy(0)) of the left and right foot COP (i.e. inter-limb synchronization) in the anteroposterior (AP) and mediolateral (ML) directions were calculated. Independent 2×2×3 ANOVAs (Group × Condition × Time) were conducted on AP and ML net COP RMS and Rxy(0). **RESULTS:** Data from 10 individuals (6 PBT/4 CIBT) with iSCI [3 M/7 F; mean age = $64.3 (\pm 14.4)$ years; mean time post injury = 4.6 (1 - 13.4) years] were included in the analysis. A significant Condition effect was found for AP COP RMS (F1,8= 11.9, p=0.009, partial η 2 =.60) with eyes closed producing greater postural sway than eyes open. No Time or Group effects were found for AP COP RMS. ML COP RMS did not show a Condition effect (p=0.060), in addition to Time or Group effects. A significant Time effect was found for AP Rxy(0) $(F2,16=6.86, p=0.007, partial \eta 2 = .46)$ and ML Rxy(0) $(F1.64,10.0=5.21, p=0.040, partial \eta 2 = .39)$

with post-hoc pairwise comparisons demonstrating an improvement in inter-limb synchronization from W4 to W8 (p=0.003) for only AP Rxy(0). No Group effects were found for AP or ML Rxy(0). **CONCLUSIONS:** Though no differences in standing balance were found between participants who completed PBT versus CIBT, individuals with chronic iSCI demonstrated improved inter-limb synchronization with balance training. Similar to other neurological populations, inter-limb synchrony shows greater sensitivity in detecting change over net measures of balance for people with iSCI. **ACKNOWLEDGEMENTS AND FUNDING:** The authors would like to thank the participants in the study and ONF-RHI and CIHR.

P1-H-62 Arm swing and gait symmetry affects gait stability and interlimb coordination

Allen Hill¹, Julie Nantel¹

¹University of Ottawa

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BACKGROUND AND AIM: Changes to arm swing and gait symmetry are symptomatic of several pathological gaits associated with reduced stability. The purpose of this study was to examine the relative contributions of arm swing and gait symmetry towards gait stability. We theorized that actively increasing arm swing would increase gait stability, while asymmetric walking would decrease gait stability. METHODS: Fifteen healthy, young adults (23.4 ± 2.8 yrs) walked on a splitbelt treadmill under symmetric (1.2 m/s) and split-belt walking (left/right, 5:4 speed ratio) with three different arm swings: held, normal, and active. Local dynamic stability of the trunk, step length and width average and standard deviation, and spatial and temporal step symmetry metrics were analyzed using a 2-way (Arms×Symmetry) repeated-measures ANOVA. The mean ensemble standard deviation of continuous relative phase between contralateral arm-leg pairs was analyzed using a 2-way ANOVA (normal and active swing). RESULTS: See Table 1 for a summary of the significant main effects. Arm swing asymmetry showed no effect of split-belt walking. Standard deviation of arm swing range of motion showed significant increases from held to normal, and normal to active swing conditions (p < .001), while swing asymmetry was decreased during the active swing compared to the held and normal swing conditions. Split-belt walking resulted in increased maximum Lyapunov exponents (MLE, p < .001), increased left and right step length variability (p < .01), and increased step width (p < .001). Additionally, left step length was significantly decreased during split-belt walking (p < .001), which resulted in increased spatial step asymmetry (p < .001), but did not affect temporal step asymmetry. Active arm swing resulted in increased step length (p < .01), increased right step length variability (p < .05), increased step width variability (p < .01), and decreased MLE (p < .01). Mean continuous relative phase variability was increased in active swing when compared to normal swing (p = .01), but unaffected by split-belt walking. CONCLUSIONS: While active arm swing decreased gait stability according to the spatiotemporal characteristics, local dynamic stability of the trunk increased in that condition. This suggest that these metrics may quantify different aspects of stability. Split-belt walking resulted in decreased stability in both local dynamic stability and spatiotemporal gait



characteristics. Additionally, arm swing symmetry was unaffected by gait asymmetry. These results suggest that deficits in gait stability in pathological gaits may be linked to increases in gait asymmetry rather than increases in arm swing asymmetry.

P1-H-63 Kinesiological study for normal walking gait on irregular surface

Kenta Igarashi¹, Koichi Koganezawa¹

¹Tohoku University

People sometimes suffer accidental falls while walking, of which the incidence rate grows when walking on irregular surfaces under a situation where walkers cannot obtain information on the terrain. Some studies have pointed out that humans dexterously control stiffness of articulations (joint stiffness, hereafter) in their lower extremity to cope with this type of situation. It is well known that joint stiffness is controlled by the strength of co-contraction of an agonist/antagonist muscle pair. It is noteworthy that it is prospectively adjusted in advance of the walker's foot stepping on the unobservable terrain. The research aims to thoroughly examine a normal person's strategy for walking on irregular surfaces, especially under unforeseeable conditions. Participating subjects walked on a flat path partly paved with irregular surface or that of no irregular surface. Kinematic data were collected at 100 Hz by the motion analysis system by using eleven cameras, and simultaneously electro-myography data were collected at 1000 Hz by surface electrodes. Participants walked under two visual conditions; one is that they cannot perceive the existence of irregular zones (Blind condition; BC), the other is that they can observe it (Normal condition; NC). On the BC, the irregular zone was covered by a cloth which is the same color as that of the normal path so that the participants do not find whether an irregular surface exists in the irregular zone or not. Experiments were firstly performed under BC and subsequently done under NC. The irregular surfaces or the flat surfaces were changed randomly without notifying the participants. The joint angle of the knee and ankle were calculated from the obtained kinematic data. Joint Stiffness Index (JSI) that quantitatively evaluates the strength of co-contraction of an antagonistic muscle pair of the knee and ankle joints were calculated form the obtained EMG data. Calculated joint angle data and JSI of knee and ankle joints during stance phase were analyzed. As for the maximum angle of flexion /extension of the knee joint, there was no significant difference between the the cases under all conditions. Regardless of the visual conditions, the maximum plantar flexion angle of the ankle joint on an irregular surface was lower than those of flat surface. However, in regard to dorsiflexion of ankle joint, there was no difference under any condition. Regardless of visual condition, the JSI of the ankle joint on an irregular surface showed a higher value than those of the flat surface. On the other hand, the JSI of the knee joint had no difference in all conditions. Under irregular conditions, it is suggested that the planter flexion of the ankle joint is suppressed by strengthening the co-contraction of the ankle joint. However, regardless of visual condition, co-contraction and joint angle of the knee and ankle joint had no significant difference. In conclusion, the joint stiffness of the ankle joint was raised more on an irregular





surface than a flat surface but there was no difference between normal condition and blind condition in terms of the joint stiffness both of ankle and knee joint.

P1-H-64 Effects of Dance for Parkinson's on gait and dual-ask gait in Parkinson's disease assessed using Vicon 3D-motion capture

Nadeesha Kalyani¹, Karen Sullivan¹, Gene Moyle¹, Sandy Brauer², Erica Rose Jeffrey³, Graham Kerr¹

¹Queensland University of Technology, ²University of Queensland, ³Dance for Parkinson's Australia and Queensland Ballet

BACKGROUND AND AIM Gait impairments are well-known in people with Parkinson's disease (PD). Parkinson's gait is characterised by reduced gait speed, stride length, and swing times, and increased stride-to-stride variability. Especially, walking becomes attention demanding when performing a secondary task resulting in a poor gait. Whilst research on dance interventions have recently been found to improve walking in people with PD, there is a limited number of studies that have objectively assessed the effects of dance in gait, particularly related to the Dance for Parkinson's Disease® (DfPD®) programme. Therefore, this study aimed to examine the effects of DfPD® on gait and dual task gait (performance of a cognitive task while walking). METHODS A quasi-experimental, parallel group pretest-posttest study was carried out with a Dance Group (DG; n= 17; age = 65.8 ± 11.7 years) and a Control Group (CG: n=16; age = 67.0 ± 7.7 years). The participants who were diagnosed with early-stage PD (Hoehn & Yahr: DG = 1.6 ± 0.7, CG = 1.5 ± 0.8), with no cognitive impairment (Addenbrooke's score: DG = 93.2 ± 3.6 , CG = 92.6 ± 4.3) and able to walk independently for ≥ 3 m without an assistive device were included in the study. The intervention group underwent one-hour dance class, twice weekly for 12 weeks. Dance for Parkinson's classes based on the DfPD® model were conducted by trained instructors from the Queensland Ballet. Biomechanical analysis of gait was conducted using a 12-camera Vicon data capturing system (Cameras: Vantage 5, Software: Nexus 2.5). The assessment of gait, was carried out at baseline and post-intervention with gait velocity as primary outcome measure. RESULTS The spatio-temporal variables of gait for normal walking and dual-tasking did not differ significantly at base-line. Based on pre-post change scores there was a significant main effect of group on gait velocity [p = 0.02, d = 0.98], cadence [p = 0.02, d = 0.08], step length [p = 0.03, d = 0.81], and stride length [p = 0.03, d = 0.84] for even surface walking. The post-hoc comparison revealed a significant improvement in the DG compared to CG in gait velocity, stride length, step length and cadence for serial subtraction and verbal fluency task during even surface walking. While there was no significant main effect of group, there was a significant main effect for task and group*task interaction for double support (%) and stance phase (%) for uneven surface walking. Double support (%) and stance phase (%) increased for normal walking, decreased for serial subtraction and remained stable for verbal fluency task across the 3-month period for uneven surface walking. CONCLUSION The study concludes that the DfPD® based classes have positive effects on



spatiotemporal parameters of normal walking on the even surface, with the highest effect size for gait speed. There is also a positive impact on walking while engaged in a cognitive secondary task (serial subtraction and verbal fluency). However, there were differential effects on uneven surface walking.

P1-H-65 Gross and fine balance control during walking in stroke patients and healthy controls

Noel Keijsers¹, Yara Luijten¹, Bart Nienhuis¹

¹Sint Maartenskliniek

BACKGROUND Quantification of balance control during gait is important for diagnosis and evaluation in neurological disorder patients with gait problems. Several gait stability outcome measures using the interaction between the Center of Mass (CoM) and the Base of support (BoS) during walking have been proposed in the literature. However, most biomechanical gait stability measures, such as the margin of stability, are highly affected by gait speed, step frequency, and step width. In addition to the margin of stability, Hof et al. (2007) also introduced parameters for the gross and fine balance control during walking based on correctness of the foot placement and adjustment for 'incorrect' foot placement during the single stance phase, respectively. So far, these measures have been studied in six above-knee amputee walkers. It was hypothesized that gross and fine balance control are affected in stroke patients and mostly affected in the paretic side and minimally influenced by walking speed. AIM Test the validity of gross and fine balance control during walking by showing differences between stroke patients and healthy controls and between paretic and non-paretic side in stroke patients. METHODS Nine stroke patients and 18 healthy controls performed a 2 minute walk test on the GRAIL. Participants performed the test in in the self-paced mode and at fixed speed. Healthy controls were also tested at half their preferred speed. Foot placement control (FPC, gross balance control) was defined as the correlation between the lateral XCoM position, and the lateral foot placement for multiple steps. Single stance control (SSC, fine balance control) was the correlation between the correction in CoP during single stance for the offset in the FPC for multiple steps. Two-way repeated measures ANOVA were used to indicate the effect of walking mode and side on FPC and SSC. RESULTS FPC and SSC were not significantly different between self-paced, fixed speed and half preferred speed in healthy controls (p=0.55, p=0.24) and stroke patients (p=0.29, p=0.10). FPC was significantly smaller (p<0.001) for the paretic side of stroke patients (r=0.84±.09) compared to the non-paretic side ($r=0.95\pm$.02) and both legs of the healthy controls (right: $r=0.96\pm$.02, left: $r=0.95\pm$.02). The SSC was significantly different between healthy controls (right: r=-0.57± .11, left: r=-0.58± .16), paretic (r=-0.36± .21) and non-paretic (r=0.15± .34) side of stroke patients (p<0.001). **CONCLUSION** Foot placement control and single stance control are valid measures to indicate the gross and fine balance control during walking irrespective of walking speed or walking mode.





Foot placement and single stance control is reduced in stroke patients and mostly affected in the paretic side.

P1-H-66 Effects of freezing joint degrees of freedom on dynamic postural balancing

Kentaro Kodama¹, Kazuhiro Yasuda², Hideo Yamagiwa³

¹Kanagawa University, ²Waseda University, ³Tokyo Metropolitan Tobu Medical Center

BACKGROUND AND AIM According to the loss of complexity (LOC) hypothesis, the age- and/or disease-related changing process is characterized by a progressive LOC within the dynamics of physiologic outputs. These dynamics are characterized by the presence of fractal scaling or the amount of predictability in the dynamics. The LOC is associated with a decline in the capability to reorganize the interactions between its functional degrees of freedom (DoF) to adjust the degree of unpredictability of behavioral fluctuations in order to meet task demands. However, most previous studies have investigated the relationship between DoF and system dynamics by comparing particular populations such as elderly/impaired people with healthy young people. In the previous studies, it is difficult to reveal the direct relationship between the DoF and system dynamics. Therefore, this study aimed to reveal the direct relationship between them in a withinsubject design experiment. Methods Six healthy male participants were recruited. We manipulated the joint DoF and compared different DoF conditions within subjects [the normal condition (no joint fixation), ankle condition (ankle joint fixation), and knee condition (knee joint fixation)]. Under the joint fixation conditions, each joint of the dominant leg of each participant was fixed. Each participant was asked to maintain single-leg standing with their dominant leg. For all the condition, they were required to repeat a 35-s trial four times. The center of pressure (COP) trajectories were measured using a force plate. As a static measure, the COP trajectory length was calculated. To obtain dynamic measures, we conducted detrended fluctuation analysis (DFA) and sample entropy (SampEn) analysis. Results The COP trajectory length did not differ significantly between the conditions. However, the significant main effect on the DFA exponent in the ML direction was found. Through multiple comparisons, significant differences were found between the ankle [mean=1.25] and normal [mean=1.17] conditions, and between the ankle and knee [mean=1.18] conditions. This means that the under-diffusive process in the ML direction weakened when the ankle joint was fixed. A significant main effect on SampEn in the ML direction was also found. Multiple comparisons revealed significant differences between the ankle [mean=0.095] and normal [mean=0.117] conditions, and between the ankle and knee [mean=0.116] conditions. This suggests that low SampEn in the ankle condition was interpreted as an increase in the effectiveness of postural control in the ML direction. Conclusions The results of comparing across conditions revealed that the static measure did not significantly differ across conditions; however, the dynamic measures differed significantly. These results appear to agree with the previous studies' insights within the loss of complexity framework suggesting that less





functional DoF might lead to LOC of the system behavior. **ACKNOWLEDGEMENTS AND FUNDING** Kanagawa University Grant for Joint Research

P1-H-67 Ankle and hip joint coordination during quiet standing for individuals with incomplete spinal cord injury

Jae Lee¹, Angela (Jaeeun) Yoo², Katherine Chan³, Janelle Unger¹, Kristin Musselman¹, Kei Masani¹

¹University of Toronto, ²Institute of Biomaterials and Biomedical Engineering, University of Toronto, ³Toronto Rehabilitation Institute

BACKGROUND AND AIM: Individuals with incomplete spinal cord injuries (iSCI) often have an impaired ability to maintain balance during quiet standing. For able-bodied (AB) individuals, the ankle and hip joint accelerate in anti-phase to minimize the body sway in the sagittal directions. Since individuals with iSCI experience motor deficits, we hypothesized that they do not sustain such joint coordination, causing difficulties in maintaining their standing balance. Here we investigated the coordination of the ankle and hip joint accelerations during quiet standing for individuals with iSCI. METHOD: Eleven individuals with iSCI (8F/3M; 61.6±14.9yr), nine age- and sex-matched AB individuals (ABm) (9F/3M; 60.1±9.7yr) and ten young AB individuals (ABy) (4F/6M; 25.4±5.4yr) participated. The participants performed quiet standing for 150 seconds while we recorded kinematics and kinetics data. The body and the joint fluctuations were quantified using the root-mean-square (RMS) of the body center-of-mass (COM) and joint angular acceleration. The ankle-hip joint coordination was quantified using the coordination index (CI) and the uncontrolled manifold (UCM) approach. In addition, the resultant body acceleration from the ankle-hip joint interactions was quantified using the RMS error between the desired and the measured ankle-hip joint accelerations. The analysis of variance (ANOVA) with Tukey's test and the post-hoc analysis, were used to compare the measures among the three groups. RESULT: The body COM accelerations was significantly larger for those with iSCI compared to AB participant (ANOVA: p<0.001; ABy vs. iSCI: p<0.001; ABm vs. iSCI p=0.004). Also, we found that the lower body angular acceleration was statistically greater for those with iSCI than the AB participants (ANOVA: p=0.004; ABy vs. iSCI: p=0.005; ABm vs. iSCI: p=0.040) while the upper body acceleration was not significantly different between those with iSCI against AB participants (ANOVA: p=0.044; ABy vs iSCI: p=0.054; ABm vs. iSCI: p=0.123). The CI and the UCM analysis were not different among the groups (ANOVA: p=0.344 [CI] and p=0.117 [UCM]), indicating that similar correlation between the two joint acceleration was observed. However, there were significant differences between the desired and the measured ankle-hip joint acceleration among the groups (ANOVA: p<0.001; ABy vs iSCI: p=0.001; ABm vs. iSCI: p=0.008), indicating that for those with iSCI, the joint accelerations were not effectively reducing the body acceleration. **CONCLUSION:** We demonstrated that individuals with iSCI sway more during standing, indicating that they have compromised ability to maintain balance, mainly due to larger ankle joint accelerations. We also demonstrated that the ankle and hip joint acceleration do not effectively



work together to reduce the overall body sway. Therefore, changes in standing posture for individuals with iSCI could perhaps be attributed to the changes in their ankle-hip joint coordination.

P1-H-68 Variability of gait, bilateral coordination in unilateral vestibular loss patients

Hwan Ho Lee¹

¹Kosin University College of Medicine, Korea

BACKGROUND AND AIM: Although patients with peripheral vestibular disorders have problems with walking, there is still lack of objective quantitative measurement of gait patterns of peripheral vestibular disorders. Based on a shoe-type wearable device, this paper develops gait analyzing to obtain quantitative measurements and explores the essential indicators from the measurements for peripheral vestibular disorder. METHODS: Between April 2017 and January 2019, 54 patients diagnosed with unilateral vestibulopathy (vestibular neuritis Left(Lt): 26/ Right(Rt): 28) were enrolled in this study. The DynaStabAnalysis (shoe-type inertial measurement units(IMU))® was used to analysis subjects. We assessed normalized stride length, stride time, cadence, time of toe off, Phase Coordination Index (PCI) and gait asymmetry (GA) of data from shoe-type IMU sensors during walking. We tested 162 healthy volunteers. RESULTS: We identified the parameters of the human walking pattern. The time of toe off rate of patients with unilateral vestibulopathy was increased to 60.48±3.66/59.6±8.25(Lt/Rt) compared to 59.55±1.4/59.2±1.38 (Lt/Rt) in healthy volunteer. In addition, there were differences in PCI, GA and related gait coordination and symmetry, when comparing peripheral vestibular disorders groups (PCI 4.14±2.6/ GA 2.9±2.34) and healthy volunteers(PCI 2.59±1.32/ GA 1.62±1.33). CONCLUSIONS: Gait analysis by the use of shoe-type IMU could provide important information regarding vestibular pathophysiology in patients with unilateral vestibulopathy. Gait performance tests can examine gait variability quantitatively. It can be considered as a vestibular function test for patients with vertigo in the future.

P1-H-69 Walking through an aperture while penetrating from the paretic side reduces the rate of collision for stroke individuals

Daisuke Muroi¹, Yutaro Saito¹, Aki Koyake¹, Takahiro Higuchi²

¹Kameda Medical Center, ²Tokyo Metropolitan University

BACKGROUND AND AIM: Safely walking through a narrow aperture requires fine-tuning and adjusting the posture to avoid contact with the frame of the aperture. One of the important findings in our previous study (Muroi & Higuchi, 2016) was that, for stroke fallers, who showed a greater number of accidental contact, penetration of an aperture from the paretic side could be an





effective method to reduce the rate of contact. To obtain clearer evidence for this possibility, we conducted two experiment. METHODS: In Experiment 1, stroke fallers (n = 12), and stroke nonfallers (n = 13) participated. The stroke participants were asked to walk through apertures of various widths (0.9-1.2 times the participant's shoulder width) with penetrating from the paretic side in one condition and with penetration from the non-paretic side in the other condition. Accidental contact with the frame of an aperture and kinematic characteristics at the moment of aperture crossing were measured. Experiment 2 was conducted to test the validity of plausible explanations by using a case-study experiment for three stroke participants who showed a dramatic decrease in contact rate when they penetrated an aperture from the paretic side. Two experimental conditions (visual occlusion and calculation) were added to the method of Experiment 1. **RESULTS:** The results of Experiment 1 supported our expectation. The tendency in stroke fallers to make more contact on the paretic side disappeared when they penetrated an aperture from their paretic side. These findings suggest that penetration from the paretic side was available for stroke fallers to successfully avoid accidental contact. The results of Experiment 2 found that the effectiveness of penetration from the paretic side was reduced from 67% to 25% when the walking task was performed under the dual task (calculation) condition. These findings suggest that the involvement of spatial attention toward the paretic side of the body is a plausible explanation for the effectiveness of penetration from the paretic side. CONCLUSIONS: The present study was designed to investigate how successfully stroke individuals walk through apertures and how they perform body rotation behavior. The results obtained from the two experiments showed that (a) Stroke fallers, but not stroke non-fallers, showed frequent contact with the frame of an aperture (Experiments 1). (b) Contact with the frame of an aperture occurred more frequently on the paretic side in stroke fallers (Experiments 1 and 2). (c) When stroke fallers penetrated an aperture from the paretic side, contact on the paretic side did not occur frequently (Experiments 1 and 2). (d) The involvement of spatial attention toward the paretic side of the body is a plausible explanation for the effectiveness of penetration from the paretic side (Experiment 2).

P1-H-70 Feasibility of visual cues to promote walking turns in Parkinson's disease

Rebecca Reed-Jones¹, Tyler Baker¹, Jenna Pitman²

¹University of Prince Edward Island, ²University of Guelph

Aim and **BACKGROUND:** Auditory and visual cues promote gait in Parkinson's disease (PD). Auditory cues (metronome) increase cadence while visual cues (typically grid lines on the floor) increase step length. When turning during gait, auditory cues have been found to reduce freezing of gait in PD, however; it does not correct axial segment coordination and increases 'en-bloc' segment control. Eye movements are proposed to be a key component of axial segment coordination during turning. Therefore, visual cues may be more effective for turning movements. The purpose of this study was to evaluate the use of visual cues placed at eye level on turning





performance in a sample group of individuals with PD. An additional sample of neurotypical young adults (NYA) was used to evaluate any negative effects of the visual cues on a group without movement difficulties. METHODS: 10 NYA (20-30 years) and 6 PD (Hoehn and Yahr stage 1-3; 45-75 years) completed three sets of trials on a course consisting of a 90-degree left turn. Trials were blocked by visual condition: non-cued baseline turns (5 trials), visually cued turns (10 trials), and non-cued retention turns (5 trials). A Delsys Trigno (Delsys, Boston, MA) Wireless Electrocardiography (ECG) sensor was used to record electrooculography (EOG), recording at a frequency of 1024 Hz. The sensor was placed on the lateral aspect of the orbit to track horizontal movement of the eye. These data were used to determine initiation of horizontal saccades into the turns and frequency of eye movements. In addition, an eye tracker (Mobile XG, Applied Science Laboratories, Bedford, MA) recorded gaze point of view to identify fixation locations. Finally, segment kinematics were recorded using two Optotrak cameras (Northern Digital Inc., ON, Canada). Rigid bodies with three IRED markers were attached to the head, trunk, pelvis and feet and anatomical landmarks were digitized. Vertical velocity of heel markers determined heel contact events used to calculate gait parameters (step length, step width, and single support time), time taken to complete the turn, and segment rotation onset time. RESULTS: PD exhibited earlier horizontal saccades following use of visual cues and increased frequency of eye movements. Segment rotations also showed improvement changing from a largely coupled coordination to more independent segment control. Increased step length and decreased turn time were also observed. No overall effects were observed on step width or single support time. In NYA, some minor alterations in segment rotations were observed but generally turning performance (turn time, gait parameters and saccade frequency) were unaltered with the visual cues. CONCLUSIONS: Results from our study support feasibility of visual cues for improving turning performance in PD. Previous studies have reported improvement in turning with auditory cues, but increased 'en-bloc' segment coordination, a coordination strategy associated with increased falls. In addition, our visual cues increased step length and decreased turn time in PD consistent with previous visual cueing studies (grid lines on floor). This study provides a step towards improving turns with visual cue training and reducing the risk of falls in PD.

P1-H-71 Haste makes waste: on the trade-off between walking speed and target-stepping accuracy

Melvyn Roerdink¹, Daphne Geerse¹, Lieke Peper¹

¹Vrije Universiteit Amsterdam

BACKGROUND AND AIM: When environmental constraints place strict limitations upon foot placement during walking, such as when walking down a rough mountain path, the need for accurate foot placement increases in order to avoid tripping, slipping or stumbling. Typically, we then also walk slower, as hurrying too much is a common situational circumstance of walking-related falls. This suggests a trade-off between walking speed and stepping accuracy in situations





that demand precise foot placement. The aim of this target-stepping study was to gain a comprehensive understanding of the trade-off, if any, between walking speed and stepping accuracy. METHODS: Participants (n=20) walked at each of five different speeds (60, 80, 100, 120, 140% of their comfortable walking speed [CWS]) multiple times over the same regularly and irregularly spaced sequences of stepping targets, with a mean inter-target distance matching participants' step length at CWS. The stepping targets were projected on a 10x1m walkway, and their size matched participants' foot size (Figure 1). Participants were instructed to place their feet accurately onto the targets (i.e., precision stepping), while following a constant-speed cue projected on the side of the walkway. Stepping accuracy was parameterized as overall (RMSE), variable (VE) and constant (CE) stepping errors, quantified over targets as well as per target, using the data of the validated Interactive Walkway (Geerse et al. 2017). RESULTS: Over targets as well as per target, significant main effects of imposed speed on RMSE (F(4,76)>20.9, p<0.001, np2>0.52) and VE (F(4,76)>6.8, p<0.001, np2>0.26) were observed: RMSE and VE grew linearly with increasing speeds (significant linear contrasts, F(1,19)>20.7, p<0.001, np2>0.52). CE, the bias in stepping errors, did not vary systematically with imposed speeds, but did vary in magnitude and sign with variations in inter-target spacing (F(9,171)=33.68, p<0.001, np2=0.639): Targets preceded by a shorter inter-target spacing were overshot (positive CE), while targets preceded by a longer inter-target spacing were undershot (negative CE). This effect was stronger for faster speeds and for targets preceded by the shortest and longest inter-target spacing (F(36,684)=5.97, p<0.001, np2=0.239). CONCLUSIONS: Participants stepped less precisely when walking faster, so haste indeed makes waste. The linear increase in VE with faster speeds is a finding in line with Schmidt's paradigm of the speed-accuracy trade-off (Schmidt et al. 1979). The systematic comparison of stepping errors over regularly and irregularly spaced stepping targets further provided important clues on how to best parameterize stepping accuracy: per stepping target using VE (i.e., stepping inconsistency), complemented with CE (i.e., stepping bias) in case of irregularly spaced stepping targets. **REFERENCES** Geerse DJ, Coolen BH, Roerdink M (2017). Walking-adaptability assessments with the Interactive Walkway: Between-systems agreement and sensitivity to task and subject variations. Gait Posture 54:194-201. Schmidt RA, Zelaznik HN, Hawkins B, Frank JS, Quinn JT Jr (1979). Motor-output variability: A theory for the accuracy of rapid motor acts. Psych. Rev. 86:415-451.

P1-H-72 Influence of body weight supported treadmill training parameters on muscle coordination in hemiparetic walking

Bryant Seamon¹, Shraddha Srivastava¹, Richard Neptune², Lindsay Perry³, Carolynn Patten⁴, Steven Kautz¹

¹Ralph H. Johnson VA Medical Center, ²University of Texas at Austin, ³University of St. Augustine for Health Sciences, ⁴University of California Davis School of Medicine





BACKGROUND AND AIM: Body weight supported treadmill training (BWSTT) has been shown to alter muscle coordination during walking for individuals post-stroke. It is unknown how manipulation of BWSTT parameters, such as percent body weight support (BWS) or therapist directed cues immediately affect muscle coordination. The purpose of this study was to examine the acute effects of 15% and 30% BWS and various combinations of therapist assistance on muscle coordination during BWSTT. METHODS: A total of 34 individuals post-stroke walked on an instrumented treadmill at their fastest comfortable (FC) speed without BWS (baseline) and again with 15% and 30%BWS. Participants also walked at their FC speed with 30%BWS and physical therapists manipulating available parameters of hands-on assistance to the trunk and/or feet. Muscle coordination was evaluated by calculating the number of modules from EMG data of 8 lower extremity muscles using non-negative matrix factorization. Paretic propulsion (Pp) symmetry was determined from ground reaction forces. Our final analysis only included participants who walked with less than 4 modules at baseline (since they had the potential to achieve the 4 modules exhibited by controls during an experimental condition: n=19). If module number increased from baseline in at least one experimental condition, we considered the participant a responder (n=13). A Wilcoxon Rank Sum test was used to evaluate the change in module number for each condition within the included sample and responder group. A Wilcoxon Two-Sample test was used to evaluate the difference in baseline Pp symmetry between the responder and non-responder groups. **RESULTS:** In response to the 15%BWS condition, we found an overall increase in module number (mean difference=0.31, p=0.03) for all participants studied (mean age 65.12 years, SD 9.06; mean months post-stroke 78.42, SD 74.32; male 14, right hemiparetic 6). In the responder group, the 15%BWS without assistance condition revealed a significant change in module number (6/13 improved; mean difference=0.46 p=0.03), while the 30%BWS with assistance at the trunk and paretic foot condition approached significance (7/13 improved; mean difference=0.46 p=0.07). Responders had significantly greater baseline Pp asymmetry (p=0.0032; median=0.26 IQR[0.11-0.32]) than non-responders (median=0.08 IQR[0.06-0.09]). Most responders (10/13) had a baseline Pp asymmetry greater than 10% (0.1, with 0=perfect symmetry). CONCLUSIONS: Our findings support that some individuals poststroke with fewer than 4 EMG modules can acutely increase module number in a corrective biomechanical environment like that used in BWSTT. We saw the most improvement for responders during conditions that consist of 15%BWS or 30%BWS with therapist assistance at the trunk and paretic foot (i.e., cueing of weight shift and paretic leg kinematics). Finally, individuals with greater Pp asymmetry may be more likely to acutely improve muscle coordination with BWS or therapist assistance walking environments. ACKNOWLEDGMENTS AND FUNDING: VA Office of Research and Development Rehabilitation R&D Service [Merit Review A6365-R], National Institutes of Health [NIH P20 GM109040], PODS Scholarship - Level I from the Foundation for Physical Therapy Research.



P1-H-73 Comparative characteristics of obstacle avoidance strategy in young and older adults in various walking conditions

Kotaro Shimizu¹, Yuriko Kihara², Koki Iwata¹, Takahiro Higuchi³, Taketo Furuna¹

¹Sapporo Medical University, ²Japan Health Care College, ³Tokyo Metropolitan University

BACKGROUND AND AIM: Obstacle avoidance is important for walking in the challenging environment such as outdoor or human crowd, and this activity is required spatial information obtained from visual sampling. In older adults, they select safer obstacle avoidance strategy. However, it has been unclear how older adults select obstacle avoidance pattern, and the risk of collision during obstacle avoidance in the situation of human crowd. The purpose of this study was to investigate the strategy of obstacle avoidance in older adults under the complex conditions such as number of obstacle and or presence of walkers. METHOD: Subjects were a total of twenty-six (twelve young adults and fourteen older adults). Four conditions set as follow: one confederate, one walker, two confederate, two walkers. We used three-dimensional motion capture system and eye tracking system to calculate kinematic strategy of obstacle avoidance and visual sampling. Kinematics strategies of obstacle avoidance were lateral spatial margin and body rotation angle at the moment of obstacle avoidance, gait speed (within 1m of obstacle: area1, within 2m of obstacle: area2), timing of maximum lateral shift during obstacle avoidance. As for visual sampling, we calculated gaze time toward obstacle. Two factors (two groups and four conditions) of repeated ANOVA was used as statistical analysis. RESULTS: Significant main effects of groups (p<0.05), conditions (p<0.05), and interaction (p<0.05) were observed in lateral spatial margin. These results showed older adults kept narrow spatial margin compare to young adults. As for body rotation angle and walking speed of area2, significant main effects of groups (p<0.05) and conditions (p<0.05), and these results indicated the difference of body rotation angle and walking speed between older adults and young adults. In addition, walking speed of area1 was significant interaction (p<0.05) between groups and conditions, and this result indicated that older adults changed their walking speed in area1. On the other hands, timing of lateral shift and gaze time to obstacle were not significant. CONCLUSIONS: Characteristics of obstacle avoidance in older adults were narrow lateral spatial margin and straight trajectory of walking, while young adults changed direction of walking path and they kept wider lateral spatial margin in this study (Figure 1). In the conditions of this study, all the subjects in the study were required lateral shift such as change direction of walking path, and this motion was needed dynamic control of posture. Therefore, older adults selected walking straight to the point of obstacle avoidance in order to avoid instability caused by the change direction of walking path or lateral step. In the gaze time toward obstacle, there was no difference of gaze time to obstacle and this result indicated that strategy of visual sampling such as central vision and peripheral vision was differ depending on the individuals.





P1-H-74 Does discrete versus cyclic full body reaching tasks influence hip and spine excursions?

James Thomas¹

¹Virginia Commonwealth University

Many of movements in our daily life consist cyclic and discrete components. While many studies have examined the influence of task constraint on motor behavior (i.e., kinematic synergies, muscle activation, interaction torques), these movement tasks have often been limited to movement of the upper extremity. We have previously shown that movement speed influences the magnitude of joint excursions discrete full-body reaching in tasks. However, it is unknown how cyclic tasks will influence the apprtioment of joint excursions in these tasks. Purpose/Hypothesis: To examine the effects of discrete versus cyclic conditions on joint excursions during full body reaching. Number of Subjects: Twenty-four healthy participants (14 men, 10 women) with no history of low back pain. Materials/METHODS: Starting from an upright posture, participants reached for two targets located in the midline. The target locations were normalized to the participant's anthropometric measures such that the participant could, in theory, reach the high target if they flexed 15° at the hip and trunk with the elbow extended and the shoulder flexed at 90°. They could reach the low target if they flexed 60° at the hip and trunk. Participants performed two trials of single reaches to the targets (i.e. discrete condition) as well as repeated reaches (i.e. cyclic condition). Both discrete and cyclic reaches were performed at a comfortable-pace and a fast-pace movement speed. For the discrete reaching trials at a comfortable pace, participants were instructed to start by standing upright with their right index finger in a sensor attached to the anterior proximal thigh. The participants reached to the target at a comfortable pace and paused until they received the return signal 2000ms after target contact. For the cyclic reaching tasks, participants were paced using a metronome set at 60 bpm for a reaching time of 1000ms. They were instructed to reach to the target and return to an upright posture without pausing during the 10 second movement trial. The cyclic and discrete reaching trials were then repeated at a fastpaced movement speed (i.e. twice comfortable pace). Kinematic data collected using a seven camera Vicon system were imported into Motion Monitor to derive joint angle data. The joint excursions were defined as the change in joint angle from initial posture to target contact and extracted from the time-series data using custom software developed in Matlab. RESULTS: Consistent with our previous research on reaching tasks, there was an increase in joint excursions of the ankle (p<.033), knee (p<.018) and hip (p<.000) at the fast-paced movement compared to the comfortable pace. Conversely, there was a decrease in lumbar spine excursion (p<.000) for fast-paced movement trials. We also observed a main effect of condition (cyclic vs. discrete) on the joint excursions of the knee (p<.034) and lumbar spine (p<.000). Specifically, the hip joint excursions increased while lumbar spine motions decreased. Finally, we found an interaction of condition by target at the elbow (p<.000) with elbow joint excursion increasing with cyclic motions for reaches to the low target. CONCLUSIONS: Increased movement speed as well as repetitive motions can increase force requirements on the joints.



I - Development of posture and gait

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P1-I-75 The development of running in children

Margit Bach¹, Francesco Menna², Andreas Daffertshofer¹, Nadia Dominici¹

¹Vrije Universiteit Amsterdam, ²University of Rome Tor Vergata

BACKGROUND AND AIM: Walking and running are generally considered as two distinct gait patterns that are modeled as an inverted pendulum and spring, respectively. During walking there is an exchange between kinetic and gravitational potential energy with each stride, i.e. the kinetic energy tends to oscillate out of phase with gravitational potential energy, whereas during running they tend to oscillate in-phase. The temporal characteristics of the gait cycle of walking and running patterns can also be defined based on the presence or absence of double support phase and flight phase. In adults the two gait modes are distinct but is this also evident in children during the development of running? Here, we investigate the relation between kinetic and gravitational potential energy in children during walking and running, the ability to run with a flight phase, and the changes of the gait modes as a function of age. METHODS: Ground reaction forces (GRF) and kinematics data were recorded in sixteen children (3-8 yrs) and seven adults (22-28 yrs) during walking and running at comfortable speeds. Step events were detected using vertical GRF and the heel markers. The kinetic and gravitational potential energies of the center-of-mass were calculated using the anterior-posterior and vertical GRF [1]. Joint angles were calculated of the right ankle and knee using the cosine rule and the leg elevation angle was determined. A principal component analysis (PCA) was applied on all variables computed from all gait cycles across all subjects and experimental conditions to identify the limited number of modes that were sufficient to explain most of the variance. RESULTS: During walking the percentage recovery - a measure of the pendular transfer between potential and kinetic energies of the center-of-mass - and the correlation between potential and kinetic energy improved as a function of age, confirming previous research [2]. Children younger than 6.5 years managed the running condition on the treadmill with a walk-run strategy. We observed strides with the presence of double support phase and strides with flight phase. Same walk-run behaviour was also observed in the analysis of the gravitational potential and kinetic energies. Furthermore, the inter-stride variability reduced as a function of age. The joint angles revealed that the running pattern in older children resembles that of the adults. The PCA revealed that data points associated with a specific experimental condition clustered in a well-defined location, and in the 2D representation of PC1 and PC2, the walk-run gait cycles observed in young children are closer to the walking gait cycles. CONCLUSION: The current results of this study reveal that children younger than 6.5 make use of a walk-run strategy during the running tasks on a treadmill. We also show high variability in the correlations between kinetic and gravitational potential energies, as well as in the kinematics limb movement and a gradual improvement of these parameters as a function of age. 1. Cavagna GA, Franzetti P, Fuchimoto T, The mechanics of walking in children. J Physiol 1983, 343:323-339. 2. Ivanenko, Y.P.,



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P1-I-76 Evaluation of balance in adolescent idiopathic toe walkers

Marybeth Grant-Beuttler¹, R. Caprice Hollandsworth¹, Shweta Chheda¹, Richard Beuttler¹, Afshin Aminian², Rahul Soangra¹

¹Chapman University, ²Children's Hospital of Orange County

BACKGROUND AND AIMS. While idiopathic toe walking (ITW) has been reported to occur in 2-7% of typical children, many researchers found no compelling reason to treat this "cosmetic" issue. Lower scores have been reported on the numerous subtests on the Bruinicks-Oseretsky (BOT-2) in 4 to 7 year-olds with ITW, but by age 8 the scores no longer differed. Little is known about balance in adolescents with ITW. The purpose of this study was to examine impairment and functional balance control in adolescents diagnosed with ITW. Methods. Six participants, 4 males/2 female with a mean age= 13.5 years (range= 11-15) demonstrating ITW, were examined. Balance measures included: the Sensory Organization Test (SOT), the Motor Control Test (MCT), the Adaptability Test (AT), and the Limits of Stability (LOS) on the Equi-test Balance Manager (EBM); the Upper-Limb Coordination (ULC), Bilateral Coordination (BC), and Balance (B) subtests on the BOT-2; the Foot Posture Index (FPI), and passive range of motion (PROM). Results. Five participants demonstrated at least one fall on the SOT conditions with decreased composite scores (mean=45) suggesting difficulty with balance under changing sensory conditions. MCT and AT suggest difficulty with motor responses relying on activating the tibialis anterior including increased backward translation latencies (range 90-220 ms) and falls (4 participants) during the Toes Up tilts with no adaptation observed. LOS subtest revealed decreased movement velocities, endpoint excursion, and maximum excursions suggesting difficulty with weight shifting particularly in the backward direction. Mean standard scores on the BOT-2 subtest were -0.4 for ULC, -0.6 for BC and -1.5 for B indicating issues using balance during functional skills. FPI scores suggested significant pronation with a mean of 9.6 on left and 9.7 on right foot. Mean maximum dorsiflexion was 3° on left and 2° on right with 3 participants demonstrating less < 5° dorsiflexion unilaterally or bilaterally. Conclusions. While our sample is small, every child in our sample of adolescents with ITW demonstrated poor balance control over multiple measures. Foot pronation and forward weight bearing may alter somatosensory input with decreased dorsiflexion potentially limiting the ability to utilize ankle strategy. Decreased ability to balance could lead to increased incidence of injury and decreased participation in physical activity. Greater sample size is needed to strengthen these findings. Interventions to address idiopathic toe walking need to focus on potential issues in balance control, foot posture, weight bearing alignment and use of ankle strategy in addition to facilitating a heel toe gait.





P1-I-77 Reactive and anticipatory postural response mechanisms during continuous platform oscillation in children and adolescents

Richard Mills¹, Heidi Sveistrup²

¹Manchester Metropolitan University, ²University of Ottawa

BACKGROUND AND AIM: Repeat experience of postural disturbance (via oscillating platform) has been shown to result in habituation in young adults whereby postural preparation occurs before the onset of perturbation [1,2]. Successive, different yet predictable perturbations show an initial reactive response to, followed by a shift to anticipation of, the postural disturbance. The oscillating platform paradigm is advantageous as it allows for both reactive and anticipatory measures of postural response to be observed. While balance has previously been welldocumented in children and adolescents, research has mostly focused on reactive postural control mechanisms through the use of discrete perturbations. Thus, the aims of this study were to (1) characterize anticipatory and reactive postural strategies in typically developing (TD) children and adolescents; (2) determine if TD youth shift from reactive to anticipatory mechanisms based on knowledge of predictable platform oscillation; and (3) determine whether TD youth further modify postural strategies when additional information about the perturbation is provided. METHODS: Sixteen typically developing youth aged 7-17 years stood with eyes open on a movable platform that progressively translated antero-posteriorly (20 cm peak-to-peak) through four speeds (0.1 Hz, 0.25 Hz, 0.5 Hz, and 0.61 Hz). Participants performed two trials each of experimenter- and self-triggered perturbations. Postural muscle activity of the legs, kinetics, and 3D whole body kinematics were recorded. The anchoring index of the head-on-trunk, and markerpair trajectory cross-correlations were calculated as indications of body stabilization. The number of steps taken to regain balance/avoid falling were counted. Transition states and steady states were analyzed separately. **RESULTS:** The results indicated a slight shift to anticipatory measures after repeated exposure to a specific frequency of platform oscillation, however, each transition to a greater speed resulted in more conservative measures of postural control, with adolescents exhibiting greater control than children. The provision of self-triggered perturbations allowed participants to make the appropriate changes to their balance by use of anticipatory postural control mechanisms. CONCLUSIONS: Postural muscle activity and kinematics suggest that children and adolescents are able to make the switch to anticipatory mechanisms. However, participants were not able to take full advantage of the platform slowing down to prepare for the upcoming change in direction well in advance, and exhibit responses similar to older adults [2]. Scaling of postural control to the level of threat may help to explain the switch to anticipatory mechanisms in self-triggered conditions [3]. Future work should aim to resolve at which frequencies children and adolescents are no longer able to make the switch from reactive to anticipatory mechanisms, and whether perturbation size should be scaled to age/height. REFERENCES: [1] Kennedy et al., 2013. Neurosci & Med, 4(1):45-49. [2] Bugnariu and Sveistrup, 2006. Arch Gerontol Geriatr, 42(1):73-89. [3] Carpenter et al., 2004. J Neurophysiol, 92(6):3255-3265



P1-I-78 Children's walking in complex environments: one step at a time?

Rachel Mowbray¹, Janna Gottwald², Manfei Zhao¹, Anthony Atkinson¹, Dorothy Cowie¹

¹Durham University, ²Uppsala University

BACKGROUND AND AIM: The natural walking environment is cluttered and changeable. For safety and efficiency, the feet must be placed precisely, into tightly constrained locations. This requires both sensitivity and responsivity to visual cues about the environment. Importantly, precision stepping must be learned in childhood. Early infant stepping is reflexive, rather than precise and visually guided (Thelen et al, 1984). But, by 9 years of age research suggests that children use visual cues (e.g. visual step targets) to make adultlike, precise steps (Corporaal et al, 2018). We explore the intermediate development of precision stepping during early-mid childhood. We ask whether children use online visual cues to improve the precision of single steps (Expt 1). We then ask whether children's walking benefits from distal visual cues about the upcoming terrain (Expt 2). Do children plan ahead like adults (Matthis et al, 2018)? Or do they control walking one step at a time, using proximal visual cues? **METHODS:** Expt 1. Adults and children (6, 7 and 8 years) made single steps toward targets in 2 directions: straight ahead and to the side. We occluded vision at movement onset on 50% of trials. We recorded error and postural stability using motion capture. Expt 2. Adults and 8 year olds walk across a series of stepping stone targets in virtual reality. We manipulate the number of visible upcoming steps to 1, 2 or 3 steps ahead. Participants also complete a virtual single-step task as in Expt 1. We use motion capture to record speed and error. RESULTS: Expt 1. Occluding vision increased absolute error. Both absolute and variable error decreased with age. By 8 years, both absolute and variable error were adultlike, despite postural stability remaining immature. Expt 2. We will present early findings from Expt 2, which is currently underway. CONCLUSIONS: By 6 years, children benefit from online visual input for precise, single steps. By 8 years, performance was mature, despite postural control remaining immature at 8 years. We therefore argue that developmental improvements in stepping accuracy are not solely a product of improving postural control. In our ongoing work, we extend our focus from single steps to walking (Expt 2). Do children plan ahead during walking? If so, providing distal visual cues about the upcoming terrain should improve foot placement accuracy. Alternatively, if children control walking one step at a time, distal visual cues should not affect foot placement. Our findings will shed light on the development of visually guided walking specifically, whether children are more reliant on proximal or relatively distal visual cues for accurate foot placement. This has both practical implications (for safety) and theoretical implications regarding sensory and motor development. ACKNOWLEDGEMENTS AND FUNDING: Materials purchased for this project were funded by NINE DTP (Northern Ireland and North East Doctoral Training Partnership).





P1-I-79 Inertial sensor based normative postural sway parameters in typically developing children and young adults

Joan O'Keefe¹, Alexandra Palmer¹, Rachel Tracy¹, Stephanie Voss¹, Medha Parulekar¹, Caitlin Bailey¹, Nicollette Purcell¹, Elizabeth Berry-Kravis¹

¹Rush University Medical Center

BACKGROUND AND AIMS: The use of inertial sensors to analyze balance is increasingly popular due to their ease of use, transportability, low cost and ability to be used in clinical, community and research settings. MobilityLab (APDMTM) is a widely used system used to analyze both balance and gait. However, normative data using this system have not yet been established in children or young adults which is essential to compare with data obtained from patients with balance impairments. Thus, our aims were to establish a normative database of postural sway parameters using MobilityLab instrumentation (APDM) in healthy typically developing children and young adults for use by clinicians and researchers. METHODS: Balance data was collected using an instrumented postural sway (i-SWAY) test including the modified Clinical test of Sensory Integration and Balance (mCTSIB), as well altered stance positions (feet together/ tandem) with and without vision in typically developing children and healthy young adults between the ages of 5 and 30 years of age (n=151). Subjects wore one Opal sensor at the level of the L5 vertebra (~ location of center of mass). Data was stratified into the following age groups 5-6 (n=14); 7-8 (n=16), 9-10 (n=22), 11-13 (n=36), 14-21 (n=36) and 22-30 (n=37) years. RESULTS: Here, we only report on total sway area (m2/sec4) and total Jerk (m2/s5) in the anterior-posterior and medial-lateral directions. There were no differences between male/ female metrics; therefore data was combined for analysis. Total sway area and jerk decreased significantly as age increased in all stance patterns with children 5-6 years of age having the largest sway area and jerk, reflecting less smoothness of the sway path (p < 0.0001). All groups had an increase in total sway area and jerk with eyes closed versus eyes open, as well on foam versus firm surfaces in all stance positions (feet apart, feet together, tandem). Eyes closed in tandem stance yielded the largest total sway area and jerk throughout the age groups. CONCLUSIONS: This is the first study to report guantitative inertial sensor based postural sway normative data in children and young adults from the mCTSIB and additional environmentally challenging balance conditions including feet together and tandem stance. This normative data may be useful to clinicians and researchers using the MobilityLab system to compare results from children and young adults with balance impairments, especially those with neurological or musculoskeletal diseases. Such normative data will allow researchers and clinicians to evaluate the sensory integration for postural control and responsiveness to treatment interventions targeted at ameliorating balance dysfunction or delaying disease progression.

P1-I-80 Inertial sensor based normative spatiotemporal gait and Timed Up and Go parameters in typically developing children and young adults





Joan O'Keefe¹, Stephanie Voss¹, Rachel Tracy¹, Alexandra Palmer¹, Medha Parulekar¹, Nicollette Purcell¹, Marie Fefferman¹, Elizabeth Berry-Kravis¹

¹Rush University Medical Center

BACKGROUND AND AIMS: The use of inertial sensors to analyze gait, turns and functional mobility is increasingly popular due to their portability, relatively low cost and ability to be used in clinical, community and research settings. MobilityLab (APDMTM) is a widely used system, however normative data has not yet been established in children or young adults which is essential to compare to clinical populations. METHODS: We collected 1) gait and turn data from an instrumented typical self- selected (SS) pace and fast as possible pace (FAP) 2 minute 25 meter walk and 2) sit-to-stand and turn-to sit data from a 7 meter instrumented Timed Up and Go (i-TUG) test in typically developing children and healthy young adults between the ages of 5 and 30 years of age (n=153). Data was stratified into the following age groups 5-6 (n=16); 7-8 (n=22), 9-10 (n=15), 11-13 (n=36), 14-21 (n=27) and 22-30 (n=37) years. **RESULTS**: There were no differences between male/female and right/left metrics; therefore data was combined for analysis. Means, standard deviations and age based comparisons for spatiotemporal and turn measures at SS and FAP paces and i-TUG data were calculated. At both SS and FAP paces stride length increased significantly and stride length variability (CoV) decreased with age. Gait speed was significantly lower in 5-8 yrs. than other ages. At SS paces cadence decreased with age reaching adult values by 11-13 yrs. Swing/stance/double support times did not differ between the groups at SS paces except were most efficient in 11-13 yrs. than adults. There were no gait or turn differences between those 14-21 and 22-30 yrs. except stride length at FAP paces was longer in the eldest group. Turns were slower in those 22-30 yrs. compared to 5-13 yrs. but the number of steps to turn and toe out angles did not vary between groups. There were no differences in sit-tostand or stand-to-sit duration between groups except those 9-10 yrs. were faster in sit-to-stand than 14-21 yrs. CONCLUSIONS: Normative data from this study may be useful to clinicians and researchers using the MobilityLab system to compare results from children and young adults with gait and functional mobility impairments. Further validation of this system with gold standard methods is needed in children.

P1-I-81 Minimum Predicted Distance: applying a common metric to collision avoidance strategies between typically developing children and adult walkers

Victoria Rapos¹, Michael Cinelli¹, Natalie Snyder¹, Armel Crétual², Anne-Hélène Olivier²

¹Wilfrid Laurier University, ²University of Rennes / Inria

BACKGROUND: Collision avoidance between two walkers involves mutual adaptation to speed and orientation in order to successfully avoid a collision. Minimum Predicted Distance (MPD) is the distance at which two walkers would cross each other if their speed and path trajectory were maintained¹. MPD has been used to describe the risk of collision between two adult walkers on a





collision course with one another and its evolution over time, beginning from the time walkers first see one another to the time of crossing¹. Obstacle avoidance studies involving children reveal high variability and different adaptive strategies compared to young adults². Research has yet to examine whether children have developed adult-like strategies to successfully avoid another walker when on a collision course. The purpose of the current study was to examine collision avoidance behaviours (via MPD calculations) of both adults and typically developing children when interacting with one another. METHODS: 18 typically developing children (10±1.5yrs) and 18 adults (34±9.6yrs) walked along a 12.6m pathway while avoiding another participant (child or adult). Groups of 3 children and 3 adults were recruited per session. Trials were randomized such that a total of 135 trials per session were recorded ensuring the same amount of interactions occurred in each of the three sets: adult/adult, adult/child, and child/child. 3D kinematic data of each participant's head was recorded using the Vicon system and reconstructed kinematic analysis was conducted to determine MPD(t). RESULTS: Groups were separated based on interactions: 1)Adult-Adult(AA); 2)Child-Child(CC); 3)Adult-Child(ie. child passing second, AC); and 4)Child-Adult(ie. adult passing second, CA). At initial sight of one another, the distance between the two walkers was computed to determine whether an adaptation to an individual's locomotor trajectory occurred in order to avoid a future collision. Computed crossing distance at MPD(tsee) was significantly different between groups (p<.05). AA MPD(tsee) threshold (0.9m) was greater than AC and CA MPD(tsee) threshold (0.8m) and CC MPD(tsee) threshold (0.7m). The progression of MPD(t), the computed increase in crossing distance, was significantly lower for the CC interaction, which was lower than the AC and CA interactions, compared to AA interactions (p<.05, Figure 1). CONCLUSIONS: Children are able to successfully avoid another individual when on a collision course. When a child is on a collision course with an adult, the progression of MPD(t) decreases with the smallest adaptation occurring when two children are avoiding one another. Based on the MPD calculations, it appears an individual's age and physical characteristics such as body anthropometrics may contribute to overall collision avoidance strategies. REFERENCES: 1 Olivier, Marin, Crétual, & Pettré. Gait & Posture, 36, 399-404 (2012). ²Hackney & Cinelli. Exp Brain Res, 229, 13-22 (2013).

P1-I-82 Experimental study of biomechanics of "military crawl" locomotion, pilot study

Dmitry Skvortsov¹, Alina Aisenshtein², Vladimir Kasatkin³, Anatoliy Shipilov², Victor Anisimov²

¹Pirogov's Medical University of Moscow, ²Rehabilitation center "Russcoe Pole", ³Dmitry Rogachev National Research Center of Pediatric Hematology, Oncology and Immunology

A few types of locomotion named crawling are described. In this research we had investigated a military type of crawl. Biomechanics of "military crawl" locomotion is poorly covered in scientific literature so far. This locomotion consists of phylogenetically ancient and well-automated motion act; which human beings acquire in early age of their ontogeny. Thus, crawling locomotion is possible to use as a testing procedure, which allow revealing not only the obvious, but also the



hidden motor function impairments. The aim of this study was to investigate biomechanics of military type of crawling among healthy adult participants. Eight healthy adults aged 15-31 years took part in our study (4 women and 4 men). Optical motion capture system "Optitrack" was used to obtain kinematic data of this locomotion. We use simple stick model of a human with calculation all parameters only at horizontal plane. The finishing data processing was at Visual3D software package. We calculate graphs of joint motion for hip, knee, shoulder and elbow joints, graphs of angles between pelvis and line connecting of shoulders joints, trajectory of Th10 vertebral spinosus process, velocity of movement. The cycle of motion (CM) was determinate as from one straight leg to next completely straight the same leg. Progressive and propulsive movement characterizes normal motion. They are additional right-left side motion with high degree of reciprocity. The trajectory of the Th10 has shape as a sinusoidal curve. They are the same as for walking (center of mass), but have higher amplitude. It was established that variability of kinematic characteristics of left upper and lower extremities are significantly lower compared to the right side. Also variability upper extremity joints were lower than for leg's joints. Probably, the left side has lower variability due to less trained, therefore moved more automatically. The maximum of flexion hip and knee joints coming at 36-37% of CM, and shoulder and elbow joints 56-59 of CM. So, the arm motion lagging behind at approximately 20% of CM. Therefore, the leading movement is leg's movement. The upper extremity motions are slave relatively leg's movements. We suppose that bipedal walking generator (as a part of central pattern generator) works for crawling. The normative data may be used for evaluating results in this test for patients with various pathologies. Data obtained allow using to describe the process of military type of crawling in a variant very similar characteristic to walking, but at level of motions are more primitive.

J - Developmental disorders

P1-J-83 Effects of saccadic eye movements on postural stabilization in dyslexic children

Jose Barela¹, Newton Tesima², Vitor Amaral², Ana Barela²

¹São Paulo State University (UNESP), ²Cruzeiro do Sul University

BACKGROUND AND AIM: Dyslexic children present poor postural control performance compared to their peers, which might be due to different eye movement strategies. It has been shown that saccadic eye movements decrease magnitude of body sway in young and older adults. However, there is no evidence if the search for visual information that occurs during eye movements affects postural control performance in dyslexic children. Therefore, the aim of this study was to examine the performance of postural control and the characteristics of eye movement of dyslexic children during upright stance. **METHODS:** Twelve children with dyslexia (10.8 \pm 1.1 years old) and 12 non-dyslexic children, matched by age (10.4 \pm 1.5 years old), participated in this study. Children were instructed to maintain an upright and quite stance for 30 s either fixating a target (fixation condition), displayed in the center of a monitor, or performing





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saccades to a target appearing on one side of a monitor, then disappearing and appearing immediately on the opposite side with a frequency of 0.5 Hz (saccadic condition). Three trials for each condition were registered. Body sway was obtained using an IRED (Optotrak Certus) placed in the children's back. Eye movements were tracked using an eye-tracking glass (ETG 2.0 - SMI). **RESULTS:** Dyslexic children swayed with larger amplitude in both fixation and saccadic conditions compared to non-dyslexic children. Both dyslexic and non-dyslexic children reduced postural sway magnitude in the saccadic compared to the fixation condition. All children were able to modulate eye movement according to the condition (fixation and saccadic) and no difference was observed between dyslexic and non-dyslexic children in the eye movement characteristics. **CONCLUSIONS:** Dyslexic children are capable of using visual information that occurs during eye movements to improve postural control, although still not reaching non-dyslexic children performance. Eye movements are modulated based upon the visual conditions similarly in dyslexic and non-dyslexic children. Eye movement strategies seem not to be the cause of poor performance of postural control in dyslexic children.

P1-J-84 Effects of neutralization of symmetry of the Maxwell spot on postural control in children with dyslexia. Clinical cases report

Emmanuelle Pivron Braquet¹, Marc Janin², Alix Couvrat³, Claire Carraurer³, Lucie Pirodeau³, Marina Vincent³, Marion Miral³, Sophie Richer de Forge³, Tipahaine Dreillard³, Valerie Riviere³, Benoit Maille³, Nicolas Imbert³, Briskmann Didier³

¹PODOLOGUE, ²Université de Pau et des pays L'adour, ³Krys Poitiers

BACKGROUND: Multi-sensory information such as somatosensory act on various areas of the brain, including eye sensory integration-coordination accompanied by optimal level of postural muscle tone to adapt posture-gait control (1). Previous research suggests that recognition performance is particularly enhanced when learning requires integration across sensory and motor systems (2). In normal binocular vision, the eye which is primarily relied on for specific positional information must be select therefore requiring some out of sight asymmetry between the two eyes. The presence or the absence of an asymmetry should play a crucial role for the visual and the phonological processes in the different modal integration of the brain (3). Sensory processing/integration difficulties and cognitive processing disturbances are reports in learning disorders like Developmental Coordination Disorders (4), Sensory Integration/Modulation Disorders (5), Dys-Proprioception Syndrome DPS (6) or Dyslexia (3, 6). For Dyslexics, one of the possible sensory integration/modulation dysfunction could be provide by the symmetry of their Maxwell centroid (7) compared to normal subjects (3). This symmetry perturbs the complex connectivity and lateralization of the different modal/cross-modal regions of the brain like reading or other tasks (3) or postural disturbances (8). This "brisure or violation of symetry" effects on postural muscle tone repartition has not been previously investigated. Device specifications: The Maxwell centroid neutralization were obtained by foveal-vision neutralization with 5 to 7 mm




frosted centre glass in respect of the functional anatomy (8, 9) of 8 right-eyes dominant dyslexics (Dys) and normal children (NDys). PDN-6 (10), Bassani-6 (score and liabilities, 6, 11, 12) exposed the functional distribution postural muscular tone in control (C), non dominant (NYD) and dominant (YD) eyes neutralizations. **RESULTS:** No differences are observed in YD or NYD neutralisation for NDys. Only NYD neutralization induces differences for all clinical scores of Dys. **DISCUSSION:** Maxwell centroid neutralization induces differentiated postural reflexes reweighting. The angular diameters of YD Maxwell centroid are similar between NDys and Dys (3). Muscular tone distribution scores do not present variations. Postural control is not influenced by its neutralisation. Contrary; the angular diameters of YND Maxwell centroid are not similar between NDys and Dys. Hence, it neutralization induce "asymmetry" into YD and YND integration, then Dys get nearer to NDys. The brisure of asymmetry (ocular dominance) may induce a negative noise on balance control of Dys children. Asymmetry appears to be a necessary condition for a normal development.

P1-J-85 The Kids-BESTest of postural control predicts gross motor coordination in primary school children with and without coordination difficulties.

Leanne Johnston¹, Gemma Allinson¹, Breanna Raatz¹, Rosalee Dewar¹, Sally Hannah¹

¹University of Queensland

BACKGROUND AND AIM: Children with Developmental Coordination Disorder (DCD) have motor skills substantially below that expected for their age. Poor postural control is thought to contribute strongly to these motor coordination difficulties. Despite this, targeted postural control treatment has been limited by assessments that do not examine all postural control domains. The aims of this study were to (i) examine postural control skills of primary school aged children using the new comprehensive 'Kids Balance Evaluation Systems Test' (Kids-BESTest) and the traditional short-form Bruininks-Oseretesky Test of Motor Proficiency, Second Edition: Balance Subscale (BOT-2), then (ii) determine relationships with gross motor coordination using the standardized Test of Gross Motor Development, Second Edition (TGMD-2). METHODS: Fifty-five children aged 4-12 years with normal intelligence attending mainstream schools participated in physiotherapy assessment of (i) postural control using the Kids-BESTest and BOT-2 Balance Subscale and (ii) motor coordination using the TGMD-2. Performance on each measure was examined using descriptive statistics (mean(SD)). Then relationships between measures were examined using Spearman's Rank Correlation for categorical variables or Pearson's Product-Moment Correlation for continuous variables. Linear regression was used to determine postural control and other factors predicting motor performance. RESULTS: TGMD-2 Total scores ranged from the 3rd to 97th percentile (mean 51st percentile) indicating the cohort included children with a wide range of motor abilities. Kids-BESTest Total scores ranged from 69 to 105 (64 - 97%) out of a possible 108 points (mean=92.4 +/- 8.54 points; 86% +/- 7.9%) indicating children also showed a wide range of postural control abilities. TGMD-2 Total scores correlated strongly with Kids-BESTest

Total Scores (p=0.60, p=<0.01) and moderately with BOT-2 Balance Subscale scores (r=0.45, p<0.01). Regression analysis showed that age and Kids-BESTest Total score predicted 44% of the TGMD-2 Total score (p<0.01) while the BOT-2 Balance Subscale predicted only 19% (p<0.01). BESTest domains best correlated with gross motor performance were: Anticipatory Adjustments, Reactionary Responses and Stability Limits (all p<0.01). **CONCLUSION**: Results show that postural control predicts a substantial degree of the variance in motor performance in primary school aged children. The more comprehensive Kids-BESTest was a better predictor of gross motor coordination difficulties than the short-form BOT-2 Balance Subscale which examines only a few balance domains. We recommend use of the Kids-BESTest for a comprehensive postural control assessment for primary school aged children in order to plan more targeted interventions for children with motor coordination difficulties.

P1-J-86 Developmental Coordination Disorder co-occurs at high rates among children and adolescents with Autism Spectrum Disorder

Haylie Miller¹, Gabriela Sherrod², Priscila Caçola³

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ispgr

¹University of North Texas Health Science Center, ²University of Alabama, Birmingham, ³University of Texas at Arlington

BACKGROUND AND AIM: Understanding of Autism Spectrum Disorder (ASD) has shifted drastically, from conceptualizing it as a social-emotional disorder to acknowledging a host of other sensorimotor symptoms including problems with standing balance, seated balance, upper extremity control, walking, and other gross motor skills. Despite similarities in motor challenges between ASD and Developmental Coordination Disorder (DCD), little is known about the prevalence of co-occurring ASD+DCD. We aimed to assess the co-occurrence of DCD in a sample of participants with ASD, and to compare the motor skills of participants with ASD versus DCD. METHODS: We assessed 61 children and adolescents with ASD (n = 43) and DCD (n = 18) aged 5 to 19 years. Participants denied any comorbid genetic or neurological disorders, intellectual disability, history of brain injury or abnormality, and medical or physical conditions causing motor differences, as well as use of medications known to affect motor functioning. We administered the Movement Assessment Battery for Children, 2nd Edition (MABC-2) and the Beery-Buktenica Developmental Test of Visual-Motor Integration, 6th Edition (Beery VMI). Participants' guardians completed the Developmental Coordination Disorder Questionnaire (DCD-Q) and questions about their child's developmental milestones. RESULTS: Over 90% of participants with ASD met criteria for DCD based on DSM-5 criteria, DCD-Q scores, and MABC-2 scores. Caregiver reports indicated that 76.2% of participants with ASD did not meet developmental motor milestones (e.g., crawling, walking). An independent-samples t-test indicated no difference between the ASD and DCD groups on current motor ability as measured by DCD-Q total score (p = 0.06), and 92.1% of participants with ASD scored in the "suspect or indication of DCD" category. Multivariate analyses of variance indicated no group differences on the Beery-VMI, the MABC-2, or their subscales (ps



> 0.05). Frequency analyses indicated that 97.5% of participants with ASD (all but 1 participant) met criteria for DCD on the MABC-2 (< 16th percentile). For participants who had both MABC-2 and DCD-Q scores (ASD = 43, DCD = 18), we examined the distribution of MABC-2 total scores relative to their corresponding DCD-Q scores (Fig. 1). CONCLUSIONS: The majority of our participants with ASD met criteria for DCD, suggesting that motor challenges may be an overlooked, clinically-significant feature of ASD. Clinicians must engage in early, vigilant surveillance for movement differences in patients with suspected ASD to prevent diagnostic overshadowing and facilitate early motor intervention. Future research on ASD+DCD is needed to support development of clinical practice guidelines for assessing and treating these two conditions. Although ASD and DCD are often viewed as disorders of childhood, the impact of co-occurrence may have lifespan consequences, including limitations on functional ability and risk for falls or injuries. FUNDING: National Institutes of Health/National Institutes of Mental Health (K01-MH107774); National Science Foundation (SMA-1514495)</p>

P1-J-87 Effect of orthopaedic shoes and orthopaedic insoles on gait in patients with Dravet syndrome

Lore Wyers¹, Karen Verheyen¹, Berten Ceulemans², An-Sofie Schoonjans¹, Kaat Desloovere³, Patricia Van de Walle¹, Ann Hallemans¹

¹University of Antwerp, ²Antwerp University Hospital, ³KU Leuven

BACKGROUND AND AIM: Dravet syndrome is a developmental epileptic encephalopathy related to sodium channel dysfunction and characterised by drug resistant epileptic seizures, cognitive impairment and motor disorders. Walking is markedly impaired and often described as crouch gait [1]. Foot deformities, especially pes planovalgus are common in patients with Dravet syndrome. Hence custom made orthopaedic footwear, such as shoes or insoles are frequently prescribed to prevent and support foot deformities. It is questionable whether this footwear can also improve lever arm function and stability and thus ameliorate gait. We therefore aimed to document the effect of orthopaedic shoes and orthopaedic insoles on kinematics of gait in patients with Dravet syndrome. **METHODS:** Fifteen patients were included, aged 4.3y to 24.2y (mean 15.6y ± 5.7y, 8m/7f) with genetically confirmed Dravet syndrome who received orthopaedic shoes (n = 5) or orthopaedic insoles in normal shoes (n = 10) during standard care. Instrumented gait analysis (Vicon, Nexus, PlugIn Gait) was performed to collect spatiotemporal parameters (STP) and lower limb joint angles for overground walking at self-selected walking velocity in two conditions: barefoot and with orthopaedic footwear. Paired samples t-test using statistical parametric mapping (www.spm1d.org, $\dot{a} = 0.05$) was used to compare STP, sagittal plane kinematics and foot progression angles between the two conditions, mean of three trials per subject. Mean kinematics of 15 age-matched typically developing (TD) peers were plotted as reference values. RESULTS: Cadence was significantly reduced from 116.7 ± 16.5 to 104.6 ± 14.5 steps/min (p = 0.001) and normalised step length increased from 63.6 ± 8.8 to 67.7 ± 10.0 %



of leg length (p = 0.012) in orthopaedic footwear condition with normalised walking velocity unaffected. Small but significant differences were only found at the knee during loading response and at the ankle during push-off and terminal swing (figure). **CONCLUSIONS:** Minor effects of orthopaedic shoes and orthopaedic insoles on gait in patients with Dravet syndrome were similar to the effect of common footwear in healthy populations [2]. Better stability could improve prepositioning of the foot at initial contact with enhanced step length as a result. Other deviations such as external foot progression, knee and hip flexion in stance and anterior pelvic tilt remained unaffected. Ankle and foot kinematics should be interpreted with caution because a basic foot model was used and foot markers were moved between conditions. Another limitation of this study was the wide age range and heterogeneity of the sample. ACKNOWLEDGEMENTS: This study was supported by the Flemish Research Council, grant number T003116N. [1] Rodda et al. (2012), Arch Neurol 69 (7):873-878; [2] Franklin et al. (2015), Gait Posture 42 (3):230-239

K - Devices to improve posture and gait

P1-K-88 Improvements in balance control for multiple sclerosis patients with vibro-tactile biofeedback of trunk sway

John Allum¹, Christel Schouenborg², Bettina Fischer-Barnicol¹, Venessa Haller¹, Nathanael Lutz², Heiko Rust³, Oezguer Yaldizli¹

¹University Hospital Basel, ²Bern University of Applied Sciences, ³Charing Cross Hospital

BACKGROUND: Balance impairment is a frequent symptom in multiple sclerosis (MS). Our pilot studies determined that vibrotactile feedback (VTf) of trunk sway, improves MS patients' balance control compared to training without VTf. The questions this project was aimed at answering were: 1) How much VTf training is needed to obtain the best benefit with VTf and the subsequent carryover benefit? 2) How long does the carry-over benefit last once VTf training terminates? 3) Is the benefit similar for stance and gait? and 4) Is position or velocity based VTf more effective in reducing trunk sway? METHODS: To date,11 MS patients with balance deficits, 8 slight paraparesis, 3 male, (9 relapsing-remitting, 2 primary-progressive, age 54.2 ± 7.5 years, median EDSS 3.0 (range 2.5 - 4.0), disease duration 10.4±12.6 years participated. Patients trained stance and gait tasks 2x per week with VTf for 4 weeks to determine when balance control with and without VTf no longer improved. The VTf thresholds were based on 90% ranges of trunk sway amplitudes and velocities for stance and gait tasks, respectively, measured before each week's training sessions. Tandem gait was tested with position and with velocity VTf. Patients were then assessed weekly without VTf for another 4 weeks and 6 months later to determine when retention of improvement ended. The difference in trunk sway between the very first assessment and subsequent assessments was used to measure improvement. Balance was measured with gyroscopes mounted at the lower trunk. The gyroscope signals drove directionally active VTf in a head-band. RESULTS: VTf showed a significant 28 to 45% decrease in pitch and roll sway angles





in all tasks after 1-2 weeks of VTf training (eg 37% for tandem steps). Trunk sway angular velocity tended to increase (17%) for stance tasks. Gait trials showed reduced sway angles (eg 28% walking eyes closed) and increased gait speed (24%) without an increase in sway velocity. The reduction of sway angles was present for angle and angular velocity based VTf for the tandem gait task. Training with VTf after 3-4 weeks produced no further improvements in balance control. Tests without VTf (short-term carry-over effect) showed less improvement but gradually improved to levels with VTf and then remained constant. At 6 months carry-over effects were absent. Conclusions. This study demonstrated that VTf training yields clinically relevant reductions in sway during stance and gait, and improved gait speed. It provides guidelines on the practical application of VTf for improved balance control in MS patients. The reduction of retained improvement 2-6 months after training is an estimate of the time when patients need to return to the clinic to receive VTf training again, but needs precise definition. The increase in sway velocity for stance tasks is assumed to be due to patients reacting quicker to imbalance. For tandem gait, velocity-based Vtf was slightly more effective than position-based VTf.

P1-K-89 Avoiding 3D holographic obstacles: Does it differ from negotiating real obstacles?

Bert Coolen¹, Daphne Geerse¹, Melvyn Roerdink¹

¹Vrije Universiteit Amsterdam

BACKGROUND AND AIM: In 1901, L. Frank Baum, famous for writing The Wonderful Wizard of Oz, already alluded to something that we would now call mixed reality. In his novel The Master Key, a teenage boy was rewarded by the Demon of Electricity with a unique pair of spectacles, coined the "Character Marker", which could project a key onto a person's forehead indicating their character. What Baum's readers might have considered impossible at that time is now close to reality. Since the 1950s, remarkable progress has been made in augmenting the real world with layers of digital content. One promising development in that regard is Microsoft's HoloLens, an untethered and see-through headset with a holographic display unit, through which 3D holograms are not only overlaid but anchored to and interacting with the wearer's environment. This merging of real and digital worlds is referred to as mixed reality, an important development affording more natural interaction during free movements in open environments. The aim of this study is to explore the use of mixed reality for studying locomotor interactions in real-world environments enriched with 3D holographic obstacles. METHODS: We compared obstacle-avoidance maneuvers of 12 subjects as they stepped over either real or 3D holographic obstacles that systematically varied in height (0cm, 10cm, 20cm, 30cm, 40cm) and depth (2cm, 30cm) across conditions. Movements of the subjects were recorded with an integrated setup consisting of three Kinect v2 sensors. The depth images of each Kinect sensor were analysed to determine maximum step height, foot clearance and obstacle hits. **RESULTS:** Leading limb step height varied linearly with obstacle height, for real and holographic obstacles alike, yielding a constant foot clearance



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over obstacles. However, foot clearance was slightly but systematically larger for holographic obstacles. There were more collisions with holographic than real obstacles, predominantly with the trailing limb and more often so for 30cm than 2cm obstacle-depth conditions. In fact, three subjects consistently did not adjust their trailing foot while stepping over holographic obstacles. **CONCLUSIONS:** These results suggest that the obstacle-avoidance maneuver in mixed reality scales with obstacle dimensions, yet with increased margins of the leading limb and more hits, predominantly with the trailing limb, possibly related to the small field of view of the HoloLens and the absence of feedback on performance. The limitations and potential benefits for studying locomotor interactions with mixed reality will be discussed, including our ongoing study on the efficacy of feedback for changing odd avoidance maneuvers in mixed reality. TEXT FIGURE 1: Figure 1: subject wearing the HoloLens mixed-reality headset (left), avoiding a real obstacle (30cm by 2 cm; center) and a holographic obstacle of the same dimension (right)

P1-K-90 Evaluating the efficacy of a novel therapeutic tool for standing balance after spinal cord injury: A case series

David Houston¹, Jae Lee², Emerson Grabke³, Angela (Jaeeun) Yoo³, Kai-Lon Fok³, Janelle Unger², Kei Masani², Kristin Musselman²

¹Rehabilitation Sciences Institute, University of Toronto, ²University of Toronto, ³Institute of Biomaterials and Biomedical Engineering, University of Toronto

BACKGROUND AND AIM: Following the occurrence of an incomplete spinal cord injury (SCI), some level of functioning is retained below the level of injury. Individuals with incomplete SCI often remain ambulatory, but impaired standing balance increases their risk of falling. Previous work has demonstrated significant improvements in static and dynamic stability following visual feedback balance training (VFBT). Functional electrical stimulation (FES) applied to the ankle plantarflexors and dorsiflexors also exhibited a positive orthotic effect in the static stability presented by the centre of pressure (COP) sway reduction. Combining FES with VFBT has not been investigated in the SCI population. The aim of this study was to investigate the therapeutic effect of FES-VFBT to elicit and maintain changes in standing balance performance. **METHODS:** Three participants (1M, 2F) with chronic SCI completed the 4-week training intervention as part of an ongoing study at the Toronto Rehabilitation Institute. Participants were assessed at baseline (3 times), immediately post-intervention, and 4 and 8-weeks post-intervention. Standing balance was evaluated using two clinical balance scales (Mini-Balance Evaluation Systems Test [MBEST], and Activities-Specific Balance Confidence [ABC] Scale) and two biomechanical measures (limits of stability [LOS], and COP velocity during quiet stance with eyes open [QSEO]). For the intervention, each participant attended twelve 1-hour training sessions (3/week for 4 weeks). During the training sessions, FES was applied bilaterally to the ankle plantarflexors and dorsiflexors while the participants completed each of the 4 VFBT exercises twice. FES was administered using a closed-loop controller using COP trajectories. RESULTS: Clinically





significant improvements on the MBEST were obtained in 2 participants, but were not maintained during the follow-up period. No clinically significant changes were observed for ABC Scale scores. For all participants, increases in LOS following the intervention were shown in both AP and ML directions (FESB01: 16% AP, 29.7% ML; FESB02: 86.6% AP, 18.8% ML; FESB04: 86.5% AP, 47.5% ML). Mean COP velocity during QSEO decreased in both directions for 2 of the participants (FESB01: 48.8% AP, 20.2% ML; FESB04: 33.2% AP, 29.8% ML). **CONCLUSIONS:** While positive changes in standing balance ability were observed immediately following the intervention, the effects did not persist once participation in the training ended. The intervention had no effect on balance confidence. The ability of FES-VFBT to improve control of the COP within the base of support, and to reduce COP velocity during quiet stance, may allow for greater functional independence in upright standing and mobility. These results highlight the variability and individualized experience of balance training after an incomplete SCI. **ACKNOWLEDGMENTS AND FUNDING:** This study was funded by the University of Toronto EMHSeed program.

P1-K-91 Design improvement and clinical assessment of personal standing mobility Qolo for voluntary sit-to-stand posture transition of persons with thoracic level spinal cord injury

Hideki Kadone¹, Yukiyo Shimizu¹, Shigeki Kubota¹, Diego Paez¹, Yasushi Hada¹, Masashi Yamazaki¹, Kenji Suzuki¹

¹University of Tsukuba

BACKGROUND AND AIM: We are developing Qolo, a new personal mobility device for those with motor disability in their lower limbs. It assists sit-to-stand and stand-to-sit postural transitions as well as navigation in standing posture with hands-free operation. Its mechanism to assist the postural transition is implemented with passive gas springs without using electric actuators, making it compact, light-weight and low cost. The alignment and strength of the gas springs are configured to achieve natural posture transition based on human biomechanics of the motion. The purpose of this study is to report clinical assessment of the device after modification of its design to realize voluntary sit-to-stand posture transition of people with thoracic level spinal cord injury (SCI). METHODS: In the improved design of the device, reviewing our preceding clinical experiments, the assistive force of the knee springs was doubled (Fig. (A)) and lumbar assist was added (Fig. (B)). Experiment 1: Seven healthy participants (age: 23-38y) were asked to conduct stand-up and sit-down postural transitions with and without using the improved device. Amount of muscle activity was compared between the conditions using surface EMG data. Experiment 2: Five participants with SCI (age: 30-52y, 3 males and 2 females, neurological level: T6-L3, AIS: A-C, MMT Hip Ext.: 0-1, Knee Ext.: 0-3) were asked to conduct stand-up and sit-down postural transitions using the improved device. Feasibility of the assisted motions were evaluated. **RESULTS:** Experiment 1: Muscle activity was reduced in the device condition compared to the without device condition, in Erector Spinae (38.5% red. p<0.01), Gluteus Maximus (51.7% red. p<0.05) and Quadriceps (48.1% red. p<0.01) during stand-up, and in Gluteus Maximus (47.2%



red. p<0.01) and Quadriceps (53.5% red. p<0.01) during sit-down. Experiment 2: All of the participants were able to voluntarily stand up and sit down using the improved device, including three among them (T11A, T10A, T6A, MMT Hip=0, Knee<=1) who could not conduct voluntary stand-up motion using the device before the improvement (Fig. (C)). **CONCLUSIONS:** The improvement of the device extended its capability to assist sit-to-stand and stand-to-sit posture transition to persons with lumbar or thoracic level SCI. At the same time, necessity of stronger support for middle to upper thoracic level SCI was investigated. For the next step, we plan to introduce stronger assistive force, and improve of harnessing and attachment and detachment processes to facilitate its daily use.

P1-K-92 Effects of sensory augmentation activation thresholds on balance performance in people with vestibular disorders

Tian Bao¹, Catherine Kinnaird¹, Wendy Carender¹, Kathleen Sienko¹

¹University of Michigan

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BACKGROUND AND AIM: Sensory augmentation (SA) devices can be used to provide cues that convey pertinent information about body orientation for balance, and they have been shown to improve balance performance during and following training. However, the effects of using narrow versus wide SA activation thresholds during balance exercise training on performance are unknown. A narrow threshold (e.g., 30% of max body sway), which provides more frequent cues, typically results in the user making more frequent postural corrections; narrow thresholds may lead to greater dependence on the cues and consequently reduce motor learning and/or be distracting. A wide threshold (e.g., 90% of max body sway), on the other hand, may enable users to sway too far prior to receiving a cue to initiate a correction, which may lead to loss of balance. However, a wide threshold may lead to greater post-training effects because users are challenged to use their own sensory inputs to initiate postural adjustments. The goal of this study was to characterize the effects of narrow and wide thresholds on balance performance. METHODS: Six participants with vestibular disorders (56 ± 6 yrs; four males) completed two identical single day sessions separated by at least 48 hours; participants used a wide SA threshold (1.5°) during one session and a narrow SA threshold (0.8°) during the other session (randomly assigned). All participants performed three 30-s trials of three different baseline exercises without SA at the beginning (pre) and end (post) of each session. During the training phase of each session, participants performed nine 30-s trials of four exercises (order randomized) including two of the baseline exercises with torso-based vibrotactile SA. Root-mean-square (RMS) of sway, percentage time of sway in a one-degree zone (PZ), and elliptical area (EA) of sway were computed from inertial measurement data to quantify balance performance. Linear mixed effect models were used to analyze the data with threshold (wide, narrow) and phase (pre-training, training, post-training) as fixed factors and participant as the random factor. The significance level was 0.05. **RESULTS:** RMS, PZ, and EA values were significantly improved during the training



phase when SA was used compared to the pre-training phase regardless of the threshold condition. No significant interaction effects between threshold and phase were observed. Although not significant, balance improvements were greater for all post- versus pre-training metrics for a subset of the exercises performed for the narrow threshold. **CONCLUSIONS:** The results of this preliminary study suggest that both narrow and wide thresholds improve real-time balance performance and facilitate short-term carryover effects following training. Based on these initial findings, narrow thresholds may lead to greater post-training improvements and be more effective for challenging exercises (e.g., foam), however, a larger sample size is needed.

P1-K-93 Staying UpRight in Parkinson's disease: a novel postural intervention

Samuel Stuart¹, Alan Godfrey², Lynn Rochester³, Fay Horak¹, Martina Mancini¹

¹Oregon Health & Science University, ²Northumbria University, ³Institute of Neuroscience, Newcastle University

BACKGROUND AND AIM: Postural changes are common in Parkinson's disease (PD), from the classic flexed posture to Pisa syndrome (lateral lean). Poor posture in PD has a negative effect on pain, balance, and mobility, with links to increased falls risk. Currently few interventions for postural misalignment exist. Recently, cueing, in the form of tactile stimulation, has shown promise in improving postural alignment in PD. Therefore, this study aimed to determine the feasibility and efficacy of an off-the-shelf tactile feedback wearable device (UpRight) for improving postural alignment in PD. **METHODS:** Postural angles were measured for two minutes in sitting, standing and during walking in 11 people with PD (Disease duration; 11.4±6.6years, UPDRS-III; 41.9±11.5, On meds, n=6 Pisa syndrome) using inertial measurement units (Moveo, Opals, APDM) under single and dual-task (forward digit span) conditions. Standardized clinical tests (distance of tragus, occipital, C7 to wall while standing) also measured posture. Testing was conducted without and with an UpRight device on the upper back, which was paired to a smartphone application. The device was calibrated after participants were positioned in an upright posture by a clinician; it then vibrated when posture became flexed ($\sim 5^{\circ}$). Primary outcomes included maximal neck and low back flexion angles. **RESULTS:** Results showed that postural alignment improved with the UpRight device in PD. A significant improvement in neck posture was found in all clinical measures (Tragus; p=.012, Occiput; p=.008, and C7; p=.008). There was also reduction in maximal neck flexion angles during sitting (Average; 8.8° to 5.4°), standing (7.3° to 6.4°) and walking (4.6° to 3.7°) under single-task, particularly for those with Pisa syndrome. However, maximal low back flexion angles did not change, and flexed posture worsened with feedback while using the UpRight under dualtask. Balance and walking were unaffected by the application of the UpRight device (e.g. mediolateral jerk during single-task p=.472 and dual-task p=.338; gait speed during single-task p=.928 and dual-task p=.158). CONCLUSIONS: Our preliminary findings suggest that an off-the-shelf, novel, wearable tactile feedback system can improve postural alignment in PD, particularly neck flexion. However, this kind of tactile feedback may distract attention and is possibly not effective

for low back postural issues. In addition, the device may be safe to use during usual daily activities (walking or standing) but long-term effects and ability of the patient to use the application need to be further investigated on a larger cohort (ongoing investigation in 25 subjects). **ACKNOWLEDGEMENTS AND FUNDING** This research is funded by the Medical Research Foundation of Oregon (PI: Stuart).

P1-K-94 Gait variability decreases with use of carbon fiber footplates in children with idiopathic toe walking

Srikant Vallabhajosula¹, Melissa Scales¹

¹Elon University

BACKGROUND AND AIM: Idiopathic toe walking (ITW) is characterized by a habitual toe-to-toe gait pattern without a known cause. Carbon fiber footplates (CFPs) have been shown to be a promising intervention because of increased wear compliance, foot contact area and stride width, and decreased cost. However, the effect on gait variability in children with ITW is currently unknown. Gait variability has been shown to be higher in children with autism spectrum disorder and developmental coordination disorder. The aim of this study was to investigate the effects of CFPs on gait variability in children with ITW. METHODS: 11 children without ITW acting as a control group (CG; age, 5.73 (1.79) years) and 16 children with ITW (ITWG; age, 5.44 (1.5) years) participated in the study. Participants completed 5 gait trials at a self-selected comfortable pace across a 16' instrumented pressure-based walkway under 2 conditions: first without using CFPs (WOCFP) and then immediately using CFPs. Coefficient of variation (CV) of stride length, time, velocity, and width were obtained. CV was defined as 100*SD/Mean of 5 trials. A group X condition mixed ANOVA was performed. **RESULTS:** Significant interaction (P = 0.022) for stride length showed that WOCFP, ITWG had greater stride length variability than CG (ITWG: 9.3 (1.1)%; CG: 5.3 (1.3)%). But when wearing the CFPs, stride length variability for ITWG decreased to a similar value as that of the CG (ITWG: 6.4 (0.6)%; CG: 6.6 (0.8)%). Significant interaction (P = 0.048) for stride time showed that WOCFP, ITWG had greater stride time variability than CG (ITWG: 7.2 (0.8)%; CG: 4.5 (1)%). But when wearing the CFPs, stride time variability for ITWG decreased to a similar value as that of the CG (ITWG: 5.6 (0.6)%; CG: 6.1 (0.7)%). Trend towards significant interaction for stride velocity (P = 0.069) showed that WOCFP, ITWG had greater stride velocity variability than CG (ITWG: 12.0 (1.1)%; CG: 8.1 (1.3)%). But when wearing the CFPs, stride time variability for ITWG decreased to a similar value as that of the CG (ITWG: 8.6 (1.1)%; CG: 9.6 (1.3)%). Significant interaction (P = 0.039) for stride width showed that WOCFP, ITWG had lesser stride width variability than CG (ITWG: 39.7 (7)%; CG: 47.8 (8.5)%). But when wearing the CFPs, stride width variability for ITWG increased while that of the CG decreased (ITWG: 48.7 (10.6)%; CG: 25.4 (12.8)%). CONCLUSIONS: Wearing CFPs helped decrease gait variability in children with ITW to the levels of children who do not walk on their toes. This was true only in sagittal plane but not frontal plane. Given that CFPs were placed underneath the length of the foot, perhaps it



resulted in biomechanical changes and more regular gait pattern only in the sagittal plane. Decrease in both spatial and temporal gait variability after wearing the CFPs could highlight the potential use of CFPs for improving gait in children with ITW. Whether such benefits carry over to long-term usage of CFPs needs to be determined.

P1-K-95 Treadmill training in a virtual environment improves gait and balance in patients with incomplete spinal cord injury

Rosanne van Dijsseldonk¹, L.A.F. de Jong², B.E. Groen², M. Vos-van der Hulst², A.C.H. Geurts³, N.L.W. Keijsers²

¹Radboudumc & Sint Maartenskliniek, ²Sint Maartenskliniek, ³Radboud University Medical Center

BACKGROUND AND AIM Many patients with incomplete spinal cord injury (iSCI) have impaired gait and balance capacity, which may impact daily functioning. Reduced walking speed and impaired gait stability are considered important underlying factors for reduced daily functioning. With conventional therapy, patients are limited in training gait stability, but gait stability can be trained on a treadmill in a virtual environment, such as with the Gait Real-time Analysis Interactive Lab (GRAIL). Our objective was to evaluate the effect of 6-weeks GRAIL-training on gait and dynamic balance in ambulatory iSCI patients. In addition, the long-term effect was assessed. **METHODS** Fifteen patients with chronic iSCI participated. The GRAIL-training consisted of 12 one-hour training sessions during a 6-week period. Patients performed 2-minute walking tests on the GRAIL in a self-paced mode at the 2nd, and 3rd (baseline measurements) and at the 12th training session (post). Ten patients performed an additional measurement after 6 months (followup). The primary outcome was walking speed. Secondary outcomes were stride length, stride frequency, step width, and balance confidence. In addition, biomechanical gait stability measures based on the position of the center of mass (CoM) or on the extrapolated center of mass (XCoM) relative to the center of pressure (CoP) or to the base of support were derived: dynamic stability margin (DSM), XCoM-CoP distance in anterior-posterior (AP) and medial-lateral (ML) directions, and CoM-CoP inclination angles in AP and ML directions. The effect of GRAIL-training was tested with a one-way repeated measures ANOVA ($\dot{a} = 0.05$) and post-hoc paired samples t-tests ($\dot{a} =$ 0.017). The long-term effect was tested with a paired samples t-test (a=0.05) between post and follow-up measurement. RESULTS Walking speed was higher after GRAIL training (1.04m/s) compared to both baseline measurements (0.85m/s and 0.93m/s) (p<.001) (Figure 1). Significant improvements were also found for stride length (p<.001) and stability measures in AP direction (XCoM-CoPAP (p<.001) and CoM-CoPAP-angle (p<.001)). Stride frequency (p=.27), step width (p=.19), and stability measures DSM (p=.06), XCoM-CoPML (p=.97) and CoM-CoPML-angle (p=.69) did not improve. Balance confidence was increased after GRAIL training (p=.001). At the 6 months follow-up measurement, spatiotemporal gait parameters and gait stability measures remained similar to the post measurement (p>.05) Figure 1. Mean and standard deviation of walking speed, stride length, balance confidence, DSM, XCoM-CoPAP and XCoM-CoPML at the



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four measurements. *indicates a post-hoc significant difference (a=0.017). CONCLUSION Increased walking speed, stride length, AP gait stability, and balance confidence suggests that GRAIL-training improves gait and dynamic balance in patients with chronic iSCI. In contrast, stability measures in ML direction did not respond to GRAIL-training. The effects were retained at 6 months follow-up. ACKNOWLEDGEMENTS AND FUNDING This work is part of the research programme Wearable robotics with project number P16-05, which is financed by the NWO.

L - Effect of medication on posture and gait

P1-L-96 Botulinum toxin injection to the upper limb may indirectly improve gait in patients with post-stroke spasticity- an open-label prospective pilot study

Shani Kimel Naor¹, Oren Cohen², Elizabeta Shprits³, Sharon Hassin-Baer¹, Yael Dotan-Marom¹, Gilad Yahalom¹, Oleg Marzeliak¹, Lilach Ephraty¹, Hanna Strauss¹, Rivka Inzelberg⁴, Meir Plotnik¹

¹Sheba Medical Center, ²Tel-Aviv University, ³Technion, Technological Institute of Israel, ⁴Tel Aviv University

BACKGROUND AND AIM: Botulinum toxin (BonTA) injection is an effective treatment for poststroke upper-limb (UL) spasticity (PSULS) [1-2]. Reduced motility and swing of a spastic arm may further compromise gait in patients with post-stroke spastic hemiparesis [3-4]. Aim: to test the hypothesis that effective treatment of arm spasticity by injection of BonTA to the spastic UL muscles will also improve gait in persons with PSULS. METHODS: BonTA was injected to UL alone, both proximal and distal muscles (mean dose: 1148±382 IU- international units), in consecutive PSULS patients (n=14; age: 58.2±15.4y, 5 women). The following evaluations were performed prior (PRE) and 4-6 weeks following (POST) treatment: 1) Ashworth Spasticity Scale (ASS); 2) Functional Ambulation Classification (FAC); 3) Functional Independence Measure (FIM); 4) Timed Up and Go (TUG); and 5) Computerized gait analysis using GAITRite® (CIR Systems Inc. Clifton) mat including walking speed, cadence, step length, swing time percentage and step width, in the paretic and non-paretic side. PRE and POST performances were compared using non-parametric Wilcoxon signed rank test. RESULTS: ASS scores were significantly improved in the POST as compared to the PRE evaluations $(11.7\pm4.8 \text{ vs.}, 19.9\pm3.5, \text{ respectively, } p<0.001)$, while FAC, FIM, TUG and gait parameters did not differ significantly ($p \ge 0.2$). In a post-hoc analysis we compared a subgroup of participants who showed improvement in at least one gait parameter, i.e. "responders", to a sub group of "non-responders" (see table 1). Clinically, 'responders' had significantly shorter disease duration, compared to "non-responders" (4.6±3.4 years vs. 10.7±3.2, respectively; p=0.019) with a trend for less disability (Pre injection FIM scale score of 93.3±11.1 in responders vs. 103.0±8.3 in non-responders, p=0.09). CONCLUSION: Isolated BonTA injection to the UL can improve gait in a subpopulation of patients with PSULS at a shorter time interval after the stroke. It appears the injection to the spastic UL should be performed rather earlier than later for beneficial effects on gait. Future studies in larger cohorts are required to substantiate our

findings, and to elucidate the importance of early intervention for maximizing outcome. **REFERENCES:**[1] Jost WH, Benecke R, Hauschke D, Jankovic J, Kaňovský P, Roggenkämper P, Simpson DM, Comella CL. Clinical and pharmacological properties of incobotulinumtoxin A and its use in neurological disorders. Drug Des Devel Ther. 2015; 9:1913-26 [2] Esquenazi A, Mayer N, Garreta R. Influence of botulinum toxin type A treatment of elbow flexor spasticity on hemiparetic gait. Am J Phys Med Rehabil. 2008; 87(4):305-10 [3] Hirsch MA, Westhoff B, Toole T, Haupenthal S, Krauspe R, Hefter H. Association between Botulinum Toxin injection into the arm and changes in gait in adults after stroke. Movement Disorders 2005; 20: 1014-20 [4] Esquenazi A, Talaty M. Normal and pathological gait analysis. In: Grabois M, Garrison SJ, Hart KA, Lehmkuhl LD (eds) Physical Medicine and Rehabilitation: The Complete Approach. Malden, Blackwell Science, 2000; 242-62.

P1-L-97 Evaluation of adult cerebral palsy gait with spasticity of gluteus medius anterior fibers before and after local treatment with botulinum toxin

Philippe Thoumie¹, Florence Babany¹

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RESEARCH

ispgr

¹Hospital Rothschild APHP Sorbonne University

BACKGROUND: The adult cerebral palsy gait is often observed with internal rotation of lower limb, especially in diplegic and hemiplegic forms. Walking disabilities could be the consequence of gluteus medius anterior fibers spasticity. A monocenter prospective pilot study was to assess the clinical and paraclinical progression of hip internal rotation, velocity and Functional Ambulation Performance (FAP) score index after local treatment of spasticity with botulinum toxin. **METHODS:** We included eight patients (nine hips) with a follow up to five weeks. Clinical (questionnaire, spasticity) and instrumental (walking on GAITRite®) assessment were performed at the beginning and at the end of the study. **RESULTS:** The FAP was significantly higher (10%) after botulinum toxin (80 to 87, p<0.05) during gait with cognitive task. There was no significant impact on internal rotation and gait velocity. The patients felt better with a fluider gait and less fall. **CONCLUSION:** Botulinum toxin increased the gait performance of adult cerebral palsy with gluteus medius anterior fibers. A randomised prospective multicentric study would be appropriate to confirm the preliminary results and to assess the impact of quality of life. Key words: cerebral palsy/ spasticity/ gluteus medius anterior fibers/ Functional Ambulation Performance (FAP).

M - Exercise and physical activity

P1-M-98 Evaluation of measurement properties of the instrumented and repeated Timed Up and Go (5iTUG)

Ronny Bergquist¹, Corinna Nerz², Kristin Taraldsen¹, Clemens Becker², Sabato Mellone³, Beatrix Vereijken⁴, Jorunn Helbostad⁴, Stefanie Mikolaizak²





¹Norwegian University of Science and Technology, ²Robert-Bosch-Krankenhaus, ³University of Bologna, ⁴The Norwegian University of Science and Technology (NTNU)

BACKGROUND AND AIM: In order to tailor interventions, objective assessments of physical function is needed. A limitation of several of today's clinical assessments is that they require too much time and/or space. The Timed Up and Go (TUG), commonly used to clinically assess physical function in older populations, is particularly useful due to the short time and little space required for administration. Instrumented versions of TUG (iTUG) are able to objectively capture movement features throughout the test duration in addition to the traditional outcome measure which is the total duration in seconds. Repeated TUG measures could further provide a proxy of physical performance otherwise obtained through for example the Five times sit-to-stand (5STS), gait assessment or the Short Physical Performance Battery (SPPB). The aim of this study is to evaluate the construct- and discriminative validity of outcomes derived from sensor signals recorded with a smartphone during a five times repeated iTUG (5iTUG) compared to standard physical performance-based measures. METHODS: This method study will recruit 20 communitydwelling older adults, 40 patients from the geriatric rehabilitation ward and out-patient clinic. We will include persons aged 60 to 80 years old, with the ability to walk 30 meters without support. Exclusion criteria include reports of any cardiovascular, pulmonary, neurological, or mental diseases. The 5iTUG consists of five repeated repetitions of the TUG, with 30 seconds between each repetition. Participants will wear a smartphone attached with a belt to their lower back during the entire test sequence. Five traditional clinical tests will be administrated: 5STS, 7m gait (fast and habitual), 30-second sit-to-stand, the SPPB, and the Community Balance and Mobility scale. Participants will be randomised to start with either 5iTUG or the clinical tests. From the sensors embedded within the smartphone, signal features such as the durations of the sub-phases of the TUG (sit-to-stand, walk, turn, second walk and second turn, turn-to-sit), and selected parameters from the walking phase will be derived. The clinical tests will be performed and scored according to standardised operating procedures for the respective tests. The construct validity of the 5iTUG will be analysed by use of correlations between selected signal features and the other clinical tests as well as activities of daily living (ADL) function (the Late Life Function and Disability (LLFDI) questionnaire). The ability of the 5iTUG-features to discriminate between patient groups and performance based measures and function will be evaluated and compared. Statistics will include univariate and multivariate regression models, and discrimination ability will be assessed using a receiver operating characteristic (ROC) curve with 95% confidence intervals. RESULTS: Recruitment of participants is ongoing, and data will be processed and analysed prior to the conference. CONCLUSIONS: At the ISPGR World Congress 2019 the newly developed instrumented version of 5iTUG will be presented along with a discussion of the measurement properties of this test when used in healthy older adults and geriatric patients. Harmonisation with standard clinical measures will be presented.





P1-M-99 Controlling the uncontrollable - perceptions of balance in people with Parkinson's disease

Hanna Johansson¹, Erika Franzén¹, Kirsti Skavberg Roaldsen¹, Maria Hagströmer¹, Breiffni Leavy¹

¹Karolinska Institutet

BACKGROUND AND AIM Exercise improves balance in Parkinson's disease (PD), yet the majority of people with the diagnosis are physically inactive.1 Knowing how patients perceive their symptoms, and their perceptions on whether they can influence them, are important to how physical therapists communicate and motivate interventions. No previous study has qualitatively explored how people with PD (PwPD) perceive the concept of balance and the beliefs they hold concerning whether balance can be affected. The aim is therefor to explore what the concept of balance means to PwPD and the perceptions they hold regarding their ability to influence their balance control. METHODS A qualitative study with an inductive approach was performed. Indepth interviews were conducted with 18 participants with PD, and transcripts were analyzed using qualitative content analysis. RESULTS Five main themes emerged from the analysis: Remaining in control over the body; Adapting behavior to deal with uncertainty; Directing focus to stay one step ahead; Resilience as a defense and Exercise beliefs and reservations. Interpretation of the underlying patterns in the main themes resulted in formation of the overarching theme "Focus and determination to regain control over shifting balance". CONCLUSIONS The concept of balance was perceived as both bodily equilibrium and mind-body interplay, and was described in the context of remaining in control over body and life. Cognitive resources were utilized in order to direct focus and attention during balance challenging situations in a process involving internal dialogue. Even participants who did not express beliefs in the ability to affect balance through exercise used psychological resilience to counter the challenges of impaired balance. **ACKNOWLEDGEMENTS AND FUNDING** We thank all participants for making this study possible. We also thank PT Sofie LaGrone for her help with recruitment and clinical testing of participants. This study was supported by grants from the Doctoral School in Health Care Sciences, the Swedish Research Council for Health, Working Life and Welfare (FORTE), Parkinson Research Foundation, the Swedish Parkinson Foundation, and the Swedish Research Council. Conflicts of Interest: none declared. 1Benka Wallen M, Franzen E, Nero H, Hagstromer M. Levels and Patterns of Physical Activity and Sedentary Behavior in Elderly People With Mild to Moderate Parkinson Disease. Physical therapy. 2015;95(8): 1135-1141.

P1-M-100 Athletes adopt different control strategies compared to non-athletes with increased postural demands

Jenna Pitman¹, Rhianna Malcolm¹, David Shulman¹, Becky Breau¹, Michael Cinelli², Lori Ann Vallis¹

¹University of Guelph, ²Wilfrid Laurier University



BACKGROUND AND AIM: Evidence-based guidelines can facilitate the proper evaluation of concussions in an athletic population (Stern et al J Neurotrauma 2017, 34(4):861-868). Recent advances in technology have made valid (Hearn et al Clin J Sport Med 2018, 28(2):177-179) consumer-grade force plates more affordable and as such, posturography measures can be used more frequently in the accurate diagnosis and treatment of concussions. We know athletes typically have more optimized postural control compared to non-athletes (Williams et al J Sport Health Sci 2016, 5(1):70-76) due to an increased exposure to posturally demanding situations (Thompson et al Sports 2017, 5(4):86). Awareness of a population's athletic background is crucial for appropriate baseline testing. This project compares postural measures in competitive athletes to non-athletes and investigates baseline differences using a portable force plate. We hypothesized that at baseline, athletes will present altered postural control compared to nonathletes, demonstrated by smaller overall center of pressure (CoP) displacement and reduced sway velocity values. METHODS: Non-athlete young adults (NA; N=33; 22.3±1.7 years; 17 males) and Varsity athletes (AT;N=21; 21.2±2.2 years; 11 males) were asked to stand for 60 seconds on a BTrackS (Balance Tracking Systems, San Diego, CA) force plate. Anteroposterior (AP) and Mediolateral (ML) CoP data were sampled at 25Hz. Participants performed 8 conditions of trials; 4 are highlighted here: eyes open (EO), eyes closed (EC), EO compliant surface (CS), and EC CS. Cumulative path length (PL: $\sqrt{(\Delta AP^2 + \Delta ML^2)}$, ML and AP of COP mean velocity (MV) and root means squared (RMS) were calculated. One AT was unable to complete the protocol and removed from analysis. A mixed factorial ANOVA was performed across groups, visual input, and surface compliance. **RESULTS:** There was a significant interaction (Group x Vision; p<0.05) for PL and AP MV. Specifically, AT showed significantly higher AP MV (1.07 ± 0.04 cm/s) in EC compared to EO (0.72 ± 0.04 cm), while NA slightly increased AP MV in EC (0.79 ± 0.03 cm/s) compared to EO (0.68 ± 0.03 cm/s). As task difficulty increased from EO to EC in CS conditions (Vision x Support interaction collapsed across Group; p<0.001) AP MV (0.69 ± 0.03 to 1.14 ± 0.02 cm/s, respectively) and ML MV (0.50 ± 0.02 to 0.59 ± 0.02 cm/s, respectively) also increased. **CONCLUSIONS:** In contrast to our hypothesis, AT showed significantly higher values in sway velocity despite their increased dynamic training. Kuczyński et al. (Hum Mov 2009, 10(1):12-15) found that volleyball players showed significantly higher CoP velocity, perhaps due to a unique sensory integration strategy. Our findings appear to agree with this observation, and suggest that athletes have postural control strategies that are different than untrained individuals. Obtaining baseline measures is critical if posturography is to be used for concussion diagnostics and treatment in athletes.

P1-M-101 Could lifestyle-integrated exercise interventions change physical activity behavior of young older adults?

Gaelle Prigent¹, Anisoara Ionescu¹, Wei Zhang¹, Kristin Taraldsen², Beatrix Vereijken³, Jorunn L. Helbostad³, Kamiar Aminian¹





¹Ecole Polytechnique Fédérale de Lausanne (EPFL), ²Norwegian University of Science and Technology, ³The Norwegian University of Science and Technology (NTNU)

BACKGROUND AND AIM: An important dimension of physical activity (PA) behavior is the temporal pattern reflecting how motion features are interwoven in daily life. The complexity of this pattern, quantified comprehensively in terms of diversity, intensity and moment-to-moment variations of activities, is believed to reflect a subject's ability to timely respond to environmental demands and to adapt to internal states [1]. In the context of the EU project PreventIT, we investigated the ability of complexity and classical metrics to capture subtle changes in PA behavior of young older adults, as a result of personalized interventions based on exercises that are embedded into daily life. We hypothesized that effective changes in PA behavior would be associated with the intensity of intervention. • METHODS: We analyzed data from a RCT including 120 young older adults (61-70yrs) from the life-style integrated interventions (delivered by the use of ICT or a paper based manual). A list of personalized exercises of different type (balance, strength, physical activity) were suggested to each participant based on their capacities at baseline. Participant were free to select the type and number of exercises to be embedded into daily life and the total number of exercise (NE) as the intensity of intervention. PA was monitored during one week using an accelerator placed on the lower back. Sedentary and active periods, as well as walking bouts were estimated. Based on back acceleration intensity, cadence and duration of walking bouts 25 states were defined and a time series (1s interval) signal Lj(t), j=[1,...25] was calculated. The complexity metric (LZ) was defined as the entropy of Li(t) over the week using Lempel Ziv algorithm [2]. Participants were assessed at baseline and after the 6 months active intervention period using complexity and classical metrics (% active, % sedentary, etc.). **RESULTS:** The number of participants with complete assessment data at baseline, and 6 months follow-up was n=120 and n=74, respectively. Participants were grouped into two groups: GLow (NE<5) and GHigh (NE>11)). Compared to low volume response (GLow), participants with high volume response (GHigh) had a significant increase (p=0.04) in complexity (LZ) post-intervention (Fig. 1a). A trend of decreased sedentary time was also observed (p=0.26), as well as increased active time (p=0.03) for GHigh. · CONCLUSIONS: The difference observed between GLow and GHigh was modest in terms of PA behavior. However, the increased complexity and time spent being active for high volume response participants, may appear as a beneficial effect of the lifestyle integrated intervention. This program was designed to improve balance, strength and physical activities by embedding exercises, such as squatting, in daily routines. This type of exercise would make participants activity more diverse and dynamics as shown by complexity change but would not necessarily influence sedentary and active percent of time, which might explain why the change observed for GHigh is small. • ACKNOWLEDGEMENTS AND FUNDING: [1] 10.1159/000490310 [2] 10.1371/journal.pone.0032239.

P1-M-102 Predicting physical activity in obese and normal weight older adults based on cognitive and physical function





INTERNATIONAL SOCIETY OF POSTURE & GAIT RESEARCH

Noah Rosenblatt¹, Sai Yalla¹

¹Rosalind Franklin University of Medicine and Science

BACKGROUND AND AIM: Obesity impairs balance and cognitive function which are critical for mobility. In turn, obesity-related declines may negatively impact activity. Nonetheless, physical activity patterns between obese and normal weight older adults are not well described. Moreover, while the relationship between physical activity, gait and balance in older adults has been extensively researched, the effect of executive-functioning, particularly in obese older adults is not well known. The aim of this study was to use regression approaches to study how executivefunctioning, gait and balance affect physical activity parameters in normal-weight and obese older adults. METHODS: We recruited 23 community-dwelling obese older adults (age: 71.8±1.0 yrs, BMI: 34.8±0.9 kg/m2) and 22 normal-weight older adults (71.6±1.5 yrs, 22.8±0.4 kg/m2) without osteoporosis, neuropathy, or musculoskeletal conditions. Participants completed: 1) Surveys: falls self-efficacy (FES score), anxiety (Speilberger Trait Anxiety), physical-and-mental-health related quality of life (SF-12) and fall history; 2) Gait and balance tests: 10 meter walk, timed-up-and-go, figure 8 walk, single leg stance (SLS) test; 3) a quantitative gait analysis; 4) five cognitive assessments in the NIH tool box: working memory, inhibitory control and attention, sequence memory, processing speed, and cognitive flexibility. One week of physical activity data was captured using PAMSys pendant sensor. All variables, excluding activity and gait data, were coded as above or below normative data from the literature. Mann Whitney U tests were used to compare physical activity parameters between groups. Rather than use step duration or step count alone as a predictor variable in a simple linear regression, which may provide misleading results - e.g., obese with slow cadence may walk for longer duration than normal adults with faster cadence to cover the same distance - we used a derived term representing the interaction (product) of walking duration (hr/day) and steps/hour. **RESULTS:** Obese participants spent 20% less time walking per day (p<.05). During each walking episode, normal-weight subjects took 59% more steps (p=0.001) with higher cadence than obese subjects. Obese participants took significantly fewer steps/day than normal weight (4869±676 vs 6543±670; p=0.01) and walked on average for less time: (1.30±0.2 hrs/day vs. 1.6±0.2 hrs/day, p=0.04). Simple linear regression showed that trait anxiety, SLS time, attention inhibition control and double-support time play a significant role in explaining the interaction of walking hours and steps per hour (F(9,16)=4.82,p<0.011, R2=0.896; Figure 1). CONCLUSIONS: Based on our model, cognitive functioning (Flanker inhibition) may play a role in increasing physical activity, and in obese older adults below normal SLS may be a strong predictor of low activity. In obese older adults, improving skills associated with SLS may help promote day-to-day activity, after which further improvements may be attainable by addressing cognitive functioning. Future studies should simultaneously consider walking duration and step count when measuring physical activity. ACKNOWLEDGEMENTS AND FUNDING: This work was partially supported by the NIH award number.



P1-M-103 Posture of lunge motion during a shuttle sprint test in soft tennis elite players

Hidenori Shinohara¹, Koji Kawakami², Kazutaka Takahashi³, Ayane Ogura⁴, Kenji Takahashi⁵, Hirofumi Ida⁴

¹Nippon Sports Science University, ²Sports Intelligence, ³University of Tsukuba, ⁴Jobu University, ⁵Aichi Gakusen University

BACKGROUND AND AIM: Athletes in ball games are required to strengthen SAQ (Speed, Agility, Quickness) ability, and at the same time, to acquire the control skills of their posture and movement for intended action. In soft tennis, a variant of tennis using a soft rubber ball and one of the official events in the Asian Games, groundstrokes were executed with relatively wide stance and low squatting position, known as 'lunge'. Thus, a shuttle sprint test that simulates the run and lunge cut movement in groundstroke has been developed to test SAQ ability of soft tennis players in the All Japan team. The purpose of this study was to investigate the posture of the lunge motion during the shuttle sprint test in terms of sexual difference and warming-up effect. METHODS: Ten male and 10 female (17.6 ± 1.3 and 16.5 ± 1.2 years old, respectively) elite soft tennis players of the All Japan team participated in the study. Half of the male and female participants warmed themselves up with lunge trainings (lunge group) in addition to general exercise and the other half did without lunge training (no-lunge group). After the warming-up session, all participants underwent the shuttle sprint test. The sprint time was measured using a wireless photocell system. In addition, the lunge motion was recorded using two high-speed digital video cameras at the sampling rate of 120 Hz and digitized on motion analysis software. Then the stride length, hip height, and trunk inclination angle (forward and lateral inclination) were calculated. The female lunge group was excluded in the following statistical analyses because there were missing data. **RESULTS:** No significant difference was shown between the lunge $(3.05 \pm 0.15 \text{ s})$ and no-lunge $(2.88 \pm 0.08 \text{ s})$ groups in the sprint time of the male participants. Meanwhile, the time of the male no-lunge group was significantly shorter than that of the female no-lunge group $(3.18 \pm 0.07 \text{ s})$. There were no significant differences between the male lunge and male no-lunge groups in the stride length, hip height, and trunk inclination angle. On the other hand, the male no-lunge group showed significantly higher hip height (0.56 ± 0.04 m) and greater trunk inclination angle ($67.6 \pm$ 8.0 deg) than the female no-lunge group (0.49 \pm 0.04 m and 57.1 \pm 2.4 deg, respectively). **CONCLUSIONS:** The results suggested that the male and female soft tennis players employed different postural movement strategy while executing a lunge motion in the shuttle sprint test. However, the effect of lunge training in warming-up session was not demonstrated in this study.

N - Falls and fall prevention

P1-N-104 Comparing muscle power and muscle strength training using Thera-band for reducing fall risk in community-dwelling older adults

Kenneth Cheng¹, Kim Chan¹





¹Chinese University of Hong Kong

SOCIETY OF

RESEARCH

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BACKGROUND AND AIM: Fall represents one of the leading causes of accidental injuries and death among the older population. With a fast growing aging population, prevalence of falls is expected to increase. In comparison to other countries, Hong Kong older adults were found to have lower muscular strength and impaired balance control, which are key risk factors for falls [1]. Traditionally, fall prevention exercise tended to focus on strength training (ST); however, recently there is an increased awareness that muscle power training (PT) should be involved to increase the effectiveness of fall prevention programs [2]. Specifically, muscle power is required to produce fast ballistic limb movement, which plays crucial roles in gait initiation and termination, sudden turning, standing up from a seated position, as well as the execution of rapid stepping and grasping balance-recovery reactions when exposed to unexpected balance disturbances. It is possible that PT may have additional benefits than ST in restoring older adult's dynamic balance control. Therefore, the objective of this study is to compare the effectiveness of PT and ST on reducing fall risk in older adults. METHODS: Community-dwelling older adults with some balance impairment (BBS < 52/56) were recruited to participant in twenty-four 1-hour training sessions to be completed within 12 weeks. They were cluster randomized into one of three groups: (1) muscle power training group (i.e. 3 sets of 6-10 repetitions with moderate resistance; rapid concentric and slow eccentric movements), (2) muscle strength training group (i.e. 3 sets of 3-5 repetitions with high resistance, slow concentric and eccentric movements), or (3) flexibility training group which serves as a control for this study. Instead of using weight machines or free weights, resistance elastic bands were used to train upper and lower limb muscles. All exercise programmes were guided by trained staffs to ensure proper resistance and techniques were used. Berg Balance Scale (BBS), Timed-Up and Go (TUG), and the Activities-specific Balance Confidence Scale (ABC) were used to evaluate their fall risk before and after training. RESULTS: Preliminary analyses revealed significant time main effect and time x group interaction for BBS, and trend for time x group interaction for TUG. Post-hoc analyses revealed no significant difference between PT and ST groups, though they have made significantly better improvement in their BBS and TUG scores than the control group. CONCLUSIONS: Our preliminary results showed that ST and PT were equally effective in lowering older adults' fall risk. Future studies are needed to determine whether PT is more effective than ST in restoring older adults' ability to executive rapid balance-recovery reactions for fall prevention. ACKNOWLEDGEMENTS AND FUNDING: Early Career Scheme (grant #24609016) REFERENCES:1. Kwan, et al., J Gerontol A, 68:946-53, 2013. 2. Skelton, et al., Age Ageing, 31:119-25, 2002.

P1-N-105 Is there an optimal recovery step landing range to prevent backward fall from slips: Evidence from large-scale overground slips

Tanvi Bhatt¹, Shuaijie Wang¹, Yiru (Emma) Wang¹

¹University of Illinois at Chicago





BACKGROUND: It is known that recovery stepping post-slip can rebuild the base of support and provide extra limb support to retard hip descent, and thus prevent a fall1, 2. Yet, less is known whether the exact recovery foot placement could affect the recovery likelihood and change the fall outcome post-slip. The study purpose was to examine whether there is an optimal recovery step landing range, within which older adults (OA) would have a highest recovery likelihood post gait-slip. Method: 195 OA (>65 yrs) experienced a novel, unannounced over-ground slip during gait. The center of mass (COM) state and hip kinematics were analyzed. A fall was identified if peak loadcell force exceeded 30% of body weight, else, the slip outcome was a recovery. Distance from the recovery foot landing position (toe of recovery foot) to COM was firstly divided into 40 subranges from -2 to 2 x foot length (FL) (+/- indicates landing posterior/anterior to COM respectively). The recovery rate = number of recoveries/the total slips in which the recovery foot placed within this subrange. If there was an optimal recovery range as expected, the subranges could be further grouped into three parts: the optimal landing range (OPT, recovery rate >50%), the backward landing range posterior to the OPT (BWD, recovery rate <50%) and the forward landing range anterior to the OPT (FWD, recovery rate <50%). Moreover, the recovery limb joint moments in sagittal plane at pre-liftoff (100 ms prior to recovery foot liftoff) and mid-swing (the instant when the recovery foot reach its maximum height) were compared among OPT, BWD and FWD. **RESULTS:** The results showed that a longer distance between the recovery foot landing position and the projected COM position at the recovery foot touchdown was conducive to stability (COM state) improvement but was adverse to limb support (hip kinematics) enhancement, and vice versa. Overall, recovery landing position could predict the recovery likelihood (accuracy =67.3%, OR =0.1, p<0.001) based on logistic regression, and if placed in the range between -0.3 and 0.3 × FL relative to the COM, the recovery rate increased to > 50%. According to the distribution of recovery rate for subranges, there was an OPT (between -0.3 and 0.3 × FL), a BWD (< $-0.3 \times$ FL) and a FWD (>0.3 × FL). Moreover, subjects landed in BWD had significant larger plantar flexor and hip flexor moments at pre-LLO compared to FWD and OPT, while the subjects landed in FWD had significant smaller hip and knee extensor moments compared to BWD and OPT. CONCLUSION: This study revealed that recovery foot placement could affect the recovery likelihood after a slip, and specifically we discovered an optimal landing range which guaranteed >50% recovery rate. In order to locate the recovery foot in the optimal range, individuals should apply sufficient plantar flexor and hip flexor moments in the pre-swing phase, as well as sufficient hip and knee extensor moments during preparation for foot touchdown. 1. Wang S., X. Liu, A. Lee and Y.-C. Pai. Can Recovery Foot Placement Affect Older Adults' Slip-Fall Severity? Annals of Biomedical Engineering 1-8, 2017. 2. Yang F., T. Bhatt and Y. C. Pai. Role of stability and limb support in recovery against a fall following a novel slip induced in differ.

P1-N-106 Towards tailored fall prevention: identifying modifiable risk factors in older people

Femke Hulzinga¹, Kimberley van Schooten², Kim Delbaere²





¹KU Leuven, ²Neuroscience Research Australia, University of New South Wales

BACKGROUND AND AIM: Numerous risk factors for falls in older people have been identified and several fall risk prediction models have been developed. The risk factors used in such models are often focused on physical health only or include factors that cannot be modified by intervention. Previous research has shown that there are three key domains to distinguish intrinsic fall risk factors: Moving (physical), Thinking (cognitive) and Feeling (psychological). The aim of this study was to create a fall risk classification model based on these domains, to identify individualized, modifiable fall risk factors and steer towards more targeted and personalised interventions. METHODS: Participants were part of the StandingTall randomized controlled trial. They were 77±6 years old, 68% were female, 38% had a history of falls and 34% experienced multiple falls or injurious falls during a 1-year prospective follow up. All participants performed a baseline assessment including physical, cognitive and neuropsychological tests. The model was developed on retrospective falls data of the total sample (N=504) and validated on the prospective data of the control group (N=224). Risk factors were identified via univariable (preselection with P<0.10) and multivariable logistic regression (forward stepwise with P<0.05). The risk factors were implemented into a decision tree to evaluate the effect of different combinations of factors on fall risk. The decision tree was subsequently validated on 1-year prospective falls data. RESULTS: Regression analyses identified risk factors in all three domains: Moving, Thinking and Feeling, A combination of the Patient Health Questionnaire (PHQ-9) for depressive symptoms (Feeling), the Victoria Stroop Task efficiency for executive function (Thinking) and the Physiological Profile Assessment (PPA) for sensorimotor function (Moving) associated best with retrospective fall risk, and these variables were subsequently entered into a decision tree analysis. The first branch was based on the Thinking domain. For people with impaired executive function, having depressive symptoms further influenced fall risk. This Feeling component was only present in people with impaired executive function. All end nodes were based on the Moving component, and consistently differentiated between low, medium and high sensorimotor function. Decision tree analysis showed that falls were most likely when all three risk factors were present and lowest in people without any risk factors. CONCLUSION: This model can provide a structured and convenient way to classify fall risk factors in older people, and steer towards personalized fall prevention interventions based on three domains: Moving, Thinking and Feeling. Future studies should investigate the implementation of this model as a clinical tool to recommend intervention programs based on impairments in the Moving, Thinking and Feeling domains.

P1-N-107 Falls in a longitudinal Parkinson's disease cohort: What can we learn from baseline gait assessment in non-fallers over six years?

Heather Hunter¹, Lisa Alcock², Sue Lord³, Rosie Morris⁴, Lynn Rochester⁵, Alison Yarnall²





¹Newcastle-upon-Tyne Hospitals NHS Foundation Trust, ²Newcastle University, ³Auckland University of Technology, ⁴Oregon Health & Science University, ⁵Institute of Neuroscience, Newcastle University

BACKGROUND AND AIM People with Parkinson's disease (PD) fall more frequently than those with other neurological conditions [1]. Understanding falls evolution is important to identify falls risk and develop effective falls prevention tools [2]. A large number of risk factors have been described [3], however, the best predictor of a future fall is previous fall. Clinicians need to understand what protects people from falling and what differentiates non-fallers in PD. This study examined baseline clinical, cognitive, and gait differences in fallers and non-fallers in the six years following diagnosis. Methods PD participants (n=119) were recruited to ICICLE-GAIT within 4 months of diagnosis. Participants completed falls diaries and underwent comprehensive clinical (including medication history, disease severity using MDS-UPDRS, depression, Activities-specific Balance Confidence Scale (ABC)), cognitive (global cognition, attention tests) and gait assessment every 18 months from baseline. Gait was measured using an instrumented walkway (GAITRite, 240Hz) and assessed under single (ST) and dual task (DT; Welchsler digit span) conditions. Participants were stratified into fallers and non-fallers at 72 months post diagnosis using falls diaries excluding those who reported a fall in the year prior to diagnosis. Betweengroup baseline measures were compared using non-parametric t-tests (Mann-Whitney U or Chi squared test). Due to multiple testing, a p value of <0.01 was considered significant. Results Ninety-six participants (54 male) (including 26 retrospective fallers who were excluded) returned falls diaries. By 72 months, only 11 (11.5%) participants had not yet fallen. Most participants reported their first fall within 36 months (76%). Baseline clinical characteristics (Table 1) demonstrated that non-fallers had lower UPDRS scores compared to fallers however these were considered not significant at p<.01. Non-fallers walked faster (p=.005) during ST walking compared to fallers. During DT, non-fallers walked faster (p=.002) with greater step length (p=.009), shorter stance time (p=.003) and reduced variability (step time p=.002; stance time p=.007). Conclusions People with PD who remain non-fallers during the first six years from diagnosis generally have a more benign presentation with less severe motor and non-motor symptoms at baseline. During complex walking under dual-task conditions, where attentional resource was required, a number of features of gait were significantly different in the non-fallers, in particular a reduced temporal variability. These findings may be useful in combination with other clinical measures to identify and mitigate fall risk in PD. [1] Stolze et al. 2004 Journal of Neurology [2] Lord et al. 2017 Journal of Neurology [3] van der Marck et al. 2014 Parkinsonism Related Disorders [4] Lord et al 2016 Movement Disorders Acknowledgements: NIHR BRU, PD UK, NIHR Infrastructure CRF funding.

P1-N-108 Motoric Cognitive Risk syndrome, falls incidence and trajectory of gait and cognitive change in an octogenarian cohort: Te Puawaitanga o Nga Tapuwae Kia Ora Tonu, LiLACS NZ





Sue Lord¹, Simon Moyes², Ruth Teh², Waiora Port², Marama Muru-Lanning², Catherine Bacon², Tim Wilkinson³, Ngaire Kerse²

¹Auckland University of Technology, ²University of Auckland, ³Otago University

BACKGROUND AND AIM A combination of slow gait speed and cognitive complaints comprise the Motoric Cognitive Risk (MCR) Syndrome1 which is associated globally with increased falls risk2. The MCR syndrome has high potential as a clinical tool for falls prediction, but its prevalence and utility has not been examined in New Zealand. Methods This study was embedded in a prospective cohort study examining falls risk in Māori and non-Māori octogenarians. A comprehensive assessment battery was administered annually for 6 years. MCR syndrome was defined by baseline 3m gait speed (I SD below cohort mean) & subjective memory loss. Participants were asked to recall number of falls over the previous 12 months at each visit. Trajectory of change in gait and cognition (modified Mini Mental Status Examination) was modelled using Latent Growth Class analysis based on repeated measures and prospective falls risk was estimated using GEE adjusted for demographic and clinical predictors. Results The mean(SD) age of Maori participants (n = 421) was 82.6 (2.7) years and non-Maori participants (n = 516) was 84.6 (.51) years. Baseline falls were reported by 138 (32.7%) Māori and 205 (39.7%) non-Māori participants. MCR prevalence was low with just 11 Māori (2.5%) and 7 non-Māori (1.6%) participants meeting criteria (MCR total cohort n = 436) and no further MCR analysis was undertaken. Modelling revealed distinct gait and cognition trajectories for Māori and non-Māori with four cognitive clusters for Māori and three for non-Māori, and three gait clusters for both groups. Gait speed in non-Maori was significantly associated with falls risk over 6 years (P < 0.001). Conclusions MCR prevalence, falls status, and trajectories of gait & cognition suggest a high preservation of function in this cohort. Prevalence of MCR syndrome was low compared to global estimates, but highly comparable to a Tasmanian cohort2. Gait rather than cognition predicts falls over time for these octogenarian cohorts. References 1. Verghese J, Ayers E, Barzilai N, et al. Motoric Cognitive Risk Syndrome: Multicenter incidence study. Neurology. 2014;83(24):2278-84. 2. Callisaya ML, Ayers E, Barzilai N, et al. Motoric Cognitive Risk Syndrome and Falls Risk: A Multi-Center Study. J Alzheimers Dis. 2016;53(3):1043-52.

P1-N-109 Increasing plantar somatosensory performance on the one leg stance test in elderly

Emmanuelle Pivron Braquet¹, Marc Janin²

¹PODOLOGUE, ²Université de Pau et des pays L'adour

BACKGROUND: Daily life requires control of standing posture (1). The decline in the balance functions recognized as a risk factor for falls in the elderly (2). Therefore the testing of balance performance should be taken into consideration (3, 4). Many tests may be used to evaluate balance, among which the 1-leg stance test (OLS) - also referred unipedal, or single leg stance





test (2, 5-7). Literature reports that elder individuals with a history of falls touch their non-weightbearing foot to the ground three times more often than elder individuals with no history of falls during the 30 seconds of unilateral standing test (7). However, impaired one-leg balance is significant predictor of fall risk or fall injury risk with a relative vulnerability doubling in value if the time required to stand on one leg is under 5s (7, 9). Performance in the OLS is age-specific, with normative values during clinician's evaluation, so a group of age-matched controls can be compared (i.e 15s for 70-79 age, 9). This timing performance could be improved by semi-custom arch supports, which enhance somatosensory stimulation of the skin on the plantar aspect of the foot (7). Posterior Bar (PBs) have also been used to promote somatosensory of the plantar foot sole in elderly (10, 11). We hypothesized that increasing the somatosensory by PBs would improve performance in elder subjects who demonstrated poor balance on OLS. METHODS: 19 elderly women (77.52 years ; Å 6.77 years) presented an OSL under the normative values. Thin PBs - 2 mm of 60sh in resin (9) - were applied on rare foot/midfoot junction under each foot (8, 9). OSL was conduct randomly on the left and right foot. Times without PBs were compared to normative values (8) and with PBs. Result: distributions were normal (KS>.20). Without PBs, all subjects were under the normative values (11s < OLS time < 11.4s). PBs had an immediate significant effect on improving subjects' balance performance (ANOVA, F=4.95; p<0.05; 13s < OLS time with PBs < 13.1s). DISCUSSION: PBs had a relatively significant effect on OLS improving subjects' balance performance of iÖ 15% time up. Those improvements were instantaneous, and similar to footorthotic intervention (8). A difference in OLS addition time between foot-orthotic intervention and our results may be due to difference into stimulations thickness and localisation. Following the plantar pressure thresholds detection on the plantar surface, the heel is lower than the arch, so we may be able to induce similar performance response by varying in sole's thickness. In terms of localisation, the artefacts improved pelvic stability and reinforced the neuromuscular synergy between the foot and balance function. These data could then be used to evaluate the efficacy of custom foot orthoses or plantar stimulation. One main clinical implication is that improving somatosensory foot sole could be used in the prevention of falls and to improve balance function among elderly patients.

P1-N-110 Aggressive proactive balance training using a multi-directional harness system and adapted video gaming: a case series

M Ann Reinthal¹, Debbie Espy¹, Lorenzo Bianco¹, John DeMarco¹, Emily Punchak¹

¹Cleveland State University

BACKGROUND AND AIM: Fall risk increases with advancing age; falling can cause serious injury or decreased activity due to fear of falling. Balance training is used to prevent falls and can be proactive or reactive. Proactive balance training is most common clinically, and is typically less aggressive, less like real-world causes of falls, and not as effective at reducing falls compared to reactive training. We hypothesize that more intense proactive training may be as effective in





preventing falls as a reactive protocol and in addition may positively impact participants' balance abilities, overall mobility, and activity levels. The purpose of this case series was to implement a short, aggressive, proactive balance training protocol using a multi-directional harness system with adapted commercial video gaming, and to show that it can be used safely and effectively to improve balance capabilities and confidence in older adults with balance difficulties and a fear of falling. METHODS: Five adults over age 55 (demographic summary in Table 1) with self-identified balance and mobility impairments participated. During the pre-test and post-test sessions, the subjects completed: Berg Balance Scale (Berg), Timed-Up and Go (TUG), Cognitive TUG, and the Activities-Specific Balance Confidence Scale (ABC). During the seven one-hour intervention sessions, they played adapted Xbox One (Kinect) video games on various balance training surfaces while using the 7' x 8' multidirectional harness system (Enliten). Game difficulty and surface type were continuously modified to maintain high intensity training using an algorithm based on the subject's Rate of Perceived Stability (RPS) scores. Motion data (Motion Analysis Corp) were used to measure base of support (BOS), center of mass (COM), movement excursion and velocity while playing the games. RESULTS: Clinical balance tests scores improved from pre to post-test sessions for the Berg, TUG, and cognitive TUG, as shown in Table 1. However, ABC scores of two participants got worse. Depending on the video game activity, movement excursion and velocity also typically increased after the training sessions. CONCLUSIONS: The training protocol was safe and effective for this group of participants. The two lowest functioning individuals had the largest changes on their BERG scores, moving out of the fall risk category. We hypothesize that the dual task demands of the video gaming tasks lead to the significant improvements in cognitive TUG score. Interestingly, the two participants with worsening ABC scores both had suffered injuries from previous falls, perhaps affecting their balance confidence. Acknowledgments and FUNDING: This project was supported by Cleveland State University's Undergraduate Summer Research Award program.

P1-N-111 Effect of the rate of change of an external balance perturbation

Thomas Robert¹, Marine Guinamard¹, Pascal Chabaud¹, Laurence Cheze¹, Marie-Laure Mille²

¹Université de Lyon, ²Aix Marseille Université

BACKGROUND AND AIM: The ability to resist an external balance perturbations has been classically used to assess the risk of fall, with contradictory results. A likely explanation for these different results comes from the variety of perturbations used: various types of perturbations (waist-pull, platform perturbation, tripping, sliding, etc.) but also various amplitude and time profiles. These last parameters received only little interest. Recently we have shown that, for compliant perturbations, the duration of the time profile has a dramatic effect on the stepping threshold (Mille et al., G&P 2018). Influence of other parameters of the perturbation time profile remains largely undocumented. In particular, the rate of perturbation, but this effect has not yet





been quantified and is rarely considered in perturbed balance experiments. This study aims at quantifying the effect of RPC on the ability to resist waist pull perturbations. It includes both experimental and numerical approaches. METHODS: 13 young volunteers were submitted to waist-pull perturbations consisting of a linear increase of perturbation (RPC=10 to 160 % BW/s) followed by a 2 seconds constant force plateau (Fmax = 30 to 50 % BW). Subjects were asked to restore their balance within a distance of 30% of their body height. 40 trials per subjects (2*20 RPC-Fmax combinations) were analysed. Two simple inverted pendulum models were used to predict the proportion of successful recovery: one assuming maximal recovery reactions (Mille et al., G&P 2018) and another including a simple regulation of the centre of pressure based on the perceived body state. RESULTS: Results showed a strong influence of the RPC on the chance of successful recovery, statistically confirmed by multiple regressions. The model based on the maximal recovery reactions, successfully used in our previous study using very high RPC, provided inconsistent results for these lower RPC perturbations. However, coherent results were obtained with the second model (see Figure). CONCLUSIONS: This study showed and quantified the RPC negative effect on the balance recovery. It highlights that RCP should then be carefully chosen and described in balance perturbation experiments. These results could also be used to assess the risk of fall in everyday life situations (e.g. assess various braking profiles for public transports). Modelling results suggest that this effect is linked with cognitive or sensory processes such as the ability to regulate the reaction based on the online self-estimate of the body state. Further investigations should assess the cross-effects between subject capacities (biomechanical, sensorial, cognitive, etc.) and perturbation profiles. A future research track would be the use of different perturbation profiles to test different balance recovery processes and capacities. ACKNOWLEDGEMENTS AND FUNDING: grant ANR-16-CE19-0006-01.

P1-N-112 Administration and scoring procedures for performance-based clinical balance tests do not accommodate practice effects among lower limb prosthesis users

Andrew Sawers¹, Brian Hafner²

¹The University of Illinois at Chicago, ²University of Washington

BACKGROUND: Performance-based clinical balance tests serve as primary endpoints in clinical trials, and are key tools for justifying treatment and documenting outcomes in clinical practice. These tests, however, typically assess balance ability using only the first two trials, when individuals may still be improving on the test. Such practice effects have in fact been reported in a few tests, yet their magnitude and clinical significance in lower limb prosthesis (LLP) users is not well documented. When practice effects are not accommodated measurements may be taken when individuals are not performing at a consistent level, misrepresenting balance ability, and/or inaccurately diagnosing fall risk. The aim of this study was therefore to characterize practice effects and their clinical significance in two balance tests among unilateral LLP users. **METHODS:** After a practice trial, 40 LLP users performed 10 trials of either the Timed Up and Go (TUG) or





the Four Square Step Test (FSST). Practice effects were quantified as significant changes (p<0.01) in the slope of each participants' trial-by-trial cumulative performance record. Trials that occurred after the last significant inflection point were deemed to represent the participants' typical level of performance. The clinical significance of any practice effects were assessed by determining if: i) differences in performance between tests scored using traditional procedures (i.e. best of trials 1 and 2) and the mean of later typical performance exceeded the standard error of measurement (SEM) of each test, and ii) if test times derived from the mean of later typical versus earlier trials re-classified participants' fall risk (i.e. above or below established thresholds). **RESULTS:** Significant changes in performance between consecutive trials of the FSST and TUG were observed in 75% (15/20) and 70% (14/20) of participants, respectively. Performance on both tests did not stabilize until the fifth trial, on average. Participants' later typical performance was also significantly better (i.e. lower time), p<0.0015, than during earlier trials. This suggests traditional procedures that utilize the best of the first two trials are insufficient to characterize typical performance on the FSST or TUG. Further, differences between the best of trials 1 and 2 and the mean of later typical performance exceeded the SEM of the FSST and the TUG in 50% (10/20) and 40% (8/20) of participants, respectively. Based on thresholds for the FSST and TUG, 30% (6/20) and 25% (5/20) of participants were re-classified from fallers to non-fallers, or vice versa, when tests were scored based on the mean of later typical performance. Statistically and clinically significant differences in balance ability appear to be overlooked when traditional administration and scoring procedures of the FSST and TUG are used. CONCLUSIONS: Traditional FSST and TUG administration and scoring procedures do not account for practice effects among LLP users. This may limit the accuracy with which these tests can assess balance ability or fall risk. Further research is needed to develop alternate procedures or tests that resolve practice effects, and improve the accuracy of balance assessments in LLP users.

P1-N-113 Kinematic analysis of videos of real-life falls in older adults using Kinovea software

Nataliya Shishov¹, Karam Elabd¹, Vicki Komisar¹, Stephen Robinovitch¹

¹Simon Fraser University

BACKGROUND AND AIM: Falls cause up to 80% of traumatic brain injuries (TBI) in older adults (Fu et al., 2017). Previously we showed, through video capture, that over one-third of falls in long-term care (LTC) result in head impact, and backward falls account for the largest portion of cases (Yang et al., 2017). Risk for TBI during these events depends, in part, on the impact velocity of the head. In this study our objectives were: (1) to measure the accuracy of Kinovea open-source digitization software, based on comparison with 3D motion capture, in determining head velocities during falls; and (2) to apply Kinovea to determine head velocities in real-life falls in older adults captured on video. **METHODS:** Laboratory experiments were conducted where the participant was instructed to either (1) fall naturally, (2) raise the legs after pelvis impact, or (3) keep the legs





on the ground (n=7 per condition), to account for falling patterns observed in older adults (Shishov et al., 2018). Velocities of the head, pelvis, ankle and hand were calculated with Kinovea (0.8.27) from planar video from one camera (Cisco WVC210, 30Hz) oriented perpendicular to the plane of the fall, and with 3D motion capture (Qualisys MIQUS, 600Hz). We then applied Kinovea to calculate head, pelvis, and ankle velocities from sagittal-view videos of 12 real-life backward falls with and without head impact (6 per group). **RESULTS:** The mean peak resultant head velocity in the laboratory falls (Fig 1a) was 3.6 m/s (SD=0.3). The mean differences between Qualisys and Kinovea in peak values of resultant, vertical and horizontal head velocity were 0.002, -0.05, and -0.03 m/s, respectively, and the mean difference in time of peak resultant velocity was 25 ms. RMSEs for peak resultant velocity of the head, pelvis, ankle and hand were 0.18, 0.25, 0.20 and 0.61 m/s, respectively. RMSE for head resultant velocity over the entire fall ranged from 0.12-0.42 m/s (mean=0.22, SD=0.07). In LTC falls, peak values of head resultant velocity averaged 3.9 m/s, and different movement patterns were displayed in falls involving head impact (Fig 1b, top panel). In most cases, we observed two peaks in head velocity, which closely aligned with the perceived instants of pelvis and subsequent head impact. The first peak was often the largest (falls 1,3,5), but the second peak was highest in other cases (fall 6) indicating rapid descent of the head and torso after pelvis impact. In other cases we observed near-simultaneous impact of the pelvis and head (fall 2) or a gradual decrease in head velocity after pelvis impact, leading to low contact velocity (fall 4). CONCLUSIONS: Our results demonstrate the accuracy of Kinovea software in measuring body segment velocities during falls from standard sagittal-plane video. We also demonstrate how Kinovea analysis of real-life falls in older adults captured on video allows us to quantify head impact severity and analyze the movement patterns leading to head impact. ACKNOWLEDGEMENTS AND FUNDING: Supported by operating grants from the Canadian Institutes of Health Research (TEI-138295) and AGE-WELL (AW CRP 2015-WP5.2).

P1-N-114 Dynamic stability measures respond uniquely to destabilization during asymmetric walking

Tarique Siragy¹, Julie Nantel¹

¹University of Ottawa

Introduction: Several measures are used to quantify dynamic balance and assess individual stability and fall risk. Recent evidence suggests that each measure quantifies a unique neuromuscular control aspect of dynamic stability.1 However, it remains unclear as to if different measures respond to destabilizing environments in a uniform manner. Objective: To examine the effects of symmetric and asymmetric walking on Spatiotemporal Variability (Coefficient of Variation for Step Time, Length and Width), Short-term Lyapunov Exponent and the Margin of Stability. **METHODS**: Fifteen young (18-30yrs) adults walked on a split belt treadmill (CAREN-Extended, Motek Medical, Amsterdam, Netherlands) during symmetric (both belts: 1.2m/s) and asymmetric walking (right belt reduced to 0.96m/s). Three minutes per conditions. Trajectory data





were collected at 100Hz (VICON, Oxford, England). RESULTS: A paired samples t-test was used to examine differences between walking conditions. During asymmetric walking, participants walked with increased Right Step Length Variability t(14) = 4.69, p< .001 and Right Step Time Variability t(14) = 4.20, p = .001, reduced Step Width Variability t(14) = -2.27, p = .04, and increased Short-term Lyapunov Exponent(14) = 4.05, p = .001. No significant differences were found in either the anteroposterior or mediolateral Margin of Stability (p > .05). CONCLUSION: Asymmetric walking has been associated with increased fall risk. However, the selected dynamic stability measures do not respond uniformly to gait asymmetry. Indeed, while Step Length and Time Variability and the Lyapunov Exponent indicate that participants were more unstable during asymmetric walking, Step Width Variability was reduced. The increased Step Time and Length Variability may be due to gait asymmetry's destabilizing effects on the neuromuscular mechanisms responsible for the foot's timing and anteroposterior placement. As for the reduced variability in the mediolateral foot placement, prior research suggests that individual's passively control step time and length while step width is actively controlled.1,2 This may indicate that participants consciously regulate mediolateral foot placement to allow for a safe COM trajectory in the frontal plane thus enhancing stability. Additionally, the increased Lyapunov Exponent indicates that participants had reduced Local Dynamic Stability during asymmetric walking. This may be due to increased difficulty in the neuromuscular system's attenuation of infinitesimal deviations in the COM's trajectory during this condition. Finally, the lack of differences in the Margin of Stability suggests that individuals potentially adapt their gait pattern to maintain the distance of their COM's dynamic state (position and velocity) to the base of support during asymmetric walking. Thus, research should carefully consider their dynamic stability measure as each reflects a specific neuromuscular mechanism and responds uniquely to destabilization. FUNDING: Funding for this project was provided by the Natural Sciences and Engineering Research Council (NSERC) Discovery grant RGPIN-2016-04928 and NSERC Accelerator supplement RGPAS-493045-2016.

P1-N-115 Total knee replacement patient's preoperative time to recovery expectations are related to fall risk

Brian Street¹

¹California State University, Bakersfield

BACKGROUND: Surgical expectations for total knee replacement (TKR) patients have been shown to be multidimensional and influenced by patient and clinical characteristics. Importantly, pre-TKR patient expectations can predict TKR surgical outcomes. Patients often seek TKR to improve function and independence, which can include reducing the number of falls. Aim: The aim of this study was to investigate the relationship between a patient's TKR time to recovery expectations and a patient's fall history and fall risk. **METHODS:** A convenience sample of twenty-one unilateral TKR patients completed a questionnaire asking about their expectations for time to recovery of 10 items related to activities of daily living (for example, rising from sitting), each were





measured over a six ordinal time scale: 1 week, 6 weeks, 3 months, 6 months, 1 year, and 'never'. Expectation data was dichotomized by median split (7.8 weeks) of the mean time to recovery into patients with short-term expectations and those above the median as having long-term expectations. Participant fall history (self-reported previous 12-months) was acquired, as well as their Timed Up-and-Go (TUG) times, Activities-specific Balance Confidence Scale (ABC) scoring, and Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) scoring. **RESULTS:** Correlation analyses revealed the relationships between a patient's expectations (short-term v. long-term), number of falls and fall risk measures. A significant and positive (long-term expectations) correlation between expectations and TUG test times (rs = .60) and numbers of falls (rs = .86) occurred. Balance confidence (ABC) was significantly and negatively correlated with patient expectation, may be important to evaluate when considering individual patient care, in particular, when determining a specific rehabilitation protocols post-TKR to address a patient fall risk.

P1-N-116 Posturography differences between recurrent and non-recurrent fallers

Kyra Twohy¹, Vinayak Vijayan¹, Kimberly Bigelow¹

¹University of Dayton

BACKGROUND AND AIM: Approximately 30% of older adults fall each year, with 20% of those falls resulting in injuries. Falls can result in expensive hospital visits that account for 6% of the total medical expenditures of Americans aged 65 and older. Balance impairments increase the risk of falling, so concerted efforts have been focused on identifying those who may have underlying balance deficits. Force platform posturography has the potential to detect subtle differences in balance that may be indicative of fall risk. However, in part due to a lack of standardization in the field of posturography, detected differences between fallers and non-fallers vary based on study methods. The objective of this study was to discriminate between fallers and non-fallers by focusing on factors previously shown to be sensitive to differences. METHODS: In this study 164 older adults, age 65 or older, were recruited from local retirement communities and senior centers. 27 subjects were identified as recurrent fallers, reporting at least two or more falls in the past 12 months, and the other 137 subjects were non-recurrent fallers. Subjects completed a quiet-standing posturography assessment consisting of four testing conditions (eyes open or closed, and feet in a comfortable or narrow stance). The recorded center of pressure (COP) data for each 60 second trial was then used to calculate six traditional time-domain measures of balance and two non-linear measures. Independent samples t-tests were used to test for betweengroup differences. Effect size was calculated using Cohen's d. RESULTS: ML sway range in the eyes open, narrow stance was found, based on effect size, to best differentiate recurrent fallers and non-recurrent fallers (p < 0.002). In this condition, the average sway range was 52.5 ± 19.7 mm for recurrent fallers and 36.6 ± 12.6 mm for non-recurrent fallers. It is also notable that the



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> eyes open, narrow stance condition had the most outcome measures that differentiated between the groups, and the largest effect sizes. Across testing conditions, non-linear outcome measures showed no differences between groups. **CONCLUSIONS:** These findings suggest that posturography assessments can provide an efficient and accurate way to differentiate older adults based on fall history, if the right set of parameters is used when testing. Our work also continues to support lateral instability as correlated with increased risk of falling. Based on our results it is recommended that eyes open, narrow stance be used and ML postural sway parameters be included in future work seeking to differentiate fallers versus non-fallers. Our findings do not suggest that non-linear measures add notable value in this differentiation. Determining an individual's fall history is important in identifying individuals who may be at future risk of falling.

P1-N-117 An examination of muscle quality, functional test performance and fall risk in "young-old" women: A pilot study

Jodi Ventre¹, Christopher Morse¹, David Tomlinson¹, Chesney Craig¹

¹Manchester Metropolitan University

BACKGROUND AND AIM: Falls are a leading cause of accidental injury and mortality worldwide. Research has primarily focused on older adults (aged 65+), despite younger populations (46-65 years), reporting falls prevalence rates of 15-21%. Various functional tests have been developed to assess balance, mobility and fall risk in individuals >65 years. However, few tests have demonstrated an ability to predict fall risk in younger populations. This preliminary study aims to examine the sensitivity of current functional tests and additional physiological measures to discriminate fall risk within a "young-old" (50-75 years) female population. We predicted that functional tests would fail to show group differences within the "young-old" age group, however, physiological measures would show differences between groups. METHODS: In this crosssectional study, 12 fallers (aged 66 ± 4.2 y) and 12 non-fallers (aged 65 ± 5 y) underwent upperbody isometric strength testing with a digital handgrip dynamometer (Takei, 5401) and lower-limb isometric knee extension strength (KES) testing at two angles (30°/70°), using an Isometric dynamometer (Cybex NORM[®], Humac). A whole body Dual Energy X-ray Absorptiometry (DXA) scan was conducted to determine lean muscle mass (LM) and muscle quality (MQ = LM/KES) controlled for body mass. Functional performance was assessed using three maximum countermovement jump height (JH) trials, the Four Square Step Test (FSST), Five Times Sit to Stand (STS5) and the Mini-BESTest. Independent samples t-tests were used to examine between group comparisons for all tests. Pearson's two tailed correlations were used to assess the relationship between the physiological tests and objective functional performance scores (e.g. FSST, STS5, JH etc.). RESULTS: Strength, functional performance and body composition parameters were not significantly different between the fall and non-fall groups (p > 0.05). Correlations revealed a strong negative association within the fall group between FSST and MQ (r = -0.786, N = 12, p < 0.05). No associations were found within non-fallers and study parameters.





CONCLUSIONS: Whilst our results need to be established in a larger sample size, our pilot data supports that current functional performance tests used in older adults to screen for fall risk, were not able to distinguish differences between "young-old" fallers and non-fallers. We did however observe a unique association between FSST score and MQ in "young-old" female fallers. Interestingly, this was not shown for grip strength, knee extension strength or LM. This may suggest that in a larger sample, MQ and the FSST could be useful predictors of fall risk in this group. Although it is known that muscle mass and strength decrease with age, future work should examine whether early assessment of MQ could predict fall risk in younger populations. Our current research aims to assess this longitudinally in a group of 180 middle-aged adults, with/out previous falls.

P1-N-118 Treadmill gait-slip training in healthy community-dwelling older adults: Mechanisms of within trial adaptation for a progressive ascending-and-mixed intensity protocol

Yiru Wang¹, Shuaijie Wang¹, Anna Lee¹, Clive Pai², Tanvi Bhatt¹

¹University of Illinois at Chicago, ²Retired from University of Illinois at Chicago

Background. Treadmill (TM) perturbation has been introduced as a task-specific training which involves practicing actual motor skill of recovering from a slip. Recent studies showed that older adults could generalize training effects acquired from the TM slip training to improve their dynamic stability control and thus to reduce over-ground (OG) slip induced falls [1]. However, few studies have reported mechanisms of training-induced adaptation to TM slips during gait and, therefore, the study purpose was to investigate older adults' within trial adaptations in dynamic stability (STA) specifically for an ascending-mixed-intensity design. Methods. 25 community-dwelling older adults (70.2±5.9 yrs) received 40 slips induced by ActiveStep TM during gait. 40 slips were given over 11 blocks at 5 intensity levels (P1-P1-P2-P3-P4-P5-P4-P5-P5-P3-P1, larger number indicating higher intensity). Increments of intensities ranged from 10%-35% were chosen based on previous studies. Slip characteristics [double-stance (DS) or single-stance (SS)] and recovery steps (RS) were recorded. COM STA and step length (SL) were taken at 2 events: pre- and postslip recovery touchdown respectively to reflect proactive (pro STA) and reactive (rea STA, rea_SL) control respectively. Novel slip of P1, P3, P4 and P5 were compared with 1st slip of last blocks of P1, P3, P4 and P5 to examine pre-to-post training effects. Results. Unlike OG and TMstance environment in which slips always occur in DS, only 14% of slips occurred during DS in TM gait slips. Training did not elicit an effect on RS at any intensity level (p>.05). Three-way repeated ANOVA indicated overall improvement from pro STA to rea STA, and improved rea_STA from pre- to post-training (both p<.001). Significant interaction between training and intensity indicated that rea STA improved pre-to-post training at P1 and P3 but not at P4 or P5 intensities. Interaction between intensity and event indicated that, post-training, subjects in P1 had largest improvement from pro_STA to rea_STA. Post-training inter-intensity comparison showed



that although subjects in P3 had lower rea_STA than P1, they were able to maintain rea_STA at P4 and P5. Further, improved rea_STA was associated with an anterior shift in COM position relative to BOS (PCOM) and faster COM velocity relative to BOS. Longer backward rea_SL was correlated with improved PCOM at recovery foot touchdown. **Conclusions**. The ascending-mixed-intensity protocol induced significant adaptive changes in dynamic STA control. Although maximum improvement was seen at lowest intensity, subjects maintained (rather than deteriorating) rea_STA at other intensities despite receiving increasing disturbance. This indicates CNS's ability to recalibrate the internal representation of STA limits to recover from a range of perturbation intensities in a similar context. Such results could explain the previously shown positive generalization of TM-slip to novel OG-slip [1]. Reference 1. Lee, A., Bhatt, T., Liu, X., Wang, Y., & Pai, Y. C. (2018). Can higher training practice dosage with treadmill slip-perturbation necessarily reduce risk of falls following overground slip?. Gait & posture, 61, 387-392.

P1-N-119 The effects of time-pressure on adaptive gait in individuals with and without central vision loss

Tjerk Zult¹, Matthew Timmis¹, Jonathan Allsop², Shahina Pardhan¹

¹Anglia Ruskin University, ²Royal Air Force College Cranwell

BACKGROUND AND AIM: Age-related macular degeneration (AMD) is a common eye condition that affects mobility due to impairments in central vision. Although AMD patients are more cautious during adaptive gait, they are at increased risk of falling in comparison to those with normal vision especially when they have poorer contrast sensitivity (CS). Adaptive gait in individuals with AMD has only been examined in temporally unconstrained situations however adaptive gait in everyday life is often performed under time-pressure (e.g., moving quickly to pick up the phone). Therefore, the present study investigated the effects of time-pressure on adaptive gait in AMD patients with good-CS and poor-CS compared to those with normal vision. METHODS: The normal vision group (n=13, aged 70;Å4 years), AMD good-CS group (n=11, aged 76;Å6 years) and AMD poor-CS group (n=11, aged 75jÅ8 years) walked along a 7m walkway, negotiating a floor-based obstacle before stepping on a curb. The experiment was performed in no-pressure and timepressure conditions. In the time-pressure condition, an intermittent tone was played that increased in frequency and participants were instructed to press the button at the end of the walkway before the tone ceased (i.e., requiring the subjects to walk 20% faster than their comfortable walking speed). Movement kinematics throughout the task were assessed using an eight-camera VICON motion analysis system. All variables were analysed using a group by condition repeated measures ANOVA. RESULTS: The ANOVA for movement times showed a group and condition effect. The group effect showed that only AMD patients with poor-CS performed the task 29% slower than those with normal vision (p=0.041). The condition effect revealed that performance times were 27% faster in the time-pressure than no-pressure condition (p<0.001). The ANOVA for movement kinematics showed group, condition, and interaction effects. Group effects revealed



that the crossing velocity of the lead foot over the obstacle and curb was 13-17% slower for the AMD poor-CS vs. normal vision group (both p<0.035). Condition effects between the time-pressure and no-pressure condition were: increased crossing velocity of both feet, foot placement further away from the obstacle and curb, and decreased single and dual support times (all p<0.05). The interaction effect showed that the AMD good-CS group reduced the crossing height 19% for the trail foot in the time-pressure vs. no-pressure condition (p=0.004), while crossing height did not change in the AMD poor-CS and normal vision group (both p_i Ý0.360). **CONCLUSIONS**: Irrespective of the temporal demand, AMD patients with low contrast sensitivity performed the task slower and they lifted the lead foot slower over hazards in the travel path to reduce the chance of tripping. The kinematic changes in the time-pressure compared to no-pressure condition were all related to an increase in walking speed.

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P1-O-120 Instrumenting gait and balance assessment at home and in the community; exploratory data from the ACTIVATE feasibility study

Christopher Buckley¹, Silvia Del Din¹, Patrica McCue¹, Heather Hunter², Sue Lord³, Chris Price¹, Lisa Shaw¹, Helen Rogers¹, Lynn Rochester⁴, Sarah Moore¹

¹Newcastle University, ²Newcastle-upon-Tyne Hospitals NHS Foundation Trust, ³Auckland University of Technology, ⁴Institute of Neuroscience, Newcastle University

BACKGROUND AND AIM: Post-stroke gait impairments limit home and community (real-world) walking. Evaluation of targeted exercise interventions to improve walking is therefore essential. Auditory rhythmical cueing (ARC) interventions show promise in improving spatiotemporal strokerelated gait deficits in laboratory settings [1]. However, their effect on community walking is unknown. Recent advances in wearable technology enable continuous monitoring of gait in 'naturalistic' home and community settings. The aim of the ACTIVATE study is to explore the acceptability of ARC to improve gait and physical activity in community-dwelling stroke survivors. This study explored the feasibility of instrumenting gait, balance and real-world walking assessments with wearable technology (Axivity, AX3 accelerometer) during the ACTIVATE study. **METHOD:** A before and after study was undertaken in the North East of England. Participants were community-dwelling stroke survivors, <two years post-stroke, able to walk ten meters indoors, and not undertaking physiotherapy. Participants received either a tailored six-week (3 times/week) treatment program of gait and balance exercises performed with an auditory cue (metronome) (n=8) or gait and balance exercise alone (n=4). Instrumented at-home gait and balance, and free-living assessments were performed with the AX3 located at the fifth lumbar vertebra. We quantified twenty-six variables indicative of gait from both lower and upper body movements during 5x4m walks, nine variables of balance during a two-minute stand and seven variables of real-world walking over seven days [2, 3]. The feasibility of the protocol for all





participants was assessed and due to the small sample size, only exploratory descriptive analysis of preliminary result was performed. **RESULTS:** Twelve participants took part in the study: age 70 ± 11yrs; sex 7 female; average time since stroke 13 months (range 6-23 months); National Institutes of Health Stroke Scale [4] M = 3 (range 1-6); walking aid use = 4 (33%). Ninety-six and eighty-one percent of the at home and free-living assessments were completed respectively. Reasons for data loss included: one participant not wishing to wear the sensor for the 7-day measurement and one unrelated serious adverse event precluding the participant undertaking the six-week assessment. Data analysis revealed selective changes to gait, postural control and real-world outcomes which will be presented in full at the conference. CONCLUSIONS: Results demonstrated the feasibility of accelerometers in home and community settings to quantify the impact of an ARC intervention on gait, postural control and real-world walking. Data will be collected on a larger sample in a subsequent pilot randomised controlled trial of the ARC intervention, starting November 2019. ACKNOWLEDGEMENTS AND FUNDING: We would like to thank all the participants that took part in the study. References 1. Langhorne et al., (2009) The Lancet. Neur. 2. Buckley et al., (2018) Gait & Post. 3. Del Din et al., (2017) J Gerontol A Biol Sci Med Sci. 4. Brott et al., (1989) Stroke.

P1-O-121 Targeted transcranial electric stimulation mitigates the dual task cost to gait speed in older adults

Brad Manor¹, Junhong Zhou¹, On-Ye Lo¹, Alexa Ludington¹, Racheli Katz², Marina Brozgol², Pablo Cornejo Thumm², Jeff Hausdorff²

¹Harvard Medical School, ²Tel-Aviv Sourasky Medical Center

BACKGROUND AND AIM: In older adults, the extent to which the performance of a concurrent cognitive task while walking reduces gait speed predicts both falls and future cognitive decline. We previously demonstrated that in healthy younger and older adults, this dual task "cost" can be reduced by using bipolar transcranial direct current stimulation (tDCS) to facilitate the excitability of the left dorsolateral prefrontal cortex (dIPFC)--a primary brain region subserving cognitive function. However, dual task walking activates brain networks related to both cognitive and motor function. We thus hypothesized that multichannel tDCS that simultaneously targets primary cognitive and motor regions (i.e., the left dIPFC and the primary motor cortex, M1) would reduce the dual task cost to gait speed more than tDCS targeting either region separately or sham stimulation. METHODS: A multi-site, randomized controlled within-subject cross-over study was completed in 48 older adults free of overt illness or disease (mean±SD age=75±6 years, 35 women). Participants completed four study visits, each separated by at least 72 hours, during which dual task gait was assessed over an instrumented walkway before and after 20 minutes of tDCS targeting 1) the left dIPFC and M1, 2) left dIPFC only, 3) M1 only, or 4) neither region (sham). Stimulation was delivered using the Starstim? system (Neuroelectrics Corp) and the same array of six gel electrodes to ensure double-blinding. Sham stimulation comprised low-level currents




designed to mimic the skin sensations of tDCS without influencing brain excitability. Participants completed tDCS blinding and side effects questionnaires at the end of each visit. Repeatedmeasures ANOVAs adjusted for age and sex tested the effects of tDCS condition, time (pre/post stimulation), and their interaction, on the dual task cost to gait speed (i.e., percent change from single to dual tasking), as well as gait speed within single- and dual-task conditions separately. **RESULTS:** Participants were successfully blinded to tDCS condition and reported no unexpected tDCS side effects. An interaction between condition and time was observed for the dual task cost to gait speed (F=3.0, p=0.04) (Figure 1). This cost was smaller (i.e., better and closer to zero) following tDCS targeted the left dIPFC and M1 simultaneously, as well as the left dIPFC alone, compared to all other time points. The dual task costs following these two types of stimulation were similar in magnitude. A trend towards a similar condition by time interaction was observed for gait speed within the dual task condition (i.e., gait speed appeared faster only following multitarget and left dIPFC tDCS, p=0.09), but not the single task condition (p=0.78). CONCLUSIONS: tDCS targeting the left dIPFC--or the left dIPFC and M1--decreased the dual task cost to gait speed in a large sample of older adults, relative to M1 only or sham stimulation. Simultaneous stimulation of the dIPFC and M1 did not significantly augment the effectiveness of targeting the left dIPFC alone. Future studies are warranted to examine the duration of tDCS-induced benefits, as well as the mechanisms through which stimulating the left dIPFC gives rise to improved dual task performance.

P1-O-122 Perturbation Induced Stepping in Stroke: a way to use the more involved leg

Katherine Martinez¹, Mary Blackinton², M. Samuel Cheng², Mark Rogers³, Marie-Laure Mille⁴

¹Northwestern University Feinberg School of Medicine, ²Nova Southeastern University, ³University of Maryland, ⁴Aix Marseille Université

BACKGROUND AND AIM: Asymmetrical sensorimotor function after stroke creates a unique challenge for bipedal tasks such as walking or perturbation-induced reactive stepping. Preference for initiating steps with the less involved (preferred) leg after a perturbation has been reported with limited information on the stepping response of the more involved (non-preferred) leg. Understanding the capacity of both legs to respond to a perturbation would enhance the design of future treatment approaches. This study investigated the difference in perturbation-induced stepping between legs in stroke and non-impaired controls. We hypothesized that stepping performance will be different between stroke and controls and between legs for stroke participants. **METHODS:** Thirty participants (15 stroke, 15 age-gender match controls) were given a waist-pull anterior perturbation equal to 10% of body weight from three stance positions (Fig A): symmetrical (SS), preferred asymmetrical (PAS), and non-preferred asymmetrical (N-PAS). Kinematic and kinetic data was collected to measure anticipatory postural adjustment (APA), characteristics of the first step (onset, length, height, duration), number of steps, landing velocity and change of momentum. Group differences were tested using the Mann-Whitney U-test and





differences between legs using the Wilcoxon signed-rank test with an alpha level of 0.05. **RESULTS:** Controls stepped more often with their non-preferred stance leg (SS) or with the leg initially supporting less weight in the asymmetrical conditions (Fig B). Stroke participants increased use of their non-preferred more-involved leg from 10% or less (SS and N-PAS) up to 44% of trials (PAS) when that leg was unweighted. They always took more steps to regain balance than controls regardless of which leg initiate stepping. Compare to controls, steps with the preferred leg were earlier and shorter (N-PAS) whereas steps with the non-preferred leg (PAS) lasted longer, tended to be shorter and had a greater change in momentum between the first and the second step (Fig C). In stroke participants steps with the more involved leg had longer duration, lower clearance, shorter APA duration, with slower velocity at heel strike, smaller change in momentum but no difference in number of steps compared to the other leg (Fig D). **CONCLUSIONS:** Unweighting the leg facilitates stepping with the more involved leg and is a simple intervention to encourage post-stroke survivors to use their weaker limb. The predilection for stepping with the less involved leg may be a learned behavior as stepping with either leg after a perturbation appears to be challenging for ambulatory stroke survivors. Consideration of the simultaneous roles (support and stepping) of both legs during reactive step is important for reactive balance training and should be of included when designing rehabilitation approaches. ACKNOWLEDGEMENTS: Financial support for the subjects was provided by PTHMS Dept., Northwestern Univ.

P1-O-123 The effect of an exergame intervention on clinical balance scales in children with cerebral palsy: preliminary results from two non-randomized trials.

Pieter Meyns¹, Ian Blanckaert², Chloé Bras³, Jaap Harlaar⁴, Laura van de Pol³, Frederik Barkhof³, Hilde Van Waelvelde², Annemieke Buizer³

¹Hasselt University, ²Ghent University, ³Amsterdam UMC, Vrije Universiteit Amsterdam, ⁴Delft University of Technology

BACKGROUND AND AIM: Children with cerebral palsy (CP) experience poor balance control during standing and walking due to sensorimotor disorders resulting from non-progressive brain lesions acquired around birth in their developing brain [Bruijn et al. 2013 Res Dev Disabil]. Several pilot studies investigated the effectiveness of video game-based or exergaming balance training in children with CP [Jelsma et al. 2013 Dev Neurorehabil & Brien et al. 2011 Pediatr Phys Ther], as literature has indicated promising effects on motivation [Meyns et al. 2017 Dev Neurorehabil] and functional outcomes [Tatla et al. 2013 Dev Med Child Neurol] in several patient populations when using exergames. These studies, however, yielded inconsistent results which could be related to the low sample size in most published studies concerning exergame balance training in CP. Therefore we combined data of two intervention trials to investigate whether exergaming is effective to improve clinical balance outcomes in CP. **METHODS:** Preliminary data of two registered trials at the Amsterdam UMC (UMC; NTR6034) and at the university of Ghent (UGhent;





NCT03219112) is presented. At UMC, ten children with bilateral CP, and at UGhent 19 children with unilateral and bilateral CP were included (table 1), if they had: spastic CP, GMFCS-level 1 or 2, no surgery <12 months, and no Botulinum-Toxin A injections <6 months. Children allocated in the intervention group performed exergame training, which comprised 6 to 8 weeks home-based X-box One Kinect (Microsoft) training. Kinect sports games focused on balance (tennis, football, bowling) were used. Time played was monitored. Functional balance was assessed with clinical balance scales at the start of the study and after 6-8 weeks; i.e. the pediatric balance scale (PBS), and two subscales of the Bruininks-Oseretsky Test of Motor Proficiency ('balance' [BOTbal] and 'speed & agility'[BOTsa]). PBS is a 14-item balance measure concerning everyday tasks (on 56 points). BOTbal is a 9-item scale which includes two walking conditions (i.e. walking forwards with hands at the waist, walking heel-to-toe) and seven standing conditions (e.g. feet apart on a line with eyes open an closed) (on 37 points). BOTsa is a 5-item scale which includes running and hopping conditions (on 52 points). High scores on the clinical scales indicate good balance. Children in the control group did not receive exergame training. **RESULTS:** On group-level, exergaming did not improve clinical balance scale outcomes in children with CP that received training (within group pre-post) and also did not improve balance more in children that received training compared to children with CP that did not receive training (between group; Table 1). CONCLUSIONS: On group-level exergaming did not appear to have a benefit on improving balance in children with CP. Previous studies have indicated that individual results may differ significantly between participants with CP [Meyns et al. 2018 Gait Posture]. As such, further subgroup (e.g. uni- versus bilateral CP) and individual analyses may provide important insights as to whether exergaming may be relevant to improve balance some children with CP.

P1-O-124 How do spatiotemporal gait parameters change from the acute phase to 3 months later following a stroke?

Ole Petter Norvang¹, Torunn Askim¹, Anne Eitrem Dahl², Pernille Thingstad¹

¹Norwegian University of Science and Technology, ²Trondheim University Hospital

BACKGROUND AND AIM: Independent ambulation is considered the most self-stated rehabilitation goal for people after stroke and safe and efficient gait is an important target for rehabilitation. Better understanding of how gait parameters changes in the early stage is important when facilitating an improvement of motor function after stroke. This study aimed to examine changes in spatiotemporal gait parameters from the acute phase to 3 months later, and whether these changes can be associated with changes in balance or walking capacity. **METHODS:** Design: Longitudinal cohort study. Study population: 79 participants diagnosed with first ever or recurrent acute ischemic or hemorrhagic stroke were included within two weeks after stroke. Measurements: Scandinavian Stroke Scale (SSS) and Modified Rankin Scale (mRS) were used to measure stroke severity and dependency at baseline. Walking speed and spatiotemporal gait parameters (step length, time in single support, walk ratio, and asymmetry for step length and





single support) were assessed while hospitalized and 3 months later using a GAITRite mat at selfpreferred gait speed. Balance was assessed using Bergs Balance Scale (BBS), and walking capacity by using the 6-minute walk test (6MWT) Statistics: Within-subject changes in spatiotemporal gait was assessed by a repeated measurement ANOVA, and linear regression used to study association between changes in spatiotemporal gait parameters and changes in balance and walking capacity. **RESULTS:** At inclusion, participants had a mean (SD) age of 75.4 (8.1), mRS 2.7 (0.8) points, SSS 52.0 (4.6) points, and an average gait speed of 0.92 (0.32) m/s. Participants increased gait speed 0.18 m/s (p<0.000, 95% CI 0.11, 0.23), step length 6.68 cm (p<0.001, 95% CI 4.50, 8.70), and walk ratio 0.02 step length/cad (p=0.002, 95% CI 0.01, 0.04), whereas single support decreased by 0.02 sec (p=0.002, 95% CI -0.03, -0.01) from the acute to the sub-acute phase. BBS score was increased by 6.0 points (p<0.001) and the 6MWT improved with 80 meters (p<0.001) Association between changes in spatiotemporal gait parameters, and balance and walking capacity are shown in table 1. For the 6MWT there was a significant and positive association with both single support, walk ratio and step length asymmetry after controlling for baseline gait speed. No significant associations were found between changes in spatiotemporal gait parameters and balance. CONCLUSION: Spatiotemporal gait parameters improved the first three months after stroke, with changes in gait speed considered as a clinical meaningful improvement. These changes was associated with improved walking capacity indicating improved gait efficiency, but not with improved balance.

P1-O-125 Robotic intervention improves lateral gait symmetry in acute post-stroke patients

Chun Kwang Tan¹, Hideki Kadone¹, Hiroki Watanabe¹, Aiki Marushima¹, Yasushi Hada¹, Masashi Yamazaki¹, Yoshiyuki Sankai¹, Kenji Suzuki¹

¹University of Tsukuba

BACKGROUND AND AIMS: Gait disturbance is commonly observed in patients with stroke, and this is usually treated with physical therapy. Exoskeletons have recently been studied as an intervention tool for stroke patients and reported improvement in patients with clinical assessment metrics. However, such metrics are unable to quantify muscle coordination change in patients after robotic intervention. Muscle synergy analysis is promising as a tool to evaluate muscle coordination and gait symmetry in stroke patients. **METHODS:** Our study quantified the symmetry of gait by analyzing muscle activation patterns on both sides of stroke patients undergoing robotic therapy. Analysis was performed with muscle synergy analysis. A total of 12 muscles, 6 muscles from each side of the lower body, were selected from 8 stroke patients in their acute phase. Patients were evaluated before and after a course of robotic therapy with the Hybrid Assistive Limb (HAL), with 9 therapy sessions over 3 weeks. **RESULTS:** We found a significant increase in similarity between muscle synergies on both sides of the body during the swing phase of walking after robotic intervention (r = -0.1 (Pre), r = 0.27 (Post), p < 0.05). Number of muscle synergies





required for reconstruction on both sides of the body tend to match after robotic therapy. Improvements in gait were also quantified by classic measures like walking speed (14 m/min (Pre), 31 m/min (Post), p < 0.05), step cadence (23 steps/min (Pre), 35 steps/min (Post), p < 0.05), stance duration percentage of gait cycle (72 percent (Pre), 64 percent (Post), p < 0.05). Clinical assessments (FIM-Locomotion, FIM-Motor (General), and FMA-LE) showed significant improvements as well. **CONCLUSIONS:** Our study showed that muscle synergy analysis can be a good tool to quantify the change in neuromuscular coordination of lower limbs in stroke patients during walking. Symmetries in muscle coordination on both sides of the body can be utilized as a relative measure for stroke patient evaluation. **ACKNOWLEDGEMENTS AND FUNDING:** This study was supported by the Industrial Disease Clinical Research Grant of the Ministry of Health, Labour and Welfare, Japan (14060101-01) and Empowerment Informatics Program of University of Tsukuba. Authors thank Ms. Mayuko Sakamaki and Ms. Yumiko Ito of Center for Innovative Medicine and Engineering (CIME) of University of Tsukuba Hospital, for their excellent assistance during HAL treatments.

P - Modeling

P1-P-126 Collision avoidance between walkers with a twist: strategies for curvilinear and rectilinear paths

Sean Lynch¹, Richard Kulpa¹, Laurentius Meerhoff², Anthony Sorel¹, Julien Pettré², Anne-Hélène Olivier¹

¹University Rennes / Inria, ²Inria Rennes

BACKGROUND AND AIM: Crowded public spaces require humans to interact with what the environment affords to regulate interpersonal distance to avoid collisions. In the case of rectilinear trajectories, the collision avoidance behaviours have been extensively studied [1,3,4,5]. It has been shown that the perceived action-opportunities of the walkers might be afforded based on a future distance of closest approach (also coined 'Minimal Predicted Distance', MPD[1]). However, typical daily interactions do not always follow rectilinear but also curvilinear trajectories. In that context, it has been shown that a ball following a curvilinear trajectory can be successfully intercepted [2]. However, it remains unclear whether the collision avoidance strategies in the wellstudied linear trajectories can be transferred to curvilinear trajectories. Therefore, the aim of this work was to examine collision avoidance behaviours when interacting with walkers following curvilinear trajectories. METHODS: An experiment was designed using virtual reality in which participants (n = 22) navigated toward a goal in a virtual environment with a joystick. A Virtual Human (VH) crossed the path of the participant from left and right with varying risks of collision. The VH followed either a curvilinear path with a fixed radius of 5 m or 10 m, approaching from infront of and behind the participant, or a control rectilinear path. The final crossing distance, the number of collisions and inversions of initial crossing order were analysed to determine the





success of the task. Further, MPD evolution over time and specific timing events was analysed across conditions. **RESULTS:** For a curvilinear path with a 5 m radius there were significantly more collisions when the VH approached from behind the participant, and significantly more inversions of the initial crossing order when the VH approached from in-front than the control rectilinear path. Final crossing distance was shorter when the VH followed a path with a 5 m radius from behind the participant. Finally, the evolution of the MPD over time was similar for paths with a 10 m radius when compared to the control rectilinear path, whereas the 5 m curvilinear paths had significant differences during the interaction. CONCLUSION: Overall, with few collisions and few inversions of crossing order we can conclude that participants were capable of interacting with virtual walkers on curvilinear trajectories. Further, the task was solved with similar avoidance adaptations to those observed for rectilinear interactions. However, paths with a smaller radius had more reported collisions and inversions. Future work should address how a curved trajectory during collision avoidance is perceived. REFERENCES:1)Olivier 2012, Gait Posture, 37:399-404, 2)Bastin 2006, Hum Mov Sci, 25:718-732, 3)Huber 2014, PlosOne, 9: e89589, 4)Knorr2016, J Exp Psychol Hum Percept Perform, 42:1332-1343 5)Lynch 2018, IEEE TVCG, 24: 2078-2088. ACKNOWLEDGEMENTS AND FUNDING: SAD 2015 -INTERACT (9297).

P1-P-127 Identification of gait characteristics for early diagnosis of Parkinson's disease with machine learning

Rana Zia Ur Rehman¹, Silvia Del Din¹, YU Guan¹, Jian Qing Shi¹, Lynn Rochester²

¹Newcastle University, ²Institute of Neuroscience, Newcastle University

BACKGROUND AND AIM: Parkinson's disease (PD) is a neurodegenerative disease characterised by motor and non-motor symptoms. Due to the diverse and progressive nature of PD, diagnosis can be challenging. In PD, gait impairments are typical and are associated with increased fall risk, loss of independence and poor quality of life. Quantification of gait (e.g. spatialtemporal characteristics) can serve as a powerful tool to identify early markers of disease and to classify PD [1, 2]. Typically studies explore differences between PD and controls using univariate statistics. To date, we do not know the best single or combination of gait characteristics that best classify early PD as a first step in developing models for disease classification. The aim of this study was therefore to use a comprehensive machine learning (ML) approach to identify the most relevant commonly measured gait characteristics for accurate classification of PD and use this as a base for inform diagnostic. **METHODS:** Gait assessment was performed at baseline on 119 people with PD (age: 66.89 ± 10.48 years) with a median of 4 months from diagnosis and 184 healthy controls (age: 69.97 ± 7.71 years) recruited from the ICICLE-GAIT study. Participants were asked to walk for two minutes at a normal pace on a 25m oval circuit. 16 gait characteristics were evaluated using an instrumented mat (GAITRite) placed in the circuit [3]. A comprehensive ML approach was used to select the most relevant gait characteristics based on their contribution to the classification modeling. Random forest (RF), support vector machine (SVM) and logistic





regression (LR) were used for feature selection. Information gain was used for RF and recursive feature elimination (RFE) technique used for SVM and LR. Our models were evaluated on training data (90%) with a 10-fold cross-validation technique and testing data (10%). RESULTS: All gait characteristics were statistically significant (p<0.05) except mean swing and step time, step width and step velocity variability (p>0.05). Overall baseline training and testing accuracy of RF, SVM, and LR ranged between 79-87% and 73-87% respectively. Five gait characteristics selected with SVM-RFE (step length, step velocity, step width, step length variability, and step width variability) in figure 1 gave the highest classification accuracy of 97.14% on testing data using RF, with 100% sensitivity and 94% specificity. CONCLUSIONS: We showed the utility of a comprehensive ML approach for selecting the most relevant clinically interpretable gait characteristics that maximised PD classification accuracy in a large cohort. This was a very early cohort with mild disease severity. These findings show the potential of ML for supporting diagnosis and clinical decision making. ACKNOWLEDGMENTS AND FUNDING: This work is supported by European Union's Horizon 2020 Marie Sklodowska-Curie grant agreement No 721577 and ICICLE-GAIT study is funded by National Institute for Health Research (NIHR) Newcastle Biomedical Research Centre based at Newcastle upon Tyne Hospitals NHS Foundation Trust and Newcastle University. **REFERENCES:**[1] Del Din et al, JBHI, 2016; 20(3): 838-847 [2] Caramia et al, JBHI, 2018; 22(6): 1765-1774 [3] Lord et al, JOG-Series A, 2013; 68(7): 820-827.

Q - Neurological diseases

P1-Q-128 Influence of mild impairment of Parkinson's disease on gait initiation

Ana Barela¹, Giovanna Machado¹, Douglas Russo-Junior¹, Flávia Doná², Henrique Ferraz², Jose Barela³

¹Cruzeiro do Sul University, ²Federal University of São Carlos (UFSCar), ³São Paulo State University (UNESP)

BACKGROUND AND AIM: Balance control in dynamic tasks such as gait initiation requires a proper integration of multiple sensory systems and motor pathways to coordinate all task components. On the other hand, a diminished dynamic balance control contributes to incapacitation of individuals with Parkinson?s disease (PD) and leads to higher risk of falling. In this way, it is important to investigate balance control in the early stages of PD, in order to develop intervention protocols to prevent accidents. The aim of this study was to examine balance control and momentum generation in patients with PD scaled in stage 2 of Hoehn and Yahr (H&Y) during gait initiation. **METHODS:** Fifteen individuals with PD without freezing of gait (59.7 \pm 6.8 years old) and 15 individuals matched by age (59.8 \pm 6.5 years old) and sex with no known orthopedic or neurologic impairment that could compromise gait (control) participated in this study. All participants were instructed to stand quietly for approximately 3 seconds with each foot on a separate force plate displaced side-by-side, and with 33 reflective markers placed on specific





body landmarks, looking straight ahead and arms hanging at side. After a verbal command, they were instructed to walk towards the end of the walkway (4m long) at a comfortable speed with no interruption. As participants initiated gait, the first step occurred on a third force plate. Center of mass (CoM) and center of pressure (CoP) in the medial-lateral (ML) and anterior-posterior (AP) directions, momentum generation of each limb (swing and stance), and the distance between CoM and CoP at specific events were obtained. **RESULTS:** Individuals with PD presented diminished momentum generation in both limbs and in both ML and AP directions, and reduced CoM-CoP distance in most of events compared to match controls. Whereas there was no difference between groups for the CoM trajectories? length, individuals with PD presented shorter CoP trajectories? length in the ML direction during the postural phase, and in the ML and AP directions during the execution phase compared to match controls. **CONCLUSIONS:** These results revealed that PD impairs balance control even in individuals with mild impairment, reducing CoP trajectories? length and momentum generation during gait initiation. Intervention protocols for individuals with PD should emphasize CoP transferences in order to reduce postural control deficit and perhaps preventing falls.

P1-Q-129 The habituation of postural responses to perturbations is delayed in people with Parkinson's disease

Victor Beretta¹, Mark Carpenter², Fabio Barbieri¹, Paulo Cezar Santos¹, Diego Orcioli-Silva¹, Marcelo Pereira¹, Lilian Gobbi¹

¹São Paulo State University (UNESP), ²University of British Columbia

BACKGROUND AND AIM: Postural control impairment is a hallmark in people with Parkinson's disease (PD). In situations of postural perturbation, reactive adjustments are necessary to maintain balance and avoid falls. Previous studies examined how PD influences the ability to change and to habituate postural responses to perturbations, usually induced by support-base rotation. Furthermore, previous studies presented trials of the same condition in sequence. Therefore, the habituation to surface-perturbation in PD remains inconclusive, since up until now, unpredictable support-base translations were not considered as an influencing factor. This study aimed to investigate the habituation of reactive postural responses to randomly presented backward support-base translations and, to investigate the capacity of people with PD (PDG) and healthy controls (CG) to change postural responses from the first trial perturbation. METHODS: Fiftyseven individuals (37 PDG and 20 CG) participated in this study. Unpredictable perturbations were applied by backward translation of the support-base (velocity: 15cm/displacement: 5cm) in 7 out of 17 randomized trials. The electromyography (EMG) and center of pressure (CoP) parameters of the reactive adjustments were analyzed by two-way ANOVAs. Two simple planned contrasts were performed to analyze the capacity to change the postural response (EMG and CoP) after the first trial (trial 2, 3, 4, 5, 6 and 7 vs trial 1), and to analyze the trial when individuals were fully habituated, represented by the last change in relation to trial 7 (trial 2, 3, 4, 5 and 6 vs 7).





Furthermore, a Student's t-test was performed to analyze the first trial effect when the group*trial interaction was revealed. **RESULTS:** For the reactive adjustments, PDG demonstrated lower range of CoP in trial 2 when compared to trial 1 (p=0.005) and the CG in trial 5 in relation to trial 1 (p=0.035). In addition, when trial 7 was contrasted to others trials, PDG showed a greater range of CoP in trial 4 (p=0.024) and CG showed a greater range of CoP in trial 3 (p=0.021). For the first trial analyses, the Student's t-test revealed a greater range of CoP in the PDG in relation to the CG (p=0.001) (Figure 1). **CONCLUSION:** People with PD demonstrated a delayed habituation compared with CG, observed by the delay to reach a steady state in the range of CoP. However, even though initial postural control was worse in PDG, unexpectedly, they were able to change their postural behavior after exposure to perturbations faster than CG. Our results, in comparison with the literature, also suggest that, for habituation, the number of perturbations is important, with similar results being evidenced when the perturbations were random or in sequence. **ACKNOWLEDGMENTS AND FUNDING:** São Paulo Research Foundation (FAPESP) [grant number #2016/00503-0; #2018/07385-9]; CAPES (Finance Code 001).

P1-Q-130 Perception of verticality correlates with postural and balance deficits in patients with Parkinson disease.

Gaia Bonassi¹, Laura Mori¹, Martina Putzolu¹, Chiara Ponte¹, Alessandro Botta¹, Giovanna Lagravinese¹, Laura Avanzino¹, Elisa Pelosin¹

¹University of Genoa

BACKGROUND AND AIM. Abnormalities of postural control are frequent in Parkinson's disease (PD) and play a prominent role in increasing the risk of falls. Perception of verticality is fundamental for postural stability and can be assessed by evaluating the subjective haptic vertical (SHV) that depends on graviceptive-somaesthetic information in the absence of visual input. The SHV is able to test perception of the verticality depending on multimodal sensory integration (i.e., haptic perception). Indeed, it requires interaction with the environment by grasping, holding and manipulating objects without visual control. Here we evaluated the verticality perception by means of SHV in a cohort of patients with PD, in order to determine whether it is associated with postural impairments and if this association may be confounded by disease severity, cognitive function, or age. We tested also if worse performances on SHV testing correlated with postural instability (evaluated by the Pull test) and fear of falling (evaluated by the Activities-specific Balance Confidence test). Methods. 39 PD patients (23 women; mean age 72.87 [] 5.78 SD; range: 60 -80) and 28 gender and age-matched healthy elderly (ELD, 16 women; mean age 69.16 [] 13.89 SD; range: 56 - 85) were enrolled in the study. The Pull test and the Activities-specific Balance Confidence (ABC) were used for evaluating balance performance, whereas measurement of posture was performed using the Physical Analyzer System[®]. For evaluating SHV, participants were instructed to provide their subjective vertical by manipulating with two hands a road while standing with their eyes closed. Results. SHV data showed that PD subjects had a greater



deviation from the objective vertical respect to the controls (p<0.001). As expected, a significant difference in balance performance (ABC and Pull test) and postural alignment was found between PD and ELD groups. Only in PD participants, SHV errors significantly correlated with (i) the lateral inclination of the trunk (r=0.618, p<0.001), (ii) pull test (r=0.519; p=0.001) and ABC (r=0.471, p=0.002) scores. Conclusions. Our results showed that the perception of verticality, driven by multimodal sensory integration, is defective in PD subjects compared to controls. Interestingly, deficits in SHV correlated with postural alignment and balance performance, independently from age, disease duration or cognitive decline. Our findings support that PD pathology is associated with a decline in haptic perception suggesting that perception per se might have a causal role in postural and balance deficits.

P1-Q-131 Repetitive head impacts do not impair single task gait in collegiate ice hockey players

Thomas Buckley¹, Melissa DiFabio¹, Jessie Oldham², Katherine Breedlove³, Curtis Johnson¹

¹University of Delaware, ²Boston Children's Hospital, ³University of Michigan

BACKGROUND/AIM: Repetitive head impacts (RHI) are subclinical head impacts or blows to the head which do not result in clinical symptom presentation or patient compliant. Recent years has seen considerable debate on the longitudinal effects of RHI on patient cognitive and quality of life; but there has been limited investigation on postural control. Therefore, the purpose of this study was to investigate the effect of RHI during a collegiate ice hockey on single task gait. METHODS: There were 13 male collegiate ice hockey players (Age: 20.2 +/- 1.6 years, Ht: 1.83 +/- 0.02 m, wt: 82.8 +/- 7.0 kg) who were tested on 3 occasions during the course of the season: preseason, midseason, and post-season. All participants completed 5 trials of gait at a self-selected pace along a 10-m walkway with 39 retro-reflective markers (Plug-In-Gait) for kinematic analysis (Qualisys Inc, Göteborg, Sweden). Participants initiated gait in response to a verbal cue and the first two steps were not included in the analysis to ensure only steady-state gait was analyzed. The two primary outcome measures were mean step length and mean step velocity. All participants wore a tri-axial accelerometer (Triax Technologies, Norwalk, CT, USA) which recorded head impact kinematics at all practices and home games. The head impact outcome measures of interest were the number of RHI over the course of the season, the mean linear acceleration, and the mean rotational acceleration. To compare performance over the course of the season, a repeated measures ANOVA with simple contrast was performed. To assess the effect of RHI, a linear regression was performed with the head impact kinematics serving as the independent/predictor variables and the gait characteristics were the dependent variables. **RESULTS:** The mean step length was 0.59 +/- 0.05 m (range: 0.48 - 0.69 m) and step velocity was 1.03 +/- 0.09 m/s (range: 0.92 - 1.24 m/s). There was a significant main effect for time for step velocity (F=6.057, p=0.025), but not step length (F=4.056, p=0.061). Post-hoc identified increased step velocity from Preseason to Mid-season (Pre: 1.00 +/- 0.07 m/s and Mid: 1.10 +/- 0.08 m/s, p=0.001), but not to post-

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season (1.02 +/- 0.13, p=0.612). The participant's number of RHI was 60.3 +/- 53.3 (range: 6 - 171 RHI), the mean linear acceleration was 34.9 +/- 4.3 g (range: 27.8 - 41.8 g's), and the mean rotational acceleration as 3.4 +/- 0.7 krad/sec2 (range: 1.9 - 4.3 krad/sec2). The RHI did not predict changes in step length (F=0.787, p=0.538) or step velocity (F=0.918, p=0.480). **CONCLUSIONS:** Similar to recent publication on RHI and gait in football players, there was no relationship between RHI kinematics and gait performance in collegiate ice hockey players. Interesting, there was a surprisingly small improvement in step velocity at mid-season (0.094 m/s) only. These results suggest that RHI do not adversely affect gait performance over the course of a single college ice hockey season.

P1-Q-132 Cholinergic upregulation in dorsomedial thalamus prior to conversion to freezing of gait in Parkinson's disease

Nicholas D'Cruz¹, Martijn Muller², Prabesh Kanel², Alice Nieuwboer¹, Nico Bohnen²

¹KU Leuven, ²University of Michigan

BACKGROUND AND AIM: The mechanisms underlying Freezing of Gait (FOG) in Parkinson's Disease (PD) are poorly understood, making it a challenging symptom to treat. Previous work identified morphological alterations in the Thalamus and Caudate nuclei as predictive of conversion to FOG, however the neurochemical changes involved in these adaptations were unexplored. In this study, we used [18F]fluoroethoxybenzovesamicol (FEOBV) radiotracer PET imaging to investigate the cholinergic activity in the Dorsomedial Thalamus and Head of the Caudate in relationship to the onset of FOG in PD. **METHODS:** Eighty-two participants (11 Healthy Controls, 71 PD - 51 Non-Freezers & 20 Freezers) underwent FEOBV PET and structural MR imaging as well as behavioral assessments at the University Hospital, Ann Arbor, MI. These participants were re-tested two years later and conversion to FOG was determined. Standardized uptake value maps for FEOBV were generated and high resolution T1-weighted scans underwent Voxel-Based Morphometry, implemented in FSL's (Oxford, UK) tool FIRST. Previously identified masks of the Dorsomedial Thalamus and Caudate Head were used to extract mean FEOBV and local shape values bilaterally which were analyzed in IBM SPSSS version 23 (Armonk, NY). **RESULTS:** Six out of the fifty-one (11.7%) Non-Freezers converted to FOG during the study (CONV). Baseline analysis revealed that CONV tended to show higher FEOBV values across groups in the right Dorsomedial Thalamus (Group effect: F3,75 = 2.268, P = 0.087), particularly with respect to the baseline Freezers (post-hoc Tukey P=0.068). Interestingly, FEOBV values in the Dorsomedial Thalamus were positively associated with local shape values (Right: r = 0.448, P < 0.001; Left: r = 0.25, P = 0.026) while in the Caudate head they showed an inverse relationship (Right: r = -0.207, P = 0.067; Left: r = -0.229, P = 0.043). Behavioral analyses showed that at baseline, Thalamus FEOBV values were associated with better performance on multiple cognitive tests [MMSE, MOCA and Parkinson's Disease Cognitive Rating Scale (r - 0.3 - 0.4, Ps < 0.012)], while change in Right Thalamus FEOBV values over two years were related to greater



improvements in Parkinson's Disease Cognitive Rating Scale (r = 0.31, P = 0.039). **CONCLUSIONS:** This study provides a link between cholinergic neuronal activity and subcortical morphological adaptations as well as converging evidence implicating the Dorsomedial Thalamus as an important player in conversion to FOG. The compensatory upregulation seen in the cholinergic neurons in the Dorsomedial Thalamus prior to the onset of FOG seems to be positive and, subject to further investigation, may provide an interesting target for clinical studies.

P1-Q-133 Turning velocity and coordination in multiple sclerosis

Brian Loyd¹, Grace Hunt¹, Annie Fangman¹, Peter Fino¹, Lee Dibble¹

¹University of Utah

BACKGROUND AND AIM: Turning during gait is a common activity which involves rapid reorientation of the head, trunk, and pelvis, requiring sophisticated sensory integration and motor planning, which may provide insight into postural instability in balance impaired individuals. People with multiple sclerosis (PwMS) often have sensory and motor symptoms which can lead to stability deficits, but it is unknown if turning is impaired by these symptoms. The aim of this study was to examine turning velocity and temporal variability in PwMS and healthy controls (HC). We hypothesized that PwMS will have slower peak turning velocities and greater temporal variability. **METHODS:** Twelve HC and 12 PwMS with central vestibular pathology (CVP) were included. Central vestibular pathology was defined as dizziness and impaired saccades, smooth pursuits, and VOR cancellation. Participants performed 3 laps on a turning course with right and left turns of 45, 90 and 135 degrees. 3-D rotational velocity was recorded by inertial sensors (Opal, APDM inc) placed on the head, thorax, and pelvis. Gyroscope data from the yaw plane were filtered with a 1.5Hz fourth order phaseless low-pass Butterworth filter. Each participant's average peak angular velocity of the head (PV-H), thorax (PV-T), and pelvis (PV-P) for all turns of the same angle were calculated. Temporal variability was quantified as the standard deviations of the timing differences between the peak velocities of the head and lumbar (V-HL) on each turn angle. Linear mixed models were fit for each peak angular velocity and V-HL, adjusted for group, angle of turn, average lap time, and a group by angle interaction. **RESULTS:** Significant effects of group and degree were detected at each sensor demonstrating that on average PwMS had lower angular velocities across sensors, and velocities varied across degrees of turn in both groups. A significant group by degree effect was detected at each sensor and indicated that PwMS varied significantly more in velocity across angles than did HC. Average lap time also significantly contributed to differences in PV at each sensor. As for the V-HL a significant effect of degree was detected, but no group effect was seen indicating that on average V-HL decreased with increasing angle regardless of group. Means of each outcome and average lap time are presented in table 1. **CONCLUSIONS:** As hypothesized, PwMS turned more slowly and demonstrated reduced peak angular velocities. PwMS may alter their turning behaviors in order to avoid disorientation and loss of postural control while reorienting the head, trunk, and pelvis. Secondarily, we expected to



see greater temporal variability in PwMS. Interestingly, no group effect was detected but variability decreased with increasing angle. Future work will benefit from examining turning ability of PwMS in situations associated with high fall risk (e.g., uneven terrain, low light) and examining associations to measures of symptom severity in PwMS.

P1-Q-134 The neural correlates of motor imagery of mediolateral dynamic balance in Parkinson's disease

Bauke Dijkstra¹, Moran Gilat¹, Sabine Verschueren¹, Alice Nieuwboer¹

¹KU Leuven

BACKGROUND AND AIM: People with Parkinson's disease (PD) experience frequent falls due to postural instability, of which compromised weight-shifting forms a component part. The underlying neural underpinnings of these deficits remain largely unknown. Motor imagery (MI) in combination with functional magnetic resonance imaging (fMRI) provides a proxy method to unravel the neural mechanisms of postural control. Hence, the objective of this study was to investigate the impact of PD on the neural correlates of postural control via MI of a dynamic mediolateral (ML) weightshifting task. As previous study showed reduced activation in the supplementary motor areas (SMA) in PD during MI of locomotion, we hypothesized that PD patients would also show reduced activation during ML weight-shifting compared to age-matched controls. METHODS: Twenty-nine people with PD and 14 age-matched controls first completed MI and visual imagery (VI) training (day 1). Following training, participants who scored average <3 on the kinesthetic and visual imagery questionnaire were excluded from the study (6 PD patients and 2 controls). Then, a ML weight-shifting task "off" dopaminergic medications was performed (day 2). During the weightshifting task, participants had to move their center of mass in the ML direction in line with a visual target displayed on a screen. Next, they underwent an fMRI protocol imagining themselves executing the ML weight-shifting task as well as a VI task "off" medication (day 3). SPM12 was used for data analysis. MI>VI was used as the first-level contrast of interest. In the second level, a control > PD group comparison was analyzed. Whole brain analysis threshold was set at p<.001and k>10. Subjects with excessive head motion were excluded (3 PD patients and 2 controls). Data collection is still ongoing. RESULTS: Patients (N=20; mean age: 65.35; SE=1.71) and controls (N=10; mean age: 68.40; SE=2.91) were well-matched for age. Patients had an average Unified Parkinson's Disease Rating Scale (part-III) score of 31.5 (SD: 6.38) and 8 patients experienced freezing of gait. People with PD showed a trend towards lower scores on our mediolateral balance assessment task compared to controls (U=69.00, p=.086). Brain imaging data showed that controls had greater activation in the SMA, anterior cingulate and the medial frontal lobe (including BA10) compared to PD on the contrast of interest (MI>VI). PD did not reveal any higher activations than controls. CONCLUSIONS: Our findings extend prior reports of reduced SMA activation in PD as also being implicated in ML weight-shifting ability. In addition, greater activity in BA10 has previously been associated with good MI performance in controls. Finally, the anterior cingulate



is integral to many functions, including cognitive penetration into motor control in healthy older adults. Future work on the final sample will enable precise interpretation of the influence of PD on dynamic postural control.

P1-Q-135 Effect of dopamine on mediolateral dynamic balance in Parkinson's disease and freezing of gait

Moran Gilat¹, Bauke Dijkstra¹, Alice Nieuwboer¹

¹KU Leuven

BACKGROUND AND AIM: Postural instability and freezing of gait (FOG) are common features of Parkinson's disease (PD) that lead to frequent falls. Both problems respond poorly to dopaminergic treatment suggesting shared underlying pathophysiology. Converging evidence indicates that dynamic balance tasks, specifically those involving weight-shifting in the mediolateral (ML) direction, are particularly affected in patients with FOG. Yet to date, no study has assessed the differential effect of dopamine on ML weight-shifting in PD with and without FOG. We hypothesized that if FOG and dynamic balance control coincide neurologically, dopaminergic treatment would have less impact on ML weight-shifting in PD patients with FOG (freezers) as compared to those without (non-freezers) and this irrespective of disease severity. **METHODS:** Fourteen freezers and 13 non-freezers performed the MELBA assessment twice: once while on their regular dopaminergic medications and once following overnight withdrawal (i.e. in 'off'). The order of test moments was counterbalanced. During the MELBA-task, subjects followed a visual target from side to side with their center of mass (CoM) by shifting their weight from one leg to the other. Both the target and the CoM were presented on a large screen in real time. Target oscillations started at 0.1Hz and increased to 1.2Hz in 0.1Hz intervals. Weight-shifting breakdown was determined by a cutoff point at which the participant was no longer able to follow the target, indicated by >90 degrees phase shift or >50% amplitude difference between the CoM and visual target. The average cutoff point of three trials was calculated as a measure of maximal ML weight-shifting performance. Due to the non-normal data distribution, a Wilcoxon signed rank tests was used with an alpha of 0.05. **RESULTS:** The groups were well-matched for age (p=0.74), MOCA (p=0.91) and UPDRS-III (OFF: p=0.43; ON: p=0.67). The analysis revealed a significant improvement in ML weight-shifting in non-freezers while on compared to off dopamine, indicating a later breakdown of ML weight-shifts (Z=-2.21, p=0.027, Median (IQR) ON=0.87 (0.68-0.92); OFF=0.77 (0.62-0.95), medium effect size r=0.43). No difference between medication states on the MELBA-task was found for freezers (Z=-1.38, p=0.169, Median (IQR) ON=0.80 (0.69 - 0.85); OFF=0.77 (0.65 - 0.84), r=0.26). CONCLUSION: Dopaminergic therapy improved dynamic weight-shifting in non-freezers, whilst freezers experienced no dopaminergic benefits. These preliminary findings are particularly meaningful against the background of similar disease severity between groups, pointing to the possibility that freezers have more extra-nigral pathology





implicated in both impaired gait and balance control. Thus, the present findings provide further evidence that postural instability and FOG are neurologically intertwined.

P1-Q-136 Effects of perturbation-based balance training on balance, gait and balance confidence in subacute persons with stroke: a randomized controlled trial

Shirley Handelzalts¹, Michal Kanner-Furman¹, Ganit Gray¹, Nachum Soroker², Itshak Melzer¹

¹Ben-Gurion University, ²Loewenstein Rehabilitation Hospital

BACKGROUND: Falls occur in up to 70% of persons with stroke (PwS) during the first six months after discharge from rehabilitation facility. Falls are major causes of functional decline, poor quality of life, dependency and mortality. Studies indicate that 30% to 80% of PwS report fear of falling that may result in greater inactivity and social isolation. Reactive balance responses are critical for fall prevention. Perturbation-based balance training (PBBT) has shown a positive effect in reducing the risk of falls among older adults and persons with Parkinson's disease, however it's effect has not been studied in persons with stroke (PwS). Objective: To explore the effect of a short-term PBBT on reactive balance responses, performance-based measures of balance and gait and balance confidence. METHODS: Thirty-four moderate-high functioning, subacute PwS (Lower Extremity Fugl-Meyer score: 29.2±4.3; Berg balance Scale score: 43.8±9.5, 42.0±18.7 days after stroke onset) hospitalized in a rehabilitation setting were randomly allocated to PBBT (n=18) and weight shifting and gait training (WS>) (n=16). Both groups received 12 training sessions, 30 minutes each, for a period of two and a half weeks. PBBT included unexpected balance perturbations during standing and treadmill walking, WS> included weight shifting in standing and treadmill walking without perturbations. The main outcome measures i.e., multiple step threshold and fall threshold were examined at baseline, immediately post-intervention and about 5-weeks post-intervention. The secondary outcome measures i.e., Berg Balance Scale (BBS), 6 Minute Walk Test (6MWT), 10 Meter Walk Test (10MWT) and Activity-specific Balance Confidence (ABC) scale were examined at baseline and immediately post-intervention. **RESULTS**: Compared with WS>, post intervention the PBBT group showed significantly higher multiple step thresholds in response to forward (p=0.013; ES=1.07) and backward (p=0.011; ES=1.10) surface translations and significant improvement in balance confidence (p=0.049; ES=0.74). No significant differences between groups were found in fall threshold, BBS, 6MWT and 10MWT scores. **CONCLUSIONS:** Reactive balance responses as well as balance confidence can be improved in PwS through PBBT. Results support the inclusion of reactive balance training during rehabilitation after stroke.

P1-Q-137 The effect of combined transcutaneous direct current stimulation and locomotor training on spinal excitability in an individual with chronic spinal cord injury

Kelly Hawkins¹, Lou DeMark², Arian Vistamehr², Geneva Tonuzi², David Fuller¹, David Clark³, Emily Fox¹





¹University of Florida, ²Brooks Rehabilitation, ³Malcom Randall VA Medical Center; University of Florida

BACKGROUND AND AIM: Walking rehabilitation for individuals with incomplete spinal cord injury (ISCI) is limited by insufficient excitation of spinal locomotor circuitries necessary to drive neuroplastic recovery. Transcutaneous spinal direct current stimulation (tsDCS) is a neuromodulatory approach that uses mild and non-invasive electrical stimulation. In animal models, tsDCS induces immediate and lasting changes in spinal cord excitability and alters reflexive and voluntary behaviors. Likewise, in humans, tsDCS modulates spinal reflexes, increases corticospinal excitability, and increases motor unit recruitment. Although ample mechanistic evidence suggests that tsDCS could substantially enhance the therapeutic effect of locomotor rehabilitation, this combinatorial approach has not been evaluated in humans with SCI. The aim of this case study is to investigate the effects of tsDCS on spinal excitability, as evidenced by changes in the Hoffman (H) reflex response, in an individual with ISCI when combined with an established rehabilitation strategy, locomotor training (LT). We hypothesized that tsDCS combined with LT would increase spinal excitability more than LT with sham stimulation. METHODS: An individual with a chronic ISCI (C1, AIS D) completed two sessions, five days apart. Sessions involved thirty minutes of either anodal (2.5 mA) or sham tsDCS, delivered over the lumbar spinal cord, applied during LT. LT emphasized repetitive stepping on a treadmill at a near normal speed with appropriate stepping kinematics. Supine tibial H reflexes were collected before and after the stimulation. Fitting of a sigmoid curve was completed for all responses along the ascending limb of a normalized H curve. Changes in spinal excitability were assessed by quantifying the area under the curve. Modulation of reflex responses to repeated stimuli (postactivation depression) was assessed by quantifying changes in reflex amplitude in response to stimuli delivered at 1 Hz. Changes in the variables were calculated pre-session to post-session. **RESULTS:** The combination of tsDCS and LT resulted in an increase of 0.042 in the area of the H-reflex stimulus response curve. In contrast, sham stimulation and LT produced a reduction of 0.021 units. Further, post-activation depression was increased by 31% after active tsDCS and LT, versus 15% after sham tsDCS and LT. CONCLUSIONS: The H reflex data obtained in this case study supports the hypothesis that tsDCS applied during walking rehabilitation can increase the excitability of spinal circuitries and induce beneficial modulation of reflex responses (postactivation depression) below the level of the injury. Altering spinal excitability may increase neuroplastic responses to rehabilitation in individuals with ISCI, particularly when combined tsDCS and LT is applied repeatedly as part of a training paradigm.

P1-Q-138 The differences in sagittal plane whole-body angular momentum during gait between patients with hemiparesis and healthy people

Keita Honda¹, Yusuke Sekiguchi¹, Takayuki Muraki¹, Shin-Ichi Izumi¹

¹Tohoku University





BACKGROUND AND AIM: Patients with hemiparesis frequently fall toward the anterior direction. Regulation of whole-body angular momentum (WBAM) is essential for maintaining dynamic balance during gait. Ankle plantar flexor muscle is important in maintaining the small range of WBAM in the sagittal plane during gait in healthy individuals. In patients with hemiparesis who have the insufficient plantar flexion moment, the range of WBAM might be different from that in healthy individuals. Therefore, the purpose of the present study was to investigate the differences in WBAM in the sagittal plane during gait between patients with hemiparesis and healthy individuals and to determine which joint moment was the most explanatory variable for the range of WBAM. METHODS: Thirty-three chronic stroke patients with hemiparesis and twenty-one ageand gender-matched healthy controls were participated. Patients with hemiparesis and healthy controls were instructed to walk at a comfortable and a slower speed along a 7-m walkway for 3 to 10 trials, respectively. Three-dimensional coordinates for 31 reflective markers attached to various body segments were recorded during over-ground walking using an 8-camera motion analysis system operating at 120 Hz. Furthermore, ground reaction force data were collected using four force plates synchronized with the 8-camera system and operated at 1200 Hz. WBAM was computed in the sagittal plane during each gait cycle and normalized by body weight, height and walking speed. Ankle, knee and hip joint moment in the sagittal plane were also calculated and normalized by body weight. The effect of the group and phase or side were examined using a two-way analysis of variance, followed by a Bonferroni post-hoc test. **RESULTS:** The walking speed of the patients with hemiparesis was not significantly different from that of the controls (P = 0.431). The range of WBAM in the sagittal plane in the second half of paretic gait cycle was significantly larger than that in the first and second half of right gait cycle in controls (P = 0.015 and P = 0.011). In multiple stepwise regression analysis, slower walking speed (P < 0.001) and the larger knee extension moment in the early stance phase on the non-paretic side (P = 0.003) were identified as contributors to the larger range of WBAM in the sagittal plane in the second half of paretic gait cycle. **CONCLUSIONS:** Our findings suggested that dynamic stability in the sagittal plane is impaired in the second half of the paretic gait cycle. Furthermore, the range of WBAM in the sagittal plane in the second half of the paretic gait cycle might be affected by the non-paretic knee extension moment rather than the paretic plantar flexion moment during gait in patients with hemiparesis. ACKNOWLEDGEMENTS AND FUNDING: The present work was supported by JSPS KAKENHI Grant Number JP18H06434.

P1-Q-139 Unravelling quantitative measures of free-living ataxic gait in cerebellar patients using wearable sensors

Winfried Ilg¹, Jens Seemann¹, Matthis Synofzik¹

¹Hertie Institute for Clinical Brain Research

BACKGROUND AND AIM: The characteristics of ataxic gait can be captured in a sensitive and specific fashion by spatio-temporal variability measures in laboratory examinations, allowing to



quantify disease stages even at preclinical stages and to determine intervention-based improvements. Identification of ecologically meaningful improvements, however, requires quantification of patients' motor behavior during everyday life. Yet transfer of laboratory-based measures of spatio-temporal step variability into free-living is complicated by that fact that freeliving gait is inherently far more variable. Moreover, patients may use various compensation strategies, thus increasing the heterogeneity of walking patterns. Here, we aimed to unravel measures that allow to quantify the specificities of ataxic gait in free living by wearable sensors. **METHODS:** We assessed gait features of 20 patients with degenerative cerebellar disease (age: 52±15, ataxia score SARA: 10.2±2.9) compared to 10 age-matched controls by 3 inertial sensors (Opal, APDM) attached to the feet and the lower back in two conditions: (i) The constrained condition assessed straight walking in a clinical setting with slow and normal speed each for 1 minute, allowing to establish characteristic features of ataxic gait; (ii) the unconstrained walking condition assessed at home, capturing 4-8 hours of free-living gait (subset: 5 patients, 5 controls), allowing to test whether features established in the constrained condition can also be identified in free-living gait. Therefore, we extracted walking bouts with 10 subsequent strides within a limited speed range, resulting in 900-2000 gait cycles. Analysis included a compound measure of spatial step variability consisting of lateral step deviation and step length variability. RESULTS: The constrained walking condition allowed to identify group differences in step length variability (p<0.005), lateral step deviation (p<0.01) and the compound measure of step variability (p<0.001)for slow and normal walk, with step variability correlating with ataxia severity (SARA, p=0.03). This compound measure of step variability was also re-identified in the unconstrained free-living condition, demonstrating a group difference (p=0.03) and showing a strong tendency towards correlation with ataxia severity (r=0.86). Moreover, step variability during unconstrained walking (filtered for walking bouts within the speed range of constrained walking) correlated with step variability during constrained walking (r=0.93, p=0.03), indicating validity of this measure across conditions. **CONCLUSIONS:** This study unravels quantitative measures that allow to quantify the characteristics of ataxic gait in free-living, using wearable sensors. In particular, the compound measure of spatial step variability can be extended from constrained to free-living gait, both times reflecting disease severity, thus yielding a promising outcome measure for natural history and treatment trials.

P1-Q-140 Can transcranial direct current stimulation improve gait initiation in individuals with Parkinson's disease?

Jonathan Lommen¹, Anthony Carlsen¹, Julie Nantel¹

¹University of Ottawa

BACKGROUND: Current treatment options for Parkinson's disease (PD) have various effect on motor symptoms across individuals with PD and in some cases their symptoms may be exacerbated. Transcranial direct current stimulation (tDCS) is a therapeutic intervention used to





up- and down-regulate cortical regions of the brain. In PD, this may serve as a viable non-invasive alternative to deep brain stimulation (DBS) and as an adjunct to pharmaceutical intervention in the treatment of neuromotor deficits involved with gait initiation (GI). AIM: The purpose of this study is to evaluate the effect of tDCS on GI in people with PD. More specifically, we will determine the effect of tDCS, applied to the supplementary motor area (SMA), on gait initiation preparation and performance. METHODS: We implemented a within subjects repeated measures experimental design to investigate the effects of a ten minute "sham" and tDCS intervention on GI in people with PD. Thirteen participants - on dopaminergic medication were subject to two separate testing sessions which included a familiarization protocol, followed by; a baseline performance test, tDCS or Sham intervention, and a final performance test. During the performance tests, participants were instructed to stand with their feet shoulder width apart, and to begin walking upon detection of an auditory cue. Surface electromyography (EMG) of bilateral tibialis anterior (TA) and medial gastrocnemius (MG), along with a force platform, were used to record muscle activity and center of pressure (CoP) coordinates. We then calculated, reaction (RT) and movement time (MT), center of pressure displacement (CoPd) in mediolateral (ML) and anteroposterior (AP) directions, root mean square (RMS) and velocity. A total of 10 GI trials, 5 seconds in length, were recorded during each performance test. Planned statistical analyses: To determine the effect of the type of intervention (sham vs tDCS) as well as the treatment effect (pre - post), EMG and force data will be analyzed using two-way repeated measures ANOVAs. Bonferroni corrections will be performed when necessary. Pearson correlation analyses between RT, MT measures and UPDRS III scores will be used to determine any associations between these GI parameters and disease severity. In the case of abnormally distributed data, z-scores will be calculated, and nonparametric (Mann-Whitney U) tests will be used to compare any kinetic differences between treatment types. CONCLUSIONS: Findings from this study could be instrumental in understanding the specific therapeutic effects of tDCS for those with PD. This could have a major impact on individuals for whom medication does not adequately improve the execution of fundamental movement such as GL

P1-Q-141 Electromyographic profiles of gait initiation in people with Parkinson's disease: the effects of external sensory cueing

Colum MacKinnon¹, Lesley Perg¹, Chiahao Lu¹, Matthew Petrucci¹, Abigail Kohut-Jackson¹, Paul Tuite¹, Sommer Amundsen Huffmaster¹

¹University of Minnesota

BACKGROUND AND AIM: Postural instability and gait disturbances are a common and debilitating motor sign in people with Parkinson's disease (PD). During self-paced (uncued) gait initiation, the magnitude of anticipatory postural adjustments (APAs) are markedly reduced and prolonged and the first step length is shortened. External sensory cues significantly improve the magnitude and timing of APAs, particularly in the off-medication state. The purpose of this study





was to quantify changes in the timing and magnitude of lower limb electromyographic (EMG) activity associated with improved gait initiation with external cueing. METHODS: The profiles of surface EMG activity in 7 lower-limb muscles (tibialis anterior, TA, soleus, SOL, gastrocnemius, GA, vastus lateralis, VL, rectus femoris, RF, biceps femoris, BF, and gluteus medius, GM), bilaterally, were examined during self-initiated (uncued) and externally cued (80dB acoustic "go" cue) gait initiation in 32 individuals with PD (off medication) and 16 healthy adults. EMG, ground reaction forces, center of pressure excursions and whole-body kinematics were quantified during the APAs, unweighting, and the first step phases of gait initiation. RESULTS: The APA phase of uncued gait initiation was associated with activity in anterior muscles (TA, VL, RF) of the stepping leg and TA activity in the stance leg. Posterior muscle (SOL, GA, BF) and GM activity on both sides predominated during unweighting and stepping. External cueing produced an earlier onset and increased magnitude of activity in anterior muscles (TA, VL, RF) of the stepping leg and TA of the stance leg during the APA phase in both groups. The timing and magnitude of posterior (SOL, GA, BF) and GM muscle activity, bilaterally, was unaffected by cueing. CONCLUSIONS: Cueing produced changes that were selective for muscles involved in the early APA phase of gait initiation, rather than a global increase in gain across all muscles and timings. These findings demonstrate that external sensory cues act specifically upon APA circuitry and not pathways mediating unloading and stepping. ACKNOWLEDGEMENTS AND FUNDING: We thank the volunteers for participation in this research. This work was supported by the following grants: NIH RO1 NS070264 & NS088679 (CDM) and MnDrive (SLAH, MP).

P1-Q-142 The effects of obstacle size and timing on prefrontal cortex activation in patients with Parkinson's disease

Inbal Maidan¹, Topaz Sharon¹, Ilan Kurz², Hagar Bernad-Elazari¹, Shiran Shustak¹, Ira Galperin¹, Anat Mirelman¹, Jeff Hausdorff¹

¹Tel-Aviv Sourasky Medical Center, ²Ben-Gurion University

BACKGROUND AND AIM: Obstacle negotiation is a daily activity that requires the integration of sensorimotor and cognitive information. Tripping over an obstacle is one of the most common causes of falls among patients with Parkinson's disease (PD). Recent studies showed the important role of prefrontal cortex during usual walking and obstacle negotiation in PD patients. However, the effects of obstacle type on prefrontal activation have not been systematically evaluated. We aimed to evaluate the effects of obstacle height and anticipation time on prefrontal activation in patients with PD and older adults. **METHODS:** 26 older adults (age: 71.3±8.9 years; 11 women) and 34 patients with PD (age: 67.4±5.7 years; 14 women, disease duration: 5.8±4.5 years) walked in an obstacle course while negotiating anticipated and unanticipated obstacles at heights of 50 mm and 100 mm. Prefrontal activation was measured using a functional near-infrared spectroscopy (fNIRS) system. Kinect cameras evaluated performance by measuring the distance of the feet from obstacle. Prefrontal activation was defined based on mean level of HbO2





at 3 seconds before the obstacle, during stepping over the obstacle, and 3 seconds after obstacle. Changes before, during and after obstacle negotiation between types of obstacles and groups were assessed using linear-mix models while controlling for age, and gender. Pearson correlations evaluated the relationship between prefrontal activation and the distance between the feet as the subjects traversed the obstacles. RESULTS: All the participants demonstrated increased prefrontal activation before, during and after obstacle negotiation, compared to guite standing (p<0.001). Interaction between obstacle height and anticipation time showed that prefrontal activity further increased during the higher anticipated obstacles (p=0.004). Prefrontal activation was higher in the patients than in the older adults in both anticipated and unanticipated obstacles (p=0.007). In addition, increased prefrontal activation during negotiation of anticipated obstacles were correlated with greater distance of the leading foot after the obstacles in the patients (r=0.409, p=0.020), but not in the controls (p=0.617). **CONCLUSIONS:** These findings provide direct evidence to the role of the prefrontal cortex during obstacle negotiation in PD patients. Moreover, the higher activation that was evident in the PD patients during both anticipated and unanticipated obstacles may indicate that the prefrontal response is not specific and does not necessarily relate to the time course of motor planning. However, the correlation with foot distance during anticipated obstacles may point to the effectiveness of this compensatory mechanism. These results suggest that with disease when activation is less efficient, a larger increase in HbO2 during complex situations will limit further activation when necessary, providing potential explanation of the high risk of falls in PD.

P1-Q-143 Post-stroke walking characteristics on association between motor paralysis and walking speed by cluster analysis

Naomichi Mizuta¹, Yusaku Takamura¹, Shintaro Fujii¹, Naruhito Hasui¹, Tomoki Nakatani², Masako Tsutsumi², Junji Taguchi², Shu Morioka³

¹Department of Neurorehabilitation, Graduate School of Health Sciences, Kio University, ²Takarazuka Rehabilitation Hospital, ³Kio University

BACKGROUND AND AIM Walking speed in post-stroke hemiplegic patients is strongly limited by motor paralysis. In clinical scenes, most of therapist empirically know some patients with mild motor paralysis showing reduction of walking speed. Few clinical studies reported to this fact and suggested that walking speed were limited by various factors not only severity of motor paralysis. In this study, we aimed to characterize relationships between motor paralysis and walking speed in patients with post-stroke hemiplegic patients. Specifically, we focused on characteristics of trunk instability and muscle activity in patients with slow walking speed and mild motor paralysis. **Method** Forty-two patients with post-stroke hemiparalysis possible to walking independently participated in this study (age: 65.9±13.7 years old, after onset: 132.1±107.6 days). Participants were asked to walk 10m walkway comfortably, putting on accelerometer on L3 and EMG on tibialis anterior and medial gastrocnemius in paralytic side. In off line analysis, we quantified the following





three characteristics from accelerometer and EMG; 1) walking speed, 2) trunk instability, 3) intramuscular beta band coherence (15-30 Hz). Severity of motor paralysis was additionally evaluated to use the synergy score of Fugl-Meyer Assessment (FMS). Results and discussion Walking speed and severity of motor paralysis indicated liner correlation ($\rho = 0.5$, $\rho < 0.01$). However, some patients showed slow/fast walking speed in spite to mild/severe motor paralysis, therefore we adapted the hierarchical cluster analysis. In this results, following five cluster were found; (1)mild-to-moderate motor paralysis and poor walking speed, (2)severe motor paralysis and poor walking speed, (3)severe motor paralysis and moderate walking speed, (4)mild-to-moderate motor paralysis and moderate walking speed, and (5)slight motor paralysis and fast walking speed. Trunk instability and muscle co-contraction during walking in cluster 1 were more increase than other clusters. Interestingly, intramuscular beta band coherence in cluster 1 was more enhanced than cluster 4 (which is similar severity of motor paralysis). Increase of intramuscular coherence showed enhanced cortical drive (ref). These results suggest that cluster 1 show powerful cortical drive for control of trunk instability. Therefore, increase of trunk instability caused to slow walking speed in spite to mild motor paralysis. Conclusions Five subgroups were identified based on the relationship between severity of motor paralysis and walking speed. Group with poor walking speed despite mild paralysis (cluster 1) was shown large trunk instability, co-contraction in the paralyzed side, and intramuscular beta band coherence during walking. Conflicts of interest statement There were no conflicts of interests related to the preparation of this manuscript or to the research discussed in the present study.

P1-Q-144 Reweighting of sensory information during gait in Parkinson's disease

Marcelo Pereira¹, Quincy Ameida², Lilian T. Gobbi³

¹São Paulo State University (UNESP), ²Wilfrid Laurier University, ³UNESP - Rio Claro

BACKGROUND AND AIM: Gait impairments in Parkinson's disease (PD) are a disabling symptom often related to sensory processing deficits, including the inability to reweigh sensory information from different sources (i.e. PD patients are unable to down-regulate irrelevant sensory information and upregulate reliable information). This reweighting deficit in PD was only observed during upright stance in PD and it is not known whether they exist during gait. Furthermore, gait impairments in PD have also been linked to attentional dysfunction, evidenced by a slower gait with increased gait variability during dual-tasking. The aim of this study was to investigate the effects of somatosensory disturbance (by means of muscle vibration - an efficient **Method** to disrupt proprioception) during gait in individuals with PD and healthy elderly. It was hypothesized that only PD patients would present worse gait performance with muscle vibration, supporting their inability to shift away from the irrelevant sensory feedback. If vibration plays an attentional effect, findings similar to dual task would be expected. **METHODS:** Fifteen healthy elderly (CG - aged 66.5±6.46 years) and 24 PD patients (PD-G: 64.4±5.3 years) walked on a pressure-sensitive carpet in two conditions: without (nVib) and with muscle vibration (Vib). Muscle vibration (100 Hz 197



and 1 mm of amplitude) was simultaneously applied bilaterally on the belly of trapezius superior, quadriceps femoris and tibialis anterior to ensure an overload of irrelevant proprioceptive inflow. Five trials per condition were performed. Spatio-temporal parameters of gait and their variability (i.e. coefficient of variation) were assessed. Two-way ANOVAs were used to assess the effects of group and condition on gait parameters. RESULTS: An interaction between group and condition was found for step length and velocity (F(1,38) > 12.89, p < 0.03). The Tukey post-hoc test showed a slower and shorter stepped gait during Vib compared to nVib only in PD. No interaction between factors were found for other variables (F(1,38) < 2.45, p > 0.12). Both groups showed a longer single support time with vibration (condition effect: F(1,38)=4.29, p=0.04); however, this increase was mainly driven by PD: increase of 0.33% in CG and 2.53% in PD-G. No interaction or main effects were found for gait variability (F(1,38) < 3.25, p > 0.08). CONCLUSIONS: Gait performance worsened during Vib only in G-PD demonstrating that this group was unable to downregulate the unreliable proprioceptive information elicited by vibration. These findings support the hypothesis that reweighting deficits are also present during gait in PD. Since gait variability was not modified by vibration, we argue that our findings were not related to attentional effects. Sensory reweighting deficits may provide important insight into the underlying mechanisms of motor impairment in PD. ACKNOWLEDGEMENTS AND FUNDING: FAPESP (#2010/50532-0); CAPES (#001).

P1-Q-145 Brain functional connectivity changes associated to freezing of gait in Parkinson's disease

Alexandra Potvin-Desrochers¹, Trina Mitchell¹, Thomas Gisiger¹, Caroline Paquette¹

¹McGill University

BACKGROUND/AIM: Freezing of gait (FOG) is a motor impairment in Parkinson's disease affecting the majority of patients in a severe stage of the disease. It is characterized by brief episodes of motor blockages of the lower limbs where feet are glued to the ground despite attempting to move. Because FOG is associated with falls and loss of autonomy, it is paramount to understand how the presence of FOG alters neural control of locomotion. Some models propose that FOG is related to PD-induced neural changes in locomotor, cognitive and limbic circuits, while others suggest that impaired visuospatial and perceptual circuity leads to FOG. Recently, brain functional connectivity at rest, a measure of connectivity between various brain regions while at rest, was used in some studies to understand how dysfunction in "baseline" (i.e. at rest) brain connectivity can contribute to FOG episodes. These studies support locomotor network reorganization but failed to provide evidence of altered connectivity in cognitive circuits. Furthermore, these studies mainly focused on functional connectivity changes between few specific brain regions, limiting the understanding of FOG at the whole brain level. Therefore, the purpose of this study was to identify FOG-related changes in whole brain functional connectivity at rest. METHODS: Thirty adults with Parkinson's disease, 15 with FOG and 15 without FOG were scanned with a resting-state functional magnetic resonance imaging ON-medication. A seed-





based analysis identified brain regions whose activation was correlated with activation within each of the seeds (basal ganglia nuclei, thalamus and mesencephalic locomotor nuclei, all bilaterally). A significant correlation between a seed region and a cluster of voxels indicates that those areas are functionally connected at rest. Group differences were determined using a mixed-effects model, corrected for multiple comparisons. **RESULTS:** FOG is associated with increased functional connectivity between bilateral thalamus and bilateral calcarine and cuneus gyri, suggesting strengthen communication between the sensory relay of the brain and visual processing areas at rest. Functional connectivity between the right globus pallidus internal and the right angular gyrus was lower in patients with FOG, suggesting decreased communication between a key structure of the striato-thalamo-cortical motor and cognitive loops and a visuospatial processing region for motor planning. **CONCLUSION:** These results support FOG-related changes in cognitive and motor circuits at rest. Indeed, functional connectivity between key brain areas for visual and sensorimotor processing is altered in patients with FOG at rest, likely further leading to visuospatial and motor planning deficits during actual locomotion, further contributing to FOG episodes.

P1-Q-146 Occupational therapy intervention to improve the quality of life of client with Friedreich's Ataxia- A case study of complete rehabilitation from complete dependency to living independently

Deepa Pradhan¹

¹Mumbai University

INTRODUCTION: A single case study was done on young male client diagnosed with Fredrick's Ataxia. Client was totally dependent for social mobility on family members and at home he was managing on ground propelling. As the client is young and is perusing studies as well as earning, dependency on the others for mobility was very depressing and was affecting his performance in social activities and day to day ADL management. So extensive Occupational Therapy program was given to do the complete rehabilitation and to make the client independent in mobility and psychologically healthy. METHODOLOGY: Detail program of exercises were designed after complete evaluation of the client. It was seen that if the client's proximal muscles were weak, which are required to stabilize his balance and to protect himself from fall but distal muscles required to do fine motor activities were good. Client's ADL, quality of life and Occupational Performance were assessed. Mobility training program was administered and follow up was taken weekly. RESULT: There was marked improvement in the stability musculature of the client which reduced his risk of losing balance and decreased the risk of falling. There was significant improvement in independence of mobility at home and in the society, which also improves his mental health and confidence. CONCLUSION: To completely rehabilitate the clients who are diagnosed with progressive condition like Fredrick's Ataxia, a customarised exercise program by Occupational Therapist should be designed along with the mobility adaptations and psychological





support, so that in spite of progressive neurology problems, the client can lead independent fruitful, and content life. KEY WORDS: Fredrick's Ataxia, ADL(Activities of daily living), Mobility adaptations, Occupational Performance.

P1-Q-147 Can saccadic eye movements minimize the deleterious effect of ankle muscle fatigue on postural control in people with Multiple Sclerosis?

Felipe Santinelli¹, Emerson Sebastião², Fabiana Silva¹, Gabriel Moretto¹, Luiz Felipe Imaizumi¹, Lucas Simieli¹, Richard Van Emmerik³, Fabio Barbieri¹

¹São Paulo State University (UNESP), ²Northern Illinois University, ³University of Massachussets

BACKGROUND AND AIM: Saccadic eye movements have been shown to reduce body sway when compared to fixating gaze in people with multiple sclerosis (PwMS) and neurologically healthy individuals [1]. On the other hand, ankle muscle fatigue affects negatively the body sway, which increases the body oscillation, in PwMS when fixating the gaze in a stationary target [2]. Therefore, saccadic eye movements could be an interesting strategy for PwMS in an attempt to reduce body sway under muscle fatigue, which is a common symptom in Multiple Sclerosis disease. However, as PwMS presents a poor ability to integrate external information and produce a correct response [4], they could not be able to use the visual feedback to improve postural control under ankle muscle fatigue. The purpose of this study was to investigate the effects of saccadic eye movements on body sway under ankle muscle fatigue in PwMS. METHODS: Thirteen PwMS (7 males, 37±7 years old, 1.72±0.09m, 75.3±10.4kg, Expanded Disability Status Scale-EDSS 1.5±1.1) and 12 non-MS controls (8 males, 33±7 years old, 1.70±0.06m, 76.8±15.2kg) performed a bipedal quiet stance task in a force platform (200 Hz) for 60 s. They performed the postural task under two visual conditions: fixation in a stationary central target in the monitor and; and saccadic eve movements, with the target moving from one side to the other side of the screen with a frequency of 1.1 Hz. Each condition was performed three times before and after ankle muscle fatigue protocol. The ankle muscle fatigue was induced by a standing calf raise protocol [3]. An eye tracker mobile was used to guarantee that the tasks were performed correctly. The following center-of-pressure (COP) variables were calculated for anterior-posterior (AP) and medial-lateral (ML) directions: displacement, velocity, and root-mean-square (RMS). Moreover, the COP area (corresponding to 95% of ellipse) was calculated. A three-way ANOVA (group x condition x fatigue) was calculated to answer the study's question. **RESULTS:** Ankle muscle fatigue affected similarly both groups, increasing body sway and velocity and variability (higher RMS) of the COP for AP and ML direction (p<0.001). The novelty of our findings was that saccadic eye movements reduced body sway in both groups before and after ankle muscle fatigue (p<0.001) as well as reduced the velocity and RMS of the COP for AP direction (p<0.001) (Figure 1). CONCLUSIONS: Our findings showed that saccadic eye movements may reduce body sway even when PwMS are under ankle muscle fatigue. This suggests that saccadic eye movements could be a safety strategy for PwMS in an attempt to reduce body sway. Our results suggest that

PwMS could integrate visual feedback and postural control under ankle muscle fatigue. **ACKNOWLEDGEMENTS AND FUNDING:** FAPESP. References [1] Santinelli et al, Multiple Sclerosis and related disorders. Submitted. [2] Kurt and Bigelow, PM&R, 949-56, (2013). [3] Barbieri et al., Gait & Posture, 542-46, (2013). [4] Cameron and Lord, Current Neurology and Neuroscience Reports, 407-12, (2010).

P1-Q-148 Adaptive capacity to split-belt treadmill walking of people with Parkinson's disease with freezing of gait

Jana Seuthe¹, Nicholas D'Cruz², Pieter Ginis², Burkhard Weisser¹, Alice Nieuwboer², Christian Schlenstedt¹

¹Christian-Allbrechts-University of Kiel, ²KU Leuven

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BACKGROUND AND AIM: People with Parkinson's disease (PD) with Freezing of Gait (FOG) have difficulty with motor switching. It is unclear how individuals with PD with FOG adapt to changing walking paradigms, such as imposed by a Split-Belt Treadmill (SBT). Specifically, insight is lacking regarding what happens during the immediate switch to a SBT condition and whether various gait features deteriorate differently. The aims of this study are to first investigate the adaptive capacity of PD with FOG (PD+FOG) and healthy control (HC) during a SBT walking paradigm and second, to compare the adaptation of different asymmetry gait parameters. **METHODS:** In this trial, conducted in two centers (CAU Kiel, Germany and KU Leuven, Belgium), PD+FOG (n=32) and HC subjects (n=24) walked on an SBT for 90 seconds under the following conditions: 30 sec Tied-Baseline, 30 sec Split-Adaptation, 30 sec Tied-Adaptation. The Split-Adaptation was characterized by a 50% reduction of one of the belts. This was applied to both legs in randomized order - best side reduction (BSR) or worst side reduction (WSR) where the belt side with the longer step length or shorter step length was slowed down. The following asymmetry parameters were evaluated: step length asymmetry [1], swing time asymmetry [2] and limb excursion asymmetry [3]. Statistical Parameteric mapping (SPM) (Matlab, spm1d package) using paired t-tests with corrections for multiple comparisons was conducted to compare asymmetry parameters between PD+FOG and HC over the 90s walking paradigm. **RESULTS:** A significant difference between PD+FOG and HC was found for step length asymmetry during BSR and WSR after the switch from Split- to Tied-Adaptation (timeframe: 69.2 - 70.8; p=0.043 and timeframe: 61.7 - 62.5; p=0.049 for BSR and WSR, respectively), where PD+FOG show smaller aftereffects. Furthermore, limb excursion asymmetry during BSR showed significantly different adaptation after the switch from Split- to Tied-Adaptation (timeframe: 60.8 - 65.1; p=0.010) and during WSR for the switch from Tied-Baseline to Split-Adaptation (timeframe: 31.8 - 32.2; p=0.049), where asymmetry was larger in PD+FOG. In contrast to HC, people with PD+FOG showed a tendency to increase their swing time asymmetry during Split-Adaptation, but differences were not significant. CONCLUSIONS: Although PD+FOG are generally able to adapt to the SBT condition, re-adaptation from Split to Tied walking seems to be more challenging



during both Best and Worst side reduction. Further, different results were found for the three asymmetry measures, indicating that especially step length and limb excursion asymmetry seemed to be most sensitive to detect adaptation differences between PD+FOG and HC. [1] Reisman DS, Block HJ, Bastian AJ. Interlimb coordination during locomotion: what can be adapted and stored? J Neurophysiol. 2005;94:2403-15. [2] Plotnik M, Giladi N, Hausdorff JM. A new measure for quantifying the bilateral coordination of human gait: effects of aging and Parkinson's disease. Exp Brain Res. 2007;181:561-70. [3] Hoogkamer W, Bruijn SM, Duysens J. Stride length asymmetry in split-belt locomotion. Gait Posture. 2014;39:652-4. ACKNOWLEDGEMENT AND FUNDING. This study was funded by the Jacques & Gloria Gossweiler Foundation.

P1-Q-149 Dual task gait cost in Parkinson's disease patients with and without depressive symptoms

Carolina Silveira¹, Frederico Pieruccini-Faria², Eric Roy³, Quincy Almeida⁴

¹Lawson Health Research Institute, ²University of Western Ontario, ³University of Waterloo, ⁴Wilfrid Laurier University

BACKGROUND AND AIM: Depression has been associated with gait slowness, greater step-tostep variability, fear of falling, and increased risk of falling in Parkinson's disease (PD). Moreover, associations between depression and cognitive deficits have been demonstrated in PD. Yet, it remains unclear whether depression interferes with the ability of individuals with PD to perform dual task walking. This study aimed to assess dual task gait cost in PD patients with and without depressive symptoms. **METHODS:** Sixty-six individuals with PD participated in the study. Demographics (age and sex), depression assessment (30-item GDS), cognitive function (MoCA), and motor symptoms severity (UPDRS-III) were collected. Participants with scores greater or equal to 9 in the GDS were categorized into the depressed group (n=22), whereas those with scores smaller than 9 were allocated into the non-depressed group (n=44). Participants walked on a 10-meter long Zeno® walkway under single and dual task conditions (3 trials per condition). In the single task condition participants were instructed to walk at their normal pace, whereas in the dual task condition they were instructed to walk and count the number of times that two preassigned digits were spoken on an audio track. Dependent variables included gait speed, step length, step time, stride width, step length and step time variabilities. Dual task cost was calculated as follows: [(single task - dual task)/single task)]*100. Dual task cost was examined in the first trial of each condition as well as average value across 3 trials in each condition. Analyses of covariance were employed to compare dependent variables between groups, while controlling for age, sex, cognitive function, and motor disease severity. Significance levels were kept at p< 0.05. **RESULTS:** Participants in the depressed group had significantly greater scores on the GDS (p<0.001), lower scores on the MoCA (p<0.001), and greater severity on the motor subscale of the UPDRS (p=0.018). Differences between groups in single task were found for step length (p=0.04), step time (p=0.02), and gait speed (p=0.003), where participants with depressive

symptoms walked with shorter steps, longer step time, and slower speed than those in the nondepressed group. Group difference in dual task cost was found for stride width, where participants with depressive symptoms had greater increase in stride width when performing the dual task than those in the non-depressed group (F(1,60)=5.21; p=0.02). This effect was only observed in the first trial. **CONCLUSIONS:** Findings from this study suggest that depression affects cognitive resources used to control medio-lateral gait stability in PD, as demonstrated by an increase in stride width when performing dual task walking even when controlling for differences in cognitive and motor impairments. Yet, this effect is attenuated as individuals become habituated with the concurrent cognitive task while walking.

P1-Q-150 Automatic detection of Bradykinesia in Parkinson's disease

Elke Warmerdam¹, Gerhard Schmidt², Clint Hansen³, Walter Maetzler³, Rana Zia Ur Rehman⁴

¹Christian-Allbrechts-University of Kiel, ²Kiel University, ³Christian-Albrechts-University of Kiel, ⁴Newcastle University

BACKGROUND AND AIM: The most important motor symptom in Parkinson's disease (PD) is bradykinesia (slowness of movement), which is reflected by clinical diagnostic criteria. This symptom can severely affect the quality of life in PD patients. Using inertial measurement units (IMUs) to track this motor symptom could help to evaluate bradykinesia in the home environment and improve the treatment of PD patients. This tracking of bradykinesia can be done during usual daily movements (e.g. walking, turning). The aim of this study is to automatically detect bradykinesia based on walking turns in PD patients. METHODS: Forty-seven PD patients performed two timed-up-and-go tests in both defined ON and OFF medication state (all had a sufficient change in bradykinesia related items of the UPDRS III between medication states). A total of 366 turns were extracted from IMU data attached to the pelvis using an existing validated algorithm [1]. The features extracted from the turning phase were angular velocity and peak angular velocity of the pelvis, and root mean square and jerk of acceleration and gyroscope data of arms, legs, pelvis and trunk IMUs. Traditional linear and non-linear machine learning (ML) models such as linear discriminant analysis, logistic regression, support vector machine (SVM), and random forest (RF) were used for classification of medication OFF (bradykinetic) and ON (non-bradykinetic) state. A feature union pipeline was developed to combine the significant turning features selected with ANOVA F-score (k=8) and transformed PCA components (n=5). The feature union data fed to ML models for training and testing with 10-fold cross validation under 10 repetitions. Average results of ML models were evaluated in terms of area under the receiver operating characteristics curve (AUROC). Feature importance for ML were further explored with RF. RESULTS: Overall ML models performance ranged in between 65-72% with 60-64% sensitivity and 63-64% specificity. Highest classification AUROC was achieved with SVM radial basis function kernel of $72 \pm 8\%$ with both 63% sensitivity and specificity. The root mean square of trunk, arm and leg in anterior/posterior direction were contributing most in the detection of

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bradykinesia. **CONCLUSIONS:** The obtained results are not good enough yet for bradykinesia detection in PD; however they help us to define explicit next steps for further refinement of such an automatic algorithm. The next steps will be to analyse the left and right turns separately, and the turns towards the most affected and less affected side separately. Moreover, we will add other movements like walking and sit to stand/stand to sit transfers with novel features to test whether this helps to further improve the clinimetric properties of the algorithm. **ACKNOWLEDGEMENTS AND FUNDING:**Received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 721577. REFERENCE: [1] M. H. Pham et al., (2017) Front. Neurol. 8:135.

P1-Q-151 Non-Invasive Vagus Nerve Stimulation: A non-pharmacological approach to target gait impairment in Parkinson's disease?

Alison Yarnall¹, Rosie Morris², John-Paul Taylor¹, Mark Baker¹, Lynn Rochester³

¹Newcastle University, ²Oregon Health & Science University, ³Institute of Neuroscience, Newcastle University

BACKGROUND AND AIM: Loss of cholinergic neurons from nucleus basalis of Meynert (nbM) may be a major contributor to the functional decline in gait and cognition in Parkinson's disease (PD). Studies of cholinesterase inhibitors for the management of PD-associated gait disorder are underway, however, drugs are not without side-effects. We have recently shown in healthy controls that non-invasive vagus nerve stimulation (nVNS) can activate cholinergic neurons in the nbM. The aim of this study was to determine whether single dose nVNS enhances gait performance in PD. METHODS: This was a single dose double-blind, sham/placebo-controlled study of 30 patients with Parkinson's disease, who were equally randomised into sham vs. active nVNS groups. Gait was measured using an instrumented walkway and sensors, with preliminary analysis focussing on step time and step length variability, as predictors of early dopa-resistant gait impairment. Attentional fluctuation was measured with computerised cognitive testing. **RESULTS:** 29 patients (mean age 63.4 years; disease duration 4.8 years, MDS UPDRS III 27.1) completed the study, with no significant differences for baseline clinical demographics between active (n=14) and sham (n=15) groups. There was an overall decrease in step time and step length variability in the active nVNS group, with the latter statistically significant compared with sham nVNS (% improvement +6.0 vs. -25.4%, p=0.045). No difference in cognitive testing was noted. **CONCLUSIONS:** This small pilot study has shown that nVNS can improve gait parameters associated with dopa-resistant gait impairment in early PD. Non-invasive VNS therefore has the potential to provide a safe, low-cost therapy that can be delivered in the community. ACKNOWLEDGEMENTS AND FUNDING: This study was funded by the MRC Concepts in Confidence scheme and was supported by the National Institute for Health Research (NIHR) Newcastle Biomedical Research Centre based at Newcastle upon Tyne Hospitals NHS Foundation





Trust and Newcastle University. The views expressed are those of the author(s) and not necessarily those of the NHS, the NIHR or the Department of Health.

P1-Q-152 Using analogies to overcome freezing of gait: a first step towards making the first step

William Young¹, Amy Maslivec¹, Anna Fielding¹, Mark Wilson², Meriel Norris¹, John Cossar¹

¹Brunel University, ²University of Exeter

BACKGROUND AND AIMS: The current project aimed to determine if a simple, novel and costeffective intervention (using movement analogies) can help people with Parkinson's who experience freezing of gait (FOG), shift their balance in a way that helps them initiate a step from a freeze. When we initiate a step, body weight must be moved to a position where the load is aligned with the non-stepping leg. This movement, known as an anticipatory postural adjustment (APA), is required to maintain balance once the stepping foot is lifted from the ground. APAs are often deficient in people who experience FOG and lead to inevitable difficulties making a step. Establishing a means by which people with Parkinson's can produce a functional APA will likely lead to an improved ability to initiate gait. Analogy learning involves repackaging lots of movement rules into one simple analogy or metaphor. Analogies (e.g., 'sway like a tree in the wind') can therefore provide an internal 'cue' to move. This is especially important when anxious, as metaphors are less disrupted by worrisome thoughts associated with anxiety than movement rules (e.g., "move backwards, left and then forwards..."). METHODS: We trained 37 people with Parkinson's who experience regular FOG to adopt a sway-like movement to help them initiate a first step by using an analogy of their choosing. We aimed to induce freezing episodes in participants using various established techniques while participants were secured in a harness. At the point when participants froze, they would attempt to initiate a step either in the way they usually would (Baseline condition) or, following a period of training, use an analogy to produce an APA and subsequent step. RESULTS: Comparing lateral APAs across conditions, results showed that participants were able to voluntarily use the weight-shifting strategy to increase their lateral APA. Results also showed that the ratio of unsuccessful:successful attempts to initiate a step was statistically higher during Baseline compared to when using a weight-shifting strategy. Indeed, the number of failed attempts to step from a freeze reduced by >97% when 'weight-shifting' compared to Baseline. We purposefully did not make any recommendations to participants regarding the daily use of any strategy evaluated in this project. However, we did conduct 4-6 week follow-up telephone calls to ask if participants had been using the strategies, and if so, what their experiences had been. Results showed that 84% said that they had been using a weight-shifting strategy in daily life. CONCLUSIONS: The current results clearly demonstrate significant potential for weight-shifting strategies to help people overcome FOG in daily life. Because the strategies are free of charge and do not rely on any equipment/gadgets, they might be considered as an ideal candidate for further research evaluating their widespread use. However, before any large-



scale research can be carried out, we must first address important outstanding issues related to the safety of people training to use the strategies without expert feedback. **ACKNOWLEDGEMENTS AND FUNDING:** This project was funded by Parkinson's UK (K-1604). We also wish to acknowledge the contribution of our Project Advisory Group.

R - Orthopedic diseases and injuries

P1-R-153 Functional electrical stimulation during gait following anterior cruciate ligament reconstruction - a preliminary study

Shmuel Springer¹, Uria Moran², Uri Gottlieb², Arnon Gam²

¹Ariel University, ²IDF Medical Corps

BACKGROUND AND AIM: Inadequate quadriceps strength following anterior cruciate ligament reconstruction (ACLR) often results in alterations in gait pattern that are commonly reported during loading response. Neuro-muscular electrical stimulation (NMES) is frequently used to overcome this quadriceps weakness. Despite the beneficial effects of NMES, persistent deficits in strength and gait are reported. The aim of this study was to investigate the feasibility of applying guadriceps functional electrical stimulation (FES) during walking in addition to standard rehabilitation, during the initial stage of ACLR rehabilitation. METHODS: Among a cohort of 40 patients, 23 were randomized to intervention FES group (n=10) or control NMES group (n=13). Both interventions were in addition to a standard rehabilitation program. Assessments were performed up to 2 weeks before the ACLR (pre-ACLR), and 4 weeks postoperatively. Outcomes measured were gait speed, single limb stance gait symmetry, quadriceps isometric peak force ratio (peak force at 4 weeks/peak force pre-ACLR) and peak force inter-limb symmetry. Gait outcomes were also assessed 1-week post-surgery. RESULTS: Subjects in both groups regained pre-ACLR gait speed and symmetry after 4 weeks of rehabilitation, with no difference between groups. However, though pre-ACLR peak force was similar between groups (FES-205 Nm, Control- 225 Nm, p=0.605), quadriceps 4 weeks/pre ACLR-peak force ratio of the FES group was 0.82 ±0.27 vs. 0.47 ±0.17 in the control group (p=0.02). In addition, after 4 weeks, the FES group had significantly better inter-limb force symmetry 0.63±0.15 vs. 0.39±0.18 in the control group (p=0.01). **CONCLUSIONS**: Quadriceps FES adjutant to traditional rehabilitation is a feasible, early intervention treatment option, post-ACLR. Furthermore, at 4 weeks post-surgery, FES was more effective in recovering quadriceps muscle strength than NMES. While spatiotemporal gait parameters did not differ between groups, kinetic and kinematic studies may be useful to further understand the effects of quadriceps FES post-ACLR. The promising results of this preliminary investigation suggest that such studies are warranted.





S - Proprioceptive function and disorders

P1-S-154 How varying levels of skin stretch affect perceived skin stretch sensitivity

William MacDonald¹, Simone Smith¹, Shawn Beaudette², Stephen Brown¹, Leah Bent¹

¹University of Guelph, ²University of Ottawa

BACKGROUND AND AIMS: Cutaneous sensory input of the hand and ankle has shown that mechanoreceptors in glabrous and hairy skin contribute to proprioception, however, little research has explored the skin surrounding the knee [1,2]. Recent work has shown a relationship between mechanics of the skin and sensitivity [3]. As such, it is thought that changes in posture (and skin mechanics) may cause deformations of the skin resulting in changes to the threshold of mechanoreceptor activation (slowly adapting type II receptors). The purpose of this study was to quantify the degree of skin stretch across the skin of the thigh and proximal knee through varying degrees of flexion and how changes in skin stretch can influence tactile perceptual sensitivity. It is hypothesized that areas which undergo the largest amount of skin stretch will convey a large change in skin stretch sensitivity, while regions with minimal skin stretch will only require a small amount of stretch to evoke a response. **METHODS:** Skin stretch was measured on five healthy individuals across the thigh and proximal knee while adopting five different degrees of passive knee flexion (0°, 30°, 60°, 90° and 115°). Stretch sensitivity testing was tested between areas of greatest and least skin stretch while at 0° and 90° of knee flexion. To evaluate skin stretch sensitivity we affixed plastic tabs to the skin of testing regions and pulled parallel to the transverse and longitudinal axis of the tab [4]. All kinematic data were measured using 3D infrared skin stretch analysis. **RESULTS:** As knee flexion increases, skin stretch increases with the greatest amount of stretch occurring at the midline of the distal thigh region. Skin stretch sensitivity had a significant interaction between angle and site (F1,16 = 13.58, p = 0.002). At 0° of knee flexion, skin stretch sensitivity was significantly lower at the distal site when compared to the proximal site (p = 0.0004). The skin needed to be stretched ~14% at the distal site to be perceived where the proximal site only needed to be stretched ~ 4%. When the knee angle changed from 0° to 90° there was no difference between skin stretch sensitivity at each site (p = 0.9994). CONCLUSIONS: It is suggested that through posture-mediated skin stretch, the skin can bring slowly adapting type II mechanoreceptors closer to their stretch activation thresholds, thus allowing for increased detection of skin stretch in specific knee postures. Furthermore, the proximal testing region may be of particular interest when looking to increase knee proprioception as the surrounding skin is already stretched to a large degree, subsequently making the slowly adapting type II receptors more sensitive. These findings collectively build a baseline of knowledge surrounding the thigh and proximal knee regarding the effect of skin stretch on skin stretch sensitivity, and can be used to aid in future work targeting biofeedback manipulation to enhance proprioception. ACKNOWLEDGEMENT AND FUNDING NSERC Discovery Grants (L.R.B) REFERENCES 1) Edin, B.B., & Johansson, N. (1995). J Physiol, 487(1), 243-251 2) Lowrey et al. (2010). Neurosci Lett,



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U - Robotics

P1-U-155 Reshaping of gait coordination with robotic intervention in myelopathy patients with residual motor disturbances after surgery

Sandra Puentes¹, Hideki Kadone¹, Shigeki Kubota¹, Tetsuya Abe², Yukiyo Shimizu¹, Yasushi Hada¹, Aiki Marushima¹, Masashi Yamazaki¹, Yoshiyuki Sankai¹, Kenji Suzuki¹

¹University of Tsukuba, ²Faculty of Medicine, University of Tsukuba Hospital

BACKGROUND AND AIM: The Ossification of the Posterior Longitudinal Ligament (OPLL) of the spine is an idiopathic degenerative disease which may induce motor impairment due to compressive myelopathy. When patients display severe motor disturbances, surgical decompression is the treatment of choice; however, despite proper decompression some patients have residual motor disturbances. After surgery, there is no available intervention to improve motor function in this population. We propose the use of Hybrid Assistive Limb (HAL) robot to promote gait recovery in OPLL patients after decompression surgery. METHODS: Twelve patients with a diagnosis of OPLL associated to severe motor symptoms were recruited for this study. Patients underwent surgical decompression and remaining motor disturbances were identified in all of them. Five patients started HAL intervention within 15 to 30 days after surgery (acute group) and 7 patients started after 2 years post-surgery (chronic). Both groups underwent 10 sessions of HAL therapy. Before the first and after the last session, walking performance was evaluated using the 10 meters walk test. To record segmental kinematics, a motion capture system (VICON MX, 100Hz) was used. Data was analyzed regarding the elevation angles described for thigh, shank and foot limb segments. Kinematic data from 8 healthy volunteers was used for comparison. **RESULTS:** HAL intervention improved the walking performance by increasing the speed and stride length in acute and chronic groups (figure 1). Kinematics evaluation showed improvement in plane fitting for acute group (Percentage of variance of third component (PV3) mean; pre: 0.03±0.01, post: 0.02±0.007. P-value: 0.02) but not for chronic group after HAL therapy. When compared to healthy, tendency of PV3 recovery was observed for acute group only (PV3 mean; healthy: 0.009±0.002. P-values; pre-acute Vs healthy: <0.01; post-acute Vs healthy: <0.01). Comparisons between chronic and healthy did not show significant differences (Figure 2). **CONCLUSIONS:** HAL intervention improved walking performance of acute and chronic patients. Interestingly, improvement of loop planarity was only found for acute patients suggesting gait coordination recovery. Chronic patients may have achieved a functional level of coordination through previous rehabilitation and daily life activities. ACKNOWLEDGEMENTS AND FUNDING: Authors thank Ms. Mayuko Sakamaki and Ms. Yumiko Ito of Center for Innovative Medicine and Engineering (CIME) of the University of Tsukuba Hospital for their assistance during HAL



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V - Sensorimotor control

P1-V-156 Testing the potential of immersive technologies for measuring motor skills

Mshari Alghadier¹, Jack Brooks¹, Faisal Mushtaq¹, Mark Mon-Williams¹

¹Institute of Psychological Sciences

Introduction: Immersive technologies are becoming ubiquitous within work and entertainment environments. The ubiquity reflects substantial global investment in the display and motion tracking systems available within Virtual Reality (VR). The good quality visual displays and high fidelity motion tracking provide a potentially powerful tool for exploring sensorimotor control. This suggests VR might allow large scale testing of sensorimotor control in field settings (e.g. museums), and thus allow comprehensive exploration of the mechanisms and ontogeny of motor control across populations. One classic question in human behavioural research relates to how adults and children use visual and kinaesthetic information when maintaining posture. This question has been addressed using physical 'swinging' rooms and conventional computer displays - but both approaches remain confined to the laboratory (Wann, Mon-Williams & Rushton 1998). The implementation of a swinging room inside a VR headset provides a test of whether laboratory experiments can be placed within non-laboratory settings. **METHODS:** The Oculus Rift Virtual Reality system was used to collect data with 333 participants (142 females, mean age = 16 ± 9.7 years). The Oculus comprised a headset, two controllers and two sensors. The virtual environment was an empty room (3m height, 6m width, 6m depth). The headset position was recorded over time (90Hz) within each trial and its pathlength was used offline for the stability measure. There were three 10 second randomised conditions: Eyes open where participants stood still and fixated a cross shown on the facing wall; Oscillation where the virtual room oscillated in a sinusoidal fashion with an amplitude of 5° and a frequency of 0.25 Hz; Eyes closed where the display was black and participants were asked to close their eyes. RESULTS: A two-way repeated measure ANOVA showed a main effect of condition [F(2, 660) = 37.47, p < .01] and age group [F(1, 330) = 87.05, p < .01]. Participants swayed least when the room was stationary and their eyes were open, and most when the virtual room oscillated. Children swayed more than adults and this interacted with condition [F(2, 660) = 4.68, p < 0.01], with children more affected by the room oscillation than adults. These results are consistent with previous findings from laboratory based experiments using non-VR displays (Wann, Mon-Williams & Rushton 1998). CONCLUSION: A classic sensorimotor issue (how children learn to use visual and kinaesthetic information to maintain postural stability) was addressed with a large sample size (n = 333) in a community based setting (a museum). The results were consistent with the hypothesis that VR

can allow large scale data collection in non-laboratory settings. This shows that VR could allow a step change in the way that scientists explore sensorimotor control across populations. Our current work is investigating how VR can be used to explore sensorimotor decision making, with the system presenting targets of different reward values at different reach distances. This allows a study of the balance between motor costs and expected value in sensorimotor decision tasks.

P1-V-157 The effects of changes to body dimensions on an aperture crossing task

Braden Boley¹, Michael Cinelli¹

¹Wilfrid Laurier University

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BACKGROUND AND AIM: The ability to successfully pass through apertures is a skill which is commonly needed on a daily basis. Changes to either an individual's shoulder width (SW) or eye height (EH) have shown to affect the way in which a person perceives the passibility of these apertures. However, if changes to a body dimension maintained the natural ratio of SW to EH, it remains unknown as to how this would affect the actions of an individual performing an aperture crossing. The purpose of the current study was to investigate the robustness of the EH to SW ratio to determine whether an aperture is passible. It was hypothesized that when individuals are made to appear taller (i.e., increase in virtual height), they would perceive apertures to be less passible, however a change in body width via holding a bar would not have the same effect because proprioceptive feedback could adjust the EH to SW ratio. METHODS: Six young adults (3 males, 3 females) completed an aperture crossing task in virtual reality (VR) using an HTC Vive headmounted display unit. The VR environment consisted of an 8m path with two poles that created an aperture (ranging in width from 0.8-1.8x each participant's SW) halfway along the path. Participants were allowed to walk through or around each aperture while completing 4 conditions: 1) normal; 2) while holding a 60cm bar at their navel; 3) while appearing taller; and 4) while both holding the 60cm bar and appearing taller. Participants' trunk movements were tracked at 60Hz using a NDI Optotrak system in order to calculate their medial-lateral center of mass (ML COM) location at time of crossing to determine their actions. A two-way repeated measures ANOVA was conducted to determine if aperture crossing behaviours changed between conditions. **RESULTS:** The results revealed that there was a significant difference between the ML COM location at the time of crossing during the normal condition (x = 62.2 cm) compared to appearing taller condition (x = 87.4cm). No other significant main effects for condition were observed. The results also revealed that when individuals were made to appear taller than normal, they acted more conservatively with their aperture crossing behaviours. This was expressed through their critical points, or the point where subjects chose to walk around the aperture instead of between the poles. The normal condition produced a critical point at 1.6x SW, compared to a critical point of greater than 1.8x SW for the appearing taller condition. **CONCLUSIONS:** This finding indicates that individuals may be dependent on EH remaining relatively constant in order to predict their own SW and act accordingly. By increasing the EH, individuals may also perceive an increase in



SW to maintain a constant EH-SW ratio. These findings indicate that changes to EH alter the ability to accurately assess aperture passability.

P1-V-158 Examining body size-characteristics on obstacle avoidance behaviour in human locomotion

Sheryl Bourgaize¹, Bradford McFadyen², Michael Cinelli¹

¹Wilfrid Laurier University, ²Université Laval

BACKGROUND: The act of steering and obstacle avoidance takes into account the interaction between the environment and the observer. Previous research using static and moving inanimate objects suggests that collision avoidance strategies in humans are affected by situational characteristics (i.e. heading direction), which elicit more cautious behaviours. However, it is not determined if behaviours are altered when avoiding animate objects of varying person-specific information. The purpose of this study was to identify the behaviours of young adults during a collision avoidance paradigm with one of two stationary people (interferers) of different body size characteristics. METHODS: To date, six healthy young adults (20±2.3 yrs) walked along an 8m pathway towards a goal while avoiding either a larger or smaller sized male interferer facing one of four directions relative to the person: forwards, backwards, left, or right and were located 2, 4, or 6m from the participant's starting position. Participants' trunk kinematics (collected at 100Hz using an NDI Optotrak system) were used to calculate Anterior-Posterior (AP) Spatial Requirement at the point of deviation and the Medial-Lateral (ML) Spatial Requirement at the time of crossing (TOC) the interferer. A three-way repeated measure ANOVA was used to determine the main effects of interactions between interferer size, facing direction, and location on AP and ML spatial requirements. **RESULTS:** Preliminary results revealed no significant main effects of interferer size characteristics. There was a significant main effect of direction on ML spatial requirements at TOC (p<.05). Left facing resulted in the smallest ML spatial requirement (M=0.71m) and was significantly different from backwards facing (p<.05). Moreover, there was a significant main effect of interferer distance and direction on the AP spatial requirements (p<.001; p<.05). AP spatial requirements were significantly larger at a distance of 6m (M=4.52m) compared to 2m and 4m (p<.05). Backwards facing situations produced the smallest AP requirements (M=3.06m) compared to forward, left, and right (M=3.39, 3.41, 3.26m, respectively). **CONCLUSION:** Results demonstrated that ML spatial requirements at TOC were smallest when the interferer was facing left. This may be explained by cultural-norms as participants tended to avoid towards the right and were less repelled by interferer's facing direction. AP spatial requirements increased as participants' start distance increased, therefore participants did not use a consistent time-to-contact to initiate a path deviation and instead avoided at approximately the same location in space. AP spatial requirements were smallest during backward-facing conditions, which may be due to an uncertainty of the future movements of the interferer. The




preliminary findings of this study suggest that situational-characteristics have a larger influence on obstacle avoidance behaviours than personal-characteristics.

P1-V-159 Balance control during the reintegration of proprioceptive and vestibular information

Jean-Philippe Cyr¹, Martin Simoneau¹, Noémie Anctil¹

¹Université Laval

BACKGROUND AND AIM: Human upright balance is inherently unstable. To reduce small deviations from a perfect upright body position, information from proprioceptive, vestibular and visual systems are combined and continuously reweighted based on their reliability. Different sensory cues provide specific information to the sensorimotor integration mechanisms in order to control balance. To assess the role of each sensory cue, it is common to experimentally induce sensory illusion, by applying muscle tendon vibration or electrical stimulation of the vestibular apparatus and measure its effect on body sways. The aims are i) to assess the ability of the sensorimotor mechanisms to reintegrate sensory information and, ii) to assess if successive stimulation of different sensory systems is beneficial for the sensorimotor integration mechanisms. METHODS: Balance control during single sensory stimulation (i.e., Achilles tendon vibration VIB or electrical vestibular stimulation EVS) was compared to successive sensory (VIB-EVS or EVS-VIB) stimulation (Mix condition). Participants stood on a force platform with their eyes closed, arms alongside, head turned at ~ 90 ° and extended at 18 °, favouring anteroposterior body sway during stimulation. Vestibular stimulation via surface electrodes placed over the mastoid processes and ankle proprioception stimulation via vibrators attached over the Achilles tendon induced backward body sway. Participants performed 10 trials of 20 s in the Single sensory condition (SS), and 20 trials of 40 s in the Mix sensory condition (MX). The RMS value of the scalar distance of the difference between the centre of pressure and the centre of gravity displacements and restabilization time (RT) were compared before, during, and after stimulation. RESULTS: In the SS condition, amplitude of body sway was similar before and during the stimulation of the vestibular and proprioceptive systems (p > 0.05). Following stimulation, body sway was greater in VIB compared to EVS conditions (p = 0.009) but RT did not differ (t(30) = 1.96, p = 0.06). Body sway amplitude was alike before and during VIB (p > 0.05) in the SS compared to MX conditions. Remarkably, following VIB, body sway amplitude was smaller in the MX compared to the SS conditions (p = 0.04). During or after EVS, no difference was found between SS and MX conditions. Following VIB or EVS, the RT was shorter in MX compared to SS (t(15)=4.36, p < 0.001 and t(15)=5.86, p < 0.001, respectively). **CONCLUSIONS:** Reduced body sway, in single sensory condition, following EVS compared to VIB suggests that vestibular efferent regulation is more efficient than proprioceptive efferent regulation to modulate sensory afference. Further, shorter restabilization time, in the mix sensory condition, suggests that the sensorimotor integration of mechanisms benefit from sequential stimulation different sensory modalities.



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P1-V-160 Frequency characteristics of heteronymous Achilles tendon reflexes during quiet stance

Gregg Eschelmuller¹, Robyn Mildren¹, Jean-Sebastien Blouin¹, Mark Carpenter¹, J. Timothy Inglis¹

¹University of British Columbia

BACKGROUND AND AIM: The primary (la) sensory afferents that innervate muscle spindles have strong synaptic inputs onto homonymous (same muscle) motoneurons, and are thought to have an important role in balance control. In addition, they also have disperse heteronymous connections to motoneurons that innervate synergistic muscles acting around the same joint, as well as to motoneurons innervating muscles with actions at different joints. The purpose of this study was to investigate the heteronymous 1a afferent reflex connections in the lower limb muscles during quiet standing in human subjects. **METHODS**: We applied noisy vibration (10-115 Hz) to right Achilles tendon and characterised the frequency characteristics of the heteronymous reflexes in bilateral Semitendinosus, Vastus Lateralis, and Erector Spinae muscles. Participants (n=12; 7 Female, 5 Male) maintained standing balance for a series of two minute trials. To activate the muscle(s) of interest, participants stood upright with their knees unlocked or a forward hip bending posture. We estimated coherence and cross-covariance between the tendon probe acceleration (input signal) and the rectified EMG (output signal) of each muscle separately. **RESULTS:** We found that all ipsilateral muscles and bilateral erector spinae were linearly correlated with the tendon probe acceleration. The homonymous muscle (Soleus) showed coherence between approximately 10-80Hz, while the heteronymous muscles showed coherence in smaller frequency bands between approximately 10-60Hz. In all muscles with significant coherence, there was also a significant waveform in the cross-covariance with an early positive occurring with a time lag between 30-41ms. Therefore, vibration-evoked muscle spindle afferent activity from the Triceps Surae project to motoneurons of muscles across different, more proximal joints during standing balance. CONCLUSIONS: We have shown using NTV that we are able to probe heteronymous reflexes during normal standing. The results from this study could have implications for understanding balance deficits in clinical populations with known changes in spinal cord excitability, such as in Parkinson's Disease, multiple sclerosis, peripheral neuropathy, and stroke. ACKNOWLEDGEMENTS AND FUNDING: Funded by NSERC.





P1-V-161 Comparing the effects of four different haptic modalities on the standing balance of individuals with an incomplete spinal cord injury

Pawan Kumar¹, Tarun Arora², Joel Lanovaz¹, Renato Moraes³, Kristin Musselman⁴, Alison Oates¹

¹University of Saskatchewan, ²Cleveland Clinic Foundation, ³University of São Paulo, ⁴University of Toronto

BACKGROUND AND AIM: Many individuals with an incomplete spinal cord injury (iSCI) fall each year. Falls may lead to injuries, a fear of falling and restriction of activities. It is important to improve standing balance in individuals with iSCI, as impaired standing balance increases the risk of falling. One way to improve standing balance is by adding haptic input which refers to the combined information from cutaneous and proprioceptive input in the upper limb while touching a stable object in contact with the external environment (e.g., cane, railing). No studies have compared the effects of different haptic modalities on standing balance in iSCI which may have implications for balance control when using some common walking aids. The aim of this study was to compare the effects of four different haptic modalities in the form of a fixed railing, haptic anchors (strings held in the hands attached to light weights resting on the ground), walking poles, and a cane on the standing balance of individuals with an iSCI. We hypothesize that individuals with iSCI will show improved standing balance with the added haptic input and that all modalities will equally impact standing balance. METHODS: Participants with an iSCI stood on a force plate for 90s with eyes open and closed, with and without using the haptic modalities in a randomized order. Centre of pressure (COP) measures included COP velocity in the medio-lateral (ML) and antero-posterior (AP) directions, path length, area of ellipse encompassing 90% of the COP samples, and AP and ML root mean square (RMS_AP & RMS_ML respectively). General linear model analyses were run on each dependent variable using vision (eyes open and closed) and modalities (4 modalities + 1 no modality condition) as within-subject factors. Post-hoc testing examined significant main effects ($\alpha \leq 0.01$). **RESULTS:** To date, 9 individuals with iSCI (7 males, 64.1 ± 19.2 y, 5 traumatic, 5 with tetraplegia, all AIS D) participated. A main effect of modality was found for RMS_ML (p = 0.005); however, further post-hoc testing did not reveal any significant differences. A main effect of vision was significant for RMS_ML (p = 0.002) indicating enhanced standing balance with eyes open. CONCLUSIONS: Standing with eyes closed reduced standing balance control in individuals with an iSCI. Adding haptic input affected variability of the COP in the ML plane; however, the individual effect of the different modalities and differences from previous research warrants further investigation. Data collection is ongoing to increase the number of participants with iSCI and to include able-bodied comparisons. Results may have implications for rehabilitation to improve standing balance in iSCI.

P1-V-162 Balance control in young adult athletes with a history of recent concussion (> 3 months) during a lower limb reaching task





Katelyn Mitchell¹, Michael Cinelli¹

¹Wilfrid Laurier University

Title: Balance control in young adult athletes with a history of recent concussion (> 3 months) during a lower limb reaching task. Authors: Katelyn Mitchell, MScPT, CAT(C) and Michael Cinelli, PhD. BACKGROUND: The demands of sport require the integration of sensorimotor and cognitive function to plan and execute goal-directed movement. A sport-related concussion (SRC) can affect these sensory systems resulting in altered balance as well as poor executive function. Athletes with recent SRC have demonstrated prolonged deficits in balance control tasks with a cognitive component, however, it is unclear the duration of these deficits 1. Aim: The purpose of this study was to assess balance control in athletes with previous SRC greater than three months beyond medical clearance compared to athletes without SRC during a visuomotor lower limb reaching task. **METHODS:** Male and female athletes (N=21, age=19-30yrs) were recruited from high risk sports (football, hockey, rugby). Athletes who had obtained medical clearance for return to sport (3- to 7-months) prior to the study (SRC= 11), were compared to sport-, sex-, and positionmatched controls (CONTROL= 10). Participants were instructed to stand in stable single support on a Nintendo Wii Balance board sampled at 100Hz, while a FitLight Trainer system (Aurora, ON) administered a concurrent Go/No-Go visuomotor task. Five FitLights were arranged on the floor in a semicircle anterior to the board at 060°, 030°, and 0° about the midline. Each light illuminated 6 times in random either Green/Go (70%) or Red/No-Go (30%). Participants were instructed to quickly hover their non-stance limb over the Green lights and withhold for Red lights. Participants completed a total of 6 trials (3 trials x 2 feet). Balance control between groups was assessed using COP RMS displacement (dCOP) and Mean Power Frequency Analysis (MPF) of A/P dCOP (0.1 to 1.0Hz). **RESULTS:** No significant main effects for RMS dCOP were observed (A/P: F(1, 19)= 0.91 p= .905; M/L: F(1, 19)= 0.52, p= .422). However, MPF revealed a significant main effect of group (p<.001) for the median value of the low frequency band (0.1Hz) for A/P dCOP (F(1, 19)= 6.07, p= .024). The low frequency (0.1Hz) indicates utilization of a "slow" feedback mechanism at higher cortical areas. These findings suggest that SRC had greater reliability on the visual system to control movement, even when they had been cleared for return to sport. In contrast, CONTROL performed the task using significantly lower mean power at 0.1Hz, indicating the use of a "fast" feedforward mechanism. CONCLUSIONS: Athletes with previous history of SRC exhibited poor neural control of dCOP in the A/P plane during a combined visuomotor balance task that may persist beyond medical clearance and return to sport. These findings highlight the importance of assessing neural control of balance integrated with a cognitive component to identify and manage persistent deficits that be undetected during clinical recovery from SRC. REFERENCES:1. Powers, K. C., Kalmar, J. M., & Cinelli, M. E. (2014). Dynamic stability and steering control following a sport-induced concussion. Gait & Posture, 39(2), 728-732.





P1-V-163 Light touch with two hands rather than one more effectively reduces postural sway, but number of contact points does not similarly influence the effectiveness of the haptic anchors in older adults

Renato Moraes¹, Bruno Bedo¹, Vitor Arpini¹, Rosangela Batistela¹, Paulo Santiago¹, Eliane Mauerberg-deCastro²

¹University of São Paulo, ²São Paulo State University (UNESP)

BACKGROUND AND AIM. Older adult fallers exhibit greater postural sway than do non-fallers. The use of haptic input via both light touch (LT) and the anchors reduces postural sway in older adults. With LT, the individual uses the finger to apply a force of less than 1 N to an adjoining surface. With the anchors, individuals hold--in each hand--a flexible cable that is attached to a small mass that rests on the ground, and which must be kept taut during the performance of balancing tasks. While both approaches require subtle contact, to reveal their respective effectiveness in reducing sway, we investigated the effects of the different points of contact (fingertip vs. palm of hand) and number of contact points (one vs. two hands) in a balancing task in faller and non-faller older adults. Methods. We recruited 44 older adults: non-fallers (n=22) and fallers (n=22: with at least one fall in the last six months). Each stood for 35-s, with feet together on a force plate, and performed tasks under nine conditions that combined the haptic contact points (LT, anchor hand [AH], and adapted anchors, in which the cables were tied to the tip of the index fingers [AF]). It was necessary to adapt them, because their loads had been replaced by a force transducer that was fixed to the ground. The conditions included the number of contact points (1 hand [dominant and non-dominant] and 2 hands). We computed the path length (PL, the sum of the scalar distance between each pair of data points) of center-of-pressure displacement in the anterior-posterior (AP) and medial-lateral (ML) directions, the mean and RMS vertical forces applied on the anchor cables and touch bar. **Results.** Fallers had fallen 2.6 times in the last six months. The MiniBESTest scores were higher ($p \le .0001$) for the non-fallers (26.0 ± 2.2 points) than for the fallers (19.4±3.5 points); the latter exhibited poorer balance function. PL: the ANOVA did not identify a main effect for group or any interaction with a group. It revealed an interaction between points of contact and number of contact points in both directions ($p \le .0001$). The LT reduced PL as compared to AF and AH, which did not differ from one another in either direction (Figure 1). The LT with two hands resulted in a greater reduction in PL than with one hand, in both directions. The ANOVA for the mean force and the RMS showed a main effect for points of contact (p≤.0001). Mean force and RMS were higher for the AH (0.98±0.04 N and 0.17±0.01 N) than for the AF (0.85±0.04 N and 0.12±0.01 N) and LT (0.45±0.02 N and 0.08±0.01 N) conditions, which differed from each other. CONCLUSIONS. LT was more effective in reducing postural sway, particularly when performed with both hands. There was no difference between the use of two hands and one hand in both anchor conditions. The mean force values were below 1 N in all conditions, but variability increased for the AH, which might indicate an exploratory behavior. FUNDING: FAPESP/Brazil (Grant #15/02404-7).





P1-V-164 Adaptability of human gait: Effect of training with red noise auditory stimuli on gait fluctuation patterns

Cecilia Power¹, Jeevaka Kiriella¹, Janessa Drake¹, William Gage¹

¹York University

BACKGROUND AND AIM: It has been shown that the structure of inter-stride variability during walking is indicative of neuromuscular control and stability [1]. Detrended fluctuation analysis (DFA) using inter-stride intervals (ISI) to construct a fractal scaling index (FSI) has revealed inherent long-range correlations (pink noise; PN) in healthy gait [1,2]. Using auditory stimuli, gait FSI can be entrained towards greater (red noise; RN) or lesser structure (white noise; WN) [2]. However, healthy individuals do not demonstrate substantive RN entrainment during relatively short periods [2]. The purpose of this study was to explore adaptability of gait and the relationship between RN auditory stimuli and gait variability structure over extended time periods. The hypotheses were: (1) FSI will increase throughout a 1000-stride trial, demonstrating greater entrainment to the RN structure; and (2) FSI will progressively increase over several days of training, demonstrating greater entrainment to the RN structure. METHODS: 10 healthy participants between the ages of 18-35 will be recruited to complete 10 sessions over a period of 2 weeks; to date, pilot data have been gathered with two individuals. Participants walked at their preferred walking speed (PWS) on a motorized treadmill (Bodyguard Fitness, Quebec, Canada) for 256 strides without an auditory metronome [2]. Participants then completed several trials walking to several metronomes with different FSI values ranging between 1.0 and 1.5; each trial consisted of 256 strides. Participants matched their right heel contact (RHC) to the beat of the metronome. Position of a retro-reflective marker placed on the right heel was collected throughout the entire duration of both the uncued and cued walking. Custom algorithms were used to extract ISI data based on RHC, which was analyzed using DFA to calculate the FSI. Individual data are presented for each participant; condition means will be presented when data collection is complete for all participants. RESULTS AND CONCLUSIONS: Gait FSI values related to walking to metronomes with different FSI values are provided in Figure 1. Participants demonstrate entrainment towards RN for metronomes below FSI=1.1. However, these early data suggest that a threshold exists when the metronome FSI exceeds 1.1; beyond this stimulus level gait FSI approaches 0.5. Moving forward, additional data will be gathered to confirm this threshold effect at FSI=1.1, after which RN metronomes with FSI below 1.1 will be used in testing whether training for extended periods of time will result in greater entrainment in the RN domain. **REFERENCES**:[1] Hausdorff (2007). Human Movement Science, 26(4); p. 555-589. [2] Kiriella, (2017). An Analysis of the Relationship Between Complexity and Gait Adaptability. York University.





P1-V-165 Assessment of balance after repeated sub-concussive head trauma in female athletes

Christopher Rhea¹, Sam DuBois¹, Victoria Blevins¹, Kristen Schleich², Scott Ross¹, Donna Duffy¹

¹University of North Carolina, Greensboro, ²Elon University

BACKGROUND AND AIM: A change in balance is a cardinal symptom of neuromotor dysfunction after head trauma. While many resources have been devoted to studying head trauma in the context of a concussion, the majority of head trauma in sports result in a sub-concussive event. Recent research has suggested that repeated sub-concussive head trauma may lead to acute and chronic neuromotor dysfunction, paralleling observations in the concussion literature. However, the majority of head trauma research (both concussive and sub-concussive) has been conducted on male athletes. The little research that has been conducted on female athletes has focused on those who have received a concussion and has shown that relative to male athletes, females report stronger and longer lasting symptoms, as well as more time before being cleared to returnto-play. This emerging research suggests there are sex differences with respect to the response to concussive head trauma. However, it is unknown if similar sex differences occur in female athletes who receive repeated sub-concussive head trauma. Thus, the purpose of this study was to examine preseason balance scores from two consecutive seasons of female athletes participating in a collision sport. METHODS: Female athletes (N=17, 32.7±7.1 yrs old) who were part of two American tackle football teams in the Independent Women's Football League participated in this study. Preseason assessments were given prior to the 2016 and 2017 seasons that included a suite of neuromotor and neurocognitive tests. This abstract focuses on the modified Balance Error Scoring System (mBESS), a balance test that assesses neuromotor dysfunction by standing for 20 seconds with the eyes closed and hands on the hips in three conditions: (1) narrow double leg stance, (2) single leg stance, and (3) tandem stance. The dependent variable was the number of errors committed, which occurred when participants deviated from their starting position. A paired samples t-test and effect size were used to examine the data. **RESULTS:** Although the number of errors did not statistically differ from 2016 (M=4.5, SD=3.7) to 2017 (M=5.8, SD=4.2), t(16)=-1.56, p=.14, there was a large effect size between the two seasons (Cohen's dz=0.85). The increase in the number of errors indicates worse neuromotor performance. CONCLUSION: Repeated sub-concussive head trauma in our female football player sample may have led to a decrease in balance control. It should be noted that the number of errors in our sample is higher than previously reported normative data for 30-39 year old women (M=2.8, SD=2.4), putting our sample in the "below average" category. This observation could be due to sub-concussive head trauma received prior to the first season of testing. However, these observations could be strengthened by including objective assessments of balance performance and quantifying the number and magnitude of sub-concussive head impacts during the season in future research.





P1-V-166 Effect of the horizontal-vertical illusion on stepping-over action

Ryota Sakurai¹, Kentaro Kodama², Yu Ozawa³

¹Tokyo Metropolitan Institute of Gerontology, ²Kanagawa University, ³Waseda University

BACKGROUND AND AIM: Tripping when stepping over an obstacle is a common factor for falls. One safety strategy to avoid tripping on an obstacle is to increase foot clearance. Although several studies have indicated the possibility that visual illusion could change how we move, the effects of a stepping-over action are poorly known. The present study aimed to determine whether foot clearance may be increased by visual illusion during a stepping-over task. **METHODS:** The participants were five healthy young adults. They were asked to judge the height of three obstacles in different conditions (control [i.e., white plane obstacle], horizontal, and vertical illusion conditions [i.e., the Helmholtz illusion]) placed 4 meters away from them and then to approach the obstacle and step over it. During the task, we measured the participants' gaze behaviors to identify the duration of gaze fixation to the obstacle. **RESULTS:** The participants perceived the obstacle to be higher in the vertical illusion condition compared to the control and horizontal illusion conditions. Similarly, the participants stepped over 73 to 139 mm higher for the obstacles in the vertical illusion condition compared to the other conditions. Regarding gaze behavior and foot clearance, the increased duration of gaze fixation to the obstacle was correlated with increased foot clearance in the vertical illusion condition. Contrarily, increased duration of fixation was correlated with decreased foot clearance in the control condition. CONCLUSIONS: Our results showed that vertical illusion influenced both height perception and foot clearance while stepping over an obstacle. The effect of visual illusion on foot clearance was enhanced by extending the duration of gaze fixation. The findings of the present study suggest that using visual illusion can promote the adoption of a safer stepping-over strategy in terms of greater foot clearance over an obstacle.

P1-V-167 Sensory weighting and organization strategies used by young adults with CLBP during standing

Jennifer Sansom¹, Karen Lomond²

¹Central Michigan University, ²Ithaca College

BACKGROUND AND AIM: Across populations, selection and organization of which postural control strategies individuals rely upon are highly dependent on what and how incoming sensory information is integrated ("weighted") from visual, vestibular, and somatosensory inputs. Chronic musculoskeletal conditions, such as chronic low back pain (CLBP), have been shown to effect sensory integration and postural sway during standing balance. Prevalence of low back pain (LBP) in young adults has been estimated at 12-20% for those aged 20-29 years old. However, limited research exists examining how young adults with CLBP integrate sensory information to maintain





postural control. The aim of this study was to characterize the sensory weighting and organization strategies used by young adults with CLBP to maintain postural control in standing. METHODS: Nineteen young adults with CLBP (18-26 y/o) and 19 matched controls without a history of LBP (18-26 y/o) participated in this study. The Neurocom Balance Manager was used to collect data for 3 testing conditions: Sensory Organization Test (SOT), Head-Shake Sensory Organization Test (HS-SOT), and Limits of Stability (LOS). During testing, participants stood on 2 forceplates. Forces were recorded to estimate center of pressure for sway analysis during testing conditions. **RESULTS:** Participants in the CLBP Group had significantly lower SOT composite scores when information from the visual system was favored and when sensory information from the vestibular system was favored. Reliability for the SOT was very good to excellent across the three trials tested for each condition. For the HS-SOT and LOS, no significant differences were found between Groups. **CONCLUSIONS:** Young adults in the CLBP Group had difficulty integrating incoming sensory information from the visual and vestibular systems during guiet standing for maintenance of postural control (SOT). During activities requiring postural control during movement (HS-SOT and LOS), there were no differences found between participants with CLBP and individuals in the control group. These results provide preliminary evidence that young adults with CLBP have adapted their postural control strategies, showing increased sensitivity and reliance on somatosensory input and reduced ability to effectively use sensory information from other systems. ACKNOWLEDGEMENTS AND FUNDING: Thank you to our participants and research teams at CMU. This research was funded by a grant from the Blue Cross Blue Shield Foundation of Michigan (2411.11).

P1-V-168 Associations between motor cortex inhibition and stable turning characteristics in healthy controls and people with multiple sclerosis

Clayton Swanson¹, Andrew Monaghan¹, Sutton Richmond¹, Tyler Whittier¹, Brett Fling¹

¹Colorado State University

BACKGROUND AND AIM: Healthy aging and diseases such as multiple sclerosis (MS) are associated with a variety of changes affecting neural structures, functions, and biochemical processes. Due to the strong cortical influence on various aspects of mobility, it is likely that these neural changes affect mobility and increase the potential for falls, subsequently reducing quality of life and increasing mortality. For example, gamma-Aminobutyric acid (GABA) is known to diminish with advancing age and levels of GABA are significantly associated with successful control of upper extremity movements. It remains unclear if this same association exists for dynamic lower extremity control for daily tasks such as turning. The purpose of this project was to understand how motor cortex inhibition contributes to turning performance in both people with MS and age-matched control participants. **METHODS:** Participants were asked to conduct a series of stable turns, defined as 360° turns performed "in place" at their self-selected pace for one minute. Quantification of turning was assessed using wireless inertial sensors placed on each





foot, around the waist, on the sternum, and on the forehead. Outcome measures included turn duration, turn error, number of turns, and turn velocity. After the turning assessment, single-pulse TMS was used to assess motor cortex inhibition via the cortical silent period (cSP). The leg regions of both motor cortices were identified by acquiring the resting motor threshold of the tibialis anterior. To assess the cSP, participants sustained an isometric contraction in dorsiflexion at 15% of their maximal voluntary contraction for two-minutes. Simultaneously, a TMS stimulation was delivered at 120% of resting motor threshold every 7-10 seconds. This procedure was conducted to both cortical hemispheres on every participant. **RESULTS:** To date, twenty participants (6 HC, 14 MS) have completed the study, thus far no statistical differences between hemisphere or group were found for cSP. Turning analysis demonstrated a significant difference in number of turns completed, with healthy controls (HC) completing more turns. Turn error, turn duration, and turn velocity were not significantly different, however, people with MS tend to have reduced performance on each of these measures. For HC, the cSP duration was significantly correlated with their nondominant hemisphere for turn duration, velocity, and number of turns completed, whereas no turn variables were correlated with cortical inhibition in the MS group. Further, cSP duration of the dominant hemisphere was not significantly correlated with any turning metrics for HC or people with MS. CONCLUSION: The results from this ongoing project demonstrate significant differences in how HC neurally control turning compared to people with MS. Additionally, these preliminary results indicate that people with MS may utilize different neural resources to perform dynamic movements associated with fall risk. ACKNOWLEDGEMENTS AND FUNDING: David Mahoney Neuroimaging Grant, The Dana Foundation. Title: 'Two legs, on brain: Transcallosal communication as a marker of asymmetric function and target for gait rehabilitation in people with multiple sclerosis' PI: Dr. Brett Fling.

W - Tools and methods for posture and gait analysis

P1-W-169 Correlation between mandibular position and modification of stabilometric parameters (LFS, VarVit)

Michele Barbera¹, Nicolò Barbera¹, Emanuele Barbera², Andrea Fregoni¹

¹Studio Dentistico Barbera, ²Università degli Studi di Milano

BACKGROUND AND AIM In this randomized study it is analyzed if the modification of some stabilometric parameters, such as LFS (length function surface) and VarVit (speed variation), occurs to the modification of the mandibular position, with the stretching of the mandibular ligaments, the roto-traslation of the mandibule and the increase of vertical dimension controlled through a standardized device. Materials and methods 35 random patients in a population are analyzed on a force sensor stabilometric platform. Two recordings of 51.2 seconds are performed, the first with closed eyes, the second with closed eyes with oral stimulation through the orthoOS device. The difference in absolute value between the first and second registration of the LFS and



VarVIT parameters is analyzed. Results VarVIT: in 100% of patients the value varies, in 94.29% the difference between the two recordings is statistically significant, the average of the variation is 22.578 mm/s. LFS: in 100% of patients the value varies, in 65.72% the value is statistically significant, the average of the variation is 0.161 1/mm. Conclusion The modification of the mandibular position through the standardized device seems to change in a reproducible and standardized manner some stabilometric parameters such as LFS and VarVit, in light of having isolated the mouth influx, performing the tests with eyes closed to exclude the eye receptor and without noiseless distractions. The study will continue on a larger number of patients to have a larger sample of the population under investigation and confirm the value. Bibliography Affidabilità intra ed inter esaminatore della pedana stabilometrica cyber sabots, uno studio sperimentale; Giulia Peruzzi, Gustavo alberto Zanioli, Daniele Zannini.

P1-W-170 Loading response peak anchoring: A novel solution for the double-belt problem

Oran Ben-Gal¹, Glen Doniger¹, Maya Cohen¹, Michal Schnaider-Beeri¹, Meir Plotnik¹

¹Sheba Medical Center

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BACKGROUND: Split-belt treadmills (SBTM) are used for studying gait adaptation. They contain force plates under each belt that measure ground reaction force (GRF). The detection of heel strikes (HSs) from the GRF curves is used for calculating temporal gait parameters (e.g., gait variability). However, if the participant occasionally steps on the contralateral belt, the HS is undetectable (Fig. 1A). We term this the Double-belt Problem (DBP). Objective: To test the hypothesis that the loading response peak (LRP; Fig. 1A) (i.e., when body weight is completely transferred to the stance leg) can serve as a surrogate detection point for reliable estimation of temporal gait parameters. METHODS: GRF gait data was from twenty middle-aged healthy adults (age 56.45±4.81 y; 6 males). Participants walked for about two minutes on an instrumented SBTM (ForceLink, the Netherlands) at fixed speeds (0.4 - 0.8 m/s). LRP and HS were semi automatically detected using custom MATLAB? graphical user interface. In the first validation phase, we used 'clean' gait segments free of the DBP (Fig. 1A top) to calculate stride time (STRIDE) and step time (STEP) from LRP and HS. We estimated accuracy of the LRP-based method by calculating true error (TE) as TESTRIDE = (STRIDEHS - STRIDELRP) using individual gait cycles across all participants (n=1166 gait cycles). TE for Stride time coefficient of variation (CV) was calculated based on 20 comparisons, one for each participants. Bivariate (Pearson) correlations were computed between LRP and HS for mean STRIDE, STEP and CV. In the second validation phase, we used DBP data and: (1) compared in the same manner as in phase 1 STRIDE and CV obtained from the left and right legs (based on the fact that these values were highly correlated between legs during phase 1 validation; R≥0.98; p≤0.001) using for the 'crossing' leg data based on the HS detection method and for the other leg data based on LRP; (2) compared correlations of gait parameters obtained from 'clean' and DBP sections from the same gait trial: the correlation of HS



to HS data was compared (by ratio) to the correlation of HS to LRP data (from the other leg). **RESULTS:** Fig. 1B details the results of the two validation phases. The highest discrepancy between the methods was for CV: $TE = 0.16 \pm 0.55$ across participants, corresponding to a relative error of estimation of 4.74 ± 14.04%. Briefly, gait parameters obtained with the HS and LRP methods were highly correlated in both validation phases. **CONCLUSIONS:** LRP anchoring is a reliable method for estimating temporal gait parameters, demonstrating high correspondence with the 'gold standard' HS detection method. To further minimize any minor differences, we propose a hybrid approach that combines HS-based data from 'clean' trial segments with LRP-based data from DBP segments.

P1-W-171 Evaluation of balance recovery from unpredictable large-magnitude perturbations through the compensatory arm and leg movements (CALM) scale

Luis Teixeira¹, Marina Betelli¹, Patricia Takazono¹, Caroline Souza¹, Julia Oliveira¹, Daniel Coelho¹, Jacques Duysens²

¹University of São Paulo, ²Catholic University of Leuven

BACKGROUND AND AIM: Following unpredictable large-magnitude stance perturbations diverse patterns of upper and lower limb movements are performed to recover balance stability. Stability of those compensatory movements could be properly estimated through qualitatively evaluation. In the present study, we present a scale for evaluation of compensatory arm and leg movements (CALM) in response to unpredictable displacements of the support base in the mediolateral direction. METHODS: Evaluation was made from data of 46 young healthy participants. Half the participants were naïve for the probing stance perturbations, and the other half experienced a sequence of 72 sudden stance perturbations through support base displacements in the mediolateral direction. Evaluation consisted in perturbations in the mediolateral direction, applied in three modes: rotation, translation or combined rotationtranslation, to either side, in three platform peak velocities: 20, 30 or 40° (cm)/s, generating 18 distinct perturbations. Reliability analysis was made through interclass correlation coefficient (ICC) and rate of score coincidence between raters. For validity assessment, separate scores of arm and leg movements were correlated to kinematic measurements of respective movement amplitudes, maximum amplitude of shoulder abduction angle for the arms, and maximum amplitude of the hip abduction angle for the legs. Sensitivity was tested to mode (rotation, translation and combined) and magnitude (velocity) of support base displacements, in addition to the effect of training. **RESULTS:** Analysis of intra-rater reliability showed ICC = 0.99 for both arm and leg movements, with coincidence of scores between evaluation times equal to 98.61% and 99.07%, respectively. Analysis of inter-rater reliability showed ICC = 0.96 for arm and 0.99 for leg movements. Validity analysis showed significant correlation values between scale scores and respective movement amplitudes both for arm and leg movements, in all but one (high velocity rotation) analyses. Assessment of sensitivity revealed that the scale discriminated the responses



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between perturbation modes, support base velocities, and gains in response stability from training. **CONCLUSIONS:** As a conclusion, the CALM scale was shown to provide adequate integrative evaluation of compensatory arm and leg movements for balance recovery after threatening perturbations, with potential application in fall risk prediction.

P1-W-172 An evaluation of a proprietary motion capture system via kinematic analysis

Vincenzo Di Bacco¹, Dmitry Verniba¹, William Gage¹

¹York University

BACKGROUND AND AIM: Physical rehabilitation often entails costly clinic visits, or in-home exercise regimen, which can suffer from poor technique and adherence. Additionally, assessment tools commonly used in a clinic (e.g., goniometer) are difficult for patients to use independently and reliably. Thus, a technology that can be used without supervision or training could improve the delivery of in-home exercise. ForaHealthyMe Inc. (FAHM) created algorithms for a commercially-available optoelectronic product (Kinect, USA) for estimating kinematic measures without using additional tools (e.g., markers). The FAHM product might be a viable option for remote assessment of patient progress outside the clinic. This study assessed agreement between the FAHM system and a gold standard (GS) method in kinematic measures estimation; and the reliability of the FAHM system. METHODS: Ten healthy males (24.3±3.2yo) visited the laboratory three times on separate days. Participants performed 10 trials of each of the following movements: hip abduction, hip extension, knee raise, and squat. The FAMH system, consisting of one camera and the proprietary algorithms, and a second motion capture system (Vicon MX, UK) recorded movements simultaneously. The following measures for each movement: peak hip extension, flexion, and abduction angle, and peak knee flexion angle, were output from the FAMH system and calculated separately from the Vicon-obtained position data. Vicon-obtained measures were considered GS to which FAMH-obtained measures were compared. Agreement was assessed using Bland-Altman (BA) plots of angle signal peaks and Mean Absolute Error (MAE) across the entire signal length. Reliability was assessed using Intraclass Correlation Coefficient (ICC 2,1) using peak angle. **RESULTS:** BA plots revealed a positive bias (FAHM-GS) of 4° with -3° to 10° (95% LOA) on average in angle peaks across all movements. MAE revealed an average of 4.3° across all angle signals with 3.5° to 5.1° (95% CI). Across all dependent measures, reliability of FAHM and GS methods demonstrated an average ICC of 0.80 and 0.87, respectively. **CONCLUSIONS:** The FAHM product demonstrated acceptable agreement to that of the GS method for estimating kinematic measures, as BA and MAE values were within the clinically acceptable level of 5°. Better agreement was found over the entire signal, suggesting the FAHM product suffers in the estimation of angles at the ends of range of motion. Since the FAHM system's camera is monocular and captures frontal view only, movements producing a larger angle displacement (e.g., squat) may obstruct body segments from camera view, causing angle estimation to suffer. Good reliability was found for the FAHM product, suggesting test-retest



reliability similar to clinical goniometry. Unlike goniometry, the FAHM product does not require training, calibration, or participant preparation; and, thus, may be a viable alternative to current clinical tools, which could improve the delivery of in-home exercises.

P1-W-173 Estimating lateral margin of stability during walking and turning using inertial sensors

Peter Fino¹, Carolin Curtze²

¹University of Utah, ²University of Nebraska Omaha

BACKGROUND AND AIM: During gait, lateral stability requires precise foot placement to redirect the center of mass within the base of support. Lateral stability is largely achieved by placing the stepping foot outside the extrapolated center of mass (XcoM), thus creating a margin of stability (MoS) between the XcoM and the new stance limb. MoS is particularly important during turning where the lateral velocity of the CoM must also be redirected towards the new heading direction. To date, most methods for estimating the MoS have relied on optical motion capture to obtain reliable spatial data. However, the growing use of wearable inertial sensors has led to new methods of quantifying gait stability outside the laboratory. Our objective was to develop a method to estimate the lateral margin of stability using inertial sensors during walking and turning. METHODS: Nine healthy older adults completed a series of walking and turning trials after providing informed written consent. Each participant completed three blocks of 10 short walking trials at both normal and fast walking speeds (60 trials total). For each trial, participants were instructed to walk towards a center point marked on the floor and continue walking towards a colored marking at the specified angle from their initial heading (e.g, "at your normal speed, make a right turn to the red line"). Optical motion capture was collected at 120 Hz (Motion Analysis Corp.), and nine inertial measurement units (Opal v1, APDM, Inc.) recorded segment kinematics of the head, trunk, lumbar, and bilateral shanks, feet, and wrists at 128 Hz. The lateral MoS was calculated using the XcoM at each foot contact of every trial based on the optical motion capture data only. The estimated MoS from the inertial sensors (e-MoS) was obtained using the following procedure: 1) identify all initial contact events using the normalized frequency content of each foot sensor, 2) rotate all sensor accelerations into a body-fixed frame initially aligned with the global frame, 3) low-pass filter the trunk accelerations using a 4th-order, 4 Hz phaseless Butterworth filter, and 4) retrieve the filtered mediolateral acceleration of the trunk at each initial foot contact. Intra-class correlation coefficients (ICCs) were used to assess the inter-instrument consistency for each subject. **RESULTS:** ICCs ranged from 0.11 to 0.60 for right foot contacts, and 0.32 to 0.61 for left foot contacts, demonstrating poor-to-moderate consistency of the e-MoS with respect to the MoS. Linear regressions of e-MoS against MoS yielded R2 values of 0.15 and 0.14 for right and left foot contacts. **CONCLUSIONS:** Initial approaches to estimating MoS using inertial sensors demonstrate promise. While some subjects demonstrated moderate agreement,





there was variability across subjects. Future work will examine subject-specific corrections that may improve the consistency of the method.

P1-W-174 Automated and quantification of the tandem walking using a wearable device

Natalie Ganz¹, Eran Gazit¹, Amit Hadad², Aron Buchman³, Anat Mirelman¹, Jeff Hausdorff¹

¹Tel-Aviv Sourasky Medical Center, ²Tel Aviv University, ³Rush Alzheimer's Disease Center

BACKGROUND AND AIM: The tandem walk (TW) is a dynamic balance task that is commonly used as part of the neurological examination. TW is typically assessed by the time to complete the task and the number of missteps, however these measures suffer from limitations and may not fully capture the range of performance in this task. We developed metrics of TW by using a bodyfixed, wearable sensor in young and older adults and examined the association of these metrics with usual-walking and postural control. METHODS: 40 healthy young men (age:34.61±9 yrs) and 362 community-dwelling older adult men (age:68.21±12.18 yrs) were included in this analysis. While wearing a 3D accelerometer on their lower back (DynaPort, McRoberts), subjects performed three different tasks: 1) TW, 2) usual-walking, and 3) quiet standing to assess postural sway. Measures of TW, postural sway and gait were extracted from 100 Hz raw acceleration data. Step detection was estimated from the AP axis. The extracted measures for TW are: High to Low frequency band ratio from the power spectral density (PSD) from the ML axis [nu] (indicates the ability to make complex movement sequences), width of the dominant frequency in the power spectrum from the AP axis [Hz] (expresses the variability of the signal), step duration [s], sample entropy from ML, AP axis [nu] (a measure that quantifies regularity and complexity in the time series), signal vector magnitude (a proxy for physical activity and overall movement), CV [%] and the number of steps. Due to non-normality distribution of the data, we used Mann-Whitney tests to investigate differences between the young and older age-groups. Spearman's rank correlations evaluated the associations between TW, usual-walk and guiet standing postural control. **RESULTS:** All of the TW metrics were significantly different in the young and older men (see Table 1). Older men completed the TW with higher CV, suggesting greater stride-to stride variability and they walked more slowly, as seen by their step duration. Additionally, the frequency ratio measure suggests that the older adults displayed less complex corrective movements in the ML axis, compared to the healthy young adults. TW measures were modestly correlated with usual-walking (e.g., average stride time with TW step time, r=0.3; p<0.001) and with quiet standing postural control (e.g., acceleration path length in the ML and AP axis with TW sample entropy in the ML axis, r=0.13; p=0.014). CONCLUSION: Automated quantitative metrics can be derived from wearable sensor recordings of TW. TW metrics differ in healthy young and older men and are not strongly related to measures of usual-walking and quiet standing postural control. These results suggest that TW metrics do not duplicate conventional gait tests and are capturing distinct facets of mobility not assessed by other performances. Further work is needed to examine the specificity of TW metrics for incident falls and mobility disability and whether these metrics can be used to



improve risk stratification of older adults for adverse health outcomes. **ACKNOWLEDGEMENTS** This work was supported in part grants from National Institute of Health R01AG17917, RF1AG22018 R01NS78009, R01AG56352. The older men were participants in the Rush Memory and

P1-W-175 Creating and validating a shortened version of the community balance & mobility scale for application in young seniors

Katharina Gordt¹, A.Stefanie Mikolaizak², Kristin Taraldsen³, Ronny Bergquist³, Jeanine Van Ancum⁴, Corinna Nerz², Mirjam Pijnappels⁴, Andrea Maier⁴, Jorunn Helbostad³, Beatrix Vereijken³, Clemens Becker², Michael Schwenk⁵

¹Robert Bosch Medical Foundation, ²Robert-Bosch-Krankenhaus, ³Norwegian University of Science and Technology, ⁴Vrije Universiteit Amsterdam, ⁵Heidelberg University

BACKGROUND AND AIM: The Community Balance & Mobility Scale (CBM) was shown to be a reliable and valid tool for detecting subtle balance and mobility deficits in young seniors. However, item redundancy and lengthy assessment time call for a shortened version. This study aimed to create and validate a shortened version of the CBM (s-CBM) while retaining reliability and validity of all psychometric properties in comparison to the original CBM scale. METHODS: Two samples of community-dwelling young seniors aged 60 to 70 years were used, one for creating and one for validating the shortened version. Participants in both samples were recruited within the EU project PreventIT. Exploratory factor analysis with data from 189 young seniors (66.3 ± 2.5; 60-70 years) was used to create the s-CBM. Sixty-one young seniors (66.5 ± 2.6 ; 60-70 years) were recruited to assess construct validity (Pearson correlation coefficient) by comparing the CBMversions with Fullerton Advanced Balance Scale, Timed Up-and-Go, habitual and fast gait speed over 7 meter, 8 Level Balance scale, 3 meter Tandem Walk, and 30 seconds Chair Stand Test. Internal consistency (Cronbach's alpha), floor and ceiling effects, and discriminative validity (area under the curve, AUC) between fallers and non-fallers, self-reported high- and low-function during different everyday activities (Late-Life Function & Disability Index) as well as balance confidence (Activities-Specific Balance Confidence Scale) were calculated. RESULTS: The s-CBM, consisting of four items, correlated excellent with the CBM (r=0.97; p<.001). The construct validity between the s-CBM and other assessments (r=0.07-0.72) was statistically comparable to the construct validity between the CBM and other assessments (r=0.06-0.80) in 90% of the correlations. Cronbach's alpha was 0.84 for the s-CBM, 0.87 for the CBM. The s-CBM and the CBM did not show floor or ceiling effects. The discriminative ability of the s-CBM was statistically comparable to the CBM (AUC=0.66-0.75 vs. AUC=0.65-0.79), in regards to faller status, selfreported function and balance confidence. CONCLUSIONS: The s-CBM has retained all psychometric properties of the CBM indicating that the expressive items are still included in the s-CBM and that no decisive information was lost due to the item reduction. Especially, the feasibility of the scale was improved by the reduced time by 50% and equipment required. The s-



CBM can be recommended as a sensitive and quick balance and mobility assessment in young seniors. Longitudinal studies with larger samples should confirm the results and additionally assess the responsiveness of the scale for detecting changes over time.

P1-W-176 Towards better quantification of freezing of gait in Parkinson's disease: The added value of performance timing

Talia Herman- Feinstein¹, Moria Dagan², Shirley Shema-Shiratzky¹, Marina Brozgol¹, Tal Reches¹, Nir Giladi¹, Brad Manor³, Jeff Hausdorff¹

¹Tel-Aviv Sourasky Medical Center, ²Tel Aviv University, ³Harvard Medical School

BACKGROUND AND AIM: Capturing freezing of gait (FOG) and quantifying its severity in patients with Parkinson's disease (PD) is often challenging; FOG is an episodic phenomenon which may be triggered by cognitive and emotional load and has limited response to medications. Objective assessment is not sufficiently established, and the current clinical tests lack good clinometric properties. The aim of the present study was to better quantify FOG severity using a modified FOG-provoking test. More specifically, we explored the added value of timing the test completion, as compared to just rating the FOG episodes, in a previously proposed test of FOG. METHODS: PD patients with marked freezing underwent the FOG-provoking test previously described by Ziegler and colleagues. The protocol includes standing up from a chair, walking to a marked square where patients complete two 360° opposite direction turns, walking through a door, turning and returning back to the chair. The test is performed under 3 conditions: (1) usual, (2) dual-task (walking while carrying a tray); and (3) triple-task (walking while holding a tray and subtracting 7s). The original method scores festination and FOG during the task, ranging from 0 to 36 points - most severe, but disregards the number and duration of the FOG episodes. We evaluated the effect sizes based on timing and conventional scoring of A) the change between condition 1 and 3 (motor-cognitive cost), and B) the change in each condition, before and after anti-parkinsonian medication intake (OFF vs. ON medication cycle). RESULTS: Sixty-six patients with PD participated (mean age: 69.9±7.5 yrs, mean disease duration: 9.1±6.0, 80% male). In general, task duration and scoring were significantly increased across conditions and differed between OFF and ON (p < 0.036). The outcome measures were moderately correlated with each other (r < 0.7, p<0.05). When comparing the motor-cognitive cost (condition 1 vs. 3), higher effect sizes were observed for timing as compared to scoring when the test was completed both OFF (-0.85 vs. -0.73, respectively) and ON (-0.84 vs. -0.55, respectively) medication. Similarly, the effect size of timing was larger than the effect size of scoring when comparing between OFF and ON under all conditions (see Table 1). CONCLUSIONS: In attempt to address limitations of the original scoring of the FOG-provoking test, the current findings support the notion that monitoring duration improves the sensitivity of the test. From a clinical perspective, the severity of FOG (frequency and duration) may be underestimated when using the conventional method alone. Thus, the simple addition of test-timing may enhance the ability to differentiate between mild and moderate



from severe freezers and the evaluation of medication and other intervention effects. In the future, it might be interesting to combine the two scoring approaches and perhaps use this modification to generate a "Hoehn & Yahr-like" scale for FOG staging.

P1-W-177 Test-retest reliability of force plate balance measures in individuals with chronic stroke

Andrew Huntley¹, Elise Belhacel², Raabeae Aryan³, Alison Schinkel-Ivy⁴, Anthony Aqui¹, Avril Mansfield¹

¹Toronto Rehabilitation Institute, ²Institut ESIPE Créteil (ISBS) - Université Paris-Est Créteil, ³University of Toronto, ⁴Nipissing University

BACKGROUND AND AIM: Force plates can be useful tools for assessing balance control poststroke. However, the reliability of these measures across multiple trials within a single assessment is still unclear. While previous work has explored the relationship between clinical tests and force plate measures [1], this does not determine whether the force plate measures used are indeed reliable. Furthermore, the few studies that have attempted to answer this guestion either span multiple stages of stroke [2], examine assessments spaced 7 days apart [3], or explore a single variable [4]. This study aimed to determine the reliability of multiple force plate measures in individuals with chronic stroke within a single session. **METHODS:** Twenty people with chronic stroke (>6 months post-stroke) were included. Participants performed 3 30-s quiet standing trials within a single testing session. Force plate data (AMTI, USA) were collected under both feet. The centre of pressure (COP) time series was calculated from the ground reaction forces and moments, and the following measures were calculated from the COP: symmetry index based on root mean square (RMS) of COP position, symmetry index from RMS of COP velocity, crosscorrelation of the antero-posterior COP, and mean net COP velocity in the antero-posterior and medio-lateral directions. Intraclass correlation coefficients (reported as ICC (3,1) and [95% confidence interval]) were determined for all measures across all 3 quiet standing trials. ICC levels were interpreted based on the following ranges: poor ≤0.40, moderate 0.41-0.60, good 0.61-0.80, and very good >0.80. **RESULTS:** Three participants only completed 2 quiet standing trials, thus a total of 57 guiet standing trials across 20 participants were included in analyses. ICC results for symmetry position and symmetry velocity indexes were 0.53 [0.14, 0.78] and 0.57 [0.20, 0.80], respectively. Antero-posterior cross-correlation had an ICC of 0.64 [0.30, 0.83]. ICCs for mean net COP velocity in the antero-posterior and medio-lateral directions were 0.73 [0.45, 0.88] and 0.83 [0.63, 0.93], respectively. CONCLUSIONS: Measures of quiet standing balance, including symmetry indexes, correlation, and velocity of the COP have moderate to good reliability within a single testing session for individuals with chronic stroke. However, lower confidence limits indicate poor ratings for measures of symmetry and displacement, with only mean COP velocity measures having a lower confidence interval in the moderate (antero-posterior direction) and good (mediolateral direction) regions. Further analyses to be presented at the conference will include the



reliability of frequency domain and non-linear measures within a single testing session. **REFERENCES:**[1] Sawacha et al (2013) J Neuroeng Rehabil 10(95):1-7. [2] Gray et al (2014) Gait Post 40(1): 198-203. [3] Gasq et al (2014) J Neuroeng Rehabil 11(39):1-10. [4] Eng et al (2002) Arch Phys Med Rehabil 83(8):1138-44.

P1-W-178 Peak plantar ankle flex push-off power estimation using single inertial measurement units

Xianta Jiang¹, Mohsen Gholami¹, Janice Eng², Carlo Menon¹

¹Simon Fraser University, ²University of British Columbia

1) **BACKGROUND AND AIM** Ankle joint power is mainly generated in a short period at the end of the stance phase to accelerate the leg into swing phase and redirect and push the body's center of mass forward. It is one of the gait parameters that can be used to diagnose and characterize gait deficits and then to develop rehabilitation protocols to improve walking performance. For example, a decrease in ankle power results in shorter step length in elderly, as well as reduced cadence, lower walking speed, shorter strides, and increased step times. It is also reported the power amplitude is lower for the affected side than unaffected side in stroke-survivors. Ankle joint power is usually estimated using a biomechanical model of the ankle based on the data collected from an instrumented treadmill and/or an optical motion tracking system, which limits its applications in outdoor or home-use environment. The goal of this study is to examine the feasibility of using a single inertial measurement unit to estimate peak ankle plantarflexion pushoff power, which can be potentially used in environments outside of lab setting. 2) Methods Nine healthy volunteers were recruited to walk on a force-plate-instrumented treadmill wearing four inertial measurement units (IMUs) (MTw Awinda, Xsens, Enschede, The Netherlands) on the foot, shank, lower thigh, and upper thigh respectively, together with 13 reflective motion tracking markers, as shown in figure 1. A Vicon motion tracker with seven cameras was also used to monitor the foot movements. The participants walked for 5 minutes, each minute at one of the five different speeds, namely 0.4 m/s, 0.7 m/s, 1.0 m/s, 1.3 m/s, and 1.6 m/s. The first half of the data of all five speeds from one IMU for all nine participants was processed to train a Random Forest model to estimate the ankle joint peak power using the second half of the data from the same IMU for each participant. This was repeated for the other three IMU sites. The performance of the model was then evaluated by comparing the estimated peak power values to the reference values provided by the motion tracking system and the force plate-instrumented treadmill (gold standard reference). 3) **Results** The proposed method achieved a very high accuracy of peak ankle joint power. The differences between the reference and predicted peak power values averaged across five speeds were 0.01, 0.04, 0.02, and 0.04 w for using the single IMUs on foot, shank, lower, and upper thigh respectively, which corresponded to 0.3 to 2.2% relative error compared to the range of power from peak to valley. There was only 0.3% to 0.6% per gait cycle delay in the detected occurrence of the power peak compared to that of reference peak power. 4) Conclusion The



results demonstrate the feasibility of using only one single IMU to estimate the peak ankle joint power. This can potentially offer an easy-to-use way of monitoring and reporting the ankle joint power in daily living.

P1-W-179 Reliability of different clinical techniques for assessing foot posture

Muge Kirmizi¹, Mehmet Cakiroglu¹, Ibrahim Simsek¹, Ata Elvan¹, Salih Angin¹

¹Dokuz Eylul University

BACKGROUND AND AIM: Many indirect clinical techniques have been developed to assess foot posture because X-ray method, which is used as a gold standard in direct assessment of foot posture, is expensive and has a potentially harmful effect on human health. There is no indirect clinical technique considered as a gold standard in the assessment of foot posture and therefore the most reliable ones are preferred to use. However, the results of the studies investigating the reliability of techniques for assessing foot posture are inconsistent, which may be due to differences in types of equipment and methods used. The purpose of the study was to determine the intra and interrater reliability of Navicular drop (NDP), Navicular drift (NDT), Foot posture index (FPI) and test-retest reliability of dynamic arch index (DAI) and static arch index (SAI). METHODS: Sixty healthy individuals aged 24.23±3.52 years (BMI:22.63±2.49 kg/m2) were assessed for intrarater and test-retest reliability. From 60 participants, 30 individuals aged 22.37±1.4 years (BMI:22.52±2.61 kg/m2) were assessed for interrater reliability. The digital vernier caliper measuring with a precision of ±0.02mm (Absolute Digimatic, Mitutoyo, Japan) was used to measure NDP and NDT values. The sagittal and horizontal plane displacements of the anteroinferior of the navicular between subtalar neutral foot posture and relaxed foot posture were measured to determine the NDP and NDT, respectively. During measurements of the NDP and NDT, antero-inferior of the navicular was palpated and marked once more after the participants were instructed to stand in relaxed foot posture to prevent measurement error caused by skin shifting. Electronic pedobarography (EMED-m, Novel GmbH, Germany) was used to measure contact area values during standing in relaxed foot posture for SAI and during preferred walking for DAI. SAI and DAI calculated by dividing the midfoot contact area by the total contact area without toes. FPI-6, which is the observational tool, was used for assessing foot posture. All assessments were applied to the participants' dominant foot, and the NDP, NDT, DAI and SAI were repeated three times and averaged. NDP, NDT, FPI-6 were conducted by two raters to determine interrater reliability and also repeated by a single rater in five days apart to determine intrarater reliability. DAI and SAI were also repeated in five days apart to determine test-retest reliability. RESULTS: NDP and FPI-6 had a perfect intrarater reliability (ICC>0.90), and NDT has a good intrarater reliability (0.80<ICC>0.90). Test-retest reliabilities of DAI and SAI were good (0.80<ICC>0.90). Interrater reliabilities of NDP and NDT were good (ICC>0.75), but FPI-6 showed an only moderate interrater reliability (ICC:0.575). CONCLUSIONS: As compared to the results of similar studies in the literature, our results showed that there is an increase in the reliability of



the techniques when technologically more advanced devices are used. Using high accuracy digital caliper, repalpating and averaging repeated measurements may improve the reliability of the NDP and NDT techniques. The results of this study can provide clinicians and researchers with a reliable way to implement clinical techniques for assessing foot posture.

P1-W-180 Factors associated with daily variation in gait performance in older adults

Alexa Ludington¹, Junhong Zhou¹, Wanting Yu¹, Brad Manor¹, On-Yee Lo¹

¹Harvard Medical School

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BACKGROUND AND AIMS: In older adults, gait metrics--especially during dual-task conditions--are predictive of future falls and cognitive decline. Walking performance is not stable from day to day; however, the magnitude of such performance variation may provide important additional insight into health status. We previously created and validated a smartphone-based assessment of dual-task walking to enable repeated assessment within non-laboratory settings. Here, we aimed to determine cognitive-motor factors associated with average daily gait performance, as well as the daily variation in performance, over a one-week period in older adults. METHODS: Eighteen older adults free of overt illness or disease (aged 71±5 years, 13 F) completed a laboratory-based functional assessment. Cognitive function, mobility, and fear of falling were tested with the Montreal Cognitive Assessment (MoCA), the Timed Up and Go (TUG), and the Falls Efficacy Scale, respectively. Participants were then familiarized with the smartphone App and instructed to complete one assessment each day for seven days. The App employed multimedia instructions to guide the participant through a 45-second trial of walking under normal conditions and again while dual-tasking (i.e., walking while performing serial subtractions). A custom processing pipeline was used to calculate average stride time and stride time variability (i.e., coefficient of variation about the average stride time) during periods of relatively straight walking within each condition. We examined if repeated testing influenced walking performance by using one-way ANOVAs to determine if, at the group level, gait performance differed by day. Regression analyses were used to analyze relationships between daily gait performance (i.e., average performance and variation in performance) and baseline cognitive-motor function (i.e., MoCA total score, TUG time, fear of falling score). The level of statistical significance was set to p=0.05 for all tests. **RESULTS:** Single and dual task stride time and stride time variability did not significantly differ across the seven days of home testing (p>0.3). Participants with worse cognitive function (lower MoCA scores) exhibited longer average daily stride time during both normal (R²=0.27, p=0.03) and dual task (R²=0.31, p=0.01) conditions. Those with worse mobility (longer TUG time) exhibited longer average daily stride times (normal: R²=0.28, p=0.03; dualtask: R²=0.30, p=0.02), and greater average daily stride time variability (normal: R²=0.29, p=0.03; dual task: R²=0.33, p=0.01). In contrast, MoCA and TUG performance were not associated with the average daily variation in gait performance. Instead, those with more fear of falling exhibited greater daily variation in stride time variability during both normal (R^2=0.25,

p=0.03) and dual task (R^2=0.42, p=0.003) walking conditions. **CONCLUSIONS:** Our results suggest that while laboratory measures of global cognitive function and mobility may predict average daily gait performance, the variation in daily performance may be uniquely related to one's fear of falling. High-frequency, remote monitoring of gait thus holds promise to aid in the characterization of health as it relates to mobility and falls in older adults.

P1-W-181 Development of instrumented shoe with miniature high-capacity load vector sensor and application to gait assessment

Masato Shindo¹, Takeshi Yamaguchi¹, Yoshihiro Sasaki², Kazuo Hokkirigawa¹

¹Tohoku University, ²Research Institute for Electromagnetic Materials

BACKGROUND AND AIM: An instrumented shoe system is currently proposed as a cheaper alternative to conventional location-specific gait analysis systems, i.e. force plates and threedimensional motion capture systems. In this current study, an instrumented shoe utilizing miniature high-capacity three-dimensional force sensors, containing strain sensitive Cr-N thin films mounted to the shoes outsole, was developed[1]. the dimension of each sensor is 20 mm×20 mm×3.0 mm, with a weight of 20 gf, and load capacity of 1000 N in the z axis and ±500 N in the x and y axis. The instrumented shoe system collected ground reaction force (GRF) data in addition to estimating the local required coefficient of friction (RCOF), body center of mass (COM), and center of pressure (COP) during straight walking. Estimated figures were compared with actual results measured from force plates and motion capture system as a means of assessing the instrumented shoe systems accuracy. METHODS: The instrumented shoe utilized seven tri-axial force sensors which were mounted to the outsole of commercially available working shoe to measure the local GRFs at the heel, mid-foot, metatarsal head, and toe locations. Five young male adults were instructed to walk in the straight direction, on the force plates, while wearing the instrumented shoe. The RCOF was defined as the maximum value of the ratio of the horizontal and vertical resultant GRFs. The COP was calculated using GRFs and sensor location data. The body COM location was estimated by taking the second order integral of COM acceleration obtained from resultant GRFs. RESULTS: The resultant GRFs measured with the instrumented shoe during stance phase (0-100%) demonstrated strong positive correlations with those measured with the force plates (r = 0.80 in the mediolateral [ML] direction; r = 0.93 in the anteroposterior [AP] direction; r = 0.97 in the vertical direction). In addition, local RCOF values at each sensor position revealed that a friction coefficient greater than 0.6 is required to prevent slipping at the heel. Furthermore, the COP location estimated with the instrumented shoe exhibited a strong correlation with that measured from the force plates (r > 0.9 both in the ML and AP directions). Finally, the estimated COM location in the AP direction showed strong positive correlation with that measured from the motion capture system (r = 0.94). **CONCLUSIONS:** The developed instrumented shoe using miniature high-capacity load vector sensors demonstrated that it has the potential to be utilized in gait analysis research. REFERENCES:[1] Niwa, E., Sasaki,

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Y., "Cr-N Strain Sensitive Thin Films and Their Pressure Sensor Applications", IEEJ Transactions on Sensors and Micromachines, vol. 134, issue 12, pp. 385-391. **ACKNOWLEDGEMENT**: This work was partially supported by JSPS KAKENHI Grant Number 16K06038.

P1-W-182 Validity and usability of a mixed reality headset for automated mobility assessment

Ruopeng Sun¹, Roberto Aldunate¹, Jacob Sosnoff¹

¹University of Illinois at Urbana-Champaign

BACKGROUND AND AIM: Sensor-based mobility assessment offers great potential for objective fall risk assessment in older adults. Yet, inertial sensors (accelerometer/gyroscope) that are commonly used as a stand-alone recording device, still require clinical guidance. An alternative approach to further improve the assessment efficiency is to use a Mixed-reality head-mounted display (Microsoft, Inc. Hololens) to automatically guide the wearer through the assessment and track wearer's mobility performance. Therefore, the aim of this study is to evaluate the validity and usability of the mixed-reality headset for automated mobility assessment in young and older adults. **METHODS:** Eight older healthy adults (79.8±7.0 yrs old) and 10 young adults (25.7±2.7 yrs old) participated in this study. An automated mobility assessment App which consists of a series of functional mobility tests (Timed Up and Go, Five-time Sit to Stand, Eyes Open and Eyes Closed standing) was developed based on the Microsoft Hololens platform. After fitted with the headset, the participant was led by the onscreen video/audio instruction and asked to self-initiate/complete the test by focusing their gaze on a start/end button. Mobility performance was recorded with the headset built-in inertial sensor, as well as four additional reference inertial sensors (Opal, APDM) placed on the headset, lower back, and both feet. Preliminary analysis compared the 3D acceleration signal agreement between Hololens and Opal sensors, as a mean to evaluate the concurrent validity of the device. User experience and acceptance were determined by the System Usability Scale (SUS) and semi-structured interview. Participant's technology proficiency was measured using the Mobile Device Proficiency Questionnaire (MDPQ). RESULTS: Preliminary data indicates 3D acceleration differences (RMSE) between Hololens and reference head-mounted Opal sensor range from 8.6% - 17.6%, with higher difference in ML direction in comparison to AP and Vertical direction. On average, after fitted with the headset, participant can complete the assessment automatically within 7 mins. As expected, older adults reported lower system usability (SUS 66.9 \pm 17.2) and technology proficiency (MDPQ 25.9 \pm 9.5) in comparison to young adults (SUS 83.0 ± 9.9, MDPQ 39.7 ± 0.8). From the user interview, older adults reported difficulties with the heaviness and fit of the headset, while also reporting ease of use and comfortable following the automated mobility assessment App. CONCLUSION: Preliminary data analysis demonstrated that the Hololens recording is acceptable in recording accuracy in comparison to reference inertial sensor. Ongoing data analysis will provide information on the validity of head mounted sensor for mobility evaluation in comparison to lower back and foot-

mount sensors. Although reported relatively low system usability, older adults still demonstrated the ability to use and follow the automated assessment through the App. With future development in improving user comfort, this Mixed Reality Headset has the potential to provide objective mobility assessment.

P1-W-183 Can we elicit increasing lumbar flexion movement using a standardized reaching paradigm in an immersive virtual reality environment?

Susanne van der Veen¹, Dana Nocera², Kellen Kubik², Emma Fish², James Thomas¹

¹Virginia Commonwealth University, ²Ohio University

BACKGROUND AND AIM: Chronic low back pain (CLBP) affects more than 25 million Americans and is the most common cause of job-related disability and missed work days. One proposed mechanism thought to lead to CLBP is through fear-avoidance or kinesiophobia, whereby patients reduce lumbar flexion due to perceptions of harm and pain expectancy resulting from the movement. While such kinesiophobia is negatively correlated with physical activity and quality of life it has been shown that exposing high-kinesiophobia CLBP patients to reaching tasks that elicit lumbar flexion can reduce pain and harm expectancy[1]. Therefore, there is a need to examine new ways in which to promote lumbar movement in spite of kinesiophobia. Due to its immersive nature, Virtual Reality (VR) provides an ideal environment for tasks (such as whole-body reaching) to be manipulated to implicitly promote greater lumbar flexion, however whole-body motions can be achieved through a variety of joint configurations. Before determining the efficacy of such a paradigm within a patient population, this study aimed to investigate a VR implementation of the standardized reaching task known to elicit varying degrees of lumbar excursion in the real world. METHODS: Healthy subjects [N=9, 27±6.04 years] with no history of LBP participated in a custombuilt VR reaching game ('Matchality'). While wearing a HTC Vive head-mounted display, subjects played two games of 'Matchality' consisting of three levels that required them to reach towards highlighted cubes in a randomized sequence. The three levels promoted greater ranges of lumbar flexion necessary for target attainment (Lv1=15-30°, Lv2=15-45°, Lv3=15-60°). Whole-body kinematics were integrated via Motion Monitor? and captured using a 10 camera Vicon Bonita system. The effects of target location on lumbar excursions during gameplay was assessed with a repeated measure ANOVA using SPSS?. RESULTS: Healthy young adults flexed their lumbar spine significantly more during movements to targets expected to elicit 60° of lumbar flexion than targets placed to elicit 15°, 30°, or 45° (F (2,16) = 14.301, p = 0.007). Intended target angles were not reached for 15°, 30°, 45°, or 60° as the averages and standard errors were 12.9±1.5°, 17.5±1.4°, 24.1±2.0° and 28.7±2.8°, respectively. CONCLUSIONS: While the intended angles were not reached for any of the heights, this study provides evidence that progressively greater lumbar excursions are elicited for reaches to the four target heights presented in the VR game. This study provides evidence that 'Matchality', an interactive VR game, successfully encourages increased lumbar excursions, which may contribute to the normalization of pain and harm



expectancy when applied to CLBP patients with kinesiophobia. 1.Trost et al,. Exposure to movement in chronic back pain: Evidence of successful generalization across a reaching task. Pain. 2008

P1-W-184 Quantification of seated balance control using system identification

Albert Vette¹, Kshitij Agarwal¹, Alireza Noamani¹, Andrew Williams¹, Hossein Rouhani¹

¹University of Alberta

BACKGROUND AND AIM: Elderly individuals and those affected by neuromuscular disorders are often not able to independently maintain seated balance. To develop targeted interventions for seated instability, it is important to identify the mechanisms responsible for controlling seated balance. In this context, classical system identification techniques are a promising tool for obtaining a quantitative description of such mechanisms. Motivated by these considerations, the objective of this study was to quantify, using system identification, the active and passive control mechanisms in seated balance of non-disabled individuals. METHODS: 14 young, non-disabled individuals were perturbed while sitting using mild, mechanical surface perturbations. The body kinematics, muscle activity, and ground reaction forces were recorded during the perturbations. Using the joint input-output system identification technique, non-parametric estimates of the active control components (neural dynamics and sensorimotor time delay) and of the active-passive control components (neural dynamics, mechanical dynamics, sensorimotor time delay, and muscular dynamics) were obtained. Parametric estimates of these components were computed using model fitting. The accuracy of the parameters was evaluated using criteria such as goodness-of-fit. RESULTS: The across-participant variability of the non-parametric estimates of the active and active-passive control components was small (Fig. 1; dashed lines). For the active control components, the gain steadily rose for all frequencies, whereas, for the active-passive control components, it was approximately constant for lower frequencies (below 1.4 Hz) and then steadily rose as the frequency increased (Fig. 1; top). The active control component had a phase of 30 degrees for lower frequencies and steadily rose as the frequency increased; it saturated around 110 degrees as the frequency reached approximately 3 Hz. The active-passive control component had a constant phase of approximately 180 degrees for the lower frequencies (below 1.4 Hz) and steadily rose as the frequency increased (Fig. 1; bottom). The neural dynamics were identified as a proportional-derivative controller with acceleration feedback; the sensorimotor time delay as an exponential decay function; the mechanical dynamics as a proportional controller; and the muscular dynamics as a third-order system. The fitting of the active control components using the stated models had a goodness-of-fit range of 99.2-99.8% across participants. Similarly, the fitting of the active-passive control components had a goodness-of-fit range of 99.6-99.8%. **CONCLUSIONS:** We successfully quantified the mechanisms of seated balance for non-disabled individuals. The identified parameters can be used as a normative benchmark for quantitatively





and mechanistically assessing the severity of seated imbalance in affected individuals, with the goal of optimizing rehabilitation therapies and interventions.

X - Vestibular function and disorders

P1-X-185 Postural instability in subjects with Usher syndrome

Simona Caldani¹, Maria Pia Bucci¹, Maud Tisne¹, Isabelle Audo², Thierry Van Den Abbeele¹, Sylvette Wiener Vacher¹

¹Hopital Robert Debré, ²CHNO

Abstract Background Sensory inputs as well as visual, proprioceptive and vestibular inputs are necessary to maintain postural control. Methods This study investigated postural performances in three groups : a group of 9 subjects with Usher type I (with visual and vestibular impairment), a group of 14 subjects with Usher type II (with only visual impairment) and a group of 14 control subjects in order to evaluate the role of sensory inputs on postural control. To measure postural stability, Framiral Multitest Equilibre platform was used. Three visual conditions (open eyes (EO), closed eyes (EC) and vision disturbed by optokinetic stimulation (OPT)) were performed during two different postural conditions standing on stable and standing unstable platform. The surface area and the mean velocity of the displacement of the center of pressure (CoP) and the postural instability index (PII) were measured. Results Both groups of patient with Usher (type I and II) were more instable than the controls subjects, particularly on unstable platform. On unstable platform Usher type I patients (with severe vestibular impairment) were significantly more unstable than Usher type II patients (with normal vestibular function). **Discussion** We suggest that the absence or abnormal visual and/or vestibular inputs could be the cause of such poor postural control in subjects with Usher; postural recordings on unstable platform can differentiate patients with Usher type I versus type II. We emphasized the importance of developing specific visuovestibular rehabilitation techniques to improve postural stability in these subjects.

P1-X-186 Balance performance in bilateral vestibulopathy in relation to sensorimotor integration

Nolan Herssens¹, Evi Verbecque², Wim Saeys¹, Luc Vereeck¹, Vincent Van Rompaey¹, Christopher McCrum³, Kenneth Meijer³, Ann Hallemans¹

¹University of Antwerp, ²University of Hasselt, ³Maastricht University

BACKGROUND AND AIM: Bilateral vestibulopathy (BVP) is characterized by (in)complete vestibular function loss in both inner ears. Patients with BVP primarily experience unsteadiness when walking or standing, worsening in darkness and/or on uneven ground 1,2. Thus, their balance





mechanisms are disturbed, however, to which extent remains unclear. Therefore, the aim of this systematic review was to investigate balance performance in patients with BVP as compared to unilateral vestibulopathy patients (UVP) and/or healthy controls (HC). METHODS: Pubmed, Web of Science and Embase were searched systematically on June 19th 2018. Case-control studies investigating balance control in adult BVP compared to UVP and/or HC were analyzed. The SIGNchecklist for case-control studies was applied to identify risk of bias. Results were classified according to the sensory perturbations: "without sensory perturbations", "visual", "proprioceptive" or "vestibular perturbations" and "more than one sensory perturbation". Within these classifications tasks were classified as "standing" or "walking". Cohen's d was calculated to estimate the standardized mean difference in performance between BVP and UVP or HC. **RESULTS:** Fifteen out of 695 unique studies met the selection criteria, containing data from 242 BVP, 237 UVP and 282 HC. When no perturbations were present, the performances of patients with BVP were indistinguishable from those of UVP, and for the most part also from those of HC. When proprioceptive or visual perturbations were present, patients with BVP showed an increase in postural sway as compared to healthy controls, however no true differences with UVP were found. The combination of more than one sensory perturbation was able to distinguish BVP from HC (Fig. 1) and UVP. CONCLUSIONS: Patients with BVP tend to perform significantly worse during tasks involving multisensory perturbations compared to HC or UVP. However, these patients may not be distinguishable from HC or UVP in clinical settings where balance control is assessed with a single sensory perturbation due to the upweighting of the remaining visual and/or proprioceptive information cues. To be able to differentiate BVP from HC or even UVP, more advanced and challenging balance tasks need to be performed, i.e. multiple sensory perturbations. 1. Wuehr M, et al. (2017) J Neurol 264(Suppl 1), S81-6 2. Strupp M, et al. (2017) J Vestib Res 27(4), 177-89 ACKNOWLEDGEMENTS AND FUNDING This work was supported by the University of Antwerp Research Council [grant number ID33586], the University of Antwerp and the Antwerp University Hospital.

P1-X-187 Determination of an objective threshold for galvanic vestibular stimulation

Youstina Mikhail¹, Jean-Marc Mac-Thiong², Dorothy Barthélemy³

¹Centre for Interdisciplinary Research in Rehabilitation (CRIR-IRGLM), ²CIUSSS Centre-Sud-del'île-de-Montréal, ³Université de Montréal

BACKGROUND: Somatosensory, visual, and vestibular mechanisms are essential to maintain balance, yet the contribution of the vestibular system is not fully understood. Galvanic Vestibular Stimulation (GVS) is used to assess the vestibular system, but vestibulospinal responses exhibit great inter-individual variability, even when the subjective perception of movement is used to determine a threshold (T). This study AIMS to develop a protocol identifying an objective T for GVS that could be relevant to reflect changes occurring in the vestibular system following injury. **METHODS:** 18 healthy right-handed subjects participated. Electromyography (EMG) electrodes





were placed on soleus (SOL) and tibialis anterior (TA), and an accelerometer was put on the vertex. Firstly, recruitment curves were collected for subjects (N=18) while standing on a force platform, eyes closed, head forward with bipolar GVS (1-4.5 mA, 200 ms, cathode on right). The T was determined at the intensity where 5/10 stimuli induced clear responses on the accelerometer. Secondly, to determine if multiples of this threshold were scaled to vestibular responses, participants (N=8) were stimulated at 0.5T, 0.75T, 1T and 1.5T, keeping the same standing posture. Thirdly, to assess whether this T is relevant in different tasks, participants (N=10) were stimulated at 1T and 1.5T with head turned to the right or to the left. In the fourth part, participants (N=7) were stimulated while walking on a treadmill at a comfortable speed. Analysis: 95% confidence ellipse area and velocity of CoP displacement were analyzed for all standing tasks. Vestibular responses in SOL and TA were averaged (n=30 stimuli) and analyzed for parts 3 and 4. **RESULTS:** 1)The T was determined based on recruitment curves observed along the mediolateral axis of the accelerometer in 15/18 subjects. In 3 subjects the recruitment curves were clearer along the anteroposterior axis. 2)Confidence ellipse area was larger at 1.5T vs 0.5T(p=0.007) and at 1T vs 0.5T (p=0.038). No difference observed between 0.5T and 0.75T. Correlation could be drawn between the area and intensity of stimulation (r=0.442, p=0.007). 3)The amplitude of the first peak of velocity of CoP displacement in the mediolateral axis was larger at 1.5T (p=0.002), 1T (p=0.008) and 0.75T (p=0.03) compared to 0.5T. Correlations were observed between the stimulation intensity and the amplitude of first peak (r=0.347) with no significance (p=0.056). 4)An inhibitory SLR and a faciliatory MLR were induced in SOL when the head was turned to the left during standing. During gait, only the MLR was clearly delineated at the intensities used. Correlation between the amplitude of the SLR and MLR responses during both tasks were not significant. CONCLUSION: Preliminary data suggest that an objective T can be identified using an accelerometer placed on the vertex. The intensity of 1T and 1.5T could induce scaled responses measured by CoP displacement, but correlations between stimulation intensity and EMG area were not as clear.

P1-X-188 Evaluation of after-effects of noisy vestibular stimulation on vestibular motion perception

Max Wühr¹, Aram Keywan¹, Klaus Jahn¹

¹Ludwig-Maximillians Universität München

BACKGROUND AND AIM: Noisy galvanic vestibular stimulation (nGVS) delivered at imperceptible intensities has been shown to improve posture and gait stability in patients with vestibular hypofunction. It was recently demonstrated that the mechanism underlying these improvements is an nGVS-induced lowering of thresholds for vestibular information processing. Here we evaluated, whether the beneficial effects of nGVS on vestibular information processing are only present during acute stimulation or may exhibit any plastic after-effects. **METHODS:** In 10 healthy subjects, we examined the effects of nGVS on vestibular roll-tilt direction recognition



thresholds during acute stimulation as well as after long-term stimulation with nGVS. **RESULTS:** In a first step, we observed that acute stimulation with nGVS effectively lowered vestibular motion perception thresholds compared to baseline in all participants (p < 0.001). Each participant was subsequently stimulated with nGVS for a period of 30-minutes. Immediately after cessation of stimulation, vestibular motion perception thresholds returned to baseline level (p = 0.044) and remained constant in a 30-minutes follow-up assessment. **CONCLUSIONS:** These results indicate that nGVS does not exhibit any after-effects on vestibular information processing. Effective treatment approaches with nGVS in patients with vestibular hypofunction will therefore require a continuous application of stochastic vestibular stimulation. However, since nGVS is non-invasive and delivered at imperceptible intensities, long-term application of nGVS is likely to be well tolerated by patients.

P1-X-189 Body equilibrium function in the course of Ménière's disease

Masahiko Yamamoto¹

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¹Toho University

Masahiko Yamamoto£±), Tomoe Yoshida£²£©, ¡¡Eigo Ohmi£³£©,;¡ Kazuo Ishikawa£´£© 1) Toho University School of Medicine 2) Clinical support Service Section, Toho University School of Medicine 3) Department of Otorhinolaryngology, Head and Neck Surgery, Akita Kousei Medical Centeriii 4) Dizziness center of Japanese Red Cross Akita Hospital [Introduction] M"Ini" re's disease (MD) shows healing recovery after dizziness attacks, but hearing loss often progresses with or without dizziness. Although deterioration of the semicircular canal function does not progress as much as hearing loss decreases, the internal lymphatic edema pathology should be continuously changing until the symptom is stabilized, and there is a possibility that it may have influenced the vestibular. If it prolongs in the course of MD seizure, patients who show licking appeal can be seen even when nystagmus etc. are not seen. Therefore, the state of body equilibrium in MD process was examined. [Subjects and Methods] The subjects were 22 MD patients (all on the left side, 24 to 80 years old). Based on the course of examination divided into cases of MD vertigo frequency group (8 cases) and vertigo stable group (13 cases). We examined the stabilometry test at the time when nystagmus was not observed in each case and compared with healthy subjects. The body equilibrium function was analyzed by the stabilometer(Anima G 620). Analysis indices were analyzed and compared with respect to the fluctuation distance (total length), the swaving area (outer circumference area), the unit area trajectory length, the power spectrum and the like. **[RESULTS]** In middle and younger age, relatively stable stabilometry test was shown even at the time of seizure of dizziness. However, above middle age, shaking was significant not only during the period of dizziness attack but also during dizziness. In addition, attitude control with closed eye sway was observed very slowly (Figure) by the new power spectrum analysis display method. The figures are new display method which improved display method of MEM power spectrum analysis. Recording data for 60 seconds are divided every 10



seconds, and the power spectra of each 10 seconds are displayed side by side over time. With this display, we can see changes in the power spectrum over time. i³/4Discussion and conclusioni/2. The MD takes a relatively long course, changes in hearing and tinnitus, positional vertigo on the way repeated, and is accompanied by mental anxiety. The age of onset also varies, and repeating dizziness affects daily QOL. In comparison with the analysis index, it was considered that the instability at the time of closing the eyes was further increased as the age increased, and it was thought that both the persistence of the MD pathology and the decrease of the age-oriented posture function were both involved. Slow swing is a type seen in psychogenic dizziness attack, mental factors also affect attitude control It was thought that. Figure:

Y - Visual function and disorders

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P1-Y-190 A perceptual perspective: Exploring visual search patterns during freezing of gait in Parkinson's disease

Lotte Hardeman¹, Elmar Kal², Toby Ellmers², Will Young², Anna Fielding²

¹Vrije Universiteit Amsterdam, ²Brunel University

BACKGROUND AND AIM: Freezing of gait is one of the most disabling symptoms of Parkinson's disease. While various theories have been proposed to explain the underlying mechanisms of freezing of gait, there is no widely accepted theory. However, recent research suggests that deficits in perceptual-motor processing may play a key role. For example, perceptual processing capability seems to be impaired in freezers, suggesting a potential association with freezing of gait. Also, freezing episodes are often provoked by 'threatening' visual stimuli such as narrow passages, cluttered spaces and doorways. The question remains, however, as to the specific perceptual-motor mechanism underpinning freezing. Therefore, the overall aim of the present study is to explore visual search patterns in a group of Parkinson patients who regularly experience freezing during a complex walking task. We speculate that, given the relationship between heightened anxiety and freezing, freezers may display a 'gaze bias' for threatening, freeze-provoking stimuli (e.g., narrow doorways) which may serve to trigger a freeze. **METHODS**: Fifteen Parkinson's patients participate in this experiment. All patients complete ten trials on a 8meter walkway (see Figure 1). The task requires patients to deal with everyday environmental constraints that often provoke freezing. Patients wear a mobile eye-tracker to measure visual search behaviour. In addition, kinematic variables related to freezing of gait (e.g. walking speed, step time variability, base of support) are collected using a GAITRite system. Demographic information, motor (TUG, grip strength) and cognitive functioning (MOCA, working memory and attention), and state anxiety is also recorded. Using a within-group analysis, we will compare gaze behaviour during freezing and non-freezing trails to determine whether patients' gaze is more (and more early) fixated on threatening stimuli before freezing occurs. Gaze data will be analysed in



relation to the number and duration of fixations towards: the immediate walkway area, the obstacle, the doorway and the cluttered surrounding. Such analysis will allow us to assess the degree to which participants visually prioritise the immediate stimuli (i.e. the doorway) and vice versa. This analysis will also allow us to assess the degree to which participants visually disengage from the walking path and fixate on task-irrelevant areas. All analyses will be conducted by a blinded researcher. **RESULTS:** Whilst data collection is ongoing, preliminary findings indicate that freezers would direct preferential attention towards threatening stimuli during 'freezing' trials. **CONCLUSION:** We suggest that the preferential attention towards threatening stimuli may serve to increase anxiety, thereby increasing the likelihood that a freezing episode will occur. Awaiting verification in the larger sample, these results suggest that suboptimal visual search may be one mechanism contributing to freezing of gait.

P1-Y-191 Examining the relationship between visual acuity, executive function and postural control in cognitively healthy adults and adults with Alzheimer's dementia

Susan Hunter¹, Alison Divine², Humberto Omana¹, Andrew Johnson¹, Jeff Holmes¹, Keith Hill³, Walter Wittich⁴

¹University of Western Ontario, ²University of Leeds, ³Curtin University, ⁴University of Montreal

BACKGROUND AND AIMS: Visual impairment is a common consequence of Alzheimer's dementia (AD) and loss of visual acuity increases falls risk in older adults. As postural stability requires higher-level cognitive processes to integrate sensory information, diminished executive function may exacerbate the effects of visual impairment on the balance of people with AD. Study objectives were: 1) to compare balance performance as measured by postural sway among people with AD, cognitively-healthy adults (OA), and healthy young adults (YA), and 2) to quantify the role of executive function on the relationship between visual acuity and postural stability in adults with AD. METHODS: Ninety-six participants were recruited: 41 with AD, (age=82.1±8.1 years), 27 OA (age=68.5±12.7 years), and 28 YA (age=25.0±2.9 years). Executive function was assessed with the Trail Making Test (TMTA, TMTB). High and low contrast visual acuity were assessed using the mixed contrast card. Postural sway area (cm2) was measured using accelerometers during the Modified Clinical Test of Sensory Interaction in Balance (mCTSIB) test. The mCTSIB assesses balance across four sensory conditions (i.e., rigid surface eyes open (RSEO), rigid surface eyes closed (RSEC), compliant surface eyes open (CSEO), and compliant surface eyes closed (CSEC)). Repeated measures analysis of variance (RM-ANOVA) assessed differences in postural sway across groups. Mediation analysis was performed to examine the indirect effects of executive function on the relationship between vision and postural sway. **RESULTS:** Mean acuity in the AD group was 20/39 for high contrast and 20/74 for low contrast. Adults with AD had greater total postural sway area (cm2) than young adults on all conditions (RSEO=1.29±3.04 cm2, p=.036; RSEC=1.37±2.28 cm2, p=.004; CSEO=2.44±2.54 cm2, p=.016; CSEC=3.95±3.34 cm2, p=.005) and OA in the RSEC (p=.009) and CSEO (p=.016) conditions. The

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average times in the AD group on the TMTA was 143.43±90.79 seconds and TMTB was 256.25±62.34 seconds. Mediation analysis indicated that low and high contrast visual acuity was related to balance performance through executive function. Specifically, TMTB accounted for the relationships between visual acuity and balance performance in all four test conditions of the mCTSIB. **CONCLUSIONS:** People with AD had larger postural sway in all test conditions compared to the control groups and greater sway was demonstrated with greater attenuation of sensory information. The association between impaired visual acuity and balance deficits was mediated through impaired EF in people with AD. Specifically, participants with poorer vision had poorer EF and participants with impaired EF have greater postural instability. In addition, the influence of EF on the relationship between visual acuity and postural instability was progressively larger as the challenge to the sensory systems increased. **FUNDING:** Alzheimer's Association Grant (AARG-16-440671)

Poster Session 2: Tuesday July 2, 2019

A - Activity monitoring

P2-A-1 The effect of sensor location on the assessment of sit-to-stand transitions

Arash Atrsaei¹, Benoît Mariani², Kamiar Aminian¹

¹Ecole Polytechnique Fédérale de Lausanne (EPFL), ²Gait Up S.A.

BACKGROUND AND AIM: There are a plethora of studies on detecting and characterizing the sit-to-stand transitions (STS) with inertial sensors (IMUs). However, most of these studies require the attachment of the sensor on a specific location of trunk, reducing the comfort for the user. The aim of this study is to design an algorithm based on a single motion sensor on the lower trunk which is robust to different sensor locations in detecting and analyzing STS. The effect of the sensor location on the accuracy and precision of the kinematic parameters are estimated using reference systems. METHODS: 15 young healthy subjects were recruited for the study. Three IMUs (Physiolg, Gait Up, CH) were attached around the waist at L5, right anterior superior iliac spine (ASIS), and an arbitrary position on the waist belt (RH). Markers were installed on the sensors for validation against optical motion capture (Vicon, USA). The participants were asked to perform a 5-time STS test as well as several daily tasks (sitting on different chairs, walking, bending to pick objects, lying, tying shoe laces, and using stairs and lift) during 10 min, simulating the home environment. For each IMU location, template matching of the vertical acceleration signal and the elevation change calculated by a Kalman filter fusion method were used to detect each STS; during the 5xSTS test, kinematics parameters such as elevation, trunk tilt, and power were estimated for each STS. The results were validated against video recording during the daily task simulation and Vicon during the 5xSTS test using paired t-test. **RESULTS:** The results show





that during the daily task simulation, the algorithm was robust to the sensor location in detecting the STSs with a positive predictive value of 90% and sensitivity of 95% which is comparable or higher to those reported in the literature by trunk IMU. The errors of the kinematic parameters during the 5xSTS test against the reference systems are reported in Table 1 for different sensor locations. L5 sensor had the highest accuracy and precision compared to the other locations in tilt angle and transition duration. **CONCLUSIONS:** The proposed algorithm was able to robustly detect the STSs in home-like activities regardless of the position of the sensor on the lower-back . However, for the kinematic parameters, the L5 location had the highest accuracy and precision compared to the ASIS and RH locations. As a result we suggest the L5 location if the goal is to have accurate kinematic parameters. **FUNDING:** This project has received funding from EU's Horizon 2020 research & innovation program, Marie SkłodowskaCurie grant agreement No 721577.

B - Adaptation, learning, plasticity and compensation

P2-B-3 Adaptation induced change in overground slip recovery outcomes: Distinct strategies or continuum of an emerging single strategy control?

Tanvi Bhatt¹, Shuaijie Wang¹, Yi-Chung Pai², Yiru Wang¹

¹University of Illinois at Chicago, ²Retired from University of Illinois at Chicago

BACKGROUND: Inter-individual differences exist to slip adaptation, resulting in different recovery outcomes. It is uncertain if the repeated-perturbation induced change in slip-outcomes represent distinct strategies or a continuum (change in same direction with only difference in magnitude) of an emerging single strategy control and at what instances do their control start differing. The study aim was to investigate joint kinematic and kinetics between four slip outcomes in early proactive (EP), late proactive (LP), and early reactive (ER) phases to determine similarities or differences in motor strategies across them. Method: 67 older adults (>65 yrs) experienced over-ground slip training during gait with a full-body safety harness. Data from the 1st and last slip trial (24) were analyzed. Slip outcomes were defined as backward loss of balance (BLOB) or no loss of balance (NLOB). BLOB includes falls (BLOB_F) and non-falls (BLOB_NF), while NLOB includes skateovers (NLOB_SK) and walk-overs (NLOB_WK)1. Segment (thigh, shank and foot) angles and velocity, and joint (hip, knee and ankle) moments in the sagittal plane of the slipping limb were calculated and compared for different slip outcomes in proactive and reactive phases. Proactive phase was defined as the duration before slip-onset which was further divided into EP (mid-swing phase) and LP (terminal-phase), and reactive phase was defined as the duration after slip-onset and only the ER (from slip-onset to recovery foot lift-off) was studied. Logistic regressions were performed respectively for outcome measures in proactive and reactive phases to exam which variables could predict BLOB.RESULTS: Results showed knee flexor, hip extensor, and plantar flexor moments of the slipping limb were significantly larger for NLOB than for BLOB in EP, leading



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to smaller shank-ground and foot-ground angles at slip onset. In ER, the hip extensor and plantar flexor moments were larger for NLOB than for BLOB, and thigh, shank, and foot angles were smaller for NLOB. Further dissecting into the BLOB and NLOB outcomes, the knee flexor moment in EP and the plantar flexor moment in LP were significantly larger for NLOB_WK than for NLOB SK, but there was no variable difference between BLOB F and BLOB NF. A model including shank angle, shank angular velocity, and foot angle at slip-onset in the proactive phase could provide a 79.8% accurate prediction of BLOB, while shank angle, shank angular velocity, thigh angle, and thigh angular velocity at liftoff in the ER could predict BLOB with 96.3% accuracy. According to logistic regression, the initial shank angle (at slip-onset) and the following joint moment in ER could predict BLOB (accuracy = 84.3%). Thus > the shank angle at slip-onset, > the knee flexor, plantar flexor, and hip extensor moments required for BLOB prevention would be in the following reactive phase. CONCLUSION: Outcomes to slip-perturbations represent continuum of motor strategies with a shared pattern of slipping limb knee flexor, hip extensor and plantar flexor moments, whose magnitude can be modulated sufficiently in the proactive phase to result in an optimal recovery outcomes (walk-overs) to minimize the reliance on reactive responses and prevent the consequences of backward balance losses.

P2-B-4 Investigating proactive balance control in individuals with incomplete spinal cord injury.

Mackenzie Bone¹, Kristin Musselman², Joel Lanovaz¹, Tarun Arora³, Gary Linassi⁴, Alison Oates¹

¹University of Saskatchewan, ²University of Toronto, ³Cleveland Clinic Foundation, ⁴Saskatchewan Health Authority

BACKGROUND AND AIM: Approximately 80% of individuals with incomplete spinal cord injury (iSCI) experience at least one fall per year. Most falls occur while walking on uneven or slippery surfaces and lead to a fear of falling. This study aimed to compare the proactive balance control of individuals with chronic iSCI to age- and gender-matched able-bodied (AB) individuals when approaching a known slippery surface. We hypothesized that individuals with iSCI would use proactive balance strategies to a greater degree than AB individuals. **METHODS:** Participants completed at least 3 non-slippery (NS) walking trials and one unexpected slip (US) trial followed by 4 expected slip (ES) trials. The slip perturbation device (steel rollers) was embedded in the middle of a 10 m walkway and provided a low-friction slip in the anterior-posterior (AP) direction. Kinematic data were collected using a motion capture system and muscle activity was measured bilaterally for tibialis anterior, soleus, and gluteus medius using surface electromyography (EMG). Main outcome variables included mean stride velocity, step width, step length, AP and mediallateral (ML) margin of stability (MOS), and integrated EMG to evaluate magnitude of muscle activity. Variables were calculated for the stride before contact with the slip device. Data were averaged over the NS trials and ES trials separately. Mixed ANOVAs compared between (iSCI vs AB) by within (NS vs ES) group results with Bonferroni corrections and post-hoc testing for





significant results (α =.01). **RESULTS:** Fifteen individuals with iSCI (64.2 ± 16.8 years, 10 males, all AIS D) and 14 AB individuals (61.4 ± 18.7 years, 10 males) completed the protocol. Preliminary results show a main effect (p < .009) for stride velocity (decreased), step width (increased), step length (decreased), and the AP MOS (shifted anteriorly) in the ES trials compared to the NS trials with no difference for ML MOS. There were no significant interaction or main effects for any of the muscles examined (AB n = 12 due to EMG data errors in 2 AB participants). **CONCLUSIONS:** Preliminary data shows that, when approaching the known slippery surface, both AB individuals and those with iSCI changed their behaviour without changing muscle activation to enhance proactive balance control. Results may have implications for the use of proactive balance strategies when approaching a destabilizing surface to reduce the risk of falling. Future analysis will compare individual ES trials to both the US and NS trials to determine if individuals with iSCI are able to use feedforward adaptations and if so, how many trials it takes for adaptation compared to AB matches. Future analysis will also explore any changes in behaviour and muscle activity after contact with the known slippery surface and will determine whether correlations exist between functional mobility and the ability to effectively use proactive balance strategies.

P2-B-5 Locomotor savings of split-belt gait adaptation indicate long-term adaptation processes

Tom Buurke¹, Claudine Lamoth¹, Lucas van der Woude¹, Rob den Otter¹

¹University Medical Center Groningen

BACKGROUND AND AIM: Motor adaptation is suggested to underlie motor learning, in which motor savings [1] are aspects of motor control that are saved for later re-use. Understanding which aspects of gait are saved in locomotor learning has strong implications for gait (re-)training. However, this knowledge is still scarce. An effective paradigm to study locomotor learning is splitbelt treadmill adaptation. In split-belt adaptation people walk faster with one leg, on the one belt, than the other leg, on the other belt. Healthy humans adapt their spatiotemporal stepping pattern and dynamic balance control to these asymmetric belt-speeds in a matter of ten minutes [2]. In the current study, we use this paradigm to study locomotor savings. The aim of this study is to reveal locomotor savings of split-belt walking. To this end, we use a repeated measures design with a second exposure after three weeks. **METHODS:** 14 healthy young adults participated in a single session of split-belt walking, and were re-exposed to the protocol three weeks later. Participants walked 5 min fast tied-belt (warm-up; 1.5 ms-1), 5 min slow tied-belt (warmup/baseline; 0.5 ms⁻¹), 10 min split-belt (adaptation; 1.5:0.5 ms⁻¹), and 5 min slow tied-belt (washout; 0.5 ms-1). An instrumented split-belt treadmill was used to measured 3D ground reaction forces (N), 3D moments of force (Nm), 2D center of pressure positions (m) and 2D (extrapolated) center of mass positions. Double support symmetry was calculated as a measure of temporal gait symmetry, and step length symmetry as a measure of spatial gait symmetry. Mediolateral margins of stability (m) were calculated as a measure of dynamic balance control.





Singular Spectrum Analysis (SSA) [3] was used to identify adaptation curves for all parameters. The resulting first and second exposure adaptation curves were compared using a Statistical Parametric Mapping (SPM) paired t-test [4]. **RESULTS:** Significant clusters were found for step length symmetry (p<.05; cluster size: 0-55.5 s), left (fast) leg margin of stability (p<.001; cluster size: 0-71.7 s) and right (slow) leg margin of stability (p<.05; cluster size: 0-11.6 s). These clusters indicate a significant difference between first and second exposure. No significant results were found for double support symmetry. Preliminary analysis of the retained adaptation curves indicated an asymptotic trend at the end of the adaptation phase for step length symmetry. **CONCLUSIONS:** Adaptive change in step length symmetry and bilateral margins of stability is retained on second exposure to split-belt walking. Furthermore, adaptation curves indicate that adaptation is not finished at the end of 10 minutes split-belt adaptation, as step length symmetry does not reach a plateau phase. Further research into this slow adaptation component is needed to better understand human locomotor adaptation and learning. **REFERENCES:**[1] Smith et al. (2006) [2] Reisman et al. (2005) [3] Hassani (2007) [4] Pataky (2010)

P2-B-7 Implicit and explicit motor learning in gait rehabilitation of people after stroke: A randomized controlled single blind trial

Li-Juan Jie¹, Melanie Kleynen², Kenneth Meijer¹, Anne Beurskens², Susy Braun²

¹Maastricht University, ²Zuyd University of Applied Sciences

BACKGROUND: Therapists may use (more) implicit or (more) explicit motor learning approaches to facilitate motor skill learning of stroke patients. The use of implicit motor learning approaches has shown promising results in healthy populations. Objective: To determine whether an implicit motor learning walking intervention (analogies) is more effective compared to a 3-week explicit motor learning walking intervention (verbal detailed instructions) delivered at home with regard to walking speed in people after stroke. METHODS: 79 people in the chronic phase after stroke (66.4 ± 11.0 years; 70.1 ± 64.3 months after stroke; walking speed 0.7 ± 0.3 m/s; Berg Balance Scale score 44.5 ± 9.5) were randomized to an implicit (n=39) or an explicit (n=41) motor learning walking intervention provided in the home environment of the participants. Both groups received 9 training sessions, 30 minutes each, for a period of 3 weeks. The primary outcome is walking speed measured by the 10-Meter Walk Test and was examined at baseline, immediately post intervention and after 1-month. Both an intention-to-treat and a per-protocol analysis were conducted. **RESULTS:** No statistically or clinically relevant differences between groups were obtained post intervention (between group difference estimated 0.02 m/s [95% CI -0.04 to 0.08] and at the 1-month follow-up (between group difference estimated -0.02 m/s [95% CI -0.09 to 0.05], p=0,563). The per-protocol analysis led to slightly larger differences between groups (difference observed Δ 0.06 m/s) but did not lead to statistically or clinically relevant changes. CONCLUSIONS: Implicit motor learning was not superior to the explicit motor learning to improve walking speed in people after stroke in the chronic phase of recovery. For tailored motor learning




approaches more insight is needed on the patient characteristics and preferences that influence the process of motor learning. While awaiting further results, therapists may consider both motor learning approaches to facilitate walking speed within the stroke population.

P2-B-8 Hands up in the air and wave them like you care: Effect of exposure on upper limb kinematics during continuous, multi-directional perturbations

Carolyn Duncan¹, Alison Schinkel-Ivy², Andrew Laing³, Vicki Komisar⁴

¹Michigan Technological Institute, ²Nipissing University, ³University of Waterloo, ⁴Simon Fraser University

BACKGROUND AND AIM: The ability to maintain balance during complex perturbations is crucial to avoid falls. Balance recovery in this context often involves rapid movements in the lower (i.e., reactive stepping) and upper limbs, which provide counter-balancing reactions that help to stabilize the center of mass (COM)1,2. With exposure to perturbations, individuals improve COM stability and take fewer reactive steps 3. However, the effects of habituation on upper limb behaviour have not been explored. This study characterized the influence of exposure to continuous, multi-directional perturbations on upper limb reaction kinematics, and concomitant COM stability. METHODS: Ten adults (7 men; 26+3 years) with no prior exposure to continuous platform perturbations underwent two 5-minute trials of continuous, multi-directional, supportsurface perturbations before and after a training session. We quantified 3D, full-body motion with motion capture. We quantified upper limb kinematics using the midpoint of distal radius and ulna markers, and estimated COM kinematics using a 13-segment, link-segment model. To control for whole-body movement (i.e., participants stepping on the platform), upper-limb position was calculated relative to COM position, and differenced to estimate velocity. For each 1-min interval, we extracted upper limb velocity amplitude range; velocity standard deviation; and wrist path length. We quantified whole-body stability by COM path length and time spent stepping. Upper limb metrics, COM metrics, and time spent stepping were compared between sessions and across the 5 1-min intervals of each session. **RESULTS:** From pre- to post-training, wrist path lengths decreased by 30%, while velocity standard deviations decreased by 27-31% (in each axis) (p's≤0.015; Figure a/b). Concomitantly, COM path length decreased by 50% and time spent stepping decreased (p≤0.001). When differences in velocity amplitude range were present (all directions for left wrist; antero-posterior direction for right wrist; significant p's≤0.02), ranges decreased by 23-26% from pre-training to post-training. CONCLUSIONS: Upper limb movement decreased after exposure to perturbations, while balance control improved, as demonstrated by reduced whole-body stability metrics. This suggests that participants relied less on their upper limbs for balance recovery with increased exposure to perturbations. Results provide insight into balance recovery strategies in moving environments, which involve upper limb movement. As such, balance control may be compromised in scenarios involving a secondary task that requires the upper limbs (leaving the upper limbs unavailable to contribute to balance control), especially

during initial exposure scenarios before improved balance control strategies (with reduced upper limb contributions) are adopted. ACKNOWLEDGEMENTS: The authors would like to acknowledge the financial contributions of MITACS, NSERC, and AGE-WELL funding agencies. **REFERENCES:**1 Cheng et al. J Biomech 2015;48:3155-62. 2 Maki et al. J Biomech 1996;29(3):343-53. 3 Duncan et al. Int J Ind Ergon 2014;44(6):876-81.

P2-B-9 Neuromuscular adaptations in balance control following a lower-limb transfemoral amputation

Cristian Pasluosta¹, Claudia Ramos Claret¹, Georg Herget¹, Lukas Kouba¹, Daniel Wiest², Jochen Adler², Vinzenz von Tscharner³, Thomas Stieglitz¹

¹University of Freiburg, ²Sanitätshaus Pfänder, ³University of Calgary

BACKGROUND AND AIM: The loss of a limb permanently disrupt activities of daily living. In the lower limb, proprioceptive and cutaneous sensations are required to maintain balance. While prosthetic devices are an alternative to partially circumvent this disability, commercially available technologies do not provide sensory feedback. Thus, amputees develop compensatory mechanisms to regain an effective postural control. In this work, we sought to investigate the neuromuscular adaptations occurring after a lower-limb amputation. METHODS: The dynamics of the center of pressure (CoP) adjustments of 12 unilateral lower-limb transfemoral amputees and 12 age-matched able-bodied subjects were evaluated. Measures of CoP data from each foot were performed during quiet stance using a force platform (zebris Medical GmbH) in the mediolateral (ML) and anterior-posterior (AP) directions. Three 30-seconds trials were performed with eyes open and closed. Postural control was characterized using the weight-bearing imbalance factor, the CoP mean distance, velocity and area, the sway activity and asymmetry, and the Entropic Half-Life (EnHL). The EnHL quantifies the complexity of time series, providing information about its temporal structure. Changes in the EnHL of CoP data suggest neuromuscular adaptations in postural control. The Berg Balance Scale (BBS) and the Timed Up-and-Go (TUG) tests were also performed. A four-way mixed ANOVA was implemented for statistical analysis. **RESULTS:** There were no differences in the EnHL between amputees and controls when combining the contributions of both feet (p=0.754). However, there was a significant difference in amputees between the EnHL values of the intact and prosthetic limb (p<0.001), with more complex CoP adjustments (lower EnHL) observed in the intact limb. Amputees had an asymmetrical stance in the AP and ML directions. Removing vision reduced the EnHL in amputees (p=0.003), but not in controls. A higher mean CoP distance (p<0.001), velocity (p<0.001) and area (p=0.007) was also observed in the amputee group. The mean distance and velocity was reduced in the prosthetic limb compared to the intact limb (p<0.001). The EnHL was positively correlated to the BBS scores and negatively correlated to the TUG times. CONCLUSIONS: The results suggest that the complexity of the CoP adjustments in lower-limb amputees wearing a prosthesis does not differ from the one in healthy subjects. However, the intact leg of amputees seems to

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compensate for the impaired control of the prosthesis. When removing vision, the CoP adjustments of amputees became faster but less precise, increasing the sway area and requiring more adjustments to maintain balance. Altogether, these findings suggest that besides the asymmetry in load distribution observed in amputees, there exist neuromuscular adaptations after an amputation, possibly related to the loss of sensory feedback and which are not entirely circumvented by current prosthetic technologies. Acknowledgment and **FUNDING:** This work was supported by the German Federal Ministry of Education and Research (INOPRO project, 16SV7656), BrainLinks-BrainTools and the Wissenschaftliche Gesellschaft Freiburg.

P2-B-10 Developing resilience to unpredictable body balance perturbations: contextual interference effect in the training of compensatory arm and leg movements

Luis Teixeira¹, Patricia Takazono¹, Marina Betelli¹, Caroline Souza¹, Julia Oliveira¹, Daniel Coelho¹, Jacques Duysens²

¹University of São Paulo, ²Catholic University of Leuven

BACKGROUND AND AIM: Unpredictable large-magnitude stance perturbations are highly challenging to maintenance of upright posture. An issue open to investigation is the extent to which training of reactive responses could favor balance recovery following challenging perturbations. In the current investigation we aimed to evaluate the effect of contextual interference in the training of compensatory movements in response to unpredictable largemagnitude stance perturbations. **METHODS:** University students (n = 38; mean age = 22 years) were evaluated in postural responses to different modes of support base displacement in the mediolateral direction: rotation, translation, rotation-translation combination. The perturbations were applied to both sides, at different speeds (20, 30 and 40 cm/s [o/s]). Participants were assigned to 3 groups: low contextual interference (LOW), with blocked perturbation sequence; high contextual interference (HIGH), with random perturbation sequence; and control (CON), not practicing. The experimental groups experienced 72 perturbation trials, in a single training session. Evaluations were performed immediately before and after practice, and 7 days afterwards (retention). The test consisted of 18 unique perturbations, applied in pseudorandom sequence, in a context of temporal uncertainty. Transfer to a dual task (n-back counting) and to a more challenging increased speed task (50 cm/s [°/s]) was also evaluated. Stability of compensatory arm and leg movements to the perturbations was evaluated by means of scale rating response stability (inter-rater reliability = .96). **RESULTS:** Analysis of the global score (arm and leg movements) indicated that in the post-test both experimental groups achieved higher scores than the control group in the more challenging combined perturbations, without significant differences between the experimental groups. In retention and in both transfer tests the HIGH group achieved more stable postural responses than the LOW and CON groups in the more challenging combined perturbations, with no significant differences between the latter. CONCLUSIONS: These results revealed that (a) reactive postural responses can be improved by training through unpredictable



large-magnitude body balance perturbations, (b) high contextual interference induces more persistent and generalizable gains than low contextual interference in postural response stability, and (c) gains from perturbation training are evident in more challenging stance perturbations.

P2-B-11 How does balance affect gait in stroke survivors?

Susanne van der Veen¹, Ulrike Hammerbeck², Kristen Hollands³

¹Virginia Commonwealth University, ²Manchester University, ³University of Salford

BACKGROUND AND AIM:Stroke survivors (SS) are known to fall more often than healthy counterparts, mostly due to trips and slips. These trips and slips may be caused by difficulty in controlling and adjusting foot placement in response to the environment. Being able to adapt walking in order to avoid obstacles and target safe foot fall locations in cluttered community environments is essential for independent mobility. In healthy adults shortening a step has been seen to be more difficult than lengthening [1]; possibly because shortening the step involves reducing the base of support and thereby challenging balance. How the direction of required foot placement adjustments, and therefore base of support, and balance, affects foot placement control for stroke survivors is not known. This is important to know in order to determine interventions which are most likely to improve independent community mobility and balance. METHODS: Young healthy (YH) adults [N 16, 30±6y age, 5 male, 1.09±0.17m/s self-selected walking speed (SSWS)] and Older healthy (OH) [N 10, 64±8y, 6 male, 0.91±0.21m/s SSWS] and SS [N 11, 67±9y, 9 male, 0.54±0.21 SSWS, 50±5 BBS] walked to 100 targets of which 24 elicited shortening and lengthening by ±25% of preferred step length and narrowing and widening by ±50% of preferred step width. Participants walked with and without balance support of arm rest crutches installed on the treadmill. Foot placement error measures were taken by subtracting the center of foot from the center of the target, when this error was larger than one foot length or width it was classified as a missed target. A repeated measures ANCOVA (covariation of SSWS) on the absolute foot placement error, with group as between factor and within factors step direction (preferred, lengthening and shortening steps) and condition (supported and unsupported). Post hoc comparisons were assessed using Bonferroni test with adjustment for multiple comparisons and a p< 0.05 was used for statistical significance. **RESULTS:**The percentage of missed targets was higher for SS than YH and OH (F (2, 31) =11.091 p=0.001), however did not decline when balance support was offered (F(4, 62) = 3.756). Foot placement error reduced with support for balance (AP F (1, 30) =13.518, p=0.001, ML F(1, 30) =18.141 p<0.001), with the biggest reduction in error for SS (fig 1). Error was larger for all groups in shortening steps compared to lengthening steps (F(2,30) = 15.025, p<0.001); possibly due to SS undershooting both lengthening -6.6 ±1.2cm and shortening -1.2 ±1.1cm steps. **CONCLUSIONS:**Results of the studies showed that success and accuracy of foot placement of SS is improved with crutches for balance support; indicating impaired balance control does indeed affect foot placement control and that walking aides may be of help. Further, SS

undershoot both lengthening and shortening step adjustments, indicating foot placement are not anticipated but follow the targets/cues as is found previously in audio cueing[2]. 1. Hoogkamer et al., Quick foot placement adjustments during gait: direction matters . Exp Brain Res . 2015. 2. Roerdink et al., Walking to the beat of different drums: practical implications for the use of acoustic rhythms in gait rehabilitation . Gait Posture . 2011.

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P2-C-12 Cognitive-motor interference in older adults while navigating in an ecological environment

Catherine Agathos¹, Marcia Bécu¹, Konogan Baranton², Delphine Bernardin³, Angelo Arleo¹

¹Sorbonne Université, INSERM, CNRS, Institut de la Vision, ²Essilor International, ³Essilor Canada

BACKGROUND AND AIM: Cognitive demands for gait control increase with old age and falls occur commonly while walking. Cognitive-motor interference exists for a number of dual walking tasks, leading to the prioritization of the motor or the concurrent cognitive task. Such interference also influences spatial navigation performance among older adults. We investigated cognitive and postural factors that may affect young and older adults' ability to learn and orient in a novel environment. We posited that upon first exposure, the act of visually and physically sampling the space may constitute a dual task for older adults. We also examined whether visual sampling and cognitive functions may be associated with navigation performance. METHODS:14 young (27.3 ± 5.4 y/o) and 14 older adults (71.4 ± 2.8 y/o) were instructed to find an invisible goal in an openfield and obstacle-free, real, ecological environment while their body and eye movements were recorded. Participants were disoriented at the beginning of each trial, performing 8 trials in total. Postural control variables were gait speed, step variability and head oscillations. Navigation performance was examined via participants' navigation efficiency (direct route toward the goal over the route taken) and visual sampling (run count ratio: number of fixations directed toward the goal area over the number of fixations directed elsewhere). We calculated dual task costs for the postural control variables and learning indices for the performance measures. Participants were also screened with a battery of visual function and neuropsychological tests. RESULTS: Older adults showed increased dual task costs for walking speed (p<.05), but not for other measures of postural control, likely indicating a posture-first strategy. Their navigation efficiency and run count ratio were lower than those of young adults (p<.05). Significant age group differences on the learning indices for the performance variables revealed a slower learning rate in older adults (p<.05). Interestingly, navigation efficiency and run count ratio were positively correlated for older but not young adults (p<.05, r²=.63). Finally, both navigation efficiency and run count ratio correlated with figural learning, working memory span and selective visual attention in older adults only (p<.05, .32≤r²≤.52). CONCLUSIONS: Cognitive-motor interference was observed in older adults while exploring a new ecological environment. Importantly, older adults' efficiency



depended on overtly attending to the goal area to orient and navigate. This did not hold for young adults, implying that they can orient based on learned relationships between environmental features or by perceiving goal-related features without explicitly fixating the goal area. Finally, age-related differences in visual sampling and subsequent learning seem related to certain cognitive deficits rather than potential sensorimotor constraints in older adults. **ACKNOWLEDGEMENTS AND FUNDING:** This research was supported by the ANR - Essilor SilverSight Chair, ANR-14-CHIN-0001.

P2-C-13 Parkinsonian gait in aging: a signature of Alzheimer's pathology

Gilles Allali¹, Eric Morel², Stephane Armand¹, Frederic Assal¹

¹Geneva University Hospitals, ²University of Geneva

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BACKGROUND AND AIM: Neurological gait disorders from central origins are frequent in aging, especially in patients with dementia. The phenotypes of the neurological gait disorders from central origins include frontal, parkinsonian and other abnormal gait patterns that are found in various neurological conditions, such as Parkinson's disease, vascular dementia or normal pressure hydrocephalus. However, the pathophysiological substrates of these gait abnormalities remain poorly studied. This cross-sectional study aims to assess the association between cerebrospinal fluid (CSF) biomarkers for Alzheimer's disease and these various phenotypes of neurological gait disorders from central origins. METHODS: A total of 52 consecutive patients (77.33 ± 6.09 years; 28.8% female) with neurological gait disorders from central origins evaluated at the Geneva University Hospitals for gait disorders were included in this retrospective study. Gait phenotypes were evaluated by two diagnosis-blinded clinicians and classified as frontal gait, parkinsonian gait or other gait abnormalities. CSF total tau (t-tau), phosphorylated tau (p-tau) and AB-42 proteins were measured in every patient. **RESULTS:** Eighteen patients presented with frontal gait, 20 with parkinsonian gait and 14 with other gait abnormalities. Parkinsonian gait was associated with decreased CSF Aβ-42 even after adjusting on age, gender, comorbidities and white matter changes (β : -0.32; [-340.6; -22.9]; p-value: 0.026). T-tau and p-tau were not associated with any gait phenotypes. CONCLUSION: Parkinsonian gait is a gait phenotype pointing to a neurodegenerative process associated with Alzheimer's pathology. This phenotypical-based approach offers new insight into the pathophysiological mechanisms underlying central neurological gait disorders in older adults. ACKNOWLEDGEMENTS AND FUNDING: Gilles Allali is supported by a grant from Swiss National Science Foundation (320030_173153).

P2-C-14 Effect of High Intensity Interval Training combined with citrulline supplementation on gait parameters and its predictors in healthy older women: a pilot study



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Mylène Aubertin-Leheudre¹

¹Université du Québec à Montréal

BACKGROUND AND AIM: During aging, one of the main factors leading to loss of autonomy is the fall. Falls and its consequences are more important in older women than in older men. Knowing that 69% of falls occur during a walk, improving the spatio-temporal gait parameters and its predictors (fat mass, muscle strength, mass and power) seems to be an important strategy to preserve the quality of life of older women. High Intensity Interval Training (HIIT) is an interesting new interventional avenue since its intervention is effective and acceptable even if its duration is short. Citrulline supplementation (CIT) appears to be promising in view of its effects observed on muscle, aerobic and fatigue metabolism in animal or human performance studies. Nevertheless, its effects combined or not to exercise intervention is unknown in older women. To evaluate if HIIT combined to CIT supplementation induce a greater improvement on gait parameters and its predictors than HIIT alone in healthy older women. METHODS: Twenty-eight older (>60 yrs old) and inactive (<3h/week of structured Physical activity) women were randomly and double-blinded divided in 2 groups: CIT (n=13) vs placebo (PLA; n=15) to follow a 12-week intervention. The supplementations are iso-caloric and consist of a single powder dose of 10g/day. The HIIT is realized 3 times per week, 30min per session (high cycle: 30sec >85 % HR max or Borg scale >17 vs moderate cycle: 90sec ~65% HRmax or borg scale between 13-16). Spatio-temporal gait parameters (speed, step length, cycle length, step width, pace of step, step length, duration of support, GVI or coefficient of variation) were measured during a 6 minutes walking test using a Zeno[®]. Body composition (DXA), muscle function (muscle strengths (upper and lower body) & power (leg power rig®) and functional capacities were also evaluated. All measures were realized pre and post intervention. RESULTS: Before the intervention the both groups are identical for all parameters. Following the HIIT intervention, we observed that the completed distance (16.96±13.25%), step duration (-0.023±0.003sec), duration of support (-0.034±0.006sec), cadence (5.42±4.73%; +7.2step) and speed (7.24±6.11%; +0.11m/sec) improved significantly (p<0.05). However, only the CIT group showed a significant increase on the coefficient of variation of the step duration (0.93±0.42%, p=0.045) and tended to improve the step length (+2.31±1.12cm, p = 0.060), the cycle length (4.63±2.25cm, p=0.062) and the coefficient of variation of the support duration (+1.92±0.91%, p=0.057). Finally, the CIT group increase significantly more the normal walking speed (+9.69 vs. +5.13%; p=0.047) than the PLA group. CONCLUSION: We confirmed that HIIT is efficient to increase statistically and clinically the gait parameters. Adding a CIT supplementation to a HIIT seems to be able to improve more the variability of the step time as well as its speed in healthy older women. Thus, the combination of these 2 non-pharmacological intervention need to be further studies to examine its potential to prevent falls and its deleterious effects.

P2-C-15 Rate of muscle force development during fatigue: Impact of age



Marc Belanger¹, Charlotte Pion¹, Justine Lai¹, Said Mamouh¹, Mylène Aubertin-Leheudre¹

¹Université du Québec à Montréal

BACKGROUND: The loss of muscle strength and the decrease in the rate of force development (rFD - the increasing slope of the contraction force) related to aging are important factors leading to a decrease in functional capacities (FC) and more importantly, mobility. In addition, the rFD become even more problematic as fatigue develops. Thus, a better understanding of these parameters (i.e., strength and rFD) during sustained or repeated activities is important to counter the loss of autonomy with aging.
 Aim: To evaluate the evolution of rFD during a fatigue test (FT) as a function of age.
 METHODS: Six young (Y [18-25 years old], 22 ± 2 years old), 5 middle-aged (M [35- 45 years old], 36 ± 3 years old) and 31 elderly men were recruited. The elderly group was subdivided into 2 groups (A55+ [55-65years old] 61 ± 3 years, A70+ [> 70 years] 71 ± 1 years old). The FT consisted of series of 2s-maximal voluntary isometric contractions (MVC) of the right knee extensors interspersed with 1s rest until the maximum muscle force (Fmax) reached 50% of the initial Fmax. The FT duration as well as the Fmax and the rFD of each MVC were measured.
 RESULTS: FT duration was similar for the 4 groups (≈107s, p> 0.05). The initial Fmax (N) of the younger group (Y: 706 ± 206) was greater than that of the other 3 groups with the M (428 \pm 126), A55+ (415 \pm 168) and A70+ (37 \pm 86) not being significantly different. Initial rFD (normalized as %Fmax/s) was greater in young and middle-aged men compared with older men (Y: 725 \pm 30 = M: 683 \pm 32> A55+: 472 \pm 11 = A70+: 448 \pm 14, p <0.05). During the fatigue test, the rFD slowed more rapidly (p < 0.05) in young (Y: y = -4.1x + 725.2) and middleaged men (M: y = -4.5x + 683.3) compared to older men (A55+: y = - 3.0x + 472.5, A70+: y = -2.94x + 448.5). There was no difference between the groups Y and M nor between the aged groups A55+ and A70+.

conclusion: The rate of force development decreases with the advancement in age and it diminishes even further as fatigue begins to appear. The middle age group behaves like the younger participants, suggesting that changes in the rFD might only occur after the age of 45. A probable explanation for these observations may lie in the alteration of the innervation and / or phenotype of the muscles of the lower limb during aging. For example, the greater decrease in the rFD in the young and middle-aged men may be explained by the higher number of larger and faster motor units observed in these groups compared to older individuals.
 FUNDING: RQRV, FRQS (MAL), FCI (MAL), GRAPA.

P2-C-17 Is trunk strength associated with functional mobility in older women?

Emily Gregg¹, Gareth Nicholson¹, Clive Beggs¹, Athanassios Bissas¹

¹Leeds Beckett University

BACKGROUND AND AIM: Age-related declines in muscle strength have been associated with reduced functional capacity, postural instability and increased risk of falls in older adults. Studies have generally focussed on the significance of lower limb strength, however more recently the





importance of trunk muscle strength has been explored, which may have been previously overlooked (Granacher et al., 2013). A limited number of studies have investigated the relationship between trunk strength and function, but this was tested under isometric contractions. Therefore, the purpose of this study was to investigate the relationship between dynamic (concentric) trunk strength and functional mobility in older women. **METHODS:** A sample of 40 older women (age: 68.9±3.73 years) participated in this study. To assess functional mobility, participants completed the timed up and go (TUG), 30 second chair stand test (CST), and a timed stair climb task (ascent and descent). Both self-selected normal and fast gait speed (GS) were also recorded. Concentric trunk flexion and extension strength data were collected using an isokinetic dynamometer (Biodex, USA). Measurements were conducted in the seated-compressed position in line with the manufacturer's guidelines. Following five sub-maximal trials, peak torque was recorded during three maximal flexion and extension trials at two testing speeds (20°/s and 45°/s). Peak torque was then normalised to body mass. Pearson's correlations were performed to investigate relationships between trunk strength and functional mobility measures. The level of significance was set at p≤0.05. **RESULTS:** A number of associations between trunk strength and functional mobility measures were revealed. Greater trunk extension strength was correlated with superior performance in the CST (45°/s: r=0.33, p=0.037), stair ascent (20°/s: r=-0.32, p=0.043; 45°/s: r=-0.56, p=<.001) and stair descent tasks (45°/s: r=-0.47, p=0.002). Trunk extension strength was also associated with GS during normal (20°/s: r=0.37, p=0.019; 45°/s: r=0.48, p=0.004) and fast trials (45°/s: r=0.34, p=0.034). Trunk flexion strength was correlated with TUG (45°/s: r=-0.42, p=0.007), stair ascent (20°/s: r=-0.41, p=0.008; 45°/s: r=-0.47, p=0.002) and stair descent times (20°/s: r=-0.44, p=0.005; 45°/s: r=-0.42, p=0.007). Trunk flexion strength was also associated with normal (20°/s: r=0.55, p=<.001; 45°/s: r=0.56, p=<.001) and fast GS (20°/s: r=0.32, p=0.047; 45°/s: r=0.34, p=0.031). CONCLUSIONS: These findings suggest that there is a moderate-strong relationship between muscle strength in the trunk area and a range of functional mobility measures in older women. These results have important practical implications which could be used to inform the inclusion of trunk exercises in interventions targeting functional mobility for older adults. REFERENCES: Granacher et al. Sports Med (2013) 43:627-641.

P2-C-19 Spatiotemporal gait parameters for older adults - an interactive model adjusting reference data for gender, age, and body height

Rolf Moe-Nilssen¹, Jorunn Helbostad²

¹University of Bergen, ²The Norwegian University of Science and Technology (NTNU)

Introduction: Since it is well documented that spatiotemporal gait parameters are affected by body size, it is of limited clinical value to compare individual scores against reference values without taking body size into consideration. For older adults, reference values have been presented in recent reports, but unfortunately the effect of body size on gait characteristics was not taken into account and neither prediction intervals nor percentile ranks were included. It is the



aim of this study to present a model where individual spatiotemporal gait parameter values for older adults can be compared to reference values adjusted for gender, age, and body height. METHODS: Reference gait data were collected from I464 older adults aged 69-80 years with no impairments believed to affect gait, stratified by gender, adjusted to a standard body height using a pendulum model and entered into simple regression models with age as predictor. From the regression statistics predicted gait parameter values can be back transformed to individual body height to be compared to individual scores. Calculations were done using spreadsheet formulae and equations. A graphical user interface (GUI) has been developed in Microsoft Excel® where individual data can be compared to normative predicted point estimates with confidence intervals, prediction intervals, and percentile ranks taking gender, age, and body height into account. **RESULTS:** A spreadsheet based graphical user interface (GUI) has been developed where individual spatiotemporal gait data can be compared to population based reference data including predicted point estimates with confidence intervals, prediction intervals, and percentile ranks taking gender, age, and body height into account. Significance: A GUI solution based upon body size adjusted data and a simple regression model is feasible to researchers and clinical users who do not have ready access to a statistical program. To the best of our knowledge, this is the first model presented for comparison of basic spatiotemporal gait parameters between individuals and a reference population of older adults where gender, age, and body height are taken into account.

P2-C-20 The effects of fatigue and age on gait dynamics

Paulo Cezar Santos¹, Tibor Hortobágyi², Inge Zijdewind³, Lilian Gobbi¹, Fabio Barbieri¹, Claudine Lamoth²

¹São Paulo State University (UNESP), ²University Medical Center Groningen, ³University of Groningen, University Medical Center Groningen

BACKGROUND AND AIM: Declines in gait performance in older adults are related to the dynamics features of gait (time-dependent variations in gait), such as higher gait variability and lower local dynamic stability and smoothness of the temporal patterns of walking. Some conditions could limit the availability of internal resources and perturb gait, such as those induced by fatigue. Fatigue can be expressed in terms of performance fatigability (a transient decline in the capacity to perform motor actions) and perceived fatigability (psychobiological state to manifest a lack of motivation and decline in cognitive function as a result of a prolonged period of demanding mental task). An important issue is whether or not old adults could adapt their gait dynamics to fatigue-related perturbations. Therefore, the aim of this study was to determine the effects of age and performance and perceived fatigability on dynamic metrics of gait. **METHODS:** Twelve young and 12 older adults walked at 1.2 m/s on a treadmill before and after the two fatigue conditions on two different days. Performance fatigability was induced by repetitive sit-to-stand (STS) task until exhaustion. Perceived fatigability was induced by performing mentally demanding tasks on a computer for 30 min. Fatigue conditions were randomized between days, about a week apart. We





calculated: long-range correlation (r = 1.0 as long-term correlation) between stride time intervals using detrended fluctuations analysis (DFA); multi-scale sample entropy (MSE), in which 0 represents a complete predictability of patterns of fluctuation; the maximal Lyapunov exponent (λ max), in which larger λ max represented lower local dynamic stability. The MSE and λ max were calculated based on the Center of Pressure signals in the mediolateral (ML) and anteroposterior (AP) directions. ANOVA was used with between-factor to age and within-factors to time (pre vs. post) and fatigue conditions (STS vs. mental tasks). The effect size is reported as eta square (η^2) . **RESULTS:** The MSE of ML decreased by 5% after mental tasks but not after STS (Time vs. fatigue conditions interaction: p < .04; $n^2 \sim .02$). Time main effect indicated significative but small increase by ~11% in λ max in ML post fatigue (p < .02; η^2 ~ .02). Age main effect revealed that older adults presented larger λ max in AP (~48%; p < .01; η^2 ~ .20) and in ML (~44%; p <.01; η^2 ~ .20) than young adults (p < .01 for both). CONCLUSION: Despite the well-documented age-related decline in gait stability, we observed minimal effects of age and performance and perceived fatigability on gait dynamics. We suspect that the treadmill makes the steps uniform, minimizing any time-related variation in the gait cycle and adaptations induced by fatigue. However, we also hypothesize that age- and fatigue-related adaptations in muscle activation underlie the uniformity of gait dynamics. Acknowledgment: Graduate School of Medical Sciences, University of Groningen, and CAPES (Finance Code 001).

P2-C-21 Age-related differences in the energy cost of walking while thinking

Britney Williams¹, Taylor Woods¹, James Lang², Jessie Vanswearingen³, Kristin Lowry¹

¹Des Moines University, ²Iowa State University, ³University of Pittsburgh

BACKGROUND AND AIM: In clinical research, there has been interest in the 'work of walking', or the energy expended to walk. The energy cost of walking (EC), or the bodily energy consumed per unit distance walked, is influenced by biomechanical and neuromuscular factors, and possibly brain function. The purpose of this study was to determine if the energy cost of an added cognitive activity during walking differs for older compared to young adults. METHODS: Twelve young adults (25.8 ± 4.3 years, 3 men) and twelve older adults (72.2 ± 7.0 years, 6 men) participated. Participants walked for 4 minutes (walking alone, WA) followed by 2 minutes of walking while completing the following cognitive conditions (walking while thinking, WWT): math updating, word recall, and listening. Treadmill speed was held constant at each participant's preferred walking speed. Additionally, participants sat for 4 minutes (sitting alone, SA) then completed a recall task (sitting while thinking, SWT). Indirect calorimetry was used to derive the EC of walking mL/kg*m (mean oxygen consumption/ treadmill speed) and respiratory exchange ratio (RER) for the WA and each WWT conditions. During SA and SWT, mean rate of VO2 and RER were determined. Paired sample t-tests were used to compare EC and RER of WA vs. WWT within young and older adult groups. Independent t-tests were used to examine differences in EC and RER for WA and each WWT condition between young and older adult groups. RESULTS: For young adults, for all





WWT conditions compared to WA, there were no differences in EC (mean difference range -0.003) - 0.01 mL/kg m, p > 0.10), while there were increases in RER (mean difference range 0.04-0.07, p<.004). Among older adults, both mean EC and RER were greater for WWT compared to WA (EC mean difference 0.01 mL/kg·m, p< .047; RER mean difference range 0.04-0.06, p<.003). Across WA and all WWT conditions, older adults had higher mean EC values but lower RER (mean difference range EC 0.06-0.08 mL/kg·m, p< 0.001; mean difference range RER 0.08 - 0.04, p< 0.03). Energy demand did not change while RER increased for SWT compared to SA for young adults (VO2 mean difference 0.16 mL/kg·min, p> 0.130; RER mean difference 0.05, p< 0.008). In contrast, among older adults, for SWT compared to SA energy demand increased (VO2 mean difference 0.19 mL/kg·min, p> 0.034) while RER was unchanged (RER mean difference 0.003, p= 0.814). CONCLUSIONS: Compared to young adults, older adults increase the energy cost of walking with added cognitive activity. Increases in RER during WWT for both groups may indicate a shift toward an anaerobic metabolism (increase RER) with the added cognitive task. The mechanism of meeting the energy cost demands of the cognitive task while walking and sitting appears to be different for young compared to older adults. Older adults could benefit from exercise preparation to increase central blood supply prior to adding cognitive challenges during gait rehabilitation.

P2-C-22 Effects of age-related changes in step length and step width on the friction requirement at shoe-floor interface during straight level walking

Takeshi Yamaguchi¹, Kei Masani²

¹Tohoku University, ²University of Toronto

BACKGROUND AND AIM: Falls are becoming an increasingly critical issue in elderly individuals aged over 65 years. Slip is one of the leading causes of falls among older adults. Older adults are considered to walk with a small anteroposterior (AP) component and a large mediolateral (ML) component of the required coefficient of friction (RCOF) due to a short step length and a wide step width, respectively. However, limited information is available. The current study aimed to assess the effects of aging on the RCOF and its ML (RCOFML) and AP components (RCOFAP) during straight walking. The study tested the following three hypotheses: 1) older adults walk with a short step length, resulting in a small AP COM-COP angle and a small RCOFAP; 2) older adults walk with a wide step width, resulting in a large ML COM-COP angle and a large RCOFML; and 3) the small RCOFAP and large RCOFML increase the slip risk in the ML direction among older adults. METHODS: We used the kinetic and kinematic data of level straight gait for 188 participants aged 20-77 years from a publicly available database (National Institute of Advanced Industrial Science and Technology Gait Database 2015 [1]). The participants were divided into the following three groups: young group (n = 56; age range, 20-34 years), middle-aged group (n = 50; age range, 35-64 years), and old group (n = 82; age range, 65-77 years). Step length and step width was normalized by subject height. **RESULTS:** The normalized step length in the older group



tended to be shorter than that in the young group whereas the normalized step width in the older group was significantly longer than that in the young group. RCOF and RCOFAP were lower in the old group than in the other groups due to the shorter step length, indicating a lower slip risk in this group. However, the RCOFML was higher and the step width was greater in the old group than in the other groups. **CONCLUSIONS:** We demonstrated that RCOFML was higher and RCOFAP was lower in the older group, which can be associated with slips in the more lateral direction. Our results indicate the need for shoes with increased slip resistance in the ML direction in addition to the AP direction to prevent lateral slips among older adults. This will provide new guidelines of shoe sole pattern design for older adults. ACKNOWLEDGEMENT: This work was partially supported by JSPS KAKENHI Grant Number 16K06038. **REFERENCES:**[1] Yoshiyuki Kobayashi, Hiroaki Hobara, Masaaki Mochimaru, 2015: AIST Gait Database 2015. http://www.dh.aist.go.jp/database/gait2015/.

D - Biomechanics

P2-D-23 Neural mechanisms of balance and gait adaptations after downslope walking

Nikki Aitcheson-Huehn¹, Jayne Kalmar¹, Michael Cinelli¹

¹Wilfrid Laurier University

BACKGROUND AND AIM: Downslope walking (DSW) has been proposed as a therapeutic intervention for people with Multiple Sclerosis (PwMS) to improve clinical gait measures and induce neuro-plastic changes without invoking excessive fatigue. DSW alters kinetic and kinematic parameters of gait and EMG activation patterns: increased tibialis anterior (TA) activity and decreased soleus (SOL) activity, resulting in a decreased SOL H reflex. However, there are mixed findings when comparing studies of PwMS and neurotypical individuals, which may be due to inconsistencies in duration and degree of DSW as well as the indirect measures being used to assess balance and gait. Therefore, the study's aim was to determine the mechanistic effects of DSW on static and dynamic balance control, and relate the changes in balance to variations in H reflex. METHODS: The study randomly allocated 30 neurotypical young adults (23±1.4y, 6 males) to either the DSW (-10°) or level (0°) condition. Both groups performed a single treadmill walking session for 30-min at a comfortable pace and completed pre- and post-testing, which included: 1) SOL H reflex recruitment curves; and 2) 10 balance control trials consisting of 30-s quiet standing followed by gait initiation for 4 self-selected steps. Kinematic data was collected using an Optotrak collection system (NDI Inc., ON, Canada) at 100Hz to calculate participants' variability in Margin of Stability (MOS) during quiet standing. The H reflex recruitment curves were generated by stimulating the tibial nerve at increasing intensities until Mmax was reached (recruitment of entire SOL motor neuron pool). The slope of the H reflex was normalized to the slope of the M wave (Hslope/Mslope) to provide an estimate of spinal motor neural pool excitability. RESULTS: AP MOS (cm) during quiet standing was not significantly different for DSW (M= 6.60) in the post-test





compared to level walking (M= 7.31). Similarly, there was no group x time interaction for Hslope/Mslope, likely because both groups experienced some degree of H reflex depression. However, there was a larger percent change in H reflex depression in DSW (-46.9%) compared to level walking (-24.2%) (p= 0.06). **CONCLUSIONS:** A change in AP MOS following 30-min of DSW was expected because DSW influences EMG activation patterns of the plantar and dorsiflexors. The lack of MOS differences between the groups was not the result of either the duration or decline angle of the treadmill because both were sufficient to induce changes in EMG activity as observed in the SOL H reflex depression. It is possible that MOS is less sensitive to changes induced during a single DSW session and balance changes may be better observed during a gait transition or dynamic situation. Conversely, neurotypical young adults may not experience static balance improvements from a single DSW session, like PwMS, because their balance control may be functioning at an optimal level with no room for improvement.

P2-D-24 Elucidation of the trunk motion affecting the knee joint stress during gait

Masahiro Edo1, Fumiko Kamijo2, Toshihiko Sato3

¹Chiba Prefectural University of Health Sciences, ²Showa University, ³Bunkyo Gakuin University

1) BACKGROUND AND AIM Previous studies have reported that abnormal mechanical stress acting on the knee joint progresses to osteoarthritis of the knee (Knecht S, et al., 2006). Since the trunk has a large mass, this abnormal stress maybe due to the movement of the trunk. The aim of the study was to clarify the relationship between knee joint stress and the trunk motion during gait. 2) Methods Eighteen healthy subjects (7 males and 11 females; age 19.5±0.5 years, height 166.3±0.1 cm, weight 60.8±10.7 kg) without a history of orthopedic disease in the lower extremities and trunk were selected. This study was approved by the Research Ethical Committee of Bunkyo Gakuin University (Approval Number: 2017-0028). Barefoot gait at a comfortable speed was measured by a 3D motion analysis system (VICON-NEXUS; Vicon Motion Systems, Ltd., Oxford, UK) and force plates (AMTI, MA, USA). Marker placement and calculation parameters were based on Plug-In-Gait full body model. The knee joint angle, moment, and the trunk related angles [relative angle between the pelvis and the thorax (trunk angle), absolute angle of the pelvis (pelvis angle) and the thorax (thorax angle)] were acquired. The distance between the center of the pelvis (pelvis deviation) and the thorax (thorax deviation) with respect to the knee in the horizontal plane was obtained. The moment was normalized by height and weight, and the deviation distance was normalized by height. The data of the left lower limb from three trials was normalized by stance phase time (SP) and averaged for further analysis. Next, the values in each phase of the gait cycle indicated by Neumann KG (2005) were extracted (10% SP [loading response; LR], 35% SP [mid stance; MSt], 65% SP [terminal stance; TSt], 90% SP [pre-swing; PSw]). The relationship between the knee parameters and trunk parameters was analyzed using Pearson's correlation coefficient (significance at p<0.05). 3) Results In relation to knee joint parameters, although the trunk, pelvis, and thorax angle showed a significant correlation only in a





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few phases, the pelvis and thorax deviation showed a significant correlation in many phases (Table 1). Specifically, positive correlation was found between backward deviation of the pelvis and the thorax and the knee flexion angle in LR-PSw, backward deviation of the pelvis and the thorax and the knee extension moment in MSt-PSw, and right deviation of the pelvis and the thorax and the knee abduction moment in TSt. 4) Conclusion The present study found that the more posterior the location of the pelvis with respect to the knee, the greater is the flexion position in the knee joint, and large extension moment is observed throughout the stance phase. In contrast, when the pelvis was positioned more inwards towards the knee, an increase in the the abduction moment of the knee in TSt was observed. Further, there is a possibility that knee joint stress during gait can be controlled not by the angle, but by deviation of the trunk.

P2-D-25 Effect of trunk brace on forward bending movement characteristics in patients with scoliosis

Wei-Chun Hsu¹, Muhammad Izhar Ahmed¹, Chao-Chin Chang¹, Chi Kuang Feng², Shi-Jinn Horng¹, Chung-Hsien Kuo¹, Shang-Chih Lin¹

¹National Taiwan University of Science and Technology, ²Taipei Veterans General Hospital, National Yang Ming University, National Defense of Medial Center.

BACKGROUND AND AIM: Trunk forward bending (TFB) is basic assessment test for scoliosis. The aim of this study was to evaluate trunk kinematics and ground reaction force with trunk brace during forward bending in adolescent idiopathic scoliosis patient. METHODS: The study included diagnosed adolescent idiopathic scoliosis patient with right thoracic apex and left lumber apex. The Cobb angle was assessed by experienced paediatric orthopaedic surgeon using X-rays and physical assessment of patient with and without brace. The X-rays were used to palpate the bony landmark of thoraco-lumbar spine for exact attachment of passive reflective markers (14mm) by well-trained physical therapist. Seven infra-red cameras (Motion Capture Systems Oqus 7, Qualisys, Inc., and Gothenburg Sweden) sampling rate 200 Hz. Three force plates (AMTI, Inc., USA and KISTLER, Switzerland) synchronized with motion capture system, were used to measure ground reaction data at a sampling frequency of 2000 Hz. For kinematic analysis, trunk was divided into five segments namely upper thorax, middle thorax, lower thorax, and lumber and pelvis segments. GRF calculation were completed in visual 3d software. Cycle started with minimum Hip Joint flexion Angle in standing, going in bending phase till Maximum Forward Bending (MFB) with maximum hip joint flexion angle and finished this cycle at end of returning phase till minimum hip joint flexion angle in standing. **RESULTS:** All the trunk segments movement were reduced in brace condition. Brace had immediate effects in all planes movements by limiting range of motion that aligned the spine. Thorax moved in thoracic apex direction in frontal plane and rotated in opposite direction that showed coupling of spine during TFB movement. Without brace, trunk shifted in frontal plane, more towards right apex side after MFB, but WB condition this was shifted before MFB, that controlled medio-lateral GRF (fx) component.





And marked correction was observed for GRF (fx) WB condition that was medio-laterally distributed under right and left foot respectively. Vertical GRF (fz) was different for both feet, greater under left foot in standing that was related to leg length discrepancy and rotational moment, which increased with brace condition in standing position. Bilaterally GRF showing more symmetrical distribution toward the terminal range of bending phase. In dynamic trial GRF became similar between two limbs. **CONCLUSIONS:** It was concluded that vertical GRF was higher towards lumber apex side on left foot. And brace treatment increased this abnormal pattern. But brace helped in medio-lateral component of GRF to improve to its normal pattern. The angles of the trunk revealed brace aligned the thoracolumbar curvature, reducing coupling of spine and limiting the range of motion in sagittal plane. This study indicated asymmetrical GRF that suggested to recruit more subject to generalize the results that might be helping to assess AIS in more critically. **ACKNOWLEDGEMENTS AND FUNDING** This study was funded by Ministry of Science and Technology, Taiwan with Project number MOST107-2218-E-011-008.

P2-D-26 Relationship between foot posture assessment techniques and dynamic plantar pressure variables

Muge Kirmizi¹, Mehmet Cakiroglu¹, Ibrahim Simsek¹, Salih Angin¹

¹Dokuz Eylul University

BACKGROUND AND AIM: It has been reported that foot posture affects whole body biomechanics, and altered foot posture has been associated with many lower extremity injuries. There are several reliable and practical techniques currently available to assess foot posture. Further, plantar pressure parameters are considered to be an important indicator of the foot function and lower extremity biomechanics. However, to the best of our knowledge, there is little research investigating the relationship between measures of foot posture and plantar pressure parameters. We aimed to investigate the relationship between clinical techniques for assessing foot posture and dynamic plantar pressure parameters. METHODS: Forty-six individuals were included in the study (31 female, 15 male, age: 25.02±3.72 years, body mass index: 22,58±2,56 kg/m2). NDP and NDT were measured by the digital caliper measuring with a precision of ±0.02mm (Absolute Digimatic, Mitutoyo, Japan). FPI scores were determined by FPI index. Electronic pedobarography (EMED-m, Novel-GmbH, Germany) was used to measure plantar pressure parameters consisting of maximum force (MF), peak pressure (PP), contact area (CA). Dynamic plantar pressure values were recorded during preferred walking. Data included into the statistical analysis were obtained from the dominant feet. Correlation analysis was computed to determine spearmen correlation coefficients. **RESULTS:** NDP was found to be poorly correlated with MF in the fifth metatarsal head, hallux and second toe (0.300<r<0.400, p<0.05). Also, a poor correlation was found between NDP and PP in the hallux (0.400<r<0.500, p<0.01). NDP was also showed a poor correlation with CA in the hindfoot, midfoot, third metatarsal head, hallux, second toe (0.300<r<0.400, p<0.05). Further, NDP was poorly correlated with CA in the total object and

second metatarsal head (0.400<r<0.500, p<0.01). NDT was poorly correlated with MF in the hallux, CA in the first and second metatarsal heads and PP in the hallux (for MF and CA values 0.300<r<0.400, p<0.05; for PP value 0.400<r<0.500, p<0.05). Further, we found that FPI was poorly correlated with MF and PP in the second toe, CA in the total object, second and third metatarsal heads and hallux (0.300<r<0.400, p<0.05). **CONCLUSIONS:** Our results indicated that MF of the hallux and second toe, PP of the hallux and CA of the second and third metatarsal heads and hallux are positively related to at least two of NDP, NDT and FPI values, which means that the increase in these plantar pressure variables is related to the prone foot. However, this relationship appears to be poor. There is a need for further research to develop a reliable and valid clinical tool highly correlated with dynamic plantar pressure values.

P2-D-27 Lateral stability during anterior and posterior support surface perturbations in people with chronic stroke

Christopher McCrum¹, Andrew Huntley², Alison Schinkel-Ivy³, Avril Mansfield²

¹Maastricht University, ²Toronto Rehabilitation Institute, ³Nipissing University

BACKGROUND AND AIM: Falls represent a large burden on people with chronic stroke. Previous work suggests that lateral stability may be important for recovery from anteroposterior balance loss (McIlroy & Maki, 1996). This study examined if lateral stability following anteroposterior perturbations in people with chronic stroke is related to: the stepping leg used (paretic vs. nonparetic); whether multiple steps are required to recover balance; and perturbation direction (anterior vs. posterior). METHODS: 19 community-dwelling people with chronic stroke (>6 months post-stroke; 13 men, 6 women) participated in this sub-study of a larger RCT (Mansfield et al., 2018). Participants completed a reactive balance assessment of 20 platform translation perturbations to stance, including 4 experimental trials per direction (anterior [1.5 m/s2], posterior, left and right [2 m/s2]; 300ms acceleration, 300ms deceleration) and 4 catch trials (once per direction with a different waveform) presented in an unpredictable order. Anterior and posterior trials were analysed. Full body kinematic data was collected (100Hz; Vicon MX40+), labelled (Vicon Nexus v.1.8.5) and then analysed in Visual 3D v.5. The mediolateral margins of stability (ML MoS) were calculated at foot contact of the first reactive step based on Hof et al. (2005). To account for missing trials, mixed models with perturbation number as a repeated factor and either perturbation direction (anterior vs. posterior), stepping leg (paretic vs. non-paretic) or recovery step number (single vs. multiple) as factors were applied to determine if these significantly affected ML MoS. RESULTS: After excluding trials with data collection or analysis issues, 122 perturbation trials (60 posterior, 62 anterior) from 16 participants (12 men, 4 women; Age: 64.8±9.3y; Years poststroke: 4.5±4.1y) were included in the analysis. These revealed no significant effect of perturbation direction (F(1, 30)=0.05, P=0.82), stepping leg (F(1, 22)=0.07, P=0.79) or number of recovery steps (F(1, 27)=1.8, P=0.19) on the ML MoS. While not statistically significant, single step reactions showed higher ML MoS than those of multi-step reactions (means

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of 15.7cm and 14cm, respectively; Cohen's d=0.39). **CONCLUSIONS:** Our results indicate that in community-dwelling people with chronic stroke, lateral stability during recovery from anteroposterior stance perturbations is not strongly influenced by perturbation direction or by which limb steps. However, lateral stability at the first recovery step may influence the need to take further recovery steps to regain balance. **REFERENCES:**Hof et al. 2005. J Biomech, 38, 1-8. Mansfield et al. 2018. BMJ Open, 8, e021510. McIlroy & Maki 1996. J Gerontol A Biol Sci Med Sci, 51, M289-96. **FUNDING:** This study was supported by the Canadian Institutes of Health Research (MOP 133577). CM was funded by an International Travel Grant of the International Society of Biomechanics.

P2-D-28 Using induced acceleration to study the effects of age and grade on the joint moment strategy to control knee flexion during weight acceptance in walking

Jeroen Waanders¹, Tibor Hortobágyi², Alessio Murgia¹, Paul DeVita³, Jason Franz⁴

¹University of Groningen, University Medical Center Groningen, ²University Medical Center Groningen, ³East Carolina University, ⁴University of North Carolina at Chapel Hill and North Carolina State University

BACKGROUND AND AIM: Deceleration of knee flexion during weight acceptance in walking prevents limb collapse. This movement is typically attributed to eccentric knee extensor function, assisted by hip and ankle extensor moments. Curiously, old age does not seem to affect the quantity of knee energy absorption, nor did it affect the hip and ankle moments during weight acceptance across level and downhill walking1. The age-sparing effect on negative work may be related to the relative maintenance of maximal voluntary eccentric knee extensor force in old age2, which could offer the mechanical energy reserve. Still, it is unclear whether joint moment contributions to the knee deceleration are similar in old and young adults during walking. This is relevant to determine, since gait becomes more hazardous with increasing descent. Therefore, the purpose of this study was to determine the effects of age and grade on the joint moment strategy to control knee flexion during walking. We hypothesized similar joint moment contributions to knee flexion deceleration in young and old adults. **METHODS:** Healthy young (n=17, age: 22.5±4.1 y, 8M) and old adults (n=22, age: 76.0±5.7 y, 9M) walked on an instrumented treadmill at 1.4 m/s for 1-minute at each of three grades: -10%, 0%, and +10%. Lower-limb joint angles and moments during walking were obtained from inverse kinematics and dynamics. These variables served as inputs for an induced acceleration analysis3 designed to estimate momentinduced knee angular decelerations (Fig. 1) that we integrated during weight acceptance and statistically tested. **RESULTS:** During weight acceptance across level and downhill walking, net hip, knee, and ankle extensor impulses were comparable between groups, but hip flexion angle was 6° greater in the older group. Two-way (age, slope) mixed ANOVAs showed no agedifferences in hip, knee, and ankle moment-induced knee deceleration across level and downhill walking (all p > 0.05, Fig. 1), and no age-by-slope interaction (all p > 0.05). **CONCLUSIONS:** As



hypothesized, young and old adults showed a similar joint moment strategy to decelerate knee flexion during weight acceptance in level and downhill walking. This may be due to the relative maintenance of maximal eccentric knee extensor strength in older adults. Interestingly, the net hip extensor moment and not the knee extensor moment, was the primary source of knee flexion deceleration during level walking. This reflects how IAA can complement inverse dynamicsresults. **ACKNOWLEDGEMENTS AND FUNDING:** Support by a grant from NIH to Jason R. Franz (R01AG051748). We also thank Dr. Greg Sawicki and the members of the NC State PoWeR Lab. **REFERENCES:**1. Waanders et al. (2018). Medicine and science in sports and exercise, (ahead of print) 2. Roig et al. (2010). Experimental gerontology, 45(6), 400-409. 3. Zajac & Gordon (1989). Exercise and sport sciences reviews, 17(1), 187-230.

E - Brain imaging/activation during posture and gait

P2-E-29 Are there associations between prefrontal cortex activity and turning behaviors in people with and without freezing of gait?

Valeria Belluscio¹, Samuel Stuart², Elena Bergamini¹, Giuseppe Vannozzi¹, Martina Mancini²

¹Interuniversity Centre of Bioengineering Bohnes, University of Rome Foro Italico, ²Oregon Health & Science University

BACKGROUND AND AIM: Turning elicits Freezing of Gait (FoG) episodes in people with Parkinson's disease (PD) and is thought to require higher cortical control mechanisms compared to straight walking. It is also known that automatic control of walking while performing a concurrent secondary task (i.e. talking), referred to as dual-task (DT), is impaired in PD. Furthermore, the literature suggests that PD impairments likely increase demand on the prefrontal cortex (PFC) to execute motor tasks via attentional processes. In this framework, functional near-infrared spectroscopy (fNIRS) has been used to examine PFC activity in PD while walking, but the relationship between PFC activity and turn performance remains unexplored. Therefore, the aims of this study were: 1) to examine PFC activity during 360° turning-in-place in PD compared to healthy controls and 2) to investigate associations between PFC activity and turning performance in PD with and without FoG. METHODS: Thirty-two subjects with PD, in the "off" medication state (15 freezers (PD+FoG), age 66.9±5.0 yrs and 17 non-freezers (PD-FoG), age 69.9±4.3 yrs), and 8 healthy controls (age 66.5±5.5 yrs) were asked to perform a 2-minute turning-in-place test at selfselected pace. The test involved 20 s of quiet standing at the beginning and at the end of the task, intermediated with 80 s of turning-in-place (alternating 360° turns to the right and left), under single-task (ST) and DT conditions. Each participant wore a fNIRS system, which consisted of a headband located over the forehead of participants, to measure changes in oxyhemoglobin, a proxy for PFC activity. In addition, six inertial sensors were placed on participant's body and were used to quantify turning through a set of outcome performance measures, such as number of turns, average duration, average peak velocity, average jerkiness, and FoG ratio. PFC activity



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between groups in both conditions was evaluated through a General Linear Model, while Pearson correlation coefficients were performed to assess relationships between turning performance and PFC activity in all groups (α = .05). **RESULTS:** Results show that PFC activity while turning is higher in PD than in CTRs in both ST and DT conditions (p<.05). Moreover, higher PFC activity is associated with higher FoG Ratio in PD+FoG in ST condition (r=.567, p=.048) and with a lower number of turns in PD-FoG in DT condition (r=.700, p=.002). **CONCLUSIONS:** This study suggests the involvement of the PFC in people with PD while performing a challenging task such as the continuous 360° turning-in-place. Specifically, increased activation of the PFC in PD compared to CTRs and the association between this increased PFC activity and poorer turning performance highlight the loss of automaticity in PD, with a switch to more voluntary control. Although further investigations are required, these results may guide development of personalized treatments to improve motor automaticity in PD. ACKNOWLEDGEMENTS: The authors would like to express warm gratitude to all patients who generously gave their time participating in this research.

P2-E-30 Validation of divergent neural dysfunction in idiopathic REM sleep behaviour disorder patients separated using clinical phenotyping

Kaylena Ehgoetz Martens¹, Elie Matar¹, James Shine¹, Joseph Phillips², Ronald Grunstein¹, Glenda Halliday¹, Simon Lewis¹

¹University of Sydney, ²University of Western Sydney

BACKGROUND AND AIM: It is currently thought that nearly everyone with idiopathic REM sleep behaviour disorder (iRBD) will ultimately develop a synucleinopathy that is either Parkinson's disease or Lewy Body Dementia. Recent work suggests that quantitative motor assessments, such as the alternate tapping test and gait, may predict when and which of these two diseases an individual iRBD patient will develop some 3-5 years prior to formal diagnosis. This study aimed to identify divergent neural dysfunction in an iRBD cohort using fMRI connectivity when performing a validated virtual reality gait paradigm compared with healthy age-matched controls. **METHODS:** Clinical phenotyping of 23 iRBD patients using validated methods was performed and a 'Phenotype Conversion Score' (i.e. UPDRS-III:Colour Discrimination ratio to give dominant motor or colour phenotypes) and 'Prodromal Severity Index' (aggregate of weighted scores for Smell: 2.8; Colour Discrimination: 2.6; and UPDRS-III: 1.18) developed to explore potentially divergent processes of neurodegeneration. Forty participants (23 iRBD, 17 healthy controls) completed the virtual reality gait task while in the MRI scanner, with 9 iRBD having a dominant motor or intermediate phenotype (2 converted to Parkinson's disease, and 1 has a severity index >1 Stdev) and 14 having dominant colour phenotypes (4 with severity indexes >1 Stdev). RESULTS: Colour dominant iRBD patients had a loss of connectivity within the fronto-parietal network, whereas motor dominant iRBD patients had a loss of frontostriatal connectivity. Increasing 'Prodromal Severity index' associated with increasing basal ganglia connectivity within the iRBD cohort.



CONCLUSIONS: Taken together, this study demonstrates divergent task-related brain connectivity in iRBD patients with different clinical phenotypes which are likely to represent the neural underpinnings of early neurodegenerative changes. Further longitudinal work will determine whether these fMRI signatures distinguish progression to Parkinson's disease or Lewy Body Dementia.

P2-E-31 Prefrontal cortex activity requirements when young and older people perform cognitively-demanding stepping tasks in supported and unsupported conditions: a fNIRS study

Jasmine Menant¹, Paulo Pelicioni¹, Daina Sturnieks¹, Stepehen Lord¹

¹Neuroscience Research Australia, University of New South Wales

BACKGROUND AND AIM: It is unclear whether activation of the Pre-Frontal Cortex (PFC) when performing a cognitive task during standing relates to the cognitive aspect of the task or also the balance requirements. We investigated PFC activation during a cognitively-demanding stepping task using functional near-infrared spectroscopy (fNIRS) with and without balance support, in young and older people. We hypothesised that if standing balance is a "special case" requiring increased attention, then PFC activation in an unsupported balance condition would be significantly increased compared with a supported condition. We also hypothesized that across conditions, older people would show increased PFC activation compared with younger people as a compensatory mechanism for reduced cognitive capacity. METHODS: Nineteen young (19-39 years) and 48 older adults (65-93 years) performed a choice-stepping reaction time task and a conflict resolution stepping task (stroop stepping test) on a computerized mat in two randomly presented conditions: supported standing using arm rests and unsupported free standing. Activation in the PFC region of interest was determined relative to a 30s baseline data collection of quiet standing (supported and unsupported) immediately preceding each test, as changes in oxygenated haemoglobin and deoxygenated haemoglobin concentrations, using 10 channels of fNIRS (NIRSport, NIRX). We computed a three-way repeated-measures ANOVA to determine between-group effects of age (old versus young) and within-group effects of task (stroop stepping versus choice-stepping reaction tests) and condition (unsupported versus supported balance) on oxygenated haemoglobin concentration and deoxygenated haemoglobin concentrations. **RESULTS:** There were significant main effects of age and condition on stepping reaction times indicating step responses were faster in the supported condition and slower in the older group. There were no significant interactions or main effects of task or condition for either oxygenated or deoxygenated haemoglobin relative concentrations (Figure 1). There was a significant main effect of age on deoxygenated haemoglobin relative concentration, indicating increased PFC activation in the older group in all conditions (Figure 1- bottom). CONCLUSIONS: Contrary to our main hypothesis, we found no significant differences in oxygenated and deoxygenated haemoglobin relative concentration when participants performed cognitively-demanding stepping

tasks in an unsupported compared with a supported balance condition. The older group, however, showed significantly increased PFC activation across both tasks and conditions (consistent with our secondary hypothesis). It is possible that the high within- and between-subject variability of the haemoglobin measures contributed to the null findings, but we found no evidence the execution of a cognitive task during unsupported standing requires additional PFC activation in both young and older people. Acknowledgements: Mr Nigel Seng and Miss Bethany Halmy for assistance with data collection.

P2-E-32 Exploration of brain cholinergic correlates of gait in Parkinson disease: An in vivo voxel-based [18F]FEOBV PET analysis

Martijn Muller¹, Prabesh Kanel¹, Nicolaas Bohnen¹

¹University of Michigan

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BACKGROUND AND AIM: Gait difficulty is a disabling motor feature of Parkinson disease (PD). Our previous study has shown that, in the context of severe nigrostriatal dopaminergic loss, decreased cholinergic innervation of the cortex was associated with decreased gait velocity. A disadvantage of our acetylcholinesterase radioligand was that it would not allow for detailed assessment of cholinergic innervation in cortical areas and the inability to accurately quantify cholinergic activity in high binding areas, such as striatum and cerebellum, regions that are critical for gait control. The purpose of this study was to explore regionally unbiased cholinergic correlates of gait using in vivo positron emission tomography (PET) with the vesicular acetylcholine transporter (VAChT) [18F]FEOBV ligand. METHODS: A total of 79 PD subjects (62M/17F; 67.7 ± 7.7 years old; median modified Hoehn & Yahr stage of 2.5; motor disease duration of 5.8±4.5 years; MDS-UPDRS part III total score: 33.9±12.8) underwent gait assessments in the dopaminergic "off" state as well as in vivo VAChT [18F]FEOBV brain PET imaging to quantify brain cholinergic innervation. Participants performed an 8 meter walk twice at normal pace on a Zeno walkway (Protokinetics) and spatiotemporal parameters were extracted using vendor-provided PKMAS software. Results reflecting mean stride-length, -time, and -width and variability thereof (quantified as coefficient of variation; CoV) are presented. Whole brain correlation between [18F]FEOBV binding and stride parameters was analyzed using a voxel-based multiple-regression analysis with the SPM12 toolbox in Matlab (MathWorks) at an uncorrected threshold of p < 0.01 with a voxel cluster size ≥ 5 . **RESULTS:** Whole brain voxel-based correlation analyses of [18F]FEOBV binding with mean stride-length showed positive correlations with bilateral temporal pole, pre-dominant left prefrontal cortex, right anterior cingulum, right caudate nucleus and the right insula. Higher stride-length CoV was associated with lower cholinergic binding in the bilateral prefrontal cortex, anterior cingulum, right caudate nucleus, bilateral hippocampi, bilateral temporal poles, bilateral insular cortices and right lateral geniculate nucleus. Mean stride-time showed weak negative correlations with anterior parts of the temporal and frontal cortices, which were more pronounced for stride-time CoV. Stride width showed negative



correlations in the cerebellum, particularly in the flocculonodular lobes, vermis and cerebellar peduncles, dorsal tegmentum and additional involvement of right caudate and putamen. There were minimal correlations of stride-width CoV with [18F]FEOBV binding in the dorsal tegmentum. **CONCLUSIONS:** Cholinergic system involvement in stride-length and stride-time gait regulation in PD involves predominantly cortical regions (prefrontal cortex and temporal pole regions), while stride-width has predominant sub-cortical involvement (cerebellar involvement, including cerebellar vestibular regions, and the right caudate nucleus. These novel findings confirm and expand on our previous findings suggesting a distinct network of cholinergic mechanisms for spatiotemporal control of strides in PD gait. **FUNDING:** NIH P50 NS091856.

P2-E-33 Brain activation associated with active and passive overground gait in a robotic exoskeleton

Sue Peters¹, Denis Louie¹, Shannon Lim¹, Chieh-ling Yang¹, Janice Eng¹

¹University of British Columbia

BACKGROUND AND AIM: Robotic exoskeletons, which partially or completely assist with gait, are currently used in neurorehabilitation. While exoskeletons do support the legs in stepping, it is unclear what role the cortical regions of the brain may play to control gait within an exoskeleton. During gait without an exoskeleton, the prefrontal, premotor, and primary sensorimotor cortices are activated. The evidence underpinning the role of the brain in robotic exoskeleton rehabilitation is sparse; traditional neuroimaging methods, such as MRI, are confined to a horizontal position. Functional near-infrared spectroscopy (fNIRS) is an ideal imaging tool as it can be used during overground exoskeletal gait to record cortical brain activation. The aim of this study was to delineate the brain activation associated with 'active' and 'passive' overground gait compared with a control condition (no exoskeleton) using fNIRS. METHODS: Ten healthy adults performed a 10meter walk test under three conditions: 1) active-exo (instruction to work with the exoskeleton), 2) passive-exo (instruction to be as relaxed as possible), and 3) no-exo (speed matched to condition 1 & 2). fNIRS recorded brain activation over bilateral frontal and parietal regions. Electromyography (EMG) of the biceps femoris and rectus femoris were recorded bilaterally. fNIRS and EMG were analyzed with the NIRS AnalyzIR toolbox and custom MATLAB scripts. The fNIRS signal underwent a first (subject)-level and second (group)-level general linear model, corrected for motion artifacts and type-I errors, then contrast t-tests were carried out (p < 0.05). EMG was bandpass filtered and rectified before the mean of 10 bursts were measured for each muscle, and normalized to EMG activity during the no-exo condition. RESULTS: EMG was highest in the active-exo (mean 119.7% of no-exo) and lowest in the passive-exo condition (70.9% of noexo) indicating participants produced the conditions asked of them. The no-exo condition showed greater levels of activation in motor planning (versus active-exo and passive-exo conditions) and sensorimotor areas (active-exo condition only). Despite lower EMG in passive-exo, neural activity for this condition was higher in the lateral primary sensorimotor (versus no-exo), and



sensorimotor, motor planning, and somatosensory association areas (versus active-exo). **CONCLUSIONS:** In 'passive' exoskeleton-assisted gait, sensorimotor regions were activated above that seen in 'active' and 'no-exo' gait. This finding may support the current use of robotic exoskeletons in neurorehabilitation with individuals who cannot walk independently, as a way to increase gait-related brain activity. Founded on these results, future work may explore how brain activity differs for gait with and without exoskeletons in individuals with neurological injury, and explore how brain activation may change as a result of retraining gait using a robotic exoskeleton.

P2-E-34 Auditory-evoked cortical activity preceding postural instability

Paula Polastri¹, Mark Laylor², Jessy Varghese², William McIlroy²

¹São Paulo State University (UNESP), ²University of Waterloo

Successful reactive balance control is essential to avoid falling events. While the process of responding to destabilizing events is important to the success of such reactions they are also dependent on the state of the central nervous system (CNS) at the time of instability. The importance of the construct of 'postural set' has been related in many studies that have explored the influence of factors such as expectation and threat. What is important is to advance understanding of the underlying cortical activity that underpins postural set. The cerebral cortex plays a role in compensatory responses for perturbation and cortical activity related to balance control is significantly influenced by factors such as expectation revealed by cortical negativity in anticipation of a temporally predictable perturbations. The aim of this study was to use the task of stimulus expectation (using an auditory tone) denoting the future occurrence of a perturbation to reveal the temporal/spatial characteristics of cortical activity. The objective is to disturbance to describe whether the preparatory activity of CNS is balance-specific or related to any contextspecific event. Young adults stood upright on a platform for 8 seconds prior an auditory cue signaling to prepare to perturbation. Unpredictable perturbation was delivered from 1 to 5 seconds after the tone to right, left, forward or backward directions in high or low amplitudes of platform translations. Initial platform acceleration generated a step at high amplitude and no step reaction at low amplitude. Cortical activity and muscle activity (tibialis anterior, gastrocnemius medialis and peroneous longus) were measured by mobile 32 channels electroencephalogram (ANT Neuro eegosports) and surface electromyography (TMSi Porti), respectively. CoP displacement and galvanic skin response (GSR) was also measured before and after the tone. Sixty four trials were randomized and counterbalanced across direction and amplitude and analysed by averaging thirty two trials of each amplitude condition. Preliminary results show larger amplitude of cortical activity after the auditory cue regardless the perturbation amplitude. EMG amplitude was the same before and after cue and consistent within each perturbation amplitude. GSR indicated higher arousal level after the tone compared to before the tone. The results confirm ability to evoke changes in postural state at the time of a cue occurring an extended time before perturbation. These temporally aligned cortical, neuromuscular and autonomic responses,

occurring in a window of relatively quiet stance, provide data from which to evaluate the changes in cortical activity (network, frequency and temporal properties) that will inform about the cortical substrate for the concept of 'postural' set. These data and approaches will be used to develop a network model for CNS control of postural set and the associated control of reactive balance control. **FUNDING** FAPESP-2018/02808-9.

P2-E-35 Brain functional substrate of gait observation in Parkinson's disease

Martina Putzolu¹, Giulia Bommarito¹, Cecilia Cerulli¹, Giovanna Lagravinese¹, Carla Ogliastro¹, Gaia Bonassi¹, Laura Avanzino¹, Matilde Inglese¹, Elisa Pelosin¹

¹University of Genoa

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BACKGROUND AND AIM: Gait disorders are extremely frequent in Parkinson's disease (PD). Action observation training (AOT), based on the involvement of Mirror Neuron System (MNS), represents a promising tool for the rehabilitation of gait impairment in PD. However, little is known about the neurophysiological substrate of the observation of gait. The aim of this study was to evaluate the neural correlates of gait observation in PD patients. METHODS: 29 PD patients and 21 gender and age-matched healthy subjects (HS) were recruited to participate in this study. PD patients were then sub-classified into two groups based on the presence of Freezing of Gait (FOG). Participants underwent a clinical evaluation, gait analysis and MRI, including functional imaging recorded during the observation of a video showing a human-gait. Spatiotemporal kinematic parameters of gait were recorded through a sensorized mat (GAITRite®). RESULTS: Between group comparison showed that HS had a significantly greater activation at the level of the cingulate cortex and the precuneus in comparison with PD patients and with the FOGsubgroup. Both FOG- and HS activated more than FOG+ at the level of the left IPL, the bilateral posterior medial frontal cortex, and the postcentral gyrus. CONCLUSIONS: The greater activations visible in HS compared to patients suggests an impairment of the MNS areas during observation of gait, in particular in FOG+ patients. In fact, IPL is involved in monitoring motor function based on visuo-spatial information and abnormal function of IPL has been associated to gait disorders in PD. However, AOT of gait could enhance MNS recruitment and, hence, improve spatiotemporal walking parameters in PD patients.

P2-E-36 Higher resting state connectivity of the dopaminergic motor network may reduce age-related step length variability

Caterina Rosano¹, Helmet Karim¹, Andrea Rosso¹, Nicolas Bohnen², Howard Aizenstein¹, Stephen Smagula¹, Stephanie Studenski¹

¹University of Pittsburgh, ²University of Michigan





BACKGROUND AND AIMS: Higher step length variability (SLV) is emerging as an early predictor of falls and dementia in older adults who are otherwise free from neurological conditions. While its association with age-related risk factors such as lower microstructural integrity, muscle strength, and diabetes have been investigated, there are fewer studies investigating the association with neural function. Dopaminergic (DA) function is a part of the core neurobiology of SLV; studies in Parkison's Disease suggest DA interventions can improve SLV. Whether DA function influences SLV in older adults free from neurological diseases is unclear. We hypothesize that higher DA motor network functional connectivity is associated with lower (better) SLV in older adults, and this association is independent of age-related risk factors for SLV (microstructural integrity, muscle strength, diabetes). We further explore whether higher DA connectivity attenuates the detrimental effects of such risk factors on SLV. METHODS: A cohort of 253 adults (79-90 years) was concurrently assessed for: SLV via gaitmat (computed as coefficient of variation); micro-structural integrity via diffusion tensor imaging for normal appearing white (fractional anisotropy) and gray matter (mean diffusivity); diabetes, muscle strength, and other chronic diseases via clinical exams. Resting state functional connectivity was extracted from the motor network of regions with DA innervation: caudate, cerebellar locomotor, putamen (rostral, ventral and caudal), nucleus accumbens, pallidum, pedunculo-pontine nucleus, substantia nigra and subthalamic nucleus. Connectivity between these regions was computed. A k-means clustering analysis yielded two groups, one with high and one with low DA network connectivity. Linear regression models estimated the association of connectivity (continuous measure) with SLV adjusting for risk factors for SLV (brain microstructural integrity, muscle strength, diabetes), sex, age, and gait speed. Analyses were repeated stratified by higher and lower levels of connectivity. RESULTS: Higher connectivity was associated with lower SLV independent of all covariates (standardized b [t], p value: -0.15 [-2.4], p=0.02). Effect sizes for connectivity were remarkably similar to those of the age-related risk factors for SLV. In stratified analyses, the association of risk factors with SLV was significant in those with low but not in those with high connectivity (conditional probability of the models: p<0.0001 and 0.41, respectively). **CONCLUSIONS:** Higher DA functional connectivity appears important for maintaining better SLV in older age. Future studies should clarify whether higher DA connectivity may protect against the detrimental effects of age-related risk factors on step length variability.

P2-E-37 Removal of artifacts to compute intra stride cortical dynamics with EEG in Parkinson's disease

Marlieke Scholten¹, Markus Siegel², Daniel Weiss¹

¹Hertie Institute for Clinical Brain Research, ²Centre for Integrative Neuroscience (CIN) & MEG Center

BACKGROUND AND AIM: Patients with Parkinson's disease (PD) are impaired in the execution of automatic movements, such as walking. Furthermore, it is unknown how deep brain stimulation





of the subthalamic nucleus (STN-DBS) aids in performing automatic movements. Electrophysiological recordings with wireless transmission enables us to study the cortical dynamics during walking. However, EEG is prone to movement-related artifact (Kline et al., 2015). Here, we test whether the combination of two methods, Independent Component Analysis (ICA) and a spatial filter (LCMV) can help to separate genuine brain activity from gait-related artifacts. **METHODS:** We analyzed 13 patients with Parkinson's disease and STN-DBS (9 male, 65 ± 9 years) and 16 healthy controls (10 male, 59 ± 5 years) during walking at their own comfortable pace on a straight walkway. We recorded video, 48-channel EEG, and gait kinematics using sensors attached to the left and right ankles measuring acceleration and angular velocity. All measurements were synchronized. The gait kinematics allowed us to extract the main gait-cycle events: heel strike, midswing and toe-off. In offline analysis, we preprocessed the data, and cut the EEG signal according to these gait cycle events. Thereafter, we applied ICA on the sensor data and computed source time series with a linearly constrained minimum variance (LCMV) beamformer. RESULTS: Using ICA, we could primarily subtract activity containing eye blinks and muscle activity from the sensor time-series. The LCMV beamformer acts as a spatial filter: It passes the activity at the location of interest with unit-gain, while optimally suppressing all other noise and source contributions to the EEG-data (Van Veen et al., 1997). Genuine brain activity have to fulfill these criteria: 1) be frequency specific, 2) be location specific, 3) be time specific. Preliminary analysis showed that by applying both ICA and the LCMV beamformer we possibly can effectively extract genuine brain activity according to our three criteria. CONCLUSIONS: Here we suggest that by using ICA and a LCMV spatial filter we can separate genuine brain activity from pure movement-related artifacts in the EEG signal. Artifacts during walking can arise from muscle activity, eye blinks, or mechanical origin. Activity localized within the brain, in a specific frequency-range, and in a certain time-range is being considered to reflect genuine neuronal activity. In the future, we can study the influence of STN-DBS on the cortical modulation of the gait cycle in PD using the method described here. **REFERENCES:**Kline JE, Huang HJ, Snyder KL, Ferris DP. Isolating gait-related movement artifacts in electroencephalography during human walking. J. Neural Eng. 2015; 12: 046022. Van Veen BD, van Drongelen W, Yuchtman M, Suzuki A. Localization of brain electrical activity via linearly constrained minimum variance spatial filtering. IEEE Trans. Biomed. Eng. 1997; 44: 867-80.

P2-E-38 Cortical response to open and closed-loop tactile cueing during walking and turning in Parkinson's

Samuel Stuart¹, Martina Mancini¹

¹Oregon Health & Science University

BACKGROUND AND AIM: Gait and turning impairments are common in Parkinson's disease (PD). Tactile cues delivered in either an open (OL) or closed-loop (CL) modality may improve gait and turning in PD, but the underlying mechanisms are unclear. Evidence suggests that attention





stemming from the pre-frontal cortex (PFC) may play a vital role in cue response. This pilot study examined PFC activity during walking and turning in response to OL and CL cueing in PD, and explored association between PFC activity and behavioral measures/cognitive function. METHODS: A mobile functional near-infrared spectroscopy device measured PFC activity during walking and turning in 25 people with PD (n=13 freezers, n=12 non-freezers PD severity, OFF medication, Aged 69.2±4.0 years, MDS-UPDRS III 36.4±11.7). Participants performed 180° and 360° turns while walking, and a two minute walk under single and dual-task (AX-CPT) condition with and without an OL (metronome-like vibration) or CL (bio-feedback vibration) tactile cue. The primary outcome was oxygenated hemoglobin (HbO2) at the PFC, which is a proxy for cortical activity. To ensure our fNIRS measure was reliable, we also performed test re-test reliability on young adults (n=19). Participants performed the same two minute walking task (single-task) as the PD cohort and then repeated this a second time following removal and re-application of the fNIRS device after a 10-minute break. **RESULTS:** PFC activity increased during a turn compared to prior-to a turn (p<.001), and was higher in the early phase (first 40sec) compared to late phase (last 40sec) of walking (p<.001) in PD. Interestingly, PFC activity did not change with the application of tactile cueing when walking (OL p=.805, CL p=.258) or turning (OL p=.392, CL p=.934) in PD, and it did not depend upon freezing status or task demands. Despite this, walking and turning significantly improved with both OL and CL cueing, specifically dual-task cost for step length improved (OL p<.001, CL p=.003) and turning slowed. PFC activity did not relate to walking or turning performance. Importantly, a higher PFC activity when walking (single-task early phase; rho=.56, p=.005) and turning (prior-to 180° turn; rho=.52, p=.008) was associated to better executive function (CLOX1 and TMT-A). Importantly, we found moderate reliability for the PFC changes while walking (Mean difference = 0.03, ICC(2,1) = 0.67, limits of agreement = 0.96). CONCLUSIONS: Our preliminary results suggest that both open and closed-loop cueing can improve behavioral measures of mobility in PD, without posing additional burden to the PFC. Future research is required to examine more brain regions and different cueing modality to provide greater understanding of cue response which could help develop effective therapeutics. ACKNOWLEDGEMENTS AND FUNDING This work has been supported by grants from the National Institute of Health via Career Development Award 5R00HD078492-04 (PI Mancini) and a PCO Pilot Grant Award (PI Mancini).

P2-E-39 Influence of anxiety on prefrontal cortical activity during usual walking and obstacle crossing in older adults.

Nubia Conceição¹, Priscila Sousa¹, Diego Orcioli-Silva¹, Victor Beretta¹, Ellen Lirani-Silva¹, Lilian Gobbi¹, Rodrigo Vitório¹

¹São Paulo State University (UNESP)

BACKGROUND AND AIM: Gait impairments are common in older adults and are associated to reduced mobility and increased incidence of falls. Additionally, gait impairments are influenced by





anxiety symptoms, which are also common in older ages. To date, anxiety symptoms are exacerbated in challenging situations (e.g. obstacle crossing and fear of falling) and are associated to reductions in walking speed and step length, as well as increased step-to-step variability. Indirect evidence (i.e. behavioural measures) suggest that anxiety may consume prefrontal processing resources relevant for the control of locomotion. However, the extent to which anxiety influence prefrontal cortical activity during locomotion is not stablished. The study aimed to analyse the influence of anxiety symptoms on prefrontal cortical activity during usual walking and obstacle crossing in older adults. METHODS: Twenty-six older adults were distributed into two groups, according to the score on the Hospital Anxiety and Depression Scale - subscale Anxiety: high-anxiety and low-anxiety older adults. Thirteen healthy young adults with low anxiety participated as a control group. Participants were invited to walk, at preferred pace, around a 26.8m oval circuit (with two 6.5-m parallel straights) under two conditions: usual walking and obstacle crossing. For the obstacle condition, participants were instructed to step over four obstacles (height = 15 cm) evenly spaced along the oval circuit. Five trials for each condition were performed in a random order. In each trial, participants initially stood still for approximately 20-30 s and then walked for 30 s. Changes in oxygenated haemoglobin in the prefrontal cortex were recorded bilaterally using an 8-channel functional near-infrared spectroscopy device, with a sampling rate of 10 Hz. Data were pre-processed using NIRS-SPM (NIRS-SPM, http://www.nitrc.org/projects/nirs spm). Analysis of oxygenated haemoglobin signal was performed using a customized algorithm. For each trial, the period of interest was defined as the middle 20 s of the walking period (initial and final 5 s were excluded), which were split into early (5-15 s) and late (15-25 s) phases. Data were analysed using three-way ANOVAs (group X condition X phase). RESULTS: Interaction between factors was not revealed. For the left prefrontal cortex, high-anxiety older adults showed greater oxygenated haemoglobin levels than young adults (F = 3.850, p = 0.031), regardless of condition and phase. CONCLUSION: Current findings suggest that high symptoms of anxiety increase prefrontal cortical activity in both usual walking and obstacle crossing in older adults. Anxiety possibly leads to increased recruitment of prefrontal cognitive resources for the control of locomotion in older adults. ACKNOWLEDGMENTS AND FUNDING: São Paulo Research Foundation (FAPESP) [grant number #2016/21499-1; #2014/22308-0]; CAPES (Finance Code 001).

F - Cognitive impairments

P2-F-40 Gait patterns and cognitive decline: A longitudinal population-based study

Oshadi Jayakody¹, Monique Breslin¹, Velandai Srikanth², Michele Callisaya¹

¹University of Tasmania, ²Peninsula Health, Monash University

BACKGROUND AND AIMS: Gait impairments are emerging as novel predictors of dementia (Allali et al. 2016). However, there is little evidence on whether gait predicts decline in specific



cognitive domains. The aims of this study were to determine 1) whether gait patterns (gait variability in temporal and spatial measures and Walking Speed Reserve) or gait speed predict decline in specific cognitive domains and 2) whether the presence of the ApoE4 genotype modifies the associations between gait and cognitive decline. METHODS: Participants (n=410; mean age 72.0±7.0 years) were randomly selected from the Southern Tasmanian (Australia) electoral roll. At baseline, gait speed was assessed using the GAITRite walkway. Intra individual variability in step time, step length, step width and double support time (DST) was calculated as the standard deviation of each measure across all steps. In a subsample (n=177), gait speed was measured under fast pace, and walking speed reserve was calculated as the difference between usual and fast pace. At baseline, 2.6 and 4.6 years executive function, processing speed, memory and visuospatial function were measured using a comprehensive battery of neuropsychological tests. Multivariable mixed models were used to examine 1) associations between baseline gait and the specific cognitive domains over time (baseline gait × time) and 2) whether the presence of ApoE4 genotype modified these associations (baseline gait × ApoE4 × time). The models were adjusted for a priori confounders baseline age, sex and education. RESULTS: Baseline higher DST variability was associated with greater decline in memory (β -0.592 95%CI -1.125 to -0.059; p=0.03). Variability in other gait variability measures and walking speed reserve did not predict decline in any of the cognitive domains (p>0.05). Slower gait speed predicted decline in processing speed (β 0.001 95%Cl 0.000 to 0.002; p=0.02) and visuospatial function (β 0.008 95%CI 0.001 to 0.015; p=0.03), and only in ApoE4 carriers, predicted decline in memory (β 0.003 95%CI 0.000 to 0.006; p=0.02). CONCLUSIONS: Our findings provide insights into that poorer gait performance is an early indicator of cognitive decline, but that discrete gait measures may be diagnostic markers of decline in specific cognitive domains. REFERENCE Allali G, Annweiler C, Blumen HM, Callisaya ML, De Cock AM, Kressig RW et al. (2016) Gait phenotype from mild cognitive impairment to moderate dementia: results from the GOOD initiative European journal of neurology 23:527-541.

P2-F-41 Is free-living gait assessment a useful marker of cognitive impairment and dementia disease subtype?

Riona Mc Ardle¹, Brook Galna¹, Silvia Del Din¹, Alan Thomas¹, Lynn Rochester²

¹Newcastle University, ²Institute of Neuroscience, Newcastle University

BACKGROUND: Patterns of gait impairment may aid differential diagnosis of dementia disease subtypes. The majority of gait research in dementia has been conducted in gait laboratories; however, these are expensive and not feasible for wide-scale clinical use. They also provide a single snapshot of gait performance, which may not be the true picture of individual function. Wearable technology allows continuous monitoring of gait in an individual's home and community. These environments are inherently complex and may therefore require cognitive input to facilitate gait. This study aimed to assess if cognitive impairment and dementia disease subtypes were





distinguishable through continuous gait assessment in free-living conditions, and if discrete gait impairments were associated with select cognitive functions. METHODS: 108 participants were recruited across three groups; 36 Alzheimer's Disease (AD; Age: 77±6; sMMSE: 23±4), 30 dementia with Lewy bodies (DLB; Age: 76±6; sMMSE: 24±4), 16 Parkinson's disease dementia (PDD; Age: 79±6; sMMSE: 24±4) and 26 controls (Age:74±9; MMSE: 29±1). Dementia disease subtypes ranged in severity from mild cognitive impairment to moderate dementia. A tri-axial accelerometer (Axivity AX3) placed on the lower back for 7 days continuously recorded data pertaining to fourteen spatiotemporal gait characteristics describing pace, rhythm, variability, asymmetry and postural control. Cognitive tests measured global cognition, memory, attention, executive function, visuospatial abilities and information processing. One way ANCOVA controlling for age, sex and height were performed and Spearman's Correlations were used to explore gait-cognition associations across disease subtypes. **RESULTS:** DLB and PDD groups took shorter steps ($p \le .001$), and demonstrated greater variability (($p \le .01$) compared to controls. People with DLB also walked slower (p<.001) than controls. The PDD group demonstrated greater asymmetry (p≤.01) compared to controls, DLB and AD participants. They were also more variable (p≤.01) compared to AD. There were no significant differences between AD and controls or AD and DLB groups (p.01). In PDD, slower gait was associated with greater visuospatial dysfunction, shorter steps and longer stance time with greater global cognitive impairment, executive and visuospatial dysfunction and slower information processing, and longer step and stance time and less step length asymmetry with greater attentional impairment. In AD, only slower step velocity was associated with greater memory impairment. There were no gait-cognition associations found in DLB. **DISCUSSION:** Free-living gait can distinguish PDD from other subtypes but fails to distinguish AD and DLB subtypes. This may be due to mixed pathology Future research should consider disease groups characterised with valid biomarkers to enhance diagnostic accuracy. Results may indicate that people with PDD require a greater amount of cognitive input to navigate complex free-living environments, and cognitive decline may impact their ability to maintain functional independence. Future research should consider both clinically-conducted and freeliving gait assessments in order to assess individual capacity and function - allowing a holistic picture of a person's gait.

P2-F-42 Developing exercise groups for persons with dementia

Kristin Taraldsen¹, Elisabeth Boulton², Jorunn Helbostad³, Ingvild Saltvedt¹, Gro Tangen⁴, Randi Granbo³

¹Norwegian University of Science and Technology, ²University of Manchester, ³The Norwegian University of Science and Technology (NTNU), ⁴Norwegian National Advisory Unit on Ageing and Health

BACKGROUND AND AIM: For persons with dementia, PA may influence physical function and ability to perform activities of daily living. In this project we wanted to gain knowledge about





characterisations of home-dwelling, older persons with impaired cognition and dementia in order to be able to develop and pilot a new exercise service for this group. METHODS: In this threestep project, the end-users were home-dwelling, older persons (65+) with impaired cognition or dementia. Participants were recruited from the outpatient geriatric clinic at time of having a cognitive evaluation. The project consists of: 1) an observational study (n=100 end-users) with assessment of physical activity, physical and cognitive function, 2) in-depth focus group interviews (n=8 spouses), 3) a pilot study evaluating a 12-week group exercise intervention, organised by use of volunteers. **RESULTS:** Results from the two first studies were included in the design of the pilot feasibility study. Participants (mean age 78.9 years, SD 6.7, 57% women) average upright time was 301 min/day and gait speed was 0.93 m/sec. Overall, home-dwelling, older persons with impaired cognition or dementia participate in few activities outside their homes. Spouses describe a situation with high burden, where there is a need for improved services from the health care system. New services should be tailored to individual needs and preferences rather than focusing on the dementia diagnosis alone. We (researchers and clinicians) developed an adapted group exercise intervention including balance, muscle strength, and physical activities lead by two physical therapists once a week for 12 weeks. We matched each participant with a volunteer that organised the transport from participants' home to the exercise group location and attended the group exercise sessions. We conducted in-depth interviews and focus groups with the participants (n=4), volunteers (n=5), spouses (n=4), and the physical therapists that lead the group exercises (n=2) at the end of the 12-week intervention period. All participants and caregivers expressed positive experiences being part of this group exercise programme. The theme "building relationships" represents the reason why attending this group was important for the participants. Findings suggest that organisation and support is important, as was the motivation for participating in such an activity outside their homes. CONCLUSION: This study shows that it is possible to involve home-dwelling persons with cognitive decline in a group exercise service. The role of building relationships was the major factor for success. Service providers should not underestimate the importance of building relationships between persons involved in service offers, where support and motivation is essential both for persons and their caregivers when accepting such offers.

P2-F-43 The effects of cognitive impairment on the multi-scale dynamics of standing postural control in older adults

Junhong Zhou¹, Brad Manor¹, J. Riley McCarten², Michael Wade³, Azizah Jor'dan¹

¹Harvard Medical School, ²Minneapolis Veterans Affairs Medical Center, ³University of Minnesota - Twin Cities

BACKGROUND: Standing postural control is dependent upon numerous inputs, including the cognitive resources, interconnecting and interacting across multiple temporal-spatial scales. The temporal dynamics of its output (i.e., postural sway) is "complex", containing fractal-like patterns





over multiple scales of time. Such complexity reflects the postural control system's capacity to adapt to "stressors". For example, decreased postural sway complexity of has been linked to aging, somatosensory impairment, and increased falls risk. Our prior work demonstrated that the ability to adapt one's standing postural control when performing a secondary task, requiring more cognitive resources, is declined in older adults with cognitive impairment. However, the effects of cognitive impairment (i.e., mild cognitive impairment, MCI and Alzheimer's disease, AD) on postural sway complexity remains unknown. We hypothesized that in older adults with cognitive impairment, postural sway complexity will be lower, particularly when standing while performing a cognitive task concurrently, compared to non-demented older adults. METHODS: Fifty-nine older adults with and without cognitive impairment participated in the study (AD: n=25, age=77.5±8.8 years; MCI: n=19, age=75±6.9 years; and non-demented: n=15, age=78.2±3.9 vears). All groups had their respective consensus diagnosis (i.e., AD, MCI, or non-demented). Participants were asked to complete two 60-second standing trials in each of the following two conditions: control and visual search. In the control condition, participants were instructed to maintain their gaze on a blank white board. In the visual search, participants were instructed to count the frequency of a designated letter in a random block of alphabet letters displayed on a white board. Standing postural sway was assessed using the fluctuation of center-of-pressure captured by the Wii Balance Board. The complexity of postural sway in both the anterior-posterior (AP) and medial-lateral (ML) directions was quantified using multiscale entropy. **RESULTS:** Across groups, both AP and ML sway complexity was significantly lower during the visual search condition compared to the control condition (F>5.6, p<0.02). There was a main effect of group in AP and ML sway complexity in both the control (F>3.9, p<0.02) and the visual search condition (F>4.4, p<0.02). Post-hoc analysis revealed that compared to the non-demented, the MCI and AD groups had a significantly lower postural sway complexity (control: p<0.03, Figure 1A; visual search: p<0.03, Figure 1B). Moreover, those with AD had greater percent reduction in AP sway complexity from the control to the visual search condition as compared to those with MCI and non-demented group (F=4.8, p=0.01, Figure 1C). CONCLUSION: In older adults, cognitive impairment disrupts the multi-scale dynamics of postural control, particularly when performing a concurrent task (e.g., visual search condition in this study), as reflected by diminished postural sway complexity. This postural sway complexity metric may provide unique insight into the characteristics of cognitive-motor control pertaining to balance and mobility.

G - Cognitive, attentional, and emotional influences

P2-G-44 The validity and predictive validity of the Gait-Specific Attentional Profile (G-SAP)

Adam Cocks¹, William Young¹, Toby Ellmers¹, Joseph McCarthy¹, Noel Kinrade¹

¹Brunel University





BACKGROUND AND AIM: Fear of falling has been shown to influence fall-risk-related behaviors of older adults. However, little information has been gathered identifying the underlying attentional mechanisms of these effects. Speculatory mechanisms include attentional disruptions caused by: conscious motor processing (e.g., 'reinvestment'), the presence of anxiety, ruminations about previous falls, and processing inefficiencies. Recent work has also argued that gait-specific measures are required to address disparities in findings. Therefore, the aim of this study was to validate a gait-specific scale to potentially provide clarification on these suggested attentional mechanisms. In addition, the predictive validity of this scale in relation to falls efficacy, functional ability, and number of previous falls was assessed. METHODS: Following face validity checks, a 22-item scale was completed by 117 older adults (M age = 74.27, SD = 7.73). Exploratory factor analysis assigned items to uncorrelated factors via principle component analysis. Maximum likelihood confirmatory factor analysis was conducted on data from a second sample of 107 older adults (M age = 78.79, SD = 9.96). Model fit indices were assessed to determine the most suitable factor structure and item inclusion. The predictive validity of the scale was then examined using a further sample of 51 older adults (M age = 75.02, SD = 6.88) who completed the G-SAP, Falls Efficacy Scale-International (FES-I), and Timed Up and Go (TUG). Number of falls in the previous twelve months were also reported. Spearman's Rank Order Correlations were conducted to assess the predictive validity of the G-SAP in relation to these other measures. RESULTS: Exploratory factor analysis produced a one-, two-, three-, and four-factor model. Following confirmatory factor analysis, the sixteen item four-factor model was selected. Additional item deletion and covariance to improve model fit resulted in an 11 item four-factor model with factors labelled: anxiety, movement processing, rumination, and processing efficiency. Model fit indices either matched or surpassed thresholds for good or acceptable fit (x²/df = 1.89, CFI = 0.97, GFI = 0.90, SRMR = 0.04, RMSEA = 0.09, AIC = 127.75). Predictive validity analyses revealed number of falls significantly correlated with total G-SAP score and the anxiety, movement processing, and rumination sub-scales (r = 0.38-0.47, p < .01). TUG significantly correlated with total G-SAP score, anxiety, and movement processing (r = 0.29-0.45, p < .05). FES-I significantly correlated with total G-SAP score and all sub-scales (r = 0.31-0.63, p < .05). CONCLUSIONS: The G-SAP, and its subscales, appear to be related to both perceived and functional fall-risk indicators. The validation of this questionnaire is the first step in a series of studies aiming to examine the underlying attentional mechanisms, and the behavioral associates, of fear of falling, which is thought to increase fall-risk.

P2-G-45 Emotional, cognitive, and postural adaptations to repeated postural threat exposure

Kyle Johnson¹, Martin Zaback², Craig Tokuno¹, Mark Carpenter², Allan Adkin¹

¹Brock University, ²University of British Columbia

BACKGROUND AND AIM: Previous research has shown that associations between threat-related changes in postural control and emotional and cognitive states are influenced by experience with



postural threat, but this has only been studied following acute threat exposure [1]. As limited work has explored individuals' capacity to adapt threat-related responses, the effects of initial and repeated threat exposure on emotional, cognitive, and postural measures were examined. **METHODS:** Young (n=27) and older (n=27) adults stood on a force plate fixed to a translating platform. Threat was manipulated through expectation of a temporally and directionally (left or right) unpredictable platform perturbation. Participants completed one 60 s stance trial with no threat of perturbation, followed by 24 trials with threat of perturbation. The stance period before each perturbation varied (5-60 s), except on the first and last threat trials (60 s) which were used for analysis. Electrodermal response frequency and medio-lateral center of pressure (COP) mean position, root mean square (RMS), mean power frequency (MPF), and COP power within low (0-0.05 Hz), medium (0.5-1.8 Hz) and high (1.82-5 Hz) frequency bins were calculated. After each trial, participants rated anxiety and attention focus to movement processes, task objectives, threatrelated stimuli, self-regulatory strategies, and task-irrelevant information [1]. Mixed 2 (age) x 3 (threat) ANOVAs were performed with planned comparisons examining initial and repeated threat exposure effects. RESULTS: Threat effects were independent of age. With initial threat exposure, participants were significantly more anxious and physiologically aroused, and directed more attention to movement processes, threat-related stimuli, task objectives, self-regulatory strategies and less attention to task-irrelevant information. Participants also significantly increased RMS, MPF, medium and high frequency COP power. With repeated threat exposure, anxiety, arousal, and attention to movement processes and threat-related stimuli significantly decreased, and attention to task-irrelevant information increased. These changes were accompanied by significant reductions in MPF and medium frequency COP power. Arousal and attention to task objectives, task-irrelevant information, and self-regulatory strategies returned to no threat levels, while postural outcomes did not. CONCLUSIONS: Postural threat elicited similar emotional, cognitive, and postural changes in young and older adults. Despite significant adaptation of individuals' emotional and cognitive responses to threat following repeated threat exposure, only some threat-related changes in standing balance adapted. This suggests that some threat-related changes in standing postural control are more closely linked with one's emotional response to threat, while others may be context-dependent. ACKNOWLEDGEMENTS AND FUNDING: Project funded by NSERC to MGC and ALA REFERENCES:[1] Johnson et al 2017 Psych Res.

P2-G-46 Reading the mind: Pupillometry as a means to measure conscious movement processing?

Elmar Kal¹, Nieck Detillon², Bram Kragting², John van der Kamp²

¹Brunel University, ²Vrije Universiteit Amsterdam

BACKGROUND AND AIM Conscious control is generally thought to impair motor performance. Conscious motor control has been linked to performance breakdown in high-anxiety conditions, increased fall risk in older adults, and impaired daily functioning post-stroke. Yet, recent studies





suggest that conscious control may also positively influence motor performance, in specific situations (e.g. high-task complexity), populations (e.g., patients with low skill), or distinct movement phases. It is therefore pertinent to further delineate when and for whom conscious control may be useful (cq detrimental). This requires a valid and direct method to quantify the degree to which a person uses conscious control while moving. Typically used assessments like retrospective verbal reports and dual-task tests are indirect measures, and influenced by factors such as (working) memory capacity and task prioritization. A promising alternative seems pupillometry. Pupil dilation is strongly positively related to a person's conscious mental effort during cognitive tasks. We aimed to test if pupillometry can also be used to gauge the amount of conscious control during a complex whole-body balance task. METHODS Fifteen healthy young adults participated (9 male, age=20-26 years). All participants were asked to stabilize a wobble board that was instrumented with a gyroscope to measure angular velocity. Participants performed fifteen 15-second trials on an "easy" board (large base of support) and 15 trials on a "difficult" board (narrow base of support). Each trial was preceded by a baseline trial during which participants stood still with one side of the board resting on the ground. An eye tracking device (Pupil Pro) measured participants' pupil movements and dilation (30 Hz). We used within analyses to compare the increase in mean, peak and time to peak pupil dilation from standing baseline to easy and difficult balance trials. Greater values signify greater cognitive effort. RESULTS Data analysis is ongoing. Preliminary results show that participants performed significantly worse on the difficult (16.1±4.8 degrees/s) than on the easy wobble board (5.2±7.5 degrees/s; p<0.01). We additionally observed a strong, significant increase in average and peak pupil dilation between standing baseline and both easy and difficult wobble board conditions (p<0.001), but no differences between the latter (p>.13). Importantly, for the balance trials, pupil data was unreliable for 7 of the participants, due to a considerable amount of head movements during balancing. **CONCLUSIONS** Our results show that pupillometry does hold promise as a method to gauge conscious control during moving. However, our results also show that its practical feasibility in dynamic (balance) tasks is quite limited. This is probably partly due to the fact that pupil dilation can be affected by fluctuations in arousal and head movements. We provide practical recommendations to overcome such issues in future research.

P2-G-47 Factors associated with texting while walking performance across different environments

Tal Krasovsky¹, Patrice Weiss¹, Rachel Kizony¹

¹University of Haifa

BACKGROUND AND AIM: Texting while walking (TeWW) is ubiquitous to modern life and associated with a dramatic increase in pedestrian injury. While it is well established that walking performance is altered when texting, the aim of this work was to examine personal and environmental factors associated with TeWW performance in a large cohort of young healthy




adults. METHODS: Sixty healthy adults (aged 18-40 years) walked in two environments: (1) a quiet indoor corridor, and (2) a busy outdoor sidewalk, with visual and auditory distractions (stores, people, etc.). Participants walked for 1 minute along a 30m path with or without a mobile phone texting task (copying simple sentences) without explicit task prioritization. Participants were also asked to perform the texting task while standing. Walking performance was monitored using inertial sensors (Mobility lab, APDM) and texting performance (speed (characters per minute -CPM), accuracy) was monitored using a custom-written mobile app. Dual task costs (DTCs) were computed for both tasks. Participants were asked about their phone use habits (texts per day) and completed tests of visual scanning, processing and cognitive flexibility (Trail Making Test A and B). Finally, participants were asked about which task they prioritized (walking/texting) on a visual analog scale. Data that were not distributed normally were analyzed with non-parametric tests. **RESULTS:** In both environments, TeWW caused a similar decrease in gait speed (m/s) (indoors:1.39±0.21 to 1.21±0.23; outdoors: 1.41±0.20 to 1.23±0.23;F(1,59)=183.3, p<.001). In addition, a small but statistically significant increase in stride time variability was found (indoors; z=-3.1;p<.01, outdoors; z=-3.8;p<.01). Typing speed (CPM) decreased during dual task in both environments (indoors:156±31.3 to 130.4±28.9; outdoors:154±29.9 to 126.8±29.4;F(1,59)=125.89, p<.001) as well as accuracy (p<.05). Participants' age and texting habits were associated with typing speed in all texting conditions such that younger participants and more frequent texters typed faster (age; r=-.35 to r=-.41; texters r=.26 to r=.27). However, age and texting habits were not associated with DTCs of either walking or texting. Results of the TMT (a,b) were associated with DTCs of walking but not texting. Finally, subjective task prioritization indicated that participants prioritized texting, but this was unrelated to objective task performance. DTCs were higher for texting than walking in both environments reaching significance outdoors (z=-2.23; p<.05). CONCLUSIONS: Young healthy adults' ability to walk and text is unaffected by age or texting habits, suggesting that more avid mobile phone users may be equally prone to texting-related distractions. In contrast to previous studies regarding default prioritization, DTCs of texting were higher than those of walking. FUNDING: Learning in a Networked Society (LINKS), Israeli Center of Research Excellence (I-CORE) and University of Haifa.

P2-G-48 Dual-task gait training is not superior to single-task gait training within 3 years of stroke: a randomized controlled trial

Prudence Plummer¹, Jody Feld¹, Lisa Zukowski², Bijan Najafi³

¹University of North Carolina at Chapel Hill, ²High Point University, ³Baylor University

BACKGROUND AND AIM: Recent research has suggested that dual-task gait training (DTGT) may be superior to single-task gait training (STGT) for improving dual-task gait speed. However, very few trials have reported the treatment effects on the non-gait task, thus intervention effects on the pattern of dual-task interference are largely unknown. We compared STGT and DTGT on dual-task interference on gait speed and cognitive task performance, as well as the pattern of





cognitive-motor interference. **METHODS:** 37 adults (mean age 57.3 [SD 15.2] years) within 3 years of stroke (median 6.9 months, range 0.3 to 36.3) were randomized 1:1 to STGT or DTGT, 3 times a week for 4weeks. DTGT involved progressive gait and balance activities with simultaneous cognitive task for 75% of repetitions. STGT performed identical balance and gait training without cognitive tasks. The primary outcome was the relative dual-task effect on gait speed (DTEg, %) and cognitive task reaction time and accuracy (DTEc, %) during walking at preferred and fast speed in two different dual-task conditions (auditory Stroop, auditory clock task). Secondary analyses examined intervention effects on average single and dual-task gait speed, cognitive-task reaction time and accuracy, as well as Timed Up and Go (TUG), balance self-efficacy, lower extremity motor impairment, and daily step activity. RESULTS: Neither group demonstrated a significant change in DTEg or DTEc post intervention for either the Stroop or clock tasks at either walking speed. Accordingly, patterns of dual-task interference, which were mostly mutual interference, cognitive-priority tradeoff, and gait interference, did not demonstrate notable intervention-related changes. Nonetheless, significant main effects of Time revealed improvements in single-task and dual-task gait speeds for both tasks at both walking speeds. Average increases in gait speed were nominally greater for STGT (0.07-0.09 m/s) than DTGT (0.03-0.07 m/s), but none of the Group x Time interactions were significant. DTGT significantly improved Stroop reaction time while walking at fast speed, whereas STGT significantly improved single-task clock-task accuracy. No other significant differences in cognitive variables were observed. Both groups significantly improved in balance-self efficacy and lower-extremity motor impairment, but there was no significant change in TUG or daily step activity for either group. **CONCLUSIONS:** There was no evidence that DTGT was superior or inferior to STGT for improving gait speed or any secondary outcomes, and neither intervention changed the degree of dual-task interference or apparent attention allocation strategy during dual-task walking. It may be that the participants did not have sufficiently large enough dual-task interference at baseline to demonstrate improvements, perhaps due to insufficiently challenging dual-tasks. Whether DTGT is superior for a particular subgroup of people with stroke is yet to be determined.

P2-G-49 Increasing the distance of an external focus of attention enhances learning: A replication and extension of McNevin, Shea and Wulf (2003)

Nadia Polskaia¹, Rebecca Bond¹, Juliane Ratte¹, Yves Lajoie¹

¹University of Ottawa

BACKGROUND AND AIM: In the context of sport, there is a substantial amount of literature to suggest that adopting an external focus of attention over an internal focus yields greater performance and learning benefits (Review: Wulf, 2013). However, when applied to the study of postural control, the effects are not as evident. For instance, Polskaia et al. (2014) and Richer et al. (2017) observed no significant differences between foci when applied to postural stability in young and older adults, respectively. However, when the focus was completely withdrawn from





postural control and placed on a cognitive task, greater postural improvements were observed compared to both attentional focuses. Therefore, the objective of the present experiment was twofold: first, to replicate the effect of attentional focus on performance and learning of a stabilometer task as reported by McNevin et al. (2003) and second, to examine if the effects of a cognitive task observed on postural control can be replicated on a stabilometer task. METHODS: Twenty-four out of 50 participants between the ages of 18-30 were collected. The task required participants to balance on the stabilometer. Participants were randomly assigned to one of five experimental conditions: internal focus, three external focus conditions, in which the distance between the feet and the markers on the stabilometer differed, or a cognitive task condition. Participants performed seven trials on each of the two days of acquisition. Specific focus instructions were provided to the participant after every other trial. To evaluate learning, a retention test comprised of seven trials was performed on the third day. Performance was measured by root-mean-square error (RMSE) in degrees using the Vicon motion capture system. **RESULTS:**Across the two days of acquisition, the results revealed no significant effect of group (p > 0.05, p2 = 0.054). However, a significant main effect of day (p < 0.001, $\eta p 2 = 0.806$) and trial (p < 0.001, $\eta p 2 = 0.466$) were observed. Consistent with previous learning experiments (Schmidt & Lee, 2005), performance improved across the acquisition days, as evident by the reduction in RMSE. Additionally, compared to trial 1, participants' performance improved as they progressed through trials 3-7 (ps < 0.01). For retention, the analysis revealed no significant effect of group (p > 0.05, $p_2 = 0.048$) or trial (p > 0.05, np2 = 0.090). **CONCLUSION**: At present, the findings were not consistent with that of McNevin et al. (2003), suggesting that the beneficial effect of an external focus may be affected by the difficulty of the balancing task. Additionally, the combined complexity of the stabilometer and cognitive tasks may have exceed participants resource capacity, and as a result did not produce the same effects as observed by Polskaia et al. (2014) and Richer et al. (2017). ACKNOWLEDGEMENTS AND FUNDING: Primary author has the NSERC Postgraduate Scholarship.

P2-G-50 Relating reaction times to local sway features to unveil intermittency in postural control

John Stins¹, Melvyn Roerdink¹

¹Vrije Universiteit Amsterdam

BACKGROUND AND AIM The control of quiet upright standing is not only realized using postural reflexes; higher cortical centers, embodying attention and cognition, also play a role. The theory of "intermittent control" states that the control of posture involves a rapid succession of brief periods of postural stability and postural instability. During stable episodes the upright body dwells relatively motionless in a particular posture. Such stable episodes are interspersed with periods of postural instability during which the body rapidly transits to a new stable point. This theory assumes a combination of two types of control: stiffness control (in order to keep the body in the





same position), and top-down ballistic control (in order to move the body to a new reference position). We tested the prediction that exerting ballistic control consumes more attention, relative to stiffness control. As index of attention load we used performance on a simple reaction time (RT) task. We predicted that reaction times would be slower when the stimulus-response events happened to coincide with episodes during which ballistic control was arguably at work. The two control regimes were classified using local features of the posturogram. Method Thirty-two participants stood on a force plate. They had to press a hand-held button as soon as they heard a stimulus tone, as soon as possible. About 40 auditory stimuli were presented at random instances during a 3-min guiet standing episode. The postural control regimes were characterized using sway-density analysis. More specifically, we computed local dwell times from the center-ofpressure samples corresponding to each individual stimulus-response interval. Our primary statistical analysis was based on correlations (within and across subjects), in that we correlated stimulus-response durations (i.e., RT) with the corresponding local dwell times. We did the same analysis with local velocity and local eccentricity (defined as distance from the postural origin). Results We observed that shorter dwell times were associated with longer stimulus-response intervals (high RTs), thus an overall significant negative correlation. We also observed a significant positive correlation between RT and local center-of-pressure velocity. The correlation between reaction times and local eccentricity was not significant. The analyses were performed using a combination of frequentist and Bayesian statistical methods. Conclusion We mapped stimulusresponse durations to local center-of-pressure features, derived from the posturogram. Importantly, we demonstrated attentional fluctuations (i.e., variations in RT) in the control of quiet upright standing, thereby validating a core assumption underlying the notion of intermittent postural control.

P2-G-51 Smartphone-based balance assessment for older adults enrolled a 12-week attentionally focused balance training intervention: Preliminary data

Ruth Stout¹, Lauren Higgins¹, Danielle Felsburg¹, Masahiro Yamada¹, Sean Cochrane¹, Chanel LoJacono¹, Amanda Barclift¹, John Palazzolo¹, Jeff Labban¹, Louisa Raisbeck¹, Jeffery Fairbrother², Christopher Rhea¹

¹University of North Carolina, Greensboro, ²University of Tennessee

International Society for Posture and Gait Research (ISPGR) Conference abstract (3000 character limit) Conference dates: June 30-July 4, 2019 Location: Edinburg, Scotland Title: Smartphonebased balance assessment for older adults enrolled a 12-week attentionally focused balance training intervention: Preliminary data Authors: Stout, R.D., Higgins, L.Q., Felsberg, D.T., Yamada, M., Cochran, S.M., Lojacono, C.T., Barclift, A.D., Palazzolo, J., Labban, J.D., Raisbeck, L.D., Fairbrother, J. & Rhea, C.K. **BACKGROUND AND AIM:** Older adults have a documented higher fall risk, starting at age 65, rising sharply by age 80. Despite interventions of many types--from strengthening, balance exercises, and fall risk education--the fall rates in older populations have





not declined overall. Newer interventions in rehabilitation have included the element of attentional focus, which differentiates internal (self-focus) from external focus (goal oriented) movement instructions. The purpose of this study was to use a recently developed smartphone balance assessment to examine spatial movement patterns during a dynamic balance task in older adults who participated in a 12-week balance training intervention, where one group was trained with internal focus (IF) cues and the other with external focus (EF) cues. It was hypothesized that the EF group would exhibit greater balance control as indicated by lower and less variable spatial movement in the post-test. METHODS: 14 older adults (81.75±3.54 yrs; 8 in the EF group, 6 in the IF group) participated in the 12 week balance training intervention, which consisted of keeping a wobbleboard level, with difficulty controlled by the size of the wobbleboard base. EF participants were given the cue to keep the wobbleboard level, while the IF participants were given the cue to keep their feet level. Training was provided twice a week for 12 weeks. Before and after the 12 weeks of balance training, dynamic balance was tested using a smartphone app attached to the thigh while the participant stepped in place for 70 seconds with their eyes closed (EC) or while shaking their head laterally (HS) for two trials each. The smartphone's sensors measured the mean peak thigh angle (deg) and standard deviation (SD) of the thigh angle range of motion (ROM) (deg) to quantify movement during the dynamic balance test. **RESULTS:** For mean peak thigh angle, no difference at baseline was observed between the EF (M=28.5, SD=22.9) and IF (M=28.8, SD=6.1) groups for HS, but there was a significant difference after the 12 weeks of training (EF group M=22.7, SD=6.8; IF group M=29.0, SD=4.8), F(1,9)=12.664, p=0.006. For SD of thigh angle ROM for EC, no difference at baseline was observed between EF (M=0.18, SD=0.16) and IF (M=0.03, SD=0.09), but there was a significant difference after the 12 weeks of training (EF group M=0.08, SD=0.08; IF group M=0.04, SD = 0.01), F(1,8)=11.34, p=0.005. CONCLUSIONS: The smartphone app detected a reduction in spatial movement and variability for participants who were part of the EF group, which provided a way to objectively measure changes in movement strategy before and after a balance intervention. These data will be compared to gait and balance data to see how they relate to fall risk.

P2-G-52 Postural adjustments during manual motor imagery in young and older people

Chloe Wider¹, Mark Andrews¹, Hayley Boulton¹, Suvobrata Mitra¹

¹Nottingham Trent University

BACKGROUND AND AIMS: We have previously shown that systematic postural adjustments accompany periods of manual motor imagery (mMI) even though there is no limb motion requiring adjustments to postural support [1]. The timing (anticipatory or reactive) and directionality (against or in the direction of arm extension) of postural motions associated with individual instances of mMI are not well understood. Here, we analyzed anteroposterior (AP) hip motion of healthy young and older participants (Ps) while they performed physical and imagined arm raises. Periods of 1 s before and after the start of arm motion or mMI were the anticipatory and reactive phases,





respectively. METHODS: Twenty healthy young (18-30 yrs) and older adults (65-88 yrs) with no balance problems stood and performed bilateral arm raises in the anterior direction. In the triggered condition (TC), Ps performed the arm raise as soon as they heard the go signal. This followed a get-ready signal at a random latency between 1-4 s, so the exact timing of the go signal could not be anticipated. In the self-initiated condition (SC) Ps were asked to initiate arm motion or MI at a time of their own choosing. In both physical and mMI trials, Ps clicked a handheld mouse to signal that they were starting their arm movement. Postural and arm movements were recorded at 100 Hz using Codamotion active markers placed at the hip and hands. In mMI trials, Ps' mouseclick was taken as the estimated start of imagined arm raise. In physical trials, the arm raise was taken to have started when the right arm's speed reached 1 m/s. Postural motion was relativized to the point of arm raise initiation. **RESULTS:** Both age groups showed statistically significant forward postural motion in the anticipatory phase of mMI (Figure, right panels). The slope was greater in young than older Ps in TC. Forward hip motion continued into the reactive phase before recovery, which was guicker for young Ps in TC. In the anticipatory phase of the physical condition, there was a slight but significant forward hip motion in both age groups in TC, but only older Ps showed this in SC (Figure, left panels). Young Ps' recovery in the reactive phase was quicker in TC and SC. CONCLUSION: We found anticipatory postural motion in the direction of imagined arm extension. The extent of this was greater in young than older participants when MI was externally triggered [2]. Given that the direction of postural motion matched in physical and imagined conditions, this result implicates incomplete inhibition of the postural component of imagined manual movements [3]. REFERENCES:1. Boulton, H., Mitra, S. (2013). J Neurophysiol, DOI: 10.1152/jn.00488.2013. 2. Mitra, S., et al. (2016). Psychol Aging, DOI: 10.1037/pag0000120 3. Jeannerod, M. (2006). Motor cognition. Oxford. ACKNOWLEDGEMENTS: Nottingham Trent University Vice Chancellor's Scholarship.

H - Coordination of posture and gait

P2-H-54 Postural control following a sport-related concussion changes in response to continuous platform rotations

Harry Bailey¹, Cameron Kirk¹, Richard Mills², Richard Foster¹

¹Liverpool John Moores University, ²Manchester Metropolitan University

BACKGROUND & AIM Biomechanical measures were previously developed to objectively quantify whether static balance tasks are sensitive enough to determine if an athlete suffering from a sport-related concussion (SRC) is ready to return to play [1]. However, these measures may not accurately represent the dynamic requirements and postural demands experienced in game situations. Concussed individuals may also present with rapid functional recovery via the adoption of new strategies which appear symptom-free during static balance tasks [2]. We investigated if athletes with a previous SRC, who had returned to play, showed deficits in whole-





body postural control in response to continuous platform rotations. We also investigated the coupling strategy between the head and trunk segments to achieve postural control of the head, where the sensory organs of the visual and vestibular system are located [3], during the same task. METHODS Sixteen participants (eight previously-concussed; eight age- and positionmatched) completed six one-minute trials (three each eyes open/closed) whilst stood on a platform rotating about the pitch axis with a peak-to-peak amplitude of 4° at 0.8 Hz. Anteroposterior margins of stability (MoS) [4] determined whole-body postural control and the anchoring index (AI) determined the coupling strategy between the head and trunk [5] during the reactive (first five cycles of platform rotations) and anticipatory (last eight cycles) phases of each trial. A three-way repeated measures ANOVA compared differences between phase, group and visual condition. RESULTS Anteroposterior MoS during platform rotations were reduced for both groups during eyes closed trials, but athletes with a previous SRC exhibited a significantly greater reduction in posterior MoS (1.97cm) compared to matched-controls (0.34cm). During the reactive stage both groups showed a greater shift towards a head-stabilised-to-trunk-strategy when visual stimulus was removed (eyes open = 0.03 ± 0.19 , eyes closed = -0.26 ± 0.23), which was not the case during the anticipatory phase (eyes open = -0.28 ± 0.16 , eyes closed = -0.35 ± 0.25). **CONCLUSIONS** This preliminary study suggests athletes with a previous SRC demonstrate a greater reduction in postural control in comparison to matched-controls whilst undergoing continuous platform rotations with eyes closed. This may be due to lingering neurological deficits from SRC, though these athletes were not likely to lose their balance. A shift towards headstabilised-to-trunk strategy during the reactive phase with eyes closed highlights an increase in task difficulty. Platform rotations used in this study may not be sufficiently destabilising to elicit a loss of balance, but our results suggest this method may be useful in developing more sensitive SRC assessments. Future research should focus on using platform rotations and/or translations to assess athletes in both symptomatic and asymptomatic phases following SRC. References Powers et al., 2014. G&P Ellemberg et al., 2009. J. Neurotrauma Pozzo et al., 1995. Exp Brain Res Hof et al., 2005. J. Biomech Amblard et al., 1997. Exp Brain Res.

P2-H-55 Control of the trunk during walking: Early manifestations of antero-posterior angle changes

Ioannis Bargiotas¹, Juan Mantilla¹, Danping Wang¹, Pierre-Paul Vidal¹

¹CNRS, SSA, University Paris Descartes (Paris IV)

BACKGROUND AND AIM: Walking properly is important in order to improve speed and efficiency while reducing the risk of injury. When uncertainty increases, slower walking, shorter step lengths, lower feet-lifting are observed even in healthy individuals. These changes appear usually after 60 years old and become a norm for more than 60 % of community-dwelling subjects over 80 years. Previous studies showed higher trunk sway angles for older compared to younger healthy individuals, especially in irregular surfaces. However it is not clear how these changes are related





to the antero-posterior angles at rest and if mild angle changes occur even in younger and middleaged individuals that walk in ideal conditions. New technologies such as Cartesian Optoelectronic Dynamic Anthropometer (CODA) motion analysis can contribute significantly to the capture of such changes. **METHODS:** We included 18 healthy individuals (females: 8, Age = 32 ± 11.9 , range: 20 - 58 years). Participants had no history of any neurological or orthopaedic impairment. Individuals walked in a treadmill with a velocity of 4km/h. We used the CODA motion analysis system to capture the sagittal movements by tracking 24 markers' position in real-time at rest and during walking. The markers were positioned on the head, shoulders, sternon, low back, right and left tibias, right and left ankles and feet. We calculated the sagittal skeletal configurations of the individuals at rest and at the moment of the heel-strikes (HS) of both legs. The sensors were grouped by body parts (Head, Trunk, Right Leg, Left Leg), their movements were centered and the angle of every part was measured. Left and Right leg were used as a reference in order to accurately define the numerous HS moments during exercise (150 approx.). We calculated four gait parameters for Head and Trunk: 1.Difference between average angle at HSs (AngleHS) and angle at rest (AngleR) - DiffAngle, 2. Ratio between AngleHS and AngleR (RatioAngle), 3. Variance of angles at HSs (VarianceHS), and 4.Skewness of angles at HSs (SkewnessHS). We performed a multivariate regression analysis (alpha = 0.05) to find any significant association between gait parameters and age, as well as possible confounders. **RESULTS:**We did not find any statistically significant result for head parameters. TrunkDiffAngle, TrunkSkewnessHS and TrunkRatioAngle were found significantly correlated with age (R:0.67, p:0.002, R:-0.52, p:0.02 and R:0.47, p:0.04 respectively). Only the first two associations remained significant after adjustment for gender, height, weight and sportive activity. Important to mention that the angle of trunk at rest (AngleR) was not correlated with age. CONCLUSIONS: Differences between trunk angles at the HS moments and trunk angles at rest tend to increase throughout age indicating a progressive trunk flexion even in the ages before 60 years old. The fact that TrunkRatioAngle increases significantly with age (at least univariately) indicates that the proportion of the aforementioned changes also increases with age. Moreover, TrunkSkewnessHS changed from positive to negative with aging, indicating that younger and older individuals walk relatively closer to their minimum and maximum values of anterior trunk angles respectively.

P2-H-56 Dual tasks during treadmill walking in a fully immersive virtual environment

Lars Peder Bovim¹, Beate Gjesdal¹, Silje Maeland¹, Bård Bogen²

¹Western Norway University of Applied Sciences, ²University of Bergen

BACKGROUND AND AIM: Treadmill walking in a virtual environment (VE) using a head-mounted display (HMD) for a fully immersive experience may be a valuable addition to traditional gait rehabilitation. To our knowledge, very little research has been undertaken to investigate the effect of dual tasking in a fully immersive VE. The aim of this study is therefore to explore changes in gait parameters in healthy adults during manual dual tasks while treadmill walking in a VE. Findings





could be helpful for designing VE-based constraints that could be applied to clinical populations. METHODS: 29 healthy, young individuals (age: 28.9±5 yrs) were recruited. They walked at a selfselected "strolling-pace" during treadmill walking (average 1.16±0.11 m/s), and this speed was set throughout testing. Gait variability in the anteroposterior (AP), mediolateral (ML) and vertical (V) directions where measured using an inertial motion sensor worn at the lower back during familiarised treadmill walking (TW) and familiarised treadmill walking in a VE (TW+VE). In addition, participants completed three consecutive manual tasks while walking in the VE; catching stationary objects (DT1), catching moving objects (DT2) and balancing a ball on a disc (DT3). The VE was designed specifically for the study. Gait variabilities are presented as autocorrelations, where values tending towards 0.0 indicate large stride-to-stride fluctuations, and values tending towards 1.0 indicate little stride-to-stride fluctuations. The results were analysed using repeated measures ANOVA with gait speed as a covariate. **RESULTS:** There were no significant differences between TW and TW+VE in any directions. During performance of the manual dual tasks (DT1-3), autocorrelations were significantly lower in all directions, compared to TW+VE. In the AP direction: DT1 mean difference (MD) -.158 (p<.001), DT2 MD -.223 (p<.001), DT3 MD -.076 (p<.01). In the ML direction: DT1 -.253 (p<.001), DT2 -.310 (p<.001), DT3 -.094 (p<.01). In the V direction: DT1 -.158 (p<.001), DT2 -.203 (p<.001), DT3 -.081 (p<.01). CONCLUSIONS: We see a significant reduced stride-to-stride fluctuation during performance of three VE-based manual dual tasks. These findings indicates that manual dual tasks in a VE during treadmill walking alters gait patterns in healthy adults, thus suggesting that balance is being challenged. Further studies are needed to investigate whether the tasks in this VE are too demanding for clinical groups.

P2-H-57 Beat perception and production abilities affect responsiveness of temporal gait asymmetry to rhythmic auditory stimulation following stroke

Lucas Crosby¹, Jennifer Wong², Jessica Grahn³, Joyce Chen¹, Dina Brooks¹, Kara Patterson¹

¹University of Toronto, ²Toronto Rehabilitation Institute, ³Brain & Mind Institute - Western University

BACKGROUND: Rhythmic auditory stimulation (RAS) is an effective intervention to improve various gait parameters following stroke, including speed and step length. However, only modest improvements to temporal gait asymmetry (TGA; gait phase inequality between the legs) have been observed. Poor rhythm ability-the ability to perceive and produce a rhythm- has been linked to a detriment to gait parameters when walking with RAS in healthy adults. Rhythm abilities are impaired post-stroke, linked to TGA, and could interfere with responsiveness of TGA to RAS. Purpose: To determine if the immediate responsiveness of post-stroke TGA to RAS is influenced by one's rhythm abilities. **METHODS:** Individuals with stroke and TGA (swing time ratio (SR) > 1.06) from the community performed computer behavioural tasks to determine their abilities of rhythm perception (identifying if overlaid beeps are on/off beat of musical clips) and production (tapping along with the beat of musical clips). Based on task scores, participants were classified





into strong perception (SPer; > 50% correct responses) or poor perception (PPer) groups, in addition to strong production (SPro; < 110 milliseconds of average tap asynchrony) or poor production (PPro) groups. The participants walked with RAS (music and metronome; three trials each in random order with tempi set to baseline cadence) and were instructed to match their footsteps to the beat. Significant differences in TGA (baseline SR - RAS SR) within strong and weak perception and production groups were determined using repeated measures ANOVA with effect size presented as bootstrapped 95% confidence intervals (CI). RESULTS: Twenty-two individuals participated in this study (SPer=15, PPer=7; SPro=11, PPro=11). Groups did not differ on baseline gait parameters or degree of leg and foot motor recovery as measured by Chedoke McMaster Stroke Assessment. When walking to a metronome, individuals classified as SPer (mean SR difference = -0.10, CI [-.18, -.05], p=0.008) and SPro (mean SR difference = -0.09, CI [-.16, -.04], p=0.018) improved TGA. When walking to music, SPro individuals also significantly improved TGA (mean SR difference = -0.10, CI [-.16, -.04], p=0.017). DISCUSSION: While some individuals classified with poor rhythm abilities were able to improve TGA, as a group, PPer and PPro did not significantly change TGA when walking to RAS. This may highlight the potential need to address rhythm ability when treating post-stroke individuals with RAS as those with strong ability may benefit the most. This study demonstrated the immediate effects of RAS on gait outcomes; therefore, before clinical recommendations can be made, the results should be further explored using a training paradigm and retention tests to determine if beat ability affects learning when treating post-stroke TGA with RAS interventions.

P2-H-58 Unwinding the control of walking turns

Carolin Curtze¹

¹University of Nebraska Omaha

BACKGROUND AND AIM: The concept of the extrapolated center of mass (XcoM) suggests a simple rule for stable walking: at initial contact the foot is placed at a certain distance behind and lateral to the XcoM, thereby redirecting the movement of the XcoM into a sinusoidal trajectory. In order to move in a circle with radius r, a centripetal acceleration has to be generated: This can be done by placing the feet more to the outside the projection of the center of mass (CoM). The distance that the center of pressure (CoP) should be outside of the CoM in a turn can be determined under consideration of the inverted pendulum model. The goal of this study is to experimentally test the proposition that turning is controlled by changes in the lateral foot placement relative to the XcoM (i.e. margin of stability 'MoS'). It was hypothesized that the lateral foot placement is proportional to the centripetal accelerations. **METHODS:** Ten healthy participants (5 male / 5 female, age 72.0 \pm 5.8 years, height 1.69 \pm 0.11 meters, and mass 71.5 \pm 17.8 kg) were recruited for this study. Participants performed preplanned turns to the left and right, at different turn amplitudes (45, 90, 135, and 180 degrees) while walking at normal and fast speeds. Floor markings similar to a clock face consisting of a turning point in the center and turn





angle marks in the periphery were used as guidance to indicate turn angle. Full-body kinematics (30 marker) were acquired at 120 Hz. The lateral MoS was calculated using the XcoM at the time of initial contact. The distance that the CoP should be outside of the CoM in a turn was obtained based on the to be generated centripetal accelerations. Linear correlations were fit for the left and right leg for each of the participants. **RESULTS:** An example of a stepping pattern of a 135-degree turn is given in Figure 1 A. Throughout the turn, both feet are placed to the outside of the CoM, redirecting the lateral velocity of the CoM into the new heading direction. The overall velocity of the CoM was reduced around the vertex of the turn (Figure B). The instantaneous centripetal acceleration is given as a normal line pointing toward the center of the turn. Linear correlation between MoS and centripetal accelerations for each participant yielded rho values of 0.56±0.19 and 0.59±0.20 for the left and right foot, respectively. CONCULSIONS: Turning is achieved by a proportional change in foot placement. This lateral foot placement is proportional to the centripetal accelerations that need to be generated to walk in a circle of a given radius. **ACKNOWLEDGEMENTS AND FUNDING** This study was supported by the Medical Research Foundation of Oregon.

P2-H-59 Head anticipation during auditory instructed locomotion

Felix Dollack¹, Hideki Kadone¹, Monica Perusquia Hernandez¹, Kenji Suzuki¹

¹University of Tsukuba

BACKGROUND AND AIM: Head orientation has been identified to anticipate trajectory direction during human locomotion. It persists in conditions with no light, suggesting that the fundamental function of gaze is independent of the visual condition. Arguably, the purpose for this anticipatory behavior is related to motor control and trajectory planning. However, experiments so far have only explored this phenomenon with visual instructions. The primary objective of this study is to describe head anticipation in auditory instructed locomotion. **METHODS:** Auditory instructed locomotion trajectories were performed in two visual conditions: eyes open and eyes closed. Eight sighted subjects (27 \pm 4 years), first, listened to a moving sound source while actively following it. Later they were asked to reproduce the trajectory of the moving sound source without sound. **RESULTS:** Anticipatory head behaviour was observed during trajectory reproduction in both, eyes open (t=-32 ms) and eyes closed (t=-34 ms) conditions. The average head lead lag is significantly smaller (eyes closed: p=0.016, eyes open: p=0.004) than 0. **CONCLUSION:** The results suggest that head anticipation is related to motor control.

P2-H-60 The effect of changes in body weight on postural control in obese and nonobese adults: a pilot study

Daniela Godoi¹, Rafael Santi¹





INTERNATIONAL SOCIETY OF POSTURE & GAIT RESEARCH

¹Federal University of São Carlos (UFSCar)

The worldwide prevalence of overweight and obesity has been rapidly increasing. In Brazil, about 20% of adults aged 18 years or over (17.3% of men and 22.7% of women) were obese in 2014. We must be concerned about these numbers because the consequences of overweight are very well documented in the literature. The relationship between obesity and postural control has been observed recently. However, although there are evidences that show the overweight influence on postural control, there is no consensus about the reasons that lead to these changes in postural stability. Considering the complexity involved in the postural control functioning it seems reasonable to question whether the effect of obesity on postural control is merely due to changes in body geometry that modify the mechanical demand involved in body stability maintenance. Therefore, the purpose of this study was to obtain preliminary data on the effects of changes in body weight on postural control in obese and nonobese. Six young male adults (age: 26.50±3.99) were equally allocated in two groups, matched by height: obese group (BMI: 37.08±3.17), constituted of obese individuals, and non-obese group (BMI: 23.22±0.84), constituted of normal weight individuals. Postural control was evaluated during upright stance maintenance under different vision (open and closed eyes), base of support (bipodal and semi tandem stance), and surface (hard and soft surface) conditions. Moreover, participants' body weight was manipulated as follows: non-obese individuals were submitted to a mass addition condition in order to present the same body weight as one participant in the obese group, and obese individuals had their body weight partially suspended by means of a partial body weight suspension system in order to present the same body weight of a participant of the non-obese group. In this way, participants were evaluated in the real body weight (non-obese real - NOR; obese real - OR) and simulated body weight (obese simulated - OS; non-obese simulated - NOS). Each participant performed two 30-second trials at each of the possible combinations of vision, support, surface, and body weight conditions, totalizing 32 trials. Dependent variables were RMS, mean velocity, range and amplitude of the center of pressure displacements, in the anterior-posterior and medial-lateral directions. Results revealed that the postural stability of both groups, obese and non-obese, was influenced by vision, base of support and surface conditions. Moreover, real and simulated body weight resulted in different postural stability. Therefore, despite the fact that current findings are based on data from a small number of subjects, the results suggest that changes in postural control of obese individuals are not merely due to increased mechanical demand resulting from additional body weight. Thus, it seems that the sensorimotor experience of being obese may also influence postural control (Supported by FAPESP #2017/17104-4).

P2-H-61 Repetitive experience touching door edges with fingers while walking through an aperture to improve fine-tuning of collision-avoidance behavior

Tomoki Hakamata¹, Yoshitsugu Kondo², Takahiro Higuchi¹

¹Tokyo Metropolitan University, ²Tokushima Bunri University





BACKGROUND AND AIM: Collision-avoidance behavior is fundamental to achieving safe locomotion. For those who have difficulty avoiding collision with an obstacle (e.g., older adults), repetitive experience with avoiding collision seems to help to improve that ability. However, there is a concern about that type of experience: the failure to avoid collision during the experience could cause pain and/or injury. We therefore developed another technique as an intervention: repetitive experience of a light touch with an obstacle during locomotion. We expected that such experience would improve perception of the spatiotemporal relationship between the obstacle and the body during locomotion and aid fine-tuning of collision-avoidance behavior. We investigated whether such an intervention would be effective to improve the fine-tuning of collision-avoidance behavior during walking through a narrow opening. METHODS: Sixty-four young adults participated (26.8±6.4 yrs old). They were randomly assigned to one of the four intervention groups: both-side contact (fingertip contact on both sides of doors when passing through the opening), one-side contact (fingertip contact only on one side of the door), pointing (pointing to, but not touching, both sides of the doors with index fingers so that the spatial margin between the door and the fingers was minimal at the time of crossing), and control (normal walking). In the pre-and post-intervention session, participants were asked to walk 4 meters while holding a parallel bar (the length of which was twice their shoulder width) and pass through an opening of various widths (0.9, 1.0, and 1.1 times the bar length). They were instructed to do so while creating a minimal spatial margin between the door and the bar at the time of crossing; that is, the smaller the safety margin was in the post-intervention session, the greater the intervention effects were. **RESULTS:** A two-way ANOVA showed that the spatial margin at the time of crossing in the intervention session became significantly smaller in the both-side contact group and the pointing group than in the other two groups. CONCLUSIONS: We showed that the intervention effects were observed not only in the both-side contact group but also in the pointing group. This suggests that the physical contact between the door and the body may not be important.Rather, the repetitive intention to cross through the doorway so that either light contact with the door or crossing with a minimal spatial margin between the finger and door may improve the accuracy of perceiving the spatiotemporal relationship between the obstacle and the body during locomotion and aid the fine-tuning of collision-avoidance behavior.

P2-H-62 The influence of anxiety on motor strategy selection during a stepping down paradigm in older adults

Nick Kluft¹, Sjoerd Bruijn¹, Jaap van Dieën¹, Mark Carpenter², Mirjam Pijnappels¹

¹Vrije Universiteit Amsterdam, ²University of British Columbia

BACKGROUND AND AIM. A large portion of older adults is concerned that they might fall during gait. This concern increases the level of anxiety during gait and might even negatively affect the control of balance and gait. The effects of anxiety on balance and gait control have been thoroughly studied; however, the influence of anxiety on older adults' movement strategy selection





in a dynamic task is not well understood. Given that appropriate motor behaviour is crucial for balance during gait, we investigated how anxiety affects movement strategy selections by using a stepping down paradigm in older adults. Stepping down to a lower level can be done selecting either 1) a less demanding but more balance threatening heel landing, or 2) a more demanding yet more controlled toe landing. The probability of selecting a toe landing grows with an increase in height difference. We hypothesised that when anxiety is induced, a more cautious toe landing is preferred over heel landing at relatively lower height differences. Methods. Twenty-two older adults (M = 73 years, IQR = 9, 12 females) performed a stepping down paradigm at a low (ground level) and high (walking on a platform of .6 m height) threat condition, while walking speed was controlled by a set of light emitting diodes along the 4×.6 meter walkway. To test the effectiveness of the threat manipulation, we recorded electrodermal activity and used self-reported questionnaires to assess anxiety, confidence, and fear. As the main outcome variable of behavioural choice, we asked participants to repeatedly walk down height differences ranging from 2.5 to 15 cm, and determined the height at which participants switched from heel landing to toe landing (i.e., hswitch). Prior to this protocol, participants completed an extensive set of practice trials to minimise learning effects. We performed a Bayesian equivalent of a one-sided paired ttest, to compare hswitch between threat conditions. **Results.** The threat manipulation effectively altered the physiological arousal, yet marginally altered the response on the self-reported questionnaires. Walking speed, despite being imposed at 1.1 m/s, was on average .05 m/s lower in the high threat condition (BF10 = 4.2). The value for hswitch was lower in the high threat condition (hswitch = 3.54 ± 2.03) compared to the low threat (hswitch = 4.24 ± 1.71 ; BF10 = 5.9), meaning that they selected the toe-landing strategy more often at lower step heights. Conclusions. The results indicate that our experimental manipulation, consisting of a .6 m elevation, increased older adults' anxiety when stepping down a level change. In accordance with our initial hypothesis, participants changed their strategy selection in stepping down due to this threat. This suggests that, despite the additional effort of a toe landing, older adults effectively adjust their motor strategies selection to a postural threat.

P2-H-63 Exploring the relationships between trunk sway, walking speed and gender

Joel Lanovaz¹, Sahya Bhargava¹, Robert Downey¹, Alison Fedoriuk¹, Logan Michalishen¹, Serena Saini¹, Alison Oates¹

¹University of Saskatchewan

BACKGROUND AND AIM: Trunk sway is often used as a measure of dynamic balance, with increases in sway related to less stability and decreases related to proactive responses. Walking speed can also alter trunk sway and possibly confound interpretation of balance. The relationship between trunk sway and walking speed has not been well explored and most studies have utilized treadmills to vary speed. The purpose of this study was to characterize how walking speed influences 3D trunk sway during overground walking. **METHODS:** Twenty healthy adults (10





females, mean age 20.3 years) wore six inertial sensors (Mobility Lab, APDM, Portland, OR) on the wrists, ankles, sternum, and lumbar region. Each participant walked down a 20 m hallway at five different walking speeds based on standardized verbal instructions asking individuals to walk at their normal pace, slightly slower than normal, slightly faster, very slow, and very fast. Six repetitions of each speed were performed in a block randomized order. Data from strides in the middle 10 m were extracted from each trial. Quadratic functions were fit to experimental data for each participant (minimum of 110 strides per participant) and were subsequently used to resample data at 0.70, 0.85, 1.00, 1.15 and 1.30 times their average normal speed. Velocity effects on trunk sway and spatiotemporal data were tested using repeated measures ANOVAs and gender differences were assessed as between subjects effects. RESULTS: All five walking speeds arising from original instructions were significantly different from each other (range 0.71 to 2.42 m/s, normal velocity 1.45 m/s). Cadence and stride length increased with walking speed as expected and both showed a significant speed by gender interaction; males had shorter stride lengths at lower speeds and females had higher cadence at faster speeds. Frontal plane sway had a significant speed by gender interaction; males showed no change while females had more sway at higher speeds. Sagittal sway was significantly increased when walking above normal speed and females had significantly higher overall sway. Horizontal plane sway was significantly higher for the two fastest walking speeds compared to normal and 0.85 x normal with no gender effects. **CONCLUSIONS:** Trunk sway was generally altered when walking above normal speed but not during slower walking, which matches with some of the previous research in this area. Since balance challenges usually result in slower walking speeds, changes to trunk sway in these situations are less likely to be confounded by walking speed. Instructions provided to participants produced the desired walking speed range, allowing for overground rather than treadmill based testing, increasing ecological validity. Furthermore, it appears that there may be some genderspecific trunk sway changes in response to walking speed. This is a novel finding and needs to be confirmed and further explored with larger sample sizes.

P2-H-64 Motor deficits in Parkinson's disease are heterogeneously corrected for by Deep Brain Stimulation

Christoph Maurer¹

¹University Freiburg

BACKGROUND: It is well known that motor deficits caused by Parkinson's disease (PD) can be improved by deep brain stimulation (DBS) of the nucleus subthalamicus (STN). However, some motor deficits seem to respond better to DBS and some less, as e.g. postural control or axial deficits. It is not known yet, however, whether this heterogeneous effect of DBS could be assigned to certain motor tasks, motor features, or body segments. OBJECTIVE: To identify the quality and the quantity of DBS effects on PD motor symptoms, separated by body segments, motor tasks, and motor features (e.g. displacement, velocity, smoothness, variability). **METHODS:** Motion





capture techniques were applied to monitor motor behavior across different motor tasks in 20 PD patients with DBS switched off and on and 25 healthy control subjects. The effect of DBS was estimated as a function of motor tasks, motor features, and body segments. **RESULTS**: In general, displacement- and velocity-related effects of DBS are superior to effects related to the smoothness of motor behavior. The distribution of DBS effects across body segments is related to motor tasks and to motor features. When e.g. comparing Sit-to-Stand to Functional Reach movements, the DBS effect on trunk velocity is significant in the first and negligible in the latter task. **CONCLUSIONS**: Each motor task has a metric which indicates the effect of DBS. The effect of DBS is related to the motor task and motor features which then determines the distribution of the effect across body segments. Moreover, motor features related to smoothness are less affected, compared to displacements and velocities of movements. This new motion analysis approach may allow for a better titration of therapeutic interventions in future, such as the potentially continuous adjustment of DBS parameters, depending on motor tasks and desired type of amelioration of motor performance.

P2-H-65 Slower reactive turning while walking in older adults: an association with cognitive-motor function

Takahito Nakamura¹, Takahiro Higuchi², Touyou Kikumoto¹, Fumihiko Hoshi¹

¹Saitama Prefectural University, ²Tokyo Metropolitan University

BACKGROUND AND AIM: Turning while walking involves altering a straight walking pattern to move the center of mass towards a new direction of travel. When individuals are unable to anticipate their turn direction (e.g., in a moment where they need to respond quickly to an unpredictable event), turning needs to be performed reactively and in a limited amount of time. Rapid reorientation of the head towards a new direction of travel is helpful in this case because it could lead to the rapid succession of trunk reorientation. We investigated the time necessary for older adults to reorient their head in response to a visual cue presented at random. We also investigated the correlation between time and cognitive-motor function. METHODS: Twelve older adults participated in this study (age:81.2±6.9 years). They were asked to walk straight in the forward direction for 4 to 7 m, and when a visual cue was presented, they were required to initiate a turn in the direction of the cue as soon as possible. The visual cue was randomly presented to the participants using a foot switch. Four feet switches were used, and these switches were attached at both the forefoot and hindfoot under participants' left and right shoes. The visual cue occurred when either of the forefoot or hindfoot contacted the ground. The onset of head reorientation, or the reaction time (RT), was measured using an inertial sensor. Cognition and motor functions were assessed using Mini-Mental State Examination (MMSE), gait speed, Berg Balance Scale (BBS), and Timed-up and Go test (TUG). Pearson's correlation coefficients between the mean RT and each of the assessment scores were calculated. RESULTS: The mean scores for each assessment were as follows: RT was 521.7±88.0 ms, MMSE was 22.8±4.8, gait



speed was 0.9±0.2 m/s, BBS was 47.2±4.2, and TUG was 14.1±3.3 s. Pearson's correlation coefficient showed significant correlations between RT and MMSE (r=-0.73, p<0.01) and RT and TUG (r=0.58, p<0.05). In contrast, the correlation between RT and gait speed (r=-0.39) and RT and BBS (r=-0.49) were not found to be significant. **CONCLUSIONS:** Slower head reorientation during reactive turning was correlated with lower cognitive function (measured with MMSE). Regarding motor function, only TUG was positively correlated with reaction time. These findings suggest that reactive turning could be slowed with delayed motor preparation and/or impaired motor planning involving turning, rather than by functions of gait or balance. **ACKNOWLEDGEMENTS AND FUNDING:** This study was supported by a Grants-in-Aid for Scientific Research (KAKENHI) under Grant 18K10681.

P2-H-66 Feedforward and feedback control components in the generation of automatic postural responses

Nametala Azzi¹, Julia Oliveira¹, Daniel Coelho¹, Luis Teixeira¹

¹University of São Paulo

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BACKGROUND AND AIM: Automatic postural responses (APR) are optimized over repeated stance perturbations, leading to more stable recovery of balance stability. This feature suggests that pure reactive responses are generated not only on the basis of online feedback signaling current balance loss, but also feedforward control based on previous postural responses to that particular perturbation. To investigate the extent to which feedback and feedforward components interact in APRs, we conducted an experiment aiming to evaluate the effect of similar versus different magnitudes of previous stance perturbations on different parameters of the current postural response. **METHODS:** Eighteen healthy participants (mean age = 22.72 years) were tested on a perturbed-balance task, consisting of unanticipated release of a load pulling their trunk backwards, leading to fast forward body sway. Three perturbation loads were employed to provoke stance perturbations: 6%, 8% and 10% of participants' body weight. Evaluation was made on eight trials for each load through ground reaction forces, kinematics of body displacement and EMG of the muscle gastrocnemius medialis. Participants were assigned to two groups, differing in the sequence of loads: increasing sequence (INC), having progressive increment of load magnitude (6% toward 10%); and decreasing sequence (DEC), having progressive decrement of load magnitude (10% toward 6%). RESULTS: Analysis showed that APRs were scaled to load magnitude from the first trial with each load. Results for center of mass peak displacement indicated that in the 10% load, but not in the others, the DEC group presented higher values than the INC group; for this load we found also decreased values over repeated perturbations for both groups. Analysis of CoP peak displacement indicated higher values for the DEC in comparison to the INC group across loads and trials. EMG analysis revealed a descriptive trend toward higher muscular activation magnitude and slope for the DEC in comparison to the INC group, but no significant between-group differences were found. CONCLUSIONS: Our results lead to the



following **CONCLUSIONS:** (a) APRs are scaled through online feedback to the current perturbation magnitude, and (b) APRs are modulated by immediate previous responses to perturbations of the same or dissimilar magnitude. **ACKNOWLEDGEMENTS AND FUNDING:** Coordination for the Improvement of Higher Education Personnel (CAPES).

P2-H-67 Postural reactions and spinal excitability modulation during balance perturbation following incomplete spinal cord injury

Charlotte Pion¹, Mélissa St-Pierre Bolduc², Zoé Miranda², Maureen MacMahon³, Dorothy Barthélemy²

¹Université du Québec à Montréal, ²Université de Montréal, ³CIUSSS Centre-Sud-de-l'île-de-Montréal

BACKGROUND AND AIM: Individuals with incomplete spinal cord injury (iSCI) show altered postural reactions leading to an increased risk of fall. To gain more insights into impaired neuronal mechanisms associated to balance deficits, changes in the amplitude of the Soleus (SOL) H-reflex during balance perturbation were assessed in individuals with iSCI. METHODS: Ten iSCI men [at least 1-year post lesion; injury above L1; ASIA D] were standing on a platform (EquiTest®). Perturbations were induced by randomized forward and backward platform tilts (8°, 20°/s). The excursion of the center of pressure (CoP) and 95% confidence ellipse area were analyzed and electromyographic (EMG) activity of SOL and Tibialis Anterior (TA) muscles were recorded. Amplitude of the SOL H-reflex was assessed by stimulating the posterior tibial nerve at different delays prior to (pre) and following the onset of the perturbations (100, 150, 200 ms). These results were then compared to control participants (CTRL; n=4). RESULTS: Confidence ellipse area was larger in the iSCI group compared to the CTRL group during backward (iSCI: 56.45±16.88cm2 vs. CTRL: 17.98±3.43cm2; p=0.073) and forward tilts (iSCI: 26.88±2.45cm2 vs. CTRL: 15.83±0.72cm2; p=0.048). No significant difference was observed between groups in the excursion of CoP. EMG activity was also compared between both groups. In SOL, the latencies of EMG responses observed in backward and forward tilts were similar between both groups for short latency (iSCI: 48.93±2.21ms vs. CTRL: 50.09±2.39ms; p=0.86) as well as for long latency responses (iSCI: 150.81±17.54ms vs. CTRL: 130.77±12.40ms; p=0.94). In TA, the latency of the short latency response observed in backward tilt was similar in both groups, but the latency of the long latency response was greater in the iSCI group during backward tilt (iSCI: 184.23±10.90ms vs. CTRL: 122.63±6.50ms; p=0.004). No significant difference was observed between groups during forward tilt. Modulation of the SOL H-reflex amplitude also differed between groups. During backward tilt a decrease in SOL H-reflex amplitude (expressed in percentage of H pre) was observed in both groups but was greater in CTRL at 100ms (16.34±4.73%), 150ms (10.61±2.16%) and 200ms (14.45±6.75%) compared to iSCI at 100ms (98.93±7.55%; p=0.002), 150ms (80.67±10.03%; p=0.006) and 200ms (79.11±8.93%; p=0.004). Furthermore, onset of inhibition of the SOL H-reflex occurred at an earlier delay in CTRL (100 ms) compared to iSCI (150 ms). During

forward tilt, an increase in H-reflex amplitude was observed in all participants, and no significant difference was observed in the amplitude or latency of the facilitation between groups. **CONCLUSION:** Data demonstrate that modulation of SOL H-reflex excitability following balance perturbation is significantly decreased and delayed in incomplete SCI individuals during backward perturbation. Impaired excitability modulation could contribute to the altered postural reactions observed after iSCI.

P2-H-68 The effects of cognitive interference on gait and turning in Huntington's disease

Nicollette Purcell¹, Jennifer Goldman¹, Bryan Bernard¹, Joan O'Keefe¹

¹Rush University Medical Center

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BACKGROUND AND AIM: Huntington's disease (HD) is characterized by a triad of symptoms: motor dysfunction (chorea), cognitive impairment, and neuropsychological disturbances. The progression of HD leads to a loss of automaticity, such that previously automatic tasks, such as ambulation, require more attentional resources. Dual-task (DT) paradigms may stress the locomotor system and reveal or exacerbate gait deficits not seen under single-task (ST) conditions. However, the extent to which dual-tasking affects specific gait domains in HD has not been thoroughly researched. Therefore, the aims of this study were to determine 1) how cognitive dual-tasking during ambulation impacts spatiotemporal aspects of gait and turning and 2) the impact of DT on retrospective falls in HD and 3) whether gait measures from wearable inertial sensors are sensitive to motor symptoms and their severity in patients with HD. METHODS: Seventeen HD participants (55 +/- 9.7 years), with UHDRS-TMS ranging from 7-39, and 17 agematched controls (56.5 +/- 9.3 years) underwent quantitative gait testing via a 25 meter, two minute walk test (2MWT) with APDM Opal inertial sensors. Gait was assessed under a ST, selfselected pace and during a verbal fluency DT, which was Animal Naming. The Unified Huntington's disease Rating Scale-total motor scores (UHDRS-TMS) was administered by a movement disorder specialist (JGG) and self-reported retrospective fall history within the past 12 months was recorded. **RESULTS:** During the ST trials, HD participants demonstrated significantly slower gait speed (p = 0.034) and shorter stride length (p = 0.026), as well as greater lateral step (p < 0.0001) and stride length (p = 0.0004) variability compared to controls. In the DT trials, individuals with HD also exhibited the same gait deficits as in the ST trials: significantly slower gait speed (p = 0.004), shorter stride length (p=0.005), increase in lateral step (p < 0.0001) and stride length (p < 0.0001) variability, compared to controls. Significant dual-task cost [DTC = (DT-ST/ST)*100)] was observed during turns; with HD participants taking more time (p = 0.013) and a greater number of steps to complete a turn (p = 0.028) while dual-tasking compared to controls. Higher UHDRS-TMS correlated to greater stride length variability under both ST and DT conditions (p = 0.008). Unexpectedly, the number of participant's falls self-reported in the past year did not correlate with any gait parameters under the ST or DT conditions. CONCLUSION: HD participants demonstrated significantly greater DTC for turning. Turning is a less automatic motion than

straight walking requiring dynamic coordination of the body and anticipatory control mechanisms. The complexity of turning may make it more susceptible to the negative effects of DT cognitive interference in HD. Furthermore, wearable inertial sensors show promise as a practical means to

provide clinically meaningful motor outcome measures in clinical trials.

P2-H-69 Sensory contributions to head and lumbar sway in healthy individuals and those

objectively assess gait deficits and disease severity in a clinical and research setting and to

with mild traumatic brain injury

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Tiphanie Raffegeau¹, Mindie Clark¹, Lucy Parrington², Robert Peterka², James Chesnutt², Laurie King², Peter Fino¹

¹University of Utah, ²Oregon Health & Science University

BACKGROUND AND AIM: Balance deficits are a common clinical sign following mild traumatic brain injury (mTBI). Balance control involves the integration of visual, vestibular, and proprioceptive sensory information to control the motion of the center of mass (CoM). However, sensory information does not directly encode CoM motion; e.g., visual and vestibular information assess head motion. Thus head stability may be critical for balance when visual or vestibular information is important. Postural stability deficits and abnormal sensory integration in people with mTBI may manifest in different sway at the head. The purpose of this study was to address two primary questions: do individuals with mTBI exhibit greater sway at the CoM and head compared to controls, and is the relationship between sway at the head and CoM different between those with mTBI and controls. METHODS: Forty-two individuals with chronic (>3 months) balance complaints after a clinically diagnosed mTBI [28 females, mean(SD) 38 (2) years] and 54 healthy controls [31 females, mean (SD) 28 (4) years] participated in the study after providing consent. Subjects wore two inertial sensors (APDM Inc.) on the lumbar spine (approximate CoM) and across the forehead. Participants completed four balance tasks for 60 seconds each: (1) standing on firm ground with eyes open (EO-Firm), (2) and eyes closed (EC-Firm), (3) standing on foam surface with eyes open (EO-Foam), (4) and eyes closed (EC-Foam). The root mean square (RMS) of acceleration in AP and ML directions was calculated for the head and lumbar sensors. The ratios of head to lumbar sway were calculated in each direction for all conditions and normalized to body height. Linear mixed models assessed the effect of group, condition, and the group x condition interaction using a = 0.05. **RESULTS:** Subjects with mTBI exhibited greater sway at both the head and lumbar for all conditions and directions (p<0.05). Compared to baseline sway levels on the EO-Firm task, subjects with mTBI had larger AP and ML head sway than controls on all other conditions (p<0.03), and larger AP and ML lumbar sway during EC conditions (p<0.03). The ratio of head-to-lumbar AP sway did not differ between groups or conditions. However, the ML head-to-lumbar sway ratio was smaller in the Foam conditions compared to EO-Firm (p < 0.001), but this ratio was larger in subjects with mTBI than in controls, particularly in the EC-Foam condition (p<0.04). CONCLUSIONS: People with mTBI exhibit greater postural sway at the head

and CoM, particularly when vision is removed. When relying on head-related sensory information (foam conditions), control subjects reduced the relative head-to-lumbar ML motion more than those with mTBI. The higher relative head motion in mTBIs than controls may indicate that subjects with mTBI exhibit abnormal sensory integration and balance strategies that impair head stabilization, particularly when accurate proprioception is compromised.

P2-H-70 Bridging the callosal gap in gait: A mechanistic evaluation of white matter's role in bilateral coordination

Sutton Richmond¹, Clayton Swanson¹, Tyler Whittier¹, Daniel Peterson², Brett Fling¹

¹Colorado State University, ²Arizona State University

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BACKGROUND AND AIM: An essential part of mobility is bilateral coordination of the legs during locomotion. In the lower extremities, coordinated patterns produce locomotive actions with each leg operating in its own spatial and temporal pattern. The corpus callosum, the anatomical structure bridging the two hemispheres of the brain, is integral for the coordination of such complex, coordinated movements. Both coordinated movement and corpus callosum structural integrity are substantially compromised in persons with multiple sclerosis (PwMS). Thus, this aim of this project was to assess MRI-derived measures of transcallosal sensorimotor fiber tract microstructural integrity (via diffusion imaging) and identify the relation to gait coordination using novel methods of ecologically-valid mobility assessments in PwMS and age and gender-matched neurotypical adults. METHODS: Neurotypical adults (1 male and 6 females; 44 ± 18 years) and PwMS (3 males and 12 females; 52 ± 12 years) underwent three, two-minute walks at a selfselected pace, fast pace, and while dual-tasking. Lower limb asymmetries were quantified via the Phase Coordination Index (PCI), a comprehensive metric to evaluate bipedal coordination by assessing both the accuracy and consistency of phase generation in locomotion. White matter microstructural integrity of transcallosal tracts connecting homologous regions of the sensorimotor cortices was evaluated with diffusion tensor imaging. Radial diffusivity, an indirect marker of myelination, was utilized as the primary outcome. **RESULTS:** In our current sample, we report no significant main effect for condition (p = 0.556) or group (p = 0.109) with regards to PCI, nor a significant group by condition (p = 0.846) interaction. For transcallosal sensorimotor fiber tract microstructural integrity, we report a significant main effect for fiber tract (p<0.001) and for group (p = 0.013), as well as a group by tract interaction (p = 0.017). Although not significant, PCI during self-selected walking was correlated with quality of fiber tracts connecting the primary motor cortices (r = 0.39; p = 0.076). Furthermore, PCI during dual-task walking was correlated with quality of fiber tracts connecting the supplementary motor areas (SMA; r = 0.4; p = 0.065) and pre-SMA (r = 0.37; p = 0.088). CONCLUSIONS: In this preliminary analysis of an ongoing data collection, results indicate that PwMS have increased impairment of bilateral coordination during over-ground walking and poorer transcallosal white matter microstructural integrity in comparison to an age and gender matched neurotypical cohort. Further, transcallosal fiber tract integrity

between the primary motor cortices may be associated with gait coordination during typical walking, whereas transcallosal fiber tract integrity between higher order motor regions like the pre-SMA and SMA appear to be associated with gait coordination during a cognitively challenging walking task (i.e. dual tasking). **ACKNOWLEDGEMENTS AND FUNDING:** David Mahoney Neuroimaging Grant, The Dana Foundation. Title: 'Two legs, on brain: Transcallosal communication as a marker of asymmetric function and target for gait rehabilitation in people with multiple sclerosis' PI: Dr. Brett Fling.

P2-H-71 The contribution of intralimb kinetic coordination in lower limb to control of propulsion and weight support at a wide range of gait speed in young and elderly people

Yusuke Sekiguchi¹, Dai Owaki¹, Keita Honda¹, Shin-Ichi Izumi¹

¹Tohoku University

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BACKGROUND AND AIM: In general, aging as well as gait speed affects kinetic pattern of three joints in lower limb in gait. However, it has not been clear how the change of the kinetic pattern has effects on the important tasks i.e. generating propulsion and supporting weigh. A previous study examined the principal components (PCs) of the sagittal kinetic variables in the lower limb during gait in healthy controls and defined intralimb kinetic coordination as inner joint coordination based on kinetic variables. Moreover, the analysis of the PCs could identify the tasks exhibited by intralimb kinetic coordination. The objective of the present study was to investigate the effects of aging on the PCs of the sagittal kinetic variables and the changes in that at a wide range of gait speed. . METHODS: We recruited 6 healthy young (YP) and 7 elderly people (EP). The 3dimensional (3-D) coordinates of 48 reflective markers attached to the subjects were measured with a 3-D motion analysis system operating at 120 Hz and force plates as the subjects walked along a 7-meter walkway at a range of speeds (0.3, 0.6, 1.0, 1.3, and 1.6 m/s). The over-time series of PCs of three joint moments in lower limb was calculated using PC analysis. We tested for main effects of speed and age on PCA-related parameters using two one-way repeated measures analyses of variance. **RESULTS:** The average values of the loadings of ankle and hip joint moments for the first PC and that of knee joint moment for the second PC were more than 0.55 in all conditions in both the groups. In the EP, the percentage of variance of the first PC was significantly lower (p < 0.05) and the peak timing of the first PC in stance phase was earlier than that in the YP (p < 0.01). On the other hand, the percentage of variance of the second PC in the EP was significantly larger compared to that in the YP (p < 0.05). There were significant main effects of gait speed on the percentage of the variance of the first and second PCs (p < 0.05) and the peak timing of the first PC (p < 0.05). As the gait speed increased, the percentage of variance of the first PC decreased although the percent of variance of the second PC increased. Moreover, the peak timing of the first PC was later as the gait speed increased. **CONCLUSION:** The results of the loadings and the time series data (Fig.) of the first and second PCs indicated that intralimb kinetic coordination may play the first role in generating propulsion and the second role in



supporting weight. As the gait speed increases, decrease of the variance and the later peak timing of the first PC demonstrated that the timing of propulsion control exhibited by kinetic coordination may play an important role in generating propulsion. In elderly people, the earlier peak timing of the first PC may cause difficulty in generating propulsion as the gait speed increases.

P2-H-72 Postural balance at children survived after posterior fossa tumor, acute lymphoblastic leukemia and hematopoietic stem cell transplantation

Dmitry Skvortsov¹, Alexey Parshikov², Daria Zhuk², Vlad Nikulin², Serafima Chechelnitskaya², Vladimir Kasatkin³, Alexander Karelin³

¹Pirogov's Medical University of Moscow, ²Rehabilitation center "Russcoe Pole", ³Dmitry Rogachev National Research Center of Pediatric Hematology, Oncology and Immunology

The postural balance at oncology survived children with Posterior Fossa Tumor (PFT), Acute lymphoblastic leukemia (ALL), Hematopoietic stem cell transplantation (HSCT) is remaining unclear. We used Stabilan-01-2® stabilometric platform. The participants were instructed to stand straight with heels together and toes apart (Europe standard position). The participants completed the Romberg test (barefoot) with eyes open (EO) and eyes closed (EC) on the platform, EO on a foam placed on the platform and EO with artificial grass placed on the platform. Each trial takes 30 sec. The parameters of the sway path were measured: average amplitude of frontal and sagittal oscillation, surface of the sway path, average velocity of the center of pressure (CP) and 60% of power of oscillation spectrum of frequency by Fourier transform for each direction - sagittal and frontal. The following groups participated in the trial: 32 PFT survivors (12 females, 20 males, mean age was 13 ± 0.5); ALL - (40 females, 48 males, mean age 10.8 ± 0.4); HSCT - (14 females, 31 males, mean age 11.5 ± 0.6) and 35 healthy controls (19 females, 19 males; mean age was 10.9 ± 0.4.) The control group has only significant difference for EO and EC by the increasing average speed CP for sagittal plane. All patient's groups have similar and statistically significant difference to control group. For EO position oscillation at frontal plane are increased, surface of the sway path also higher for ALL and HSCT group and power of Fourier transform spectrum more for sagittal plane for group PFT. For EC position found higher amplitude of oscillation at frontal plane at PFT group. At the same time power of oscillation significantly lower the control group for all three groups of patients. EO position has difference from EC at patient's groups by significant increasing velocity of CP. The first point in this research is that healthy children at average age of 10 years old do not use visual input for balance as it known for adults. The second point is all three groups have similar abnormalities in spite of different diagnosis. They are having no statistically significant difference between each other by stabilometric parameters. Possibly it is result common parts of conventional therapy. By the cluster analysis we found at the whole number of patients two significant groups. The first - 104 patients have no statistical difference to control group. The second - 46 patients who had higher average speed of CP and surface of the sway path for EO position. Therefore, all three groups have decreasing balance at upright position.

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But, the physiological basis of balance is the same as for normal children. We did not get any functional difference between groups of patients. So, it is no clinically specific abnormality. Two-thirds of patients at the investigated period have no postural disturbances detected by stabilometry method.

P2-H-73 Tandem Walking Test kinematics - a normal data

Dmitry Skvortsov¹, Alina Aisenshtein², Vladimir Kasatkin³, Anatoliy Shipilov²

¹Pirogov's Medical University of Moscow, ²Rehabilitation center "Russcoe Pole", ³Dmitry Rogachev National Research Center of Pediatric Hematology, Oncology and Immunology

Tandem Walking test (TW) is the procedure widely used for screening patients suspected of having vestibular and neurologic impairments. There are various versions of tandem walking test. Most commonly used measures of TW performance are number of steps taken and time of walking task performed. Biomechanics data about angular and linear characteristics of lower limb motion may improve validity and reliability of TW and help to determine the diagnosis. Unfortunately, there is no data about normal joint kinematics of lower limbs during TW. 15 healthy adults 4 males and 11 females took part in our research. Optical motion capture system of ten cameras (Qualisys, Sweden) was used to collect kinematic data. A set of 26 reflective markers were placed on anatomical landmarks of subject's body to identify kinematics of 7 segments: pelvis, right thigh, right shank, right foot, left thigh, left shank, left foot. "Visual 3D" software was used to calculate angular kinematics of hip and knee joints as well as angular and linear characteristics of pelvis segment motion within full gate cycle for both left and right legs. Subjects were asked to walk 4,5 meters, heel-to-toe, along the straight line marked on the floor. Subjects were tested with eyes open condition. All data are calculated with respect of walking cycle (WC). The first and last WC did not include to calculation. The 3D data of pelvis rotation, hip and knee joint were taken into consideration. The ankle joint was excluded as a slave from hip and knee joints in this test. The flexion-extension graphs are close to that for normal walking. However, amplitudes and phases are slightly modified. All motions have a good symmetry between right and left side. Adductionabduction movements are remains almost the same for hip joint and do not exist for knee joint. Rotation movements expressed, generally, only at swing phase. The pelvis movements are shown pattern close to normal walking. The time of WC was for left and right side 2.4 ± 0.5 c. Pelvis movement at vertical and frontal plane has two extremums consequently the single support phase with higher degree of symmetry between left and right side. The same regularity shown pelvis rotation at sagittal and transversal plane. Rotation at frontal plane has maximum at and of stance phase. The graphs of flexion-extension for hip and knee joints are shown symmetrical function, modified by task. It was not the first flexion of the knee joint at the beginning of the stance phase. The hip joint also shown high amplitude of flexion and extension at the last half of swing phase. Due to we could not to find out at published papers the kinematic data for this test it should be





impossible to compare our findings with any another. However, the TW is modified of normal walking. In this, reason to helpful to use the model and report existing for this matter.

P2-H-74 Postural adaptations in response to haptic forces during self-paced treadmill walking post-stroke

Gianluca Sorrento¹, Philippe Archambault², Joyce Fung²

¹Jewish Rehabilitation Hospital (CISSS-Laval), ²McGill University

BACKGROUND: We previously reported that spatiotemporal gait adaptation and post-adaptation effects in healthy young, elderly, and post-stroke individuals can be prompted by robot-powered tensile forces applied to the hand when walking on a self-paced treadmill in a virtual environment (VE) (Sorrento et al., 2018). The present study focuses on the evaluation of lower limb segment coordination during the gait adaptation and post-adaptation processes. Our objective was to investigate the extent of lower limb kinematic and kinetic changes when either 10 or 15N forces are applied and subsequently removed, compared to baseline or instrumented cane walking (Perez & Fung, 2011). METHODS: Fourteen post-stroke participants were stratified into lower functioning (LF, n=7, 70.4 \pm 3.3 y.o., 0.6 \pm 0.2 m/s overground gait speed) and higher functioning (HF, n=7, 70.9 ± 2.9 y.o., 1.0 ± 0.3 m/s). The control group included 14 age-matched healthy subjects (71.8 ± 2.7 y.o., 1.3 ± 0.2 m/s). They walked on a self-paced treadmill in a VE with either a robotically controlled haptic leash or instrumented cane. Leash trials consisted of pre-force, 10 or 15N force (onset at ~30 seconds), and post-force (offset at ~90 seconds) epochs. An innovative 3D phase diagram approach was developed to investigate the dynamical changes in segmental coordination and momentum. The position of the thigh, leg, and foot segments were recorded relative to the neutral standing position. Their 3D coordinates were then plotted to illustrate angular displacement throughout the average gait cycle. The corresponding angular velocity values were expressed orthogonally to the angular displacement traces (see Figure). **RESULTS**: The LF group showed an average angular position change of 9.1° in dorsiflexion of the foot segment and 8.6° in flexion for the thigh segment during the 10N force epoch compared to the pre-force for the paretic limb. This coordination pattern was preserved for the foot (p<0.05) and thigh segments, even after the force was removed. A similar coordination pattern change was seen in the HF group. In contrast, the control group showed little change relative to pre-force levels. Cane walking brought mixed results for the post-stroke groups, while the control group on average decreased angular position of limb segments. Additionally, the post-stroke groups increased bilateral angular momentum during leash walking for force (10N, p<0.05) and postforce (15N, p<0.05) epochs and cane walking, when compared to pre-force levels. The control group also increased angular momentum. The phase diagrams of an HF participant (shown in the figure) depict increases in primarily foot and thigh segments in the post-force trace relative to the pre-force. Angular momentum was also increased, most notably during the swing phase. CONCLUSIONS: Adaptive and post-adaptive changes in coordination occur in both paretic and

non-paretic lower limbs when haptic forces are present and released, respectively, during selfpaced treadmill walking post-stroke. Specifically, the increases in dorsiflexion, thigh flexion and angular momentum can potentially favour functionally beneficial postural adaptations for gait rehabilitation.

P2-H-75 The role of vision in backward walking in patients with stroke

Meng Ru Tsai¹, Pei-Yun Lee², Nai-Hua Kuo¹, Chih-Hung Chen¹, Sang-I Lin¹, Pei-Yun Lee²

¹National Cheng Kung University, ²National Taiwan University Hospital Bei-Hu Branch

BACKGROUND AND AIM: Vision plays an important role in locomotion to maintain dynamic stability. During forward walking, vision provides information of the environment to adjust gait and plan the heading route. Not only forward walking but also backward walking requires the information about the environment from vision. Backward walking has recently been used as a training program for patients with stroke to improve gait performance. During backward walking the environment information of the heading direction is lacking and the optic flow is in the reverse direction than forward walking. Considering that stroke patients often rely more on vision when they are in motion, it is not clear how the visual information would influence backward walking. This study aimed to investigate the influence of partial deprivation visual information on backward walking in patients with stroke. METHODS: Twenty-nine stroke patients (61.72±10.5 years) were recruited in this study, of which 14 were right-affected. The patients were asked to walk backward on an eight-meter walkway with two visual conditions: 1) normal vision (NBW), and 2) wearing a pair of blurry goggles (GBW). SIMI MOTION analysis system with eight cameras was used to record three-dimensional positions of the reflective markers attached on bilateral heels and first metatarsal heads. Spatiotemporal gait parameters of the affected leg, containing gait velocity, stride length, stride time and duration of the stance and swing phase, were calculated from the positions of the markers. Paired t test was used to compare differences between the two visual conditions. Significance level was set at p < 0.05. **RESULTS:** The stride time was significantly shorter in GBW than NBW (p=0.034). No significant difference between the two visual conditions was found in other gait parameters, including gait velocity, stride length and duration of stance and swing phase. However, there was a trend showing longer stride length, faster gait velocity, and longer duration of the swing phase in GBW than NBW. CONCLUSIONS: Surprisingly, the stroke patients did not significantly change their backward walking gait performance when the vision was partially deprived. The results might indicate that the stroke patients possibly rely less on their vision during backward walking. Although vision can provide information of the front during backward walking, lack of information of the heading direction, swing limb trajectory, and foot positions can be difficult for the patients to adjust gait. Furthermore, the stroke patients showed slightly better gait performance when walking backward with blurry goggles than normal vision. The stroke patients might be able to concentrate more on walking and perform better, when they could not have a clear image of the environment during backward walking.



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P2-H-76 Fluctuation of center of pressure and the affecting factors in young children

Naomi Tsugita¹, Syuhei Kobayashi¹, Shino Ogawa¹, Taiko Shiwa¹, Yasuko Funabiki¹

¹Kyoto University

BACKGROUND AND AIM: The human body sways finely and spontaneously while he is standing quietly. It is suggested that human can deal with perturbation because the spontaneous and fine sway has the fractal behavior. The nervous system required for posture control develops in early childhood. Therefore, in order to understand the background mechanism of posture control system, it is necessary to investigate the fluctuation in the posture control system of young children when the development of the nervous system is remarkable. The aims of this study are to examine the dynamic and static fluctuation of the center of pressure in young children and to examine the relationships between each fluctuation and physical and developmental characteristics respectively. METHODS: Each of 14 people of 3-year-olds stood on the Balance Wii Board in a resting position for 70 seconds with his or her eyes open, while we acquired the center position of foot pressure. Fractal index (Alpha) was calculated from the acquired data using Detrended Fluctuation Analysis and used as an evaluation index of dynamic fluctuation. The evaluation index of static fluctuation was calculated as Coefficient Variability (CV). In addition, in order to grasp the attributes of the young children, we first explored relationships of the fluctuations with How to give birth, Gestational age, Head girth, Apgar score (1 min, 5 min) and each time about Head up, Sit up, Rolled over, Pulls oneself up, Crawls, Cruising and The first step. Also, we investigated relations with scores of fine motor and gross motor on the Bayley-III and the Multi-dimensional Scale for PDD and ADHD (MSPA). RESULTS: Neither the Alpha nor the CV had any significant differences between directions of Front-Back (F-B) and Right-Left (R-L). In R-L direction, the Alpha had significant correlations with Gestational age (r=.618, p<.05) and Head girth (r=.588, p<.05), and the CV had significant negative correlations with Gestational age (r=-.584, p<.05) and Head girth (r=-.675, p<.05). Besides, we found a significant negative correlation between the Alpha in R-L direction and Height at the age of three (r=-.606, p<.05), and a significant correlation between the Alpha in F-B direction and hyperactivity scores on the MSPA (r=.574, p<.05). On the other hand, the CV in R-L direction had a significant negative correlation with Birth physique (Height Birth: r=-.573, p<.05; Weight Birth: r=-.574, p<.05). And the CV in both directions significantly correlated with impulsivity scores on the MSPA (R-L: r=.646, p<.05; F-B: r=.575, p<.05). CONCLUSIONS: The present study showed that spontaneous sway during quiet standing in young children was affected by other fluctuation factors. Physical characteristics might relate to the fluctuation in R-L direction and features of developmental disorder to that in F-B direction both on dynamic and static fluctuations. We need to continue exploring in detail what kind of elements of each factor influence to fluctuation.



P2-H-77 Age-related changes in reactive arm responses following support surface perturbations

David Shulman¹, Jaykob Price¹, Lori Ann Vallis¹

¹University of Guelph

BACKGROUND AND AIM: Older adults (OA) exhibit increased difficulty in recovering balance following an unexpected perturbation (pert). Previous research has mainly focused on lower limb responses [McIlroy & Maki, Age & Aging 2006; McIntosh et al, J Motor Behav 2017], with only a few research groups considering the upper limb [Marigold et al, J Neurophys, 2003]. OA move their arms in the direction of the pert, whereas younger adults (YA) move their arms in the opposite direction to maintain the center of mass within the base of support [Cham & Sandrian, Proc Hum Factors Ergon Soc 2007]. Given the degrees of freedom associated with the upper limb, we are proposing a method for quantifying the direction and angular velocity of these arm responses during a goal-oriented locomotor task. By dividing the upper and forearm segments into frontal and sagittal components we describe control and coordination of responses in young and OA following a support surface pert coupled with a gait initiation (GI) task. METHODS: A total of 18 YA and 16 OA (>65) performed 35 randomized trials; 6 left, 4 right, 4 forward, 6 backwards (catch trials) and 15 no pert. Kinematic markers tracked body segmental motion (100 Hz, Optitrack). Gait was initiated from quiet stance on force plates (AMTI; 1000Hz) mounted on a robotic platform. In certain trials, pert of the support surface (18 cm, 60 cm/s, 2 m/s2) were triggered in the mediolateral (ML) direction during initiation (vertical force of 104% body weight) and in the anteriorposterior direction at heel contact (15% body weight). Arm responses were quantified [adapted from Inkol et al, J Mot Behav 2018]. At the discrete event of peak elevation velocity (wpeak) the magnitude was resolved into sagittal (ωS) and frontal (ωF) components for the L/R Upper Arm (L/RUA) and Forearm (L/RFA). Multivariate ANOVA was conducted using SPSS. RESULTS: No interaction effects were observed, however main effects of Age were present. Our results demonstrated that OA increased the magnitude and not the direction of the response. We did not observe an arm countermovement in either population. Following forward perts, we observed significantly faster LFA ω F in the OA (p<0.01; OA = 4.9±2.7, YA = 2.4±2.4 deg/sec), and LFA ω S (p<0.02; OA = 0.7 ± 0.1 , YA = 0.05 ± 0.1 deg/sec). Following left pert all angular velocities (ω F and ω S) for both the L/R UA/FA were significantly different (p<0.05). And in the right pert trials, a difficult cross-over step was evoked and age-related differences were noted for LFA; ωF (p<0.01; $OA = 4.6\pm2.2$, $YA = 3.4\pm2.1$ deg/sec) ωS (p<0.05; $OA = 0.1\pm0.06$, $YA = 0.08\pm0.06$ deg/sec). CONCLUSIONS: Our work shows age-related changes in the arm responses critical for the recovery of balance when coupled with a challenging GI task. This task may be more 'destabilizing' requiring a larger whole-body response. We will continue to examine the associated mechanisms driving these responses to inform future research and intervention paradigms aimed to reduce falls.



P2-H-78 Exploring the interaction between motor competence and dual task walking in adolescents

Benjamin Weedon¹, Patrick Esser¹, Johnny Collett¹, Hooshang Izadi¹, Shawn Joshi¹, Andy Meaney¹, Anne Delextrat¹, Helen Dawes¹

¹Oxford Brookes University

BACKGROUND AND AIMS: Motor competence (MC) is an important factor in the development of health, fitness, physical activity and may be reflected in walking control. This study aims to explore the spatial-temporal (S-T) gait parameters in a single task (STW) and dual task walking (DTW), between adolescents with low MC and typically developed MC (TD). METHOD: MC was assessed in 13-14 year olds, attending three mainstream schools in Oxfordshire using the Movement Assessment Battery for Children 2nd edition (MABC2). With low MC defined by the MABC2 as <16th and TD \geq 16th percentile total score. Normalised S-T walking parameters (walking speed, cadence, stride length and walk ratio) were measured by an inertial measurement unit, placed over the centre of mass during a 10m STW and DTW. Differences between low MC and TD adolescents and the effect of dual task walking were evaluated in a 2x2 (MC x Dual Task) ANOVA with repeated measures. Post-hoc t-tests were used to examine the interaction effect in more detail. **RESULTS:** 204 boys (Low MC = 67) and 161 girls (Low MC = 58) were assessed. There was no significant interaction between MC group and the effects of DTW for any S-T parameters for boys and girls. There was an adverse main effect of DTW on all S-T parameter for boys and girls, but no main effect of MC group on any S-T parameters for boys. Girls showed a significant main effect of MC group for stride length (F 5.779, p = 0.017), which was longer in the Low MC (1.7 \pm 0.2au) compared to the TD group (1.6 \pm 0.1au) for STW (p = 0.046). **CONCLUSION:** Results suggest that both low MC and TD adolescents are adversely affected by DTW. There were minimal differences between low MC and TD suggesting low MC may not be reflected in S-T parameters when performing STW and DTW in this age group. ACKNOWLEDGEMENTS AND FUNDING: We would like to acknowledge the three schools who took part in this study Cheney School, Cherwell School and Wheatley Park School, with a special thank you to the physical education departments. This study was part of a clinical trial (ClinicalTrials.gov Identifier: NCT03150784) and was funded by Action Medical Research for children, Chartered Society for Physiotherapy (CSP), CLEAR Trust and the Lottery.

P2-H-79 Mechanical consequences of trunk flexion on slopes during human walking

Amy Wu¹, Salman Faraji², Christopher Easthope³, Auke Ijspeert²

¹Queen's University, ²Ecole Polytechnique Fédérale de Lausanne (EPFL), ³University Hospital Balgrist





BACKGROUND AND AIM: The human upper body requires balancing during gait but may serve to ease some costs of walking. Greater trunk flexion requires more positive hip work (Kluger et al., 2014). Yet humans prefer a trunk flexion angle that increases with steeper slopes (Leroux et al., 2002). Here we investigate what mechanical benefits could be gained from trunk flexion while walking on three different slopes. Uphill walking requires greater ankle extensor moments, and downhill walking requires greater knee extensor moments (Lay et al., 2006). We hypothesize that greater trunk flexion would lead to increased effort at the hip but would mitigate ankle and knee costs for non-zero slopes. METHODS: We measured healthy, adult subjects (N=12, 8 male, 4 female, 23 to 47 years of age) walking on a treadmill at 1.2 m/s with varying ground slopes and trunk angles. The slopes tested were -8 deg (downhill), 0 deg (flat), and 8 deg (uphill). Subjects walked with self-selected and imposed trunk flexion angles. These angles, defined relative to gravity, of 0 deg and 30 deg (all slopes), 50 deg (flat), and -15 deg (downhill) were imposed by real-time visual feedback. We measured kinematics and kinetics with a motion capture and instrumented treadmill system (Motekforce Link, Amsterdam, Netherlands) and obtained lowerlimb joint torques from inverse dynamics to calculate work rates. We performed linear fits of all subject data (trend significant if p<0.05). For downhill walking, separate fits were performed on trunk flexion and extension. All subjects provided written informed consent according to Institutional Review Board procedures. RESULTS: We found that trunk flexion did increase hip work rate while decreasing ankle work and knee extensor moment but at the greatest rate for uphill walking. For each slope, the mean preferred trunk angle was 6.5 deg (downhill), 7.9 deg (flat), and 14.3 deg (uphill) on average. Greater trunk flexion resulted in higher positive hip joint work rates at 1.5 and four times greater rates for uphill than for flat and downhill, respectively. This was accompanied by a decrease in positive ankle joint work with the uphill rate at five times that of flat walking. Peak knee extensor moment also decreased with trunk flexion, at 4.5 times higher rate for uphill than for downhill. For comparison, trunk extension increased hip work rate by 1.5 times and ankle work rate by 2.6 times the flexion hip rate. **CONCLUSIONS:** Subjects preferred some trunk flexion, inducing greater work at the hip while gaining decreased effort at the ankle and knee. This could be relevant to the reported distal-to-proximal shift in joint contributions for aging adults (DeVita and Hortobagyi, 2000). Although trunk flexion is highly penalized during uphill walking, subjects favored lowering load at the distal joints. In contrast, when downhill, trunk flexion is penalized to a much lesser degree, yet the preferred angle is halved. As trunk extension seems more disadvantageous than beneficial, the motivations for a smaller trunk flexion angle are unclear. Further investigations will include negative work and comparisons with 3LP, a mechanical walking model (Faraji and Ijspeert, 2017). ACKNOWLEDGEMENTS AND FUNDING: RoboCom++, Swiss Center for Movement Analysis.

I - Development of posture and gait

P2-I-81 Characteristics of postural adjustments in sitting reach task in adults with cerebral palsy.



Yui Sato¹, Hideyuki Tashiro¹, Naoki Kozuka¹

¹Sapporo Medical University

BACKGROUND AND AIM: Adults with cerebral palsy (CP) have impaired postural adjustment. Especially spasticity bilateral CP has severe disability in the lower limbs than in the upper limbs. Therefore, many spasticity bilateral adults with CP remain seated in daily life. However, little is known about postural adjustments while adults with CP are in a sitting position. This study aimed to investigate the characteristics of postural adjustments while adults with CP are in a sitting position, focusing on anticipatory postural adjustments (APAs) and compensatory postural adjustments (CPAs) due to lower muscle activity. METHODS: Ten community-dwelling adults with CP (CP group) and 13 healthy adults (CR group) were included in the study (age: 25.4 ± 8.6 years and 21±1.4 years, respectively). The subjects performed a front-reach task in a sitting position. During the task, the participants were instructed to reach as quickly as possible. The target was placed at distances of 120% and 140% of the upper limb length and at a maximum reachable distance. Surface electromyography of the anterior deltoid (AD), rectus femoris (RF), biceps femoris (BF), anterior tibialis (TA), and soleus (SoL) on the reach side and non-reach side were obtained. APAs and CPAs were calculated as root mean square (RMS). APAs were defined from -200 ms before AD muscle activity was initiated to 50 ms, and CPAs were defined from 50 ms to 300 ms. APAs and CPAs were compared between the groups according to distance type. **RESULTS:** In distance type, APAs showed no significant difference between the CP and CR groups. The reach-side BF activity in the CP group and non-reach-side TA activity in both groups tended to significantly increase as the distance increased (p < 0.05). CPAs were significantly greater than APAs in all tasks and both groups (p < 0.05). **CONCLUSION**: This study suggests that APAs were not affected by distance in both CP and CR, and that the lower limb muscles might contribute to the CPAs in the sitting reach task in both groups. Especially in CP, the BF of reach side changed the muscle activity by distance during the CPA phase.

P2-I-82 Balance recovery following mediolateral pelvis perturbations during slow walking

Michelle van Mierlo¹, Boris Ruwe¹, Mark Vlutters¹, Edwin H. F. van Asseldonk¹, Herman van der Kooij¹

¹University of Twente

BACKGROUND AND AIM: Healthy humans have the ability to handle balance perturbations during walking very well. The ankle moment, as well as the foot placement location and timing are altered to counteract the perturbations and maintain balance.[1] Previously, healthy subjects have shown a strong linear relation between the body's centre of mass (COM) velocity at heel contact (HC), and both the foot placement location and centre of pressure (COP) at subsequent toe off (TO) during laterally perturbed walking.[2] The walking speeds were 0.63 and 1.25 m/s.[2] In this





study, it is questioned whether this relation also exist during very slow walking, because there will be more time during the double support phase to alter the balance recovery strategy. Therefore, we investigated the relation between the body's COM velocity, and both the foot placement location and COP during a very slow walking speed. METHODS: Mediolateral (ML) pelvis perturbations were applied to 10 healthy subjects, during very slow (0.36 m/s) and normal (1.25 m/s) treadmill walking at TO of the right foot. An active optical motion capture system was used to record the body kinematics. Ground reaction forces were measured with the built-in force plates in the treadmill. The data was analysed to obtain COM velocities at HC right, foot placement location at HC right, COP locations at TO left and phase durations. RESULTS: Figure 1 presents the durations of the double and single support phases for the different perturbation magnitudes. The ML perturbations significantly affected the double and single support durations during very slow walking, while these durations were not affected during normal walking. Additionally, the COM velocity at HC right showed to have a high predictive value for the foot placement of the leading foot during the normal walking speed, whereas this was considerable lower during the very slow walking speed. The predictive value of the COM velocity was present for the COP location at the subsequent TO for both the normal and very slow walking speed. **CONCLUSIONS:** The results showed altered recovery strategies in the frontal plane during very slow walking compared to the normal walking speed. These differences were potentially caused by the longer double support phase duration, in which subjects used other strategies to control the distance between the COM and COP. REFERENCES:[1] A. L. Hof, R. M. van Bockel, T. Schoppen, and K. Postema, "Control of lateral balance in walking. Experimental findings in normal subjects and above-knee amputees," Gait Posture, vol. 25, no. 2, pp. 250-258, 2007. [2] M. Vlutters, E. H. F. van Asseldonk, and H. van der Kooij, "Center of mass velocity-based predictions in balance recovery following pelvis perturbations during human walking," J. Exp. Biol., vol. 219, no. 10, pp. 1514-1523, 2016.

J - Developmental disorders

P2-J-83 Reproducibility of the Timed Up and Go (TUG) standard and dual task versions in school-aged children with and without coordination difficulties.

Leanne Johnston¹, Breanna Raatz¹, Gemma Allinson¹, Rosalee Dewar¹, Sally Hannah¹

¹University of Queensland

BACKGROUND AND AIM: Developmental Coordination Disorder (DCD) is a neurodevelopmental disorder which is present in 5-6% of children. Poor postural control is thought to contribute strongly to these motor coordination difficulties, particularly in gait. Dynamic assessment of postural control is gait has been limited by assessments that do not have adequate psychometric data. The aim of this study was to evaluate intra-rater and test-retest reproducibility of the Timed-Up-and-Go (TUG) standard and the TUG-motor and TUG-cognitive dual-task subtests in children





with and without coordination difficulties. **METHODS:** Children aged 4-12 years were recruited for intra-rater (n=28) and test-retest (n=21) reproducibility evaluation of the TUG-standard (walk only), TUG-motor (walk carrying a cup of water) and TUG-cognitive (walk while counting) assessments. Gross motor function was quantified with the Test of Gross Motor Development (TGMD-2) percentile rank. Analyses were performed for TUG Trial-1, Trial-2 and Trial-average. Reproducibility was examined by reliability and agreement. Reliability of raw scores was examined using Intra-class Correlation Coefficients. Agreement of category scores for the TUG-standard and TUG-cognitive (from the Kids-BESTest) were examined using exact agreement, kappa, limits of agreement and smallest detectable change. RESULTS: TGMD-2 Total scores ranged from the 3rd to 97th percentile indicating the cohort included children with a wide range of motor abilities. Reliability of all TUG subtests was good-excellent for all intra-rater and test-retest analyses (ICC = 0.63-0.86), except for moderate intra-rater reliability of the TUG-cognitive subtest (ICC=0.44). For all subtests, data from Trial-2 showed better reliability than Trial-1 or Trial-average. Both the TUG-standard and TUG-cognitive showed excellent agreement when scored using BESTest category scores (Kappa = 0.77-1.0). Children showed a reduction in time for all TUG subtests with increasing age. **DISCUSSION:** This study provides new data on the reproducibility of the original TUG protocol and its TUG-motor and TUG-cognitive subtests for children. All three TUG subtests are reproducible clinical tools for children aged 4-12 years and can be recommended for assessment of dynamic balance difficulties during gait in school aged children. During assessment, children should be provided with one practice turn, then the results of their second trial recorded. Further research is recommended to extend normative data for adolescents and to examine performance in response to intervention.

P2-J-84 Will my child walk? New insights into the relationship between lower limb muscle strength and gross motor function in children with spina bifida myelomeningocele.

Leanne Johnston¹, Ashleigh Gehrig¹, Nicole Thomas²

¹University of Queensland, ²Children's Health Queensland Hospital & Health Service

BACKGROUND AND AIMS: Spina Bifida (myelomeningocoele) is a congenital neurological disorder caused by failed neural tube closure, which results in weakness of the lower limbs and deficits in the ability to attain walking and other posture and motor skills. Muscle strength is measured regularly in children with Spina Bifida, initially to determine mobility prognosis, then to set mobility goals and monitor improvements with treatment or decline due to neurological compromise. Despite this, there is little published evidence of the relationship between lower limb muscle strength and gait, and no information on the relationship with other gross motor skills such as crawling, standing or running. The aim of this study was to examine the relationship between lower limb muscle strength and gross motor skill acquisition in school aged children with myelomeningocele. **METHODS:** Thirteen children with myelomeningocoele aged 4-12 years (mean 7 years, 8 months; SD 2 years, 8 months; 5 males) were recruited from a state-wide Spinal





Disabilities service. Children were assessed by a physiotherapist for lower limb muscle strength (Manual Muscle Testing: MMT) and Gross Motor Function (Gross Motor Function Measure 66: GMFM-66). Descriptive statistics were calculated, then Spearman's Rank Correlations were calculated to determine relationships between categorical scores for muscle strength and gait and gross motor capacity. RESULTS: Children with greater overall muscle strength on MMT showed better overall gross motor performance on the GMFM-66 (p<0.05). All children attained basic posture and motor skills in supine, sit and 4-point kneel. Greater guadriceps strength was correlated with improved reciprocal crawling (r = 0.992). Greater hip muscle strength was correlated with better lower limb weight bearing ability (r = 0.605-0.992). Greater strength in quadratus lumborum, abdominals and foot control muscles was highly important for independent walking (r = 0.586-0.788). High level balance skills such as hopping were only achieved by children with almost full muscle strength. CONCLUSION: In school-aged children with spina bifida myelomeningocoele, there is a relationship between greater lower limb muscle strength and the acquisition of gait. There are also specific anti-gravity muscle strength / innervation patterns that predict acquisition of other gross motor skills. This data provides a foundation for improved clinical assessment, prognosis development, and goal setting for treatment in this population.

P2-J-85 A retrospective study towards characterizing the long-term effects of singleevent multilevel surgery on gait consistency in children with spastic bilateral cerebral palsy

Rosa Visscher¹, Nadine Hasler¹, Marie Freslier², Navrag Singh¹, Reinald Brunner², Erich Rutz²

¹ETH Zurich, ²University Children's Hospital Basel

1) BACKGROUND AND AIM: Single-event multilevel surgery (SEMLS) is increasingly used to treat (and prevent further) deteriorations in children with cerebral palsy (CwCP, specifically bilaterally spastic CP) [1]. While previous studies have looked at the influence of SEMLS on the clinical gait scores [2], the influence on gait pattern and their consistency remains unknown. The main purpose of this study is therefore to evaluate the effect of SEMLS on sagittal joint angles and their consistency (investigated as meanSD [3]). Second purpose is to test whether these effects are durable 10 year-post treatment. 2) METHODS: Retrospective patient history as well as threedimensional gait data from 16 subjects (11 males and 5 females) aged between 8 to 23 years at time of intervention (mean age: 13.5 years), gross motor function classification system levels between I-III, were used to analyze the following primary outcomes: sagittal joint angles and their meanSD scores. All required data were collected at four pre-defined time intervals: one preoperative (E0), and three post-operative measurements, namely short-(E1: up to 2 years postindex surgery), mid-(E2: up to 6 years post-index surgery) and long-term (E3: >8 years post-index surgery) follow up. For analysis of the joint angles, statistical parameter mapping (SPM{F}, posthoc SPM{t}) with repeated measures analysis of variance model (rm-ANOVA) was used. To determine differences in meanSD between the time intervals, one-way rm-ANOVA with post hoc Bonferroni was performed. Significance was set at α =0.05 for all procedures. 3) **RESULTS:** SPM





revealed that all sagittal joint angles, except ankle dorsiflexion, were significantly influenced by the SEML, see figure 1. All differences showed to be durable over a 10-year period. MeanSD decreased significantly between the time intervals, for ankle dorsiflexion (p=0.03), foot progression (p=0.007), hip flexion/extension (p=0.003), and pelvic tilt (p=0.013), see figure 1. Further surgical interventions, 13 (3 after E1, 8 after E2, 2 after E3), were required in 10 patients due to relapse (5), new developed biomechanical problems (7) or other problems (1). 4) CONCLUSIONS: To our knowledge, this study is seminal in providing long-term functional outcome evaluations of SEMLS in CP. It presents a novel multidimensional representation demonstrating that the consistency of gait pattern improved over time, as you would expect in maturing CwCP. However, CwCP had a higher variability in their gait patterns compared to agematched controls. While the effects of SEMLS on the sagittal joint angles were durable for 10 year period, more than half of the subjects from our cohort needed additional surgery after E1. REFERENCES: [1] Bell et al. J Pediatr Orthop. 2002.22(5):677-682. [2] McGinley et al. Dev Med Child Neurol. 2012.54(2):117-128 [3] Dingwell et al. J Biomech Eng. 2001.123(1):27-32. ACKNOWLEDGEMENTS AND FUNDING: The authors would like to thank the laboratory of movement analysis from the University of Basel Children's Hospital for their support in data collection.

P2-J-86 Functional gait in children with developmental coordination disorder compared to typically developing children

Rosanne Kuijpers¹, Ellen Smulders¹, Vivian Weerdesteyn²

¹Radboud University Medical Center, ²Donders Institute, Radboud University Medical Centre

BACKGROUND AND AIM: Children with Developmental Coordination Disorder (DCD) are impaired in the coordination of movements, causing problems in both gross and fine movements. This limits them in their 'functional gait', such as sports and play, where they report problems in interacting with the dynamic environment and while being distracted. However, there is a lack of knowledge on functional gait deficits in children with DCD, as most studies have focused on fine motor skills. The aim of this study was to gain insight into functional gait problems in children with (probable) DCD, as compared to typically developing (TD) children. METHODS: Fifty-seven TD children and 27 children with confirmed DCD or meeting the research criteria for DCD (pDCD)1, aged six to twelve years, participated. Functional gait was assessed both overground and on a treadmill. Overground tasks were the 10 Meter Walk Test (10MWT), an obstacle task based on the Emory Functional Ambulation Profile (EFAP), and the new Timed Agility Ladder test (TAL-test, see figure 1). During this TAL-test, children had to step in a ladder as fast and as accurately as possible, with one foot and with two feet in each target. A total score was composed of the time to completion and the number of failures (0.5 sec penalty each). We used the C-mill (a treadmill with embedded force plates that evokes gait adjustments by projecting visual context) to assess walking adaptability. The children had to place each step on a projected target, with 10% of the





targets suddenly changing colour and becoming 'obstacles'. This was done as a single task, with a motor dual task, and with a cognitive dual task. The primary outcome was the success rate. Analyses for comparing functional gait of TD and (probable) DCD children were performed using a one-way ANCOVA (i.e. age as covariate). RESULTS: Children with (p)DCD performed significantly worse on all functional gait tasks (p<0.032) compared to TD children, except for the 10MWT. The most pronounced differences between the groups were observed for the EFAP (45.3% difference between the group means), the TAL-test with two feet in each target (27.4%) and the C-mill walking adaptability task with the motor dual task (25.8%). For all tasks age was a significant covariate, except for the 10MWT. No significant differences were found between the groups of pDCD and DCD. **CONCLUSIONS:** The results of this study highlight the functional gait problems that children with (p)DCD experience, which problems likely hinder them in sports and play. Training aimed at improving their functional gait might therefore be beneficial for enabling children with (p)DCD to participate on a more comparable level as their TD peers. ACKNOWLEDGEMENTS AND FUNDING: This study was funded by the Dutch Revalidatiefonds, Johanna Kinderfonds and Stichting Rotterdams Kinderrevalidatie Fonds Adriaanstichting. **REFERENCES:1.** Smits-Engelsman et al. Hum mov sci. 2015;42:293-306.

K - Devices to improve posture and gait

P2-K-87 Non-invasive spinal cord stimulation for the treatment of motor symptoms of Parkinson's disease

Maria Alamos¹, Aquiles Martinez², Carlos Juri¹, Rómulo Fuentes²

¹Pontificia Universidad Catolica de Chile, ²Universidad de Chile

BACKGROUND AND AIM: Spinal cord stimulation (SCS) has shown positive outcomes for gait impairments of Parkinson Disease (PD), advancing its potential use as a new clinical treatment option. Although SCS is an expensive, invasive surgical procedure that requires a functional neurosurgeon. There are also associated risks such as infection and lead migration. This is the first study to-date to explore the effects of Non-Invasive Spinal Cord Stimulation (NISCS), a non-invasive technique that delivers current by electrodes located on the skin surface above the spinal cord at the thoracolumbar level. **METHODS:** We used adult Sprague Dawley male rats with unilateral nigrostriatal dopaminergic lesions induced by 6-hydroxydopamine (6-OHDA), we evaluated the effectiveness of Non-Invasive Spinal Cord Stimulation (NISCS) by measuring the neural activity in the cortico-basal ganglia circuit and the motor function. For the first outcome, we compared the local field potential (before, during and after stimulation) from 5 different areas of the motor circuit, using the uninjured hemisphere as a control. For the second outcome, we evaluated the motor performance during 11 days of stimulation, using the cylinder test and the amphetamine-induced rotation test. We compared the motor performance between the treated and non-treated (control group) parkinsonian rats. **RESULTS:** NISCS was able to modulate the




pathological neural activity and also motor function. **CONCLUSIONS:** Since this strategy is less expensive, safer, and easier to administer than other neuromodulation techniques, our findings might be relevant to the clinical practice.

P2-K-88 Effect of postural insoles on iliotibial band syndrome in runners: a multicentre prospective study

Isabelle Barnier¹, Marie-Emmanuelle Rouchon², Frédéric Viseux³

¹Posturopody Class 2016/17, Connaissance & Evolution, FR75012, ²Posture Lab, FR75012 Paris, ³LAMIH - University of Valenciennes - France

BACKGROUND AND AIM: Iliotibial band syndrome (ITBS) is a common overuse knee injury in runners [Ellis et al, 2007]. In recent years, the number of runners and the prevalence of ITBS have increased around the world. Although the pathophysiological mechanism is well documented, etiologies are poorly defined and management uncertain [Aderem et al, 2015]. Some studies showed that exteroceptive plantar inefficiency could interfere with the integration of plantar afferents required for static and dynamic postural control [Foisy et al, 2017]. Specifically, latent somaesthetic plantar dysfunction [Foisy et Kapoula, 2016; Janin, 2009] as an unconscious nociceptive zone under the first metatarsal could alter postural stability and lower limb kinematics. Assuming that exteroceptive plantar inefficiency may promote postural and kinetic control disorders underlying ITBS, it was hypothesized that the use of postural insoles may play a role in the recovery of recreational runners with ITBS. METHODS: Seventeen recreational runners (age = $37 \pm 7,5$ years, height = 1.72 ± 0.12 m, weight = 65 ± 12 kg) with ITBS voluntarily participated in this study. They gave their informed consent to the experimental procedure as required by the Helsinki declaration and the local institutional review board. All participants had running more than 15 km / week. Other concomitant knee injuries, lower limb surgery or trauma in the last 6 months were exclusion criteria. Clinical and postural examination were performed early (T0), and customized postural insoles were provided to the subject. Participants were reviewed later at 2 (T1) and 4 months (T2) respectively. At each consultation, three assessments were performed: (i) Pain assessment with Visual Analog Scale, (ii) evaluation of ITBS symptoms with Noble and Renne tests, and (iii) postural tone assessment using the posturodynamic test. RESULTS: Our results showed that the use of postural insoles induced (i) a constant decrease in VAS score (p<0,01), (ii) a symptomatic improvement of ITBS with fewer positive Renne and Noble tests, and (iii) a modification of postural tone with better scores at the posturodynamic test. **CONCLUSION:** This study evidences a positive correlation between postural change induced by use of postural insoles and improvement of ITBS symptoms. Our results suggest that the use of postural insoles may have therapeutic benefits to symptomatic improvement in runners with ITBS. However, future investigations will have to be considered to confirm these findings.





P2-K-89 Effect of learning to use a single-point cane on gait and cognitive demands of walking in people with mild to moderate Alzheimer's dementia

Susan Hunter¹, Alison Divine², Humberto Omana¹, Walter Wittich³, Andrew Johnson¹, Keith Hill⁴, Jeff Holmes¹

¹University of Western Ontario, ²University of Leeds, ³University of Montreal, ⁴Curtin University

BACKGROUND AND AIM: People with Alzheimer's dementia (AD) exhibit balance and walking impairments that increase falls risk. Prescription of a mobility aid is done to improve stability, yet also increases demand for cognitive resources. Single-point canes require unique motor sequencing for safe use. The effect of learning to use a single-point cane has not been evaluated in people with AD. In people with AD and healthy adult controls(CON), the aim of this study was: 1) to examine changes in gait while using a cane under various walking conditions; and 2) to determine the cognitive and gait costs associated with concurrent cane walking while multitasking. METHODS: Seventeen participants with AD (age 82.1 ± 5.6 years) and 25 CON (C; age 70.8 ± 14.1 years) walked using a single-point cane in a straight (6 meter) and a complex (Figure of 8) path under three conditions: single-task (no aid), dual-task (walking with aid), and multi-task (walking with aid while counting backwards by ones). All trials were completed at a self-selected speed and no instructions on task prioritization for multi-task conditions were given. Velocity and stride time variability were recorded using tri-axial accelerometers (LEGSys, BioSensics, Cambridge, MA). Cognitive performance was evaluated as a single-task in sitting and then responses were recorded during multi-task condition. Gait and cognitive task cost was the difference in velocity performance between baseline and multi-task conditions as a percentage of the baseline performance. Two-way repeated measures ANOVAs adjusted for age were used to analyze the study aims. A performance-resource operating characteristic graph of gait cost versus cognitive task visually presented task trade-offs. **RESULTS:** Gait velocity significantly slowed for both groups as task complexity increased, AD demonstrated slower gait compared to controls across all test conditions (p<0.001; Cohen's d effect size >0.80 indicating large effect). Stride time variability was greater in AD with observed statistical differences between groups for Figure of 8 single-task (p=0.009) and multi-task conditions (p<0.001). Overall, multi-tasking produced a decrease in gait and cognitive performance for both groups. During straight path multi-tasking, both groups showed similar self-prioritization towards the gait task (CON: 65%, AD: 68%); while for the Figure of 8 pathway, the AD group prioritized the cognitive task over the gait task (CON: 68%, AD: 47%). CONCLUSIONS: Learning to use a single-point cane increased cognitive demands resulting in detrimental changes to velocity and stride time variability. Impaired walking effects with the cane were greater in people with mild to moderate AD. When presented with a complex multi-tasking condition, the AD group exhibited a posture-second strategy that may increase risk for falls. Future research needs to investigate the effects of mobility aid training on gait performance. FUNDING: Alzheimer's Association Grant (AARG-16-440671).





P2-K-90 The effect of Arctic Grip contact area on footwear performance during winter walking

Kristie Liu¹, Tilak Dutta²

¹University of Toronto, ²Toronto Rehabilitation Hospital

BACKGROUND AND AIM: Eighty percent of falls occur during the winter months, and snow and ice are responsible for two-thirds of pedestrian injuries[1]. Slip-resistant footwear can reduce the risk of slips and falls in winter conditions by increasing the available coefficient of friction (COF) at the footwear-surface interface. The COF is dependent on the material properties of the contact area at the interface; these factors should be optimized in the design of slip-resistant footwear[2]. Vibram® Arctic Grip? (AG) is a proprietary polymer blend material designed for performance on wet ice; yet, it is unclear how contact area (CA) affects the performance of footwear in winter conditions. The objective of this study was to explore potential relationships between CA, AG, and footwear performance under four different winter walking conditions. **METHODS:** Men's size 9 boots with AG material (n=24) were included in this study. Boot performance was tested using the maximum achievable incline (MAI) method^[2]. Each boot was tested by four subjects who walked up and down an ice surface that incrementally increased in slope angle following each successful excursion. MAI is the greatest angle successfully traversed prior to a slip. MAI was found for each of the four combinations of uphill/downhill and dry/wet ice conditions. To analyze CA of the boots, prints were made of the soles of the boots by applying a thin layer of paint and taking a stride onto paper. Prints were scanned, and CA was calculated using MATLAB®. Next, Arctic Grip contact area (AGCA) was determined, and both CA and AGCA were split into forefoot and heel regions. The proportions of AGCA to CA (regional and total) were calculated. Correlations were calculated to assess the interaction of CA and AGCA with MAI scores. A two-way repeated measures ANOVA was run to determine the factors and interactions with a significant effect on MAI scores. **RESULTS:** Total CA was not correlated with MAI under any of the four conditions (p>0.05); forefoot CA was correlated with downhill dry ice MAI (p<0.05), while heel CA was negatively correlated with uphill wet ice MAI (p<0.05). Total AGCA, forefoot AGCA, heel AGCA, and the respective proportions of AGCA in these regions were all correlated with MAI in both wet ice conditions (p < 0.001), but not in either of the dry ice conditions (p > 0.05). The ice condition had a significant main effect on MAI, F(1,95)=66.672, p<0.001; direction did not have a significant main effect. There was also a significant effect of ice on direction F(1,95)=7.944, p=0.006. **CONCLUSIONS:** AGCA and proportion of AG are strongly correlated to the performance of slipresistant boots on wet ice. Ice condition affects boot performance, but slope direction does not. These findings demonstrate ice condition and AG contact are key factors affecting winter footwear performance. 1Rolfsman E et al. (2012). Safety Science Monitor 16(1):5. 2Hsu J et al. (2016). Ergonomics 59(5):717-28.





P2-K-91 The effect of real-time biofeedback on lumbar spine and lower limb kinematics and kinetics during repetitive lifting

Yanto Naudé¹, Grant Mawston¹, Jeff Kilby¹, Mark Boocock¹

¹Auckland University of Technology

BACKGROUND AND AIM: The incidence of low back pain (LBP) in jobs that involve repetitive lifting is disproportionately high compared to other physical occupations. This has been attributed to repetitive and sustained end range spinal flexion, a known risk factor for LBP. To improve lifting posture and reduce the risk of low back injury, health practitioners often provide manual handling training and advice on appropriate lifting techniques. However, evidence supporting manual handling training is poor and prescribed lifting techniques are not easily transferable to the workplace. Real-time biofeedback may provide an alternative or adjunct to manual handling training within the workplace, although its benefits have not yet to be evaluated. The aim of this study was to investigate the use of lumbar posture biofeedback as a method to affect lifting posture and reduce spinal loading, prior to implementation in the field. METHODS: Thirty-four participants were randomly allocated to 2 groups: biofeedback (BF); and a non-biofeedback (NBF). Participants lifted a 13kg box at a frequency of 10 lifts per minute for up to 20 minutes. Two wireless inertial measurement units (IMU) were attached to the lumbar spine. These were active for the BF group who received audible feedback on lumbosacral flexion (LSF) when lumbar flexion exceeded 80% maximum flexion. Prior to lifting, both groups were familiarised with the lifting task. A nine-camera motion analysis system recorded three dimensional (3D) motion. Force plates were used to record 3D ground reaction forces. A biomechanical model provided estimates of joint reaction forces and moments, and bending moments on the passive structures of the lumbar spine at one-minute intervals throughout the lifting task. Ratings of perceived exertion (RPE) were also recorded at one-minute intervals. **RESULTS:** The BF group had significantly reduced peak lumbar flexion (p < 0.001) at the start and over the duration of the task, compared to the NBF condition. The BF group was able to maintain a maximal flexion posture of less than 80%, whereas, the NBF group reached approximately 99% of maximal flexion at 20 minutes. The BF group adopted significantly greater peak knee flexion, and increased peak hip and knee extension angular velocities, compared to the NBF group. There were no differences between groups in the bending moment on the lumbar spine, although estimates of biomechanical loads on the passive structures of the lumbar spine were significantly different. The number of times participants in the BF group received feedback reached a peak after seven minutes, but then declined thereafter. There was no difference in RPE between groups. CONCLUSIONS: Providing BF on LSF during repetitive lifting enabled those participants who received biofeedback to avoid increasing LSF and reduced the passive loading on the musculoskeletal structures of the lumbar spine. Thus, BF of the lumbosacral posture offers a potential preventative adjunct to educate clients about their lifting posture, which has potential for use in the workplace. This could be particularly important for young, inexperienced workers employed in repetitive manual handling who appear at increased risk of back injury.

P2-K-92 The effects of non-invasive transcranial brain current stimulation (tDCS) on posture over stable and unstable surfaces in people with Parkinson's: A randomised double-blind sham-controlled crossover study

Jing Qi¹, Graham Kerr², Karen Sullivan², Simon Smith³, Marcus Meinzer^₄

¹Institute of Health and Biomedical Innovation, ²Queensland University of Technology, ³University of Queensland, ⁴UQ Centre for Clinical Research

BACKGROUND AND AIM: Parkinson's disease (PD) is a degenerative disease of the central nervous system. Motor dysfunction is a primary feature of PD, with postural instability, one of the key features that leads to an increased likelihood of falls. When asked to perform concurrent motor and cognitive tasks, (e.g. standing while counting numbers), postural control can deteriorate further. Transcranial Direct Current Stimulation (tDCS) can be used to safely modulate cortical excitability without serious adverse effects. The study aimed to investigate the effect of tDCS on dual-task performance over different standing conditions in people with Parkinson's disease. **METHODS:** tDCS was delivered with an intensity of 1 mA during 20 minutes using a constant current stimulator. The anode electrode was placed over the left dorsolateral prefrontal cortex (Left-DLPFC), and the cathodal electrode was placed over the right supraorbital area (R-SO). The sham condition consisted of 15 seconds of stimulation at the beginning and the end of the intervention period separately. 16 PD participants (age = 65.38 ± 9.722, ACE-R = 91.88 ± 4.177, MMSE = 29.13 ± 1.088, ABC = 80.21 ± 17.637), with a mean UPDRS of 37.69 ± 18.311 and a mean Hoehn-Yahr score of 1.60 ± 0.713 completed 4 single tDCS sessions in a randomised order. Under both real and sham stimulation conditions, participants stood either directly on the force plate or a foam placing on the force plate. Single task and dual task performance were assessed prior to, during, and immediately after possible stimulation. Path length, sway area, velocity, medial-lateral sway, and anterior-posterior sway were recorded during the performance. Figure 1 presented the comparison between the real tDCS and sham tDCS under stable and unstable standings on all the outcome measures. There were significant main effects of stimulation (P = (0.000) and task (P = 0.000) on all measures under stable standings. However, under unstable standing, only significant main effect of task (P = 0.000) was observed. CONCLUSIONS: The results suggest a single session of tDCS targeting the left dorsolateral prefrontal cortex improved the ability to adapt posture to a motor-cognitive dual task under stable standing. There are no effects of tDCS on posture under unstable standing condition. ACKNOWLEDGEMENTS AND FUNDING: I would like to thank you to: My supervisors Prof. Graham Kerr, Prof. Karen Sullivan, A/Prof. Simon Smith, and A/Prof. Marcus Meinzer for sharing your expertise throughout all phases of the research. My participants for donating your time and effort during data collection. Parkinson's Queensland Inc. for supporting my participant recruitment. There is no funding for the PhD project.



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P2-K-93 Examining the long term effects of using the anchor system on postural control during walking

Kirat Shukla¹, Joel Lanovaz¹, Alison Oates¹

¹University of Saskatchewan

BACKGROUND AND AIM: Adding haptic input using an anchor system (AS) can increase postural control during walking in young and older adults. The AS consists of strings attached to 125 g weights that can be dragged on the floor. Haptic feedback is provided via skin mechanoreceptors in the hand when tension in the string is produced by the weights which provides sensory input about where one is in space. While there are positive short-term effects on postural control using the AS during walking, the long-term effects of AS use are not known. The purpose of this pilot project is to determine if practicing difficult walking tasks while using the AS will have an effect on postural control during walking in healthy adults. METHODS: Participants were randomly assigned to one of three groups. Two groups regularly practiced three times per week for six weeks performing tandem and backward walking with eyes closed; one group with the AS (wAS, n=4), and one group without the AS (nAS, n=2). The third group (CTL, n=2) was a control and did not practice. 3-D kinematic data was collected pre- and post-practice using a motion capture system (Vicon Nexus, Centennial, CO) with a custom 12-segment full body model. For pre/post-testing, participants were asked to complete five trials each for normal and tandem walking with and without using the AS, and with eyes open and eyes closed. Walking ability was evaluated using stride length (SL), stride velocity (SV), and percent double support (%DS) and postural control was evaluated using anteroposterior (AP) and mediolateral (ML) margins of stability (MOS) and step width (SW). Percent change scores (((Pre score - post score)/prescore)*100%) for all variables were assessed with separate MANOVAs for normal walking (NW) and tandem walking (TW) with group as an independent variable. Follow up univariate ANOVAs and Tukey's post hoc tests evaluated main effects and differences between groups. **RESULTS**: There was a main effect of group on the combined dependent variables for NW (p < .05) and TW (p < .05). There was a main effect of group for SL, AP-MOS and ML-MOS for NW and for SV, %DS, and AP-MOS for TW. Tukey's post hoc tests revealed that for NW, wAS and nAS had an increase in SL compared to CTL; wAS had in increase in ML-MOS compared to nAS; and wAS had an increase in AP-MOS compared to CTL. For TW, nAS had an increase in SV compared to CTL; wAS and nAS had a decrease in %DS compared to CTL; and wAS had an increase in AP-MOS compared to CTL. CONCLUSIONS: Preliminary findings suggest that practicing difficult walking tasks over six weeks improves walking performance and postural control and that practicing with the AS may produce a slight advantage in improving walking performance and postural control over practicing without the AS. Data collection will continue with a larger sample size to expand the results. Future work could study the effects of long term AS use in older adults and clinical populations.



P2-K-94 A feasibility study for gait training with foot-floor contact angle feedback

Christina Ma¹, Tian Bao², Victor Le², April Chambers³, Peter Shull⁴, Yong-Ping Zheng⁵, Rakié Cham³, Kathleen Sienko²

¹Jönköping University, ²University of Michigan, ³University of Pittsburgh, ⁴Shanghai Jiao Tong University, ⁵The Hong Kong Polytechnic University

BACKGROUND AND AIM: Slip events are responsible for up to 20% of falls and often result in severe injuries, and significant mortality and morbidity. Prior research has revealed several factors that increase the likelihood of a slip event including walking with a large foot-floor contact angle (FFCA) at heel-strike (>20°). Numerous feedback systems leveraging wearable sensors that measure gait-related kinematic or kinetic data have been used to improve balance and gait performance. In this feasibility study we demonstrated the use of a wearable feedback device for modifying FFCA during treadmill walking. METHODS: Ten healthy participants (3 females and 7 males, aged 22.0±1.6 years) with fewer than 75% of baseline overground FFCA values falling within a range of 10-20° were recruited for inclusion in the study. A feedback system comprising two IMUs attached to the mid-foot regions of participants' dominant and non-dominant feet to measure FFCA during heel strike events, a laptop for calculating FFCA, and speakers for providing auditory cues to participants was used. Participants received cues during the non-dominant foot stance phase if the average of the two preceding dominant FFCAs was outside of the target range (10-20°). Participants performed 2-min baseline and post-training treadmill trials with a speed of 1.35 m/s prior to and following four 4-min treadmill training trials with FFCA feedback. The percentage of FFCAs within the target range, and the mean and variability of FFCAs were computed for baseline, training, and post-training trials, and one-way repeated measures ANOVA and post-hoc comparisons were performed. The significance level was 0.05. RESULTS: Participants increased their percentage of FFCAs within the target range when feedback was provided during the training trials compared to the no feedback condition during the baseline trials (66.9% vs. 53.9%, P=0.028). Increased percentages of FFCAs within the target range were also observed during the post-training trials (75.8% vs. 53.9%, P=0.027). The average FFCA increased from 9.9° during baseline trials to 13.7° during training trials (P=0.028). The FFCAs were less variable during the training (P=0.028) and post-training (P=0.028) trials compared to the baseline trials. CONCLUSIONS: The findings suggest that participants could use the auditory cues to dynamically adjust their FFCAs while walking on a treadmill and that the training effects were present for a short period of time following the completion of the training. The FFCA is one of several gait parameters that could be used for gait training purposes to potentially reduce the likelihood of a slip event. Future work should examine the effects of gait training with FFCA feedback on the incidence and severity of slips, and on other gait parameters.





L - Effect of medication on posture and gait

P2-L-95 The effects of levodopa on prefrontal activation during gait in individuals with Parkinson's disease

Moria Dagan¹, Hagar Bernad-Elazari², Talia Herman², Rachel Harrison³, Junhong Zhou⁴, Shiran Shustak², Marina Brozgol², Nir Giladi², Anat Mirelman², Brad Manor⁴, Jeff Hausdorff²

¹Tel Aviv University, ²Tel-Aviv Sourasky Medical Center, ³Institute for Aging Research, Hebrew SeniorLife, Harvard Medical School, ⁴Harvard Medical School

BACKGROUND AND AIM: Previous work suggests that gait disturbances, in general, and freezing of gait (FOG), in particular, are related to prefrontal cortex (PFC) dysfunction in Parkinson's disease (PD). The "levodopa overdose hypothesis" posits that levodopa is necessary to remedy performance on tasks associated with the dorsal striatum (e.g., motor control circuits). Concurrently, it may impair performance on tasks associated with regions connected to the ventral striatum (e.g., nucleus accumbens and PFC). Several imaging studies have compared gait OFF and ON dopaminergic medications, however, no study has used brain-imaging during actual walking. We hypothesized that dopaminergic medications will improve motor performance, i.e., gait, while interfering with PFC functioning. METHODS: 34 Individuals with PD and advanced FOG were assessed in the OFF (withdrawn for more than 12 hours) and in the ON dopaminergic medication state (self-reported peak). Functional near infrared spectroscopy (fNIRS) was used to measure PFC oxygenated hemoglobin (HbO2). Subjects walked for 20 meters, 4 times, while performing usual, single-task (ST) and dual-task gait (DT; serial 3 subtractions), both in the OFF and ON states. The straight-line walking segments were analyzed (14 sec. each); FOG episodes were removed from the analyses. RESULTS: As expected, gait improved in the ON state compared to the OFF state (gait speed; ST: Δ 11.80±11.67 cm/s, p=0.009, DT: Δ 13.26±17.68cm/s, p=0.0001, step length; ST: ∆4.94±4.85 cm, p<0.001, DT: ∆6.37±6.46 cm, p=0.0002). For PFC HbO2 levels, there was no significant main effect for Gait condition (ST/DT) or Medication (OFF/ON: p>0.33). A significant interaction effect was found for Gait x Medication condition (UPDRS-III as a covariate); subjects in the OFF state had higher PFC activation during DT than usual gait, but not in the ON state. The number of serial subtractions was lower (worse) (p=0.004) in the ON (11.4±3.3) than in the OFF state (12.8 ±3.3). Levodopa equivalent daily dose (LEDD) was negatively correlated with the amount of subtracted numbers during DT in the ON state (mean stride time as a covariate, R=-0.58, p<0.001); the higher the LEDD, the less numbers they managed to count while walking. In contrast, this association was not significant in the OFF state (R=-0.27, p=0.127). CONCLUSIONS: This study demonstrates the beneficial effect of levodopa on gait PD patients with FOG and the negative impact on cognition, as represented by serial subtractions during DT. PFC activation depended on the combination of medication state and DT condition, with the highest values observed during DT in the OFF state. Possibly there is less need for PFC activation in the ON state, as gait has become more automatic. Alternatively, levodopa may have a negative effect on PFC functioning that might be caused by insufficient recruiting of





neurons in this area. The present results highlight the likely role of the PFC in gait in PD, both OFF and ON medication state.

P2-L-96 The effects of dopaminergic drug on turning in people with and without Parkinson's disease

Douglas Martini¹, Graham Harker¹, John Nutt¹, Fay Horak¹

¹Oregon Health & Science University

BACKGROUND AND AIM: Gait dysfunction is a hallmark complication of Parkinson's disease (PD). Although dopaminergic treatment (DopaT) improves some aspects of gait, nearly 50% of people with PD ON DopaT will fall within a period of three months. Complex gait (e.g.: turning and dual tasking) is also related to increased fall risk in people with PD. Sensorimotor integration, regulated by cortical cholinergic inhibition, is worse in people with PD while ON DopaT. The interaction between DopaT and cholinergic mediated sensorimotor integration is not well understood. The purpose of this ongoing study is to determine if DopaT alone negatively effects cortical cholinergic sensorimotor integration or if there is a DopaT-disease interaction effect on sensorimotor integration. We hypothesize that there is a drug-disease interaction which decreases cholinergic inhibition, altering sensorimotor integration. This will cause worse turning characteristics while ON DopaT. The controls will not exhibit a relationship between ON DopaT sensorimotor integration and turning characteristics. METHODS: To date, seven people with idiopathic PD and six healthy older adults have been recruited. Sensorimotor integration was assessed using the transcranial magnetic stimulation technique short-latency afferent inhibition (SAI). Turning characteristics of gait (e.g.: turn velocity and number of steps in a turn) were measured during a two-minute continuous walk, with and without a secondary task, while wearing six inertial body worn sensors (APDM, Portland, OR). All participants were tested OFF and ON DopaT. People with PD took their regular dose, controls took a single 25/100 milligram dose of carbidopa/levodopa. Independent samples t-tests compared groups, Pearson's correlation assessed the relationship between SAI and turning. α set to <0.05, a priori. **RESULTS:** Age and global cognition (Montreal Cognitive Assessment) were not different between groups. The PD group had significantly worse SAI in both the OFF (PD:91[11]; Control:71[9]; p<.01) and ON (PD:100[12]; Control:69[21]; p<.01) DopaT states. The PD group yielded significantly different SAI between DopaT states (p<.01). Number of steps in a turn dual task OFF (PD:4.8[1.0]; Control:3.6[0.2]; p=.02) and single task ON (PD:4.5[0.9]; Control:3.5[0.5]; p=.03) were different between groups. The change in SAI from the OFF to ON states was significantly related to the ON state number of steps in a turn for the single task (r=.79; p<.05) and dual task (r=.84; p=.02) conditions for the PD group and the dual task (r=.82; p<.05) condition for the controls. **CONCLUSION:** The preliminary data of this study indicates that DopaT decreases the cholinergic inhibition mediation of sensorimotor integration in people with PD, but not controls. In the ON DopaT state, worse cholinergic inhibition is related to more steps in a turn regardless of disease



state, especially during dual task gait. Our future work will determine if worse cholinergic inhibition mediation of sensorimotor integration is associated with fall risk in people with PD.

P2-L-97 Objective gait and balance outcome measures for efficacy of cyclodextrin treatment in Niemann-Pick Type C (NPC): a case series

Joan O'Keefe¹, Jessica Joyce¹, Nicollette Purcell¹, Kathryn Wrobel¹, Medha Parulekar¹, Elizabeth Berry-Kravis¹

¹Rush University Medical Center

BACKGROUND AND AIMS: Niemann-Pick C (NPC) is a neurodegenerative disorder characterized by lysosomal accumulation of cholesterol in brain and peripheral tissues. Cerebellar ataxia, apraxia, balance deficits and cognitive decline are seen in many NPC patients. 2-Hydroxypropyl-ß-cyclodextrin (HP-ß-CD) extends life and dramatically slows disease in NPC animal models. Some patients were treated with HP-ß-CD through an Investigational New Drug protocol. We aimed to examine the efficacy of HP-ß-CD in slowing the typical deterioration in NPC via sensitive gait and balance testing. **METHODS:** Five patients with NPC were treated biweekly with HP-ß-CD intrathecally. Disease course for gait and balance was tracked every 2 to 3 months for 24 to 54 months with an inertial sensor system (APDM) and computerized dynamic posturography (CDP). 4/5 patients performed a 2 minute walk test and one performed a 7m instrumented Timed Up and Go. Gait and turn variables chosen for analysis were in the domains of pace (stride length and velocity), rhythm (cadence), variability (stride length/velocity CoV), gait phase cycle [% double support (DS) and swing time] and turn duration/number of steps to turn. Global function was assessed by the NPC Severity Scale. Percent of scores improved by >10%, changed by <10% (unchanged/stable), and worsened by >10% from baseline was guantified for gait and balance parameters. RESULTS: Subject 1 (age 14; treated for 48 mo.) presented with an apraxic gait and severe cognitive dysfunction. No gait variables improved, 5/10 remain unchanged and 5/10 worsened. This subject was not able to complete CDP testing. Subject 2 (age 15; treated for 54 mo.) presented with normal gait except for slightly increased gait variability and DS time. 8/10 gait variables remained in the normal range and gait variability and DS time improved to normal values. Composite CDP postural sway scores improved by 37%. Subject 3 (age 17; treated for 48 months) presented with cerebellar gait ataxia. Gait variability improved 28-42% and 8/10 variables stayed the same. CDP postural sway scores improved 91%. Subject 4 (age 31; treated for 24 mo.) presented with cerebellar gait ataxia. 10/10 variables worsened and the patient now requires a walker. CDP scores were stable at 15 months but the subject became too unstable and claustrophobic to complete recent testing. Subject 5 (age 30; treated for 30 mo.) presented with cerebellar gait ataxia. 5/10 gait variables remained unchanged and 5/10 worsened with gait variability having the greatest decline. CDP postural sway scores improved 44%. CONCLUSIONS: These gait and balance measures shows overall NPC disease stability or improvement in the majority of gait and balance outcomes in 3 out of the 5 patients receiving HP-ß-CD treatment.

These findings support the concurrent lack of worsening on the NPC Severity Scale which deviates from the natural history of NPC. Wearable inertial sensor based gait analysis and CDP balance measures are feasible to determine efficacy of pharmaceutical interventions in neurological populations. Ongoing tracking with these sensitive measures will help quantify the chronic impact of HP-ß-CD on gait and balance function in NPC and determine phenotypes that might best benefit from treatment.

M - Exercise and physical activity

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P2-M-98 Lifestyle integrated functional exercise for inpatients suffering from cognitive impairment - a transitional approach to prevent hospitalized older adults from functional decline

Nacera Belala¹, Michael Schwenk¹, Clemens Becker²

¹Heidelberg University, ²Robert-Bosch-Krankenhaus

BACKGROUND AND AIM Every other patient admitted to hospital is a geriatric one. Around 40% are in addition to their medical condition suffering from different kinds of cognitive impairment. This results in increasing numbers of cognitively impaired acutely ill patients being present for inpatient treatment. Especially for this patient group, sedentary behavior represents a huge issue due to its negative impact on the health status and the consequence of functional decline. Adequate interventions which increase physical activity during hospital stay, are resource efficient and possible to implement become more necessary but are to date still lacking. The lifestyle integrated functional exercise (LiFE) concept uses activities of daily living (ADL) as opportunities to improve balance and strength. First, a pilot study was performed to test the feasibility and acceptability of the LiFE exercises in a geriatric subacute setting. Second, an observational study is being conducted to get detailed insights of structures and routines on the geriatric acute care including professionals' and patients' daily routines. The aim is to design a suitable intervention to close the gap of lacking physical exercise interventions for cognitively impaired inpatients. Methods In the pilot study, 20 moderately cognitively impaired rehabilitation patients tested the feasibility and acceptability of the LiFE exercises. During the observational study, 20 moderately cognitively impaired acute care patients are being provided with two activity tracking monitors to collect reliable data on the patients' activity behavior throughout the day during the hospital stay.Additional information on structures, procedures and routines are being collected via interviews with all professional groups working on the ward.Furthermore, randomly selected time periods are being observed and rated according predefined categories by different observers to guarantee interrater reliability. Results The testing of the exercise framework resulted in floor effects for every exercise from which two were even too difficult for over 50% of the participants. The frequency of floor effects for the remaining exercises varied between 20% and 40%. The interviews of our second study already revealed that cognitively impaired inpatients are



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inactive for more than 75% of the day (7AM-8PM) owed to hospital routines. Further 20% are insufficiently covered, while only 4-6% of the day are designed active. These data are still being supplemented by sensor and observational data at the moment. **Conclusions** Cognitively impaired inpatients are during the hospital stay in addition to their mental status and medical conditions suffering from sedentary behavior causing a functional loss which affects their autonomy and independence. Periods of immobility are frequently occurring and fostering functional decline during the hospital stay. To prevent patients from functional loss these periods need to be designed more active with more common interrupts of sedentariness. Nevertheless, in this target group, the LiFE exercise framework was feasible only under supervised conditions and with additional physical support. Adjusting these exercises is therefore the next step before a larger trial can be conducted.

P2-M-99 Association between motor skills and physical activity in preschoolers

Becky Breau¹, Berit Steenbock², Marvin Wright², Christoph Buck², Mirko Brandes²

¹University of Guelph, ²Leibniz Institute for Prevention Research and Epidemiology

BACKGROUND: The preschool years (ages 3-5) encompass several essential developmental milestones, including the acquisition of basic motor skills such as running, jumping and balance (1). A consistent positive association between motor skill performance and physical activity (PA) has been reported for preschoolers but the relationship varies with age, sex, type of PA and PA on week vs weekend days (2). This study aimed to investigate the relationship between motor skills and habitual levels of moderate-to-vigorous PA (MVPA), light PA (LPA) and sedentary behaviour (SB) on week and weekend days. It was hypothesized that children with higher levels of MVPA and LPA and decreased levels of SB, would perform better on motor skills testing. **METHODS:** 154 children (4.3, 76 boys) were recruited from daycare facilities across Germany. Five motor skill tests were administered (3; KiMo test) including shuttle run (SR, seconds), jumping side to side (JSS, # of jumps), standing long jump (SLJ, cm), one leg stand (OLS, # of touchdowns), sit and reach (SAR, cm). Children wore a GENEActiv (100 Hz, ActivInsight Ltd, Kimbolton, UK) on their wrist for 7 days, 24 hours/day. Raw data was analyzed using the R package "GENEAread" (version 3.4.3). Periods of non-wear were removed and data between the hours of 7pm and 7am was excluded to remove sleep data. Inclusion criterion included a wear time of at least 8 hours/day on at least 3 weekdays and 1 weekend day. Energy expenditure was predicted using a Random Forest Model (4) to determine percentage of wear time spent in SB, LPA and MVPA. Multiple linear regression analyses were conducted to predict motor skill performance based on %MVPA, %LPA and %SB on weekday and weekend days (SPSS V24; p <0.05). **RESULTS:** Standard multiple regression equations adjusted for age, sex and height indicated significant associations between motor skills and PA variables. Weekday %MVPA had significant associations with better SR and JSS performance and was associated with decreased SLJ performance. Weekday %LPA and %SB was significantly associated with decreased performance



for SR, SLJ, JSS and OLS tests. Weekend MVPA had no significant associations, but decreased weekend %SB and %LPA was significantly associated with better performance on SLJ, JSS, OLS and decreased performance on SR. **CONCLUSIONS:** Results suggest a relationship between PA, SB and motor skills in preschoolers. The associations between weekday MVPA and SR and JSS tests indicate that MVPA acquired during the week may play an important role in development of speed and strength-endurance skills in early childhood. Controversially, the impact of weekend and weekday %LPA and %SB on motor skills remains questionable and further investigation is needed to determine the impact of LPA and SB on motor skills in preschool aged children. REFERENCES:1.Dosman et al. PMC 3549694. 2.Figueroa et al. doi:10.1007//s10995-016-2101-1. 3.Dordel et al "KiMo Test Manual". 4.Steenbock et al. in print.

P2-M-100 A validation and comparison of Actigraph GT9X Link and RunScribe Plus accelerometers for the estimation of skeletal loading during habitual physical activities

Simon Higgins¹, Srikant Vallabhajosula¹

¹Elon University

BACKGROUND AND AIM: Physical activity (PA), specifically weight-bearing activities, infers benefits to skeletal health across the lifespan, primarily through the loads applied to bone. However, much of the evidence used to inform current PA guidelines utilizes energy expenditure based accelerometer outcomes such as time in moderate-to-vigorous intensity PA, rather than estimates of mechanical load. To improve our understanding of skeletal loading in a free-living context, accurate methods for the assessment of ground reaction forces (GRFs) during habitual PA are needed. Advances in accelerometry; providing a wider dynamic range, higher sampling frequency, and prolonged battery life, may provide simple and inexpensive methods to assess skeletal load. Moreover, commercially available devices are making the assessment of skeletal load accessible by reducing the cost and need for technical expertise associated with researchgrade devices. The purpose of this study was to examine the concurrent validity of research-grade and commercially available accelerometers in the estimation of skeletal load during several simulated habitual physical activities. **METHODS:** Healthy young adults (n=27; 22.1 ± 3.5 years, 55.6% female) were fitted with research-grade (Actigraph GT9X Link; ±8g, 100Hz) and commercially available (RunScribe Plus®; ±16g, 500Hz) accelerometers, superior to their right lateral malleolus and on the heel of their right shoe, respectively, using manufacturer supplied mountings. Participants completed eight trials of walking $(1.4 \pm .2 \text{ m/s})$, jogging $(2.6 \pm .4 \text{ m/s})$, and running (3.8 ± .6 m/s) over an in-ground force plate (AMTI; 1000Hz) at a self-selected speed. Peak vertical and resultant GRFs were assessed during one step of each trial. Impact, braking, and shock accelerations of the corresponding step were quantified using the RunScribe proprietary footstep model. Peak vertical (ACCvert) and resultant accelerations were isolated from raw Actigraph data. Pearson's correlations between GRFs and accelerometer outcomes were calculated for each participant, individually and compared between devices using Fisher's rz



transformation. **RESULTS:** Small to moderate correlations were identified between peak accelerations from Actigraph and RunScribe devices and GRF values during walking (r range = .20 - .43), jogging (r range = .35 - .38), and running (r range = .36 - .39), however, there were no differences between devices (all p >.05). Actigraph ACCvert exhibited the strongest relationship with GRF, with a moderate correlation (r = .43, Cl: .05, .85). **CONCLUSIONS:** Both devices correlated positively with GRFs during walking, jogging, and running. These data suggest that the use of foot/ankle accelerometry has potential as a bone-specific physical activity measure. However, due to the limited strength of associations, further research is needed to identify alternative accelerometry outcomes and wear-sites that best predict skeletal loading during habitual PA.

P2-M-101 The beneficial effects of multisensory balance training in older adults: A systematic review

Shu-Chun Lee¹, Li-Yun Yeh¹

¹Taipei Medical University

BACKGROUND AND AIM: Effective postural control requires the integration of visual, vestibular and proprioceptive sensory input. However, both postural control and sensory system degenerate with age. Multisensory balance training has been reported to improve the weighting and integration of sensory systems by manipulating visual, proprioceptive, and vestibular information. It also contributes to increase the postural stability, improve walking function and decrease risks of falls. Many studies examined the effects of multisensory exercise on physical function in older adults but there is no study to review the content of multisensory exercise and its effectiveness. Therefore, this study was to systematically review the literature investigating the beneficial effects of multisensory balance training in older adults. METHODS: Systematic identification of published literature was performed adhering to PRISMA guidelines. Database searches were conducted in PubMed, Medline, EMBASE, CINAHL, and Web of Science from 2008 until 2018 for the following keywords: multisensory OR multiple sensory OR sensory input AND training OR exercise AND older adults OR elderly. Inclusion criteria were 1) multisensory exercise; 2) English article; 3) reporting motor related parameters; 4) older adults. Exclusion criteria were 1) no reporting training effects; 2) investigation in children or patients; 3) review article, conference paper, or thesis. Two independent reviewers (SCL and LYY) applied the selection criteria and assessed the quality of the studies. **RESULTS:**Six articles met all inclusion criteria including 4 randomized controlled trials (RCTs) and 2 quasi-experimental studies. A total of 218 older adults were included. All studies adopted multisensory training by manipulating vision and proprioception but two studies additionally add vestibular exercise. Of four RCTs, two compared multisensory balance exercise against strengthening exercise, one compared with stretching exercise and one compared against balance exercise without altered sensory input. Training duration was varied between studies from 1 to 3 sessions per week for 3 to 16 weeks. Significant improvements after intervention of



multisensory exercise were reported by all studies in lower limbs strength, balance ability, walking function, fall risks, and vertigo symptom. However, multisensory exercise in comparison with control intervention only has greater beneficial effects on balance (Timed Up and Go Test, Berg Balance Scale, Modified Clinical Test of Sensory Interaction on Balance), walking (Functional Gait Assessment, 10 Meters Walk Test) and fall risks (Physiological Profile Assessment). **CONCLUSIONS:** This review suggests that multisensory balance training significantly improved balance and walking function as well as decreased the risks of falling. However, the majority of studies applied multisensory exercise with only visual and proprioceptive manipulation and lack of vestibular exercise. Heterogenetic exercise mode of control intervention could influence between-groups comparison. Further studies with large sample size and longer exercise duration are needed to confirm these findings. **ACKNOWLEDGEMENTS AND FUNDING:** This study was funded by Taipei Medical University (TMU106-AE1-B50).

P2-M-102 The effect of bed rest on balance control in healthy adults: A systematic scoping review

Tyler Saumur¹, Sarah Gregor¹, George Mochizuki¹, Avril Mansfield², Sunita Mathur¹

¹University of Toronto, ²Toronto Rehabilitation Institute

BACKGROUND AND AIM: Hospitalization due to acute medical or surgical conditions can result in prolonged periods of inactivity and bed rest. Following bed rest, there are changes in the systems responsible for balance control. Despite these deficits, there have been heterogeneous results from studies investigating the effect of bed rest on balance control. The objective of this systematic scoping review was to determine the effect of bed rest on balance control in healthy adults. It further aimed to determine which outcome measures, bed rest models, and countermeasures have been previously used in the context of balance following bed rest. The mechanisms responsible for balance deficits following bed rest were determined through evaluating the effectiveness of countermeasures. **METHODS:** Studies published from January 1946 to May 2018 were included in the present review. We included studies with healthy adults who were subjected to bed rest (1.5 days), and had balance assessed before and after bed rest. Searches were conducted in six databases (MEDLINE, Embase, Allied and Complementary Medicine, Cumulative Index to Nursing and Allied Health Literature, SPORTDiscus, and Cochrane Library) with the search strategy initially adapted for MEDLINE. Risk of bias was assessed using the NIH Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies. **RESULTS:** After the screening of 8,897 articles, 16 were included for qualitative synthesis. The mean number of participants in the included studies was 13 (range: 4-30), with the mean age ranging from 20 to 60 years of age, and mean length of bed rest length of 33.8 days (range: 5-90). Balance measures were most commonly collected using force plates and assessed during various postural conditions, which manipulated the amount of available sensory information (e.g. visual, vestibular). Fourteen studies found balance decrements in at least one balance measure,



whereas six studies found impairments in the majority of their collected balance measures. Of the 12 studies that included a countermeasure, three successfully offset most balance deficits following bed rest. The effective countermeasures were low magnitude mechanical signals, lower-body negative pressure, or a combination of balance, strength, and aerobic training. These interventions aimed to offset deficits primarily of the musculoskeletal and cardiovascular systems. The main limitations of the studies reviewed were a lack of both sample size justification and inclusion of female participants, limiting the generalizability of these findings. **CONCLUSIONS:** While bed rest appears to have a negative effect on balance, the mechanisms responsible for these deficits are still not well understood. Future work should include larger sample sizes of males and females, and older individuals, and further test the systems involved in balance control to understand the cause of these deficits. PROSPERO Registration: CRD42018098887 **ACKNOWLEDGEMENTS AND FUNDING:** The authors would like to thank Ms. Erica Lenton for her assistance advising search methods and developing a search strategy. **FUNDING:** Ontario Graduate Scholarship, Peterborough KM Hunter Charitable Foundation Graduate Award, University of Toronto Fellowship Top-Up.

P2-M-103 Effect of slope squat on lower-extremity muscle activity

Yi Wan¹, Jianqiao Wang², Jennifer Davies¹, Kate Button¹, Mohammad Al-Amri¹

¹Cardiff University, ²China Rehabilitation Research Center

BACKGROUND AND AIM: Squat is a common multi-joint close-kinetic exercise used by clinicians and sport coaches to strengthen the lower-extremity (LE) muscles and enhance the posture and balance control of the lower limb. However, squatting on level ground with inappropriate load and posture may cause ligament, meniscus, and muscle injuries. Excessive shear and compressive forces at the knee are the main risk factors for injuries during squatting. These forces are produced by cross-joint muscles (quadriceps, hamstrings, and gastrocnemius) during contraction. Previous studies indicate that exercise on a decline surface can decrease force generation and tension of the LE muscles, and allow better isolation of the knee extensor mechanism. Therefore, squatting on a decline slope might reduce the load on the knee joint by reducing LE muscle activation compared to level squat. Most previous studies have evaluated the effect of slope on LE muscles during walking, and few have studied the effect during squatting. Furthermore, previous squat studies did not have a unified squat depth, which is essential for a valid comparison of muscle activity. Therefore, this study aimed to explore the effects of a decline surface on LE muscle activity during double-leg squats in healthy subjects. METHODS: Fifteen participants (age 24.5 ± 3.2 years) performed five squats on both 5-degree slope and level ground. Surface electromyography (EMG) was recorded from three muscles of the dominant leg: rectus femoris, biceps femoris, and gastrocnemius. Participants were instructed to squat to a depth at which their thighs were parallel to the treadmill surface, which is around a 70-degree squat. A GoPro camera recorded the squat performance, and the peak knee joint angle (PKJA) was





measured by Kinovea software. The rectified and smoothed EMG at PKJA was used for statistical analysis, including Shapiro-Wilk test and paired t-test. **RESULTS:** There was no significant difference in PKJA between squats on a 5-degree slope and on level ground ($70 \pm 2.6^{\circ}$ and $72 \pm 4.6^{\circ}$ respectively, P = 0.095), which laid a valid foundation for the muscle activation comparison. For biceps femoris, EMG at PKJA was significantly lower on the 5-degree slope than on level ground ($54 \pm 36.4 \mu$ V and $60 \pm 32.9 \mu$ V respectively, P = 0.016). For rectus femoris and gastrocnemius, there was no significant difference in EMG at PKJA. **CONCLUSIONS:** Less activity in biceps femoris is required to perform squat on a 5-degree decline than on level ground. In clinical rehabilitation, patients with knee injury who have LE muscle weakness may benefit from performing squats on a decline surface. In addition, athletes and body builders who use progressive strength-gain programs may benefit from decline squat.

N - Falls and fall prevention

P2-N-104 A novel multivariate approach to characterise stair-negotiating behaviour and detect fall risk in older adults

Thijs Ackermans¹, Natasha Francksen¹, Raul Casana-Eslava¹, Carolyn Lees¹, Vasilios Baltzopoulos¹, Paulo Lisboa¹, Mark Hollands¹, Thomas O'Brien¹, Constantinos Maganaris¹

¹Liverpool John Moores University

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BACKGROUND AND AIM: Stair negotiation is amongst the most challenging daily tasks performed by older adults, often resulting in falls. Stair fall risk has typically been assessed by quantifying mean differences between subject groups for single biomechanical parameters indicative of risk. This approach overlooks the fact that certain individuals within a group may also display more conservative stepping strategies, which could potentially compensate for the risky behaviours. The aim of this study was to group individuals based on multiple biomechanical outcome measures indicative of riskier and safer stepping behaviour using a clustering approach and investigate which combination of behaviours could eventually lead to a future stair fall. METHODS: Twenty-five younger (24.5±3.3 yrs) and 70 older adults (71.1±4.1 yrs), with (27) and without (43) a history of falling, ascended and descended a custom-built instrumented seven-step staircase at their self-selected pace in a step-over manner without using the handrails. Measured biomechanical parameters included: foot clearance, foot contact area, required coefficient of friction, cadence, and variance of the above parameters. Centre of mass angular acceleration and its variation were included for descent. Subsequently, all older participants were followed for 6 months and falls on stairs were recorded. K-means clustering was performed to group individuals based on biomechanical stair negotiation behaviour. The cluster profiles were calculated to examine differences between clusters and kaplan-meier survival modelling was executed to estimate fall survival rates for the clusters. RESULTS: Five clusters during stair ascent and four clusters during stair descent were identified, all containing a mix of younger, older non-fallers and





previous fallers. The cluster profiles revealed that clusters differed from the overall mean by showing: a) solely risky strategies; b) solely conservative strategies; c) a combination of risky and conservative strategies or d) no particularly risky or conservative strategies (Table 1). Sixteen stair falls, 12 during ascent and 4 during descent, were reported during the follow-up period in the older adults. No significant differences in stair fall survival rates for the clusters during stair ascent and descent were identified. **CONCLUSIONS:** In contrast to the conventional grouping approach, the current multivariate approach revealed that the clusters were not unique to old age and a previous fall, highlighting the limited predictive power of conventional comparisons of individual parameters. The total number of falls sustained in the six month follow-up period were insufficient to identify the behaviour that can differentiate stair fallers from non-fallers. Therefore, the follow up is extended to 12 months, which may lead to the identification of the specific stepping behaviour causing the stair falls, this would enable the design of targeted interventions to improve stair safety.

P2-N-105 Walking for better outcomes and recovery: The effect of WALK-FOR in preventing hospital-associated functional decline among older adults

Maayan Agmon¹, Anna Zisberg¹, Yaniv Cohen¹, Efrat Gil², Yehudith Chayat³, Chedva Levin⁴, Nurit Gur-Yaish¹, Debbi Rand⁵

¹University of Haifa, ²Clalit Health Services, Israel, ³Hemek Medical Center, ⁴Lev Academic Center, Jerusalem, ⁵Tel-Aviv University

BACKGROUND: Hospitalization of older adults for non-disabling conditions, such as pneumonia or chronic illness exacerbations, results in 30 to 50% functional decline and long-term community mobility limitations. Limited in-hospital mobility is strongly linked to hospital-associated functional decline (HAFD) among older adults, even after controlling for important confounders such as prior functioning, comorbidity, illness acuity, depression, and malnutrition. Immobility of older adults during hospitalization is associated with hospital-associated functional decline (HAFD). Several interventions demonstrated the potential to prevent HAFD, however the effect of a measurable mobility dose is yet to be examined. The goal of the current study is to examine the effect of mobility dose targeted intervention (i.e., more than 900 steps per day) on the prevention of HAFD. **METHODS:** A guasi-experimental pre-post two-group (intervention group [IG] n = 188, control group [CG] n = 189) design was applied in two hospital internal-medical units. On admission, patients were asked about pre-hospitalization functional status, which was assessed again at discharge and at 1-month follow-up. Primary outcome was decline in basic activities of daily living (BADL), using Modified Barthel Index (MBI). Secondary outcomes were: instrumental ADL (Lawton's IADL scale), and community mobility (Yale Physical Activity Survey). All participants (75.1 ± 7 years old) were cognitively intact and could walk at admission. The WALK-FOR intervention included a unit-tailored mobility program utilizing patient-and-staff education with a specific mobility goal (900 steps/days), measured by accelerometer. RESULTS: Number of



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patients who walked above 900 steps per day was 1.4 times higher than CG patients (87% vs. 61%, respectively, $\chi 2 = 34.1$, P < 0.001). Decline in BADL occurred among 33% of the CG versus 23% of the IG (p = 0.02) at discharge, and among 43% of the CG versus 30% in the IG (p = 0.01) at 1-month follow-up. Similarly, 33% of the CG versus 23% of the IG declined in community mobility at 1-month follow-up (p = 0.01). Adjusted for major covariates, the intervention reduced the odds of decline in BADL by 41% (p = 0.05) at discharge and by 49% at 1-month follow-up (p = 0.01), and of decline in community mobility by 45% (p = 0.04). There was no significant effect of the intervention on IADL decline (p = 0.19). **CONCLUSIONS:** The WALK-FOR intervention is an effective way to reduce HAFD.

P2-N-106 Lateral loss of balance among one-time fallers and recurrent fallers reveals contrasted differences in step thresholds and spatiotemporal parameters compared to non-fallers

Shani Batcir¹, Guy Shani¹, Amir Shapiro¹, Yoav Gimmon¹, Ilan Kurz¹, Itshak Melzer¹

¹Ben-Gurion University

BACKGROUND AND AIM: Older adults have impaired lateral stability during loss of balance even in falls that are initiated by anterior-posterior direction. Lateral falls are associated with a risk of hip fracture. Effective recovery steps play a critical role in preventing falls. We aimed to explore differences in single-step and multiple step thresholds, and the kinematics of recovery step following unexpected loss of balance in older adults who reported past falls. METHODS: Eightyseven independent older adults were recruited: 55 Non-Fallers (NF), 20 One-time Fallers (OF) and 12 Recurrent-Fallers (RF). Subjects were exposed to random right and left surface translations that systematically increased from low to high (1-13) magnitudes. They were instructed to "react naturally". Single-step and multiple-steps thresholds and their kinematics were analyzed using 3D motion analysis system. RESULTS: A total of 2059 balance recovery trials were evaluated (1325 for NF, 488 for OF and 286 for RF). There were no significant group-related differences in age, gender, height, Body-Mass-Index, Mini-Mental, medication per day and diagnosed diseases. However, NF showed lower Fall-Efficacy score than OF (P=0.009), and higher self-reported lower extremity functions compared with RF (P=0.005). Compared with NF, OF had significantly lower single-step threshold (8.79±3.5 vs. 6.90±3.0, p=0.033) and multiplesteps threshold (11.88±3.5 vs. 9.47±3.4, p=0.013). Surprisingly there were no differences in single-step and multiple-steps thresholds between NF and RF (8.79±3.5 vs 8.08±2.3 and 11.88±3.5 vs. 10.27±3.5, respectively). The probabilities of stepping in increasing perturbation magnitudes were higher in OF compared with NF in 3-7 magnitudes, while RF showed higher probabilities of stepping in 9-13 magnitudes. Surprisingly, we found no differences between the NF and OF in their first-recovery step (step initiation duration, swing duration, step time) and total time to complete whole recovery reaction. RF however, exhibited larger first recovery step length, larger total recovery steps lengths and larger total Center-Of-Mass (COM) displacements,



compared with NF and OF. **CONCLUSIONS:** The step thresholds were lower in OF while larger recovery step lengths and COM displacement were larger in RF, both compared to NF. The results suggest that the balance control system in both faller groups triggered in different level of sensitivity. OF showed hypersensitive balance responses, causing use of stepping strategy in lower level of balance disturbance, and higher probabilities of stepping in lower perturbation magnitudes, but with no differences in kinematic of stepping compared to NF. Higher Fear of falling may be the cause. The RF balance control system may be hyposensitive, they had similar step thresholds as the NF but with differences in kinematics (i.e. larger recovery step lengths and COM displacement) This highlight the importance of perturbation training to improve compensatory stepping abilities in RF. ACKNOWLEDGEMENTS: This study was supported by a grant from the Israeli Ministry of Health (2011-056) and partially by the Helmsley Charitable Trust through the Agricultural, Biological and Cognitive Robotics Initiative of Ben-Gurion University of the Negev.

P2-N-107 Falling down - limbs and trunk muscles responses to vertical perturbations

Desiderio Cano Porras¹, Jesse Jacobs², Rivka Inzelberg³, Ofer Keren¹, Gabriel Zeilig¹, Meir Plotnik¹

¹Sheba Medical Center, ²University of Vermont, ³Tel Aviv University

BACKGROUND AND AIM: Destabilizing perturbations in a safe and controlled environment are an emerging training method to improve reactive balance control. Loss of balance is often related to changes in the surface height, i.e. in the vertical plane. Research, however, has historically focused on horizontal perturbations. The aim of this study is to map muscles' responses (i.e., as expressed by electromyography - EMG) to vertical perturbations and compare them with responses to horizontal perturbations. **METHODS:** Fourteen healthy participants (10 male; age: 27±4y) stood on a moveable platform within a virtual reality system with a 360° dome-shaped screen. Amid a larger protocol that included other conditions and tasks, subjects responded to 24 perturbations (12cm displacement in one second) randomized across three repetitions for each of four perturbation directions and two sensory conditions. Perturbations included forwards (FP), backwards (BP), downwards (DP) and upwards (UP), each with the eyes open (EO) and the eyes closed (EC). EMG activity was recorded bilaterally in eight muscles (Fig 1); differences were not often evident across the left and right muscles, so here we report on the right-side activations. We calculated three muscle activation parameters: onset latency, duration of activation, and magnitude. Separate 2-factor repeated-measures ANOVA were applied for each outcome measure across factors of perturbation direction (FP, BP, UP and DP) and condition (EC, EO). **RESULTS:** All muscles had a lower activation magnitude during vertical perturbations; for example, the gastrocnemius: 35.5±3.43 µV*s in FP, 28.3±2.49 µV*s in BP, 13.6±1.50 µV*s in UP, and 15.1±1.47 µV*s in DP; P<0.05. Vertical perturbations also often generated larger onset latencies; for example, the tibialis anterior: 229±10.0 ms in FP, 248±12.2 ms in BP, 310±24.2 ms in UP, and 440±39.7 ms in DP; P<0.05. When comparing conditions, the EO condition elicited



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lower-magnitude activations than the EC condition for the tibialis anterior ($22.8\pm2.71 \mu$ V*s in EO, $30.2\pm3.70 \mu$ V*s in EC; P<0.05), gastrocnemius ($19.9\pm1.56 \mu$ V*s in EO, $26.8\pm2.44 \mu$ V*s in EC; P<0.05), and paraspinal muscles ($7.12\pm0.44 \mu$ V*s in EO, $8.75\pm0.60 \mu$ V*s in EC; P<0.05). In addition, the paraspinal muscles had a shorter duration of activation in EO conditions: 534 ± 35.3 ms in EO, 663 ± 42.4 ms in EC; P<0.05 (Fig. 1). **CONCLUSIONS:** This study lays groundwork for investigating muscular activation following vertical perturbations. Our results suggest that vertical perturbations provoke delayed and less intense reactions than horizontal perturbations. Our findings that shank and paraspinal muscles were more active during EC conditions suggest an additional load on postural responses driven by the absence of visual input. Future research might explore the incorporation of vertical perturbations in early stages of balance reaction therapies and in research projects on falls risk. **FUNDING:** Marie Sklodowska-Curie grant agreement No 642961.

P2-N-108 Falls and locomotor capabilities in lower limb amputees. First results of a retrospective study from the MOTU project

Lorenzo Chiari¹, Serena Moscato¹, Pericle Randi², Luca Palmerini¹, Angelo Davalli², Pierpaolo Palumbo¹

¹Alma Mater Studiorum - Universita' di Bologna, ²INAIL Prosthesis Centre

BACKGROUND AND AIM The annual incidence of lower limb amputations is around 20 new cases for 100,000 persons. Lower limb amputees (LLA) face problems in static and dynamic equilibrium and an increased risk of falling. Some studies have investigated personal fall risk factors of LLA within rehabilitation units, but the safety of different prosthetic components with respect to falls has not been adequately assessed. Here we announce the first results of a study which aims at investigating the efficacy of different exoskeletal prosthetic knees with respect to fall risk and locomotor capabilities. Characteristics of LLA and their prostheses, and preliminary analysis on study outcomes are presented. Methods This is a retrospective study on the archive of INAIL (Italian Institute of Insurance against Job Injuries) prosthesis centre. We take falls at the rehabilitation unit and the Locomotor Capability Index (LCI) as clinical outcomes. The study has been approved by the local ethical committee. Results We have extracted so far data of 218 hospital stays relative to 198 patients (about 20% of the archive). The sample is heterogeneous with respect to age (mean 57, std. dev. 15.7 years), causes of amputation (job injuries 68%, vascular pathologies 11%, road accidents 7%, infections 3%, cancer 3%, others 9%), time from amputation (mean 17.9, std. dev. 17.6 months). Rehabilitation stays relative to training for the first prosthesis (first stays) are 26,5%. The sample is a mix of two populations with different funding schemes: 68% are covered by INAIL job insurance, 32% are covered by the national health system. Twenty-two different types of prosthetic knees are used by patients. They can be grouped in microprocessor-controlled knees (44.2%) and non-microprocessor-controlled knees (55.8%). Fall rate during the rehabilitation stay amounts to 16 falls for 1,000 person-months, decreasing

with age after the thirties. LCI during first stays increases on average from 28.9 to 42.2 points. During successive rehabilitation stays it increases from 43.6 to 46.8. **Conclusions** The sample is characterized by a heterogeneous population and a high number of different prosthetic knees. The association between falls and personal risk factors (e.g. age) may significantly differ from that found in older adults. LCI is responsive to rehabilitation treatment. It may be used together with falls as an outcome to investigate the efficacy of the different prostheses.

P2-N-109 Measuring foot clearance on outdoor walkways

Ghazaleh Delfi¹, Megan Kamachi¹, Jose Beltran², Tilak Dutta³

¹Toronto Rehabilitation Institute / University of Toronto, ²Toronto Rehabilitation Institute, ³Toronto Rehabilitation Hospital

Over half of falls in older adults are caused by tripping. Many of these trips are caused by small obstacles present on outdoor walkways. The current practice for many municipalities is to repair outdoor walkway tripping hazards that are higher than 6mm, ignoring the rest. There is evidence that older adults are likely to trip on obstacles smaller than this cut-off. We hypothesize that smaller obstacles may be just as hazardous, if not more hazardous, for older adults; because smaller obstacles are more difficult to see and therefore adjust for. To test this hypothesis, there is a need to measure foot clearance in a real-world setting. The existing evidence reporting foot clearance of younger and older adults include only lab-based measurements with many gathering data from participants walking on a treadmill. Studies have shown that these settings have significant effects on gait. There are currently no existing studies that report on measurement of foot clearance from pedestrians in real-world settings. Our team has developed a system for measuring foot clearance on outdoor walkways we call the Parallel Laser Array Recording device (PLAR). The device is comprised of a camera and two lasers and is designed to be positioned at ground level next to a public walkway to collect sagittal plane videos of a pedestrian's lower body as they walk by. The parallel laser beams provide the ability to convert distances measured in pixels in the video images to real-world distances (mm). The benefits of this system are that (1) it can easily collect large amounts of video data quickly from many pedestrians and (2) there is no need for applying any markers to the "participants" or the environment being controlled in any way. This paper reports on our use of machine learning and computer vision methods to analyze the recorded videos to automatically locate the pedestrians' feet and measure their minimum foot clearance values. This data will be used to provide evidence-based guidelines for outdoor walkway maintenance. Our preliminary results show that we were able to locate the footwear with 76% IOU (intersection over union), the bottom of the shoes were located within 4 pixels of the ground truth and the laser beams were successfully located in 60% of the cases. Our findings to-date indicate that our system will have an overall accuracy of ±1mm for estimating minimum foot clearance when compared to manual measurements.



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P2-N-110 Wearable sensor detection of real-world trips in at-fall risk community dwelling older adults

Shirley Handelzalts¹, Neil Alexander², Linda Nyquist², Debra Strasburg², Nicholas Mastruserio², Lauro Ojeda²

¹Ben-Gurion University, ²University of Michigan

BACKGROUND: Near falls, such as trips, involve a loss of balance (LOB) that does not result in a fall, occur more frequently than actual falls, and associate with fall risk in older adults. There are few data on the objective detection of and kinematics associated with near falls in older adults during daily life activities. Monitoring of near falls during daily activities could provide important information for ascertaining fall risk and targeted interventions to reduce fall risk. Aim: To determine key body kinematics using inertial measurement units (IMU) underlying real life near falls, with an emphasis on trips. METHODS: Eleven community dwelling older adults at fall-risk (6F, 5M, mean 76 years) recorded near falls context information using a voice recorder worn on their wrist during waking hours for two weeks. Near falls were defined as events where balance control was lost at least momentarily, such as a slip, trip, stumble, or misstep. Body kinematics were recorded using four IMUs (Opal, APDM Inc.) mounted on the feet, lumbar spine and wrist. A 10-minute window of IMU data prior to the time-stamped voice recording notation of an LOB were processed to estimate feet trajectory as well as trunk and arm orientations. This information was combined to estimate the body pose and used to generate an animation showing kinematic representation of body movement. An observer, blinded to the context of the reported event, viewed the signals aiming to identify an LOB event. Upon identifying these potential events, the observer used the animation to corroborate the occurrence of the LOB. RESULTS: Only the events that were reported as "trips" by the participants are reported here. A total of 29 trips were reported from 7 out of 11 participants. Fifteen trips occurred while walking in the home, 2 while ascending/descending home stairs ,8 while walking outside and 4 with unknown environment. Of the 29 trips reported, 21 (72%) were corroborated as 'trips' by the observer. Trips were identified from feet velocities demonstrating irregularities in foot velocity during the swing phase. (i.e., unusual high frequency oscillations indicating a change in foot velocity during the swing phase, Figure 1). In some cases, irregularity in lumbar signals (i.e., pitch angular velocity) was observed as well. The 28% of trips reported by the participant but not observed kinematically might represent kinematic irregularities during the viewing epoch or reported LOBs that were outside the viewing epoch. CONCLUSIONS: This sensor-based approach combined with voice recordings of near falls demonstrates the feasibility of identifying trip-related LOBs during real world activities. These preliminary results constitute the basis for development of an algorithm for automated detection of near falls among older adults.



P2-N-111 Static balance following a 12-week attentionally focused balance training intervention: preliminary data

Lauren Higgins¹, Masa Yamada¹, Ruth Stout¹, Danielle Felsberg¹, Chanel LoJacono¹, Sean Cochran¹, Amanda Barclift¹, John Palazzolo¹, Jeff Labban¹, Jeffrey Fairbrother¹, Christopher Rhea¹, Louisa Raisbeck¹

¹University of North Carolina, Greensboro

BACKGROUND AND AIM: Poor balance increases risk of falling and consequently the incidence of physical disability and early mortality in older adults. Balance can be defined statically as the ability to maintain a base of support with minimal movement (e.g. single leg stance) and dynamically as the ability to perform a task while maintaining a stable position (e.g. walking up stairs). The decline in balance associated with aging presents an opportunity for primary prevention through effective interventions. Previous interventions have focused largely on the biomechanical aspects of balance, while overlooking the potential contributions of cognitive factors such as attentional focus. Which can be further be differentiated into internal focus, directing a learners' attention to their body movements, or external focus, directing attention to the effects of their movement on the environment. The purpose of this study was to evaluate changes in static balance, evaluated as postural sway, following 12 weeks of attentionally focused, dynamic balance training. It was hypothesized that participants who received internal focus instructions would have greater postural sway compared to those who received external focus instructions. **METHODS**: Older adults (N=13, 6 males, 7 females; 79.1 ± 6.2 yrs) who reported a fall in the past year were recruited for this study. Participants were randomly assigned to either an external focus group (EF, N=8) or internal focus group (IF, N=5). Prior to each trial, the EF group was instructed to, "Focus on keeping the board level with the floor", while the IF group was instructed to, "Focus on keeping your feet level with the floor". Participants completed 12 weeks of dynamic balance training utilizing CanDo® Balance Boards. Training occurred twice per week for 20 minutes (20 continuous rounds; 30 sec balance, 30 sec rest). At baseline and 12 weeks, the BTrackS? Balance Tracking System with Sport Balance Software was used to quantify postural sway via force plate center of pressure. For three, 20-second trials, participants stood on the force plate with hands on hips and eyes closed. Hedges' g effect size calculations were used to quantify the effect of group assignment. **RESULTS:** In the EF group, there was a small negative effect of training on static balance, with postural sway improving by 8.5% (d= -0.18). In contrast, postural sway in the IF group increased by 10.5% (d= 0.33). CONCLUSION: The positive effects of dynamic balance training with EF relative to IF suggests that an external focus of attention may be an advantageous training strategy for improving static balance. Whereas, internal focus may lead to maladaptation, which is consistent with previous literature. Adopting an external focus of attention may be a cost effective and beneficial way to enhance balance interventions for the prevention of falls in older adults.





P2-N-112 Joint angle variance in the bipedal linked chain during curb negotiation

Ashwini Kulkarni¹, HyeYoung Cho¹, Chuyi Cui¹, Shirley Rietdyk¹, Satyajit Ambike¹, Fabio Barbieri²

¹Purdue University, ²São Paulo State University (UNESP)

BACKGROUND AND AIM: Curb negotiation is a challenging activity for older adults. Approximately 15% of falls in this population occur during traversing a curb [1]. During curb descent, downward acceleration of the center of mass (COM) must be controlled, while during curb ascent, the body must be pushed upward and forward. Heel contact is an important event for both tasks because it marks the establishment of a new base of support following the single support phase, and the limb must be correctly positioned to ensure safe weight transfer across the limbs. The joint angle variance in lower limbs at heel contact may shed insight regarding why people are more likely to fall when stepping down from a curb versus stepping up [2]. Therefore, the aim of this study is to quantify the lower limb joint angle variance at heel contact during stepping up and down a curb. METHODS: Six older adults (75±5 years, 5 females) performed 40 trials (20 trials each for stepping down and stepping up a curb). Three-dimensional lower-limb joint angles were obtained at heel contact for each condition. Segment motion was quantified with marker clusters (Vicon, Nexus 2.7), and 3D joint angles were calculated using the MotionMonitor software (IL, USA). Across-trial joint angle variances were quantified for the hip, knee, and ankle in all three planes. These individual variances were summed to quantify total joint angle variance (1) within each plane and (2) across three planes. **RESULTS**: The total joint angle variance during stepping down was more than stepping up the curb (paired t-test: t(5)=3.6, p=0.007; Fig.1). Joint angle variance in the sagittal (p=0.01) and the transverse (p=0.03) planes was higher for the stepup condition, but there was no difference in the variance in the frontal plane (p=0.32). **CONCLUSION:** The ability to perform controlled eccentric contraction is compromised much more in the older adults than the ability to perform concentric contraction, suggesting curb descent to be more challenging than ascent [3]. This may be responsible for the increased jointangle variance while stepping down, which may, in turn, be related to the increased likelihood of falls [2]. ACKNOWLEDGMENTS AND FUNDING: Fulbright Scholar Program REFERENCES:[1] Jacobs, J. V. (2016). Gait & Posture, 49, 159-167. [2] Startzell, J. K. et al. (2000). Journal of the American Geriatrics Society, 48(5), 567-580. [3] Hortobágyi, T. et al. (2001). The Journals of Gerontology. Series A, Biological Sciences and Medical Sciences, 56(1), B38-47.

P2-N-113 Functional Gait Assessment (FGA) after a 12-week attentionally focused balance training intervention: Preliminary data

Danielle Felsberg¹, Lauren Higgins¹, Ruth Stout¹, Masahiro Yamada¹, Sean Cochran¹, Chanel LoJacono¹, Amanda Barclift¹, John Palazzolo¹, Jeff Labban¹, Jeffrey Fairbrother¹, Christopher Rhea¹, Louisa Raisbeck¹

¹University of North Carolina, Greensboro





BACKGROUND AND AIM: The incidence of falls in older adults is a major public health concern, with approximately 15 million experiencing a fall each year. Fall prevention programs to-date have only been moderately successful, potentially due to the types of instructional cues provided during the training. When performing a motor task, research has shown an external focus of attention (i.e., attending to the effect of the movement) leads to greater motor skill learning/retention relative to an internal focus (i.e., attending to the performers own body movements). However, clinicians tend to use internally focused cues during motor skill rehabilitation. Thus, the purpose of this study was to do a head-to-head comparison of external vs. internal cues provided during a 12-week balance training program using a clinical trail approach. This abstract reports on the Functional Gait Assessment (FGA) data, which is part of the larger study dataset. The FGA was used to assess fall risk before and after the 12-week intervention. It uses higher-level balance tasks aimed to mimic everyday dynamic challenges and has established cut-off scores to assess fall risk. For community dwelling adults a FGA score <22 indicates fall risk. We expected to see improvements in dynamic balance as measured by the FGA following the 12-week balance intervention with greater improvement in the external focus group versus the internal focus group. METHODS: Older adults with a history of falls (N=14, 79.2 ± 6.5 yrs) were recruited from a retirement community to participate in the study. Participants were placed into either the external focus (EXT) group (N=8, 81.8 ± 3.5 yrs) or internal focus (INT) group (N=6, 75.8 ± 8.4 yrs) to complete the intervention. Each participant completed 20 minutes of balance training using a 30" wobble board, twice per week for 12 weeks in a community space at their retirement community. Twenty trials of balance practice were performed with 30 seconds of balancing and 30 seconds of rest. The EXT group was given the cue to "please keep the board as level as possible" while the INT group was given the cue "keep your feet as level as possible." The FGA was performed at baseline and week 12. **RESULTS:** At baseline, both groups were indicated as a fall risk as measured by the FGA (EXT M=18.4±3.2; INT M=20.8±4.4). Both groups improved their FGA score after the 12 weeks of balance training (EXT M=20.3±5.0) and INT (M=23.0±5.5), with a Cohen's d effect size comparing week 0 to week 12 within each group approaching moderate (EXT d=0.45; INT d=0.43). Of note, following intervention, the INT group improved their FGA score (M = 23.0) above threshold for fall risk. CONCLUSIONS: To our knowledge, this is the first study to investigate the effects of attentional focus on balance training using a 12-week intervention performed in a community setting. These preliminary findings suggest a positive practice effect of balance training with use of attentional cues.

P2-N-114 Falling for it: The effects of anxiety on balance control

Anna Fielding¹, Will Young¹, Andrew Parton¹

¹Brunel University

BACKGROUND/AIM: Fear of Falling (FoF) in older adults is known to increase the likelihood of falling. FOF has an estimated prevalence of up to 85% in older adults (OAs), and can cause





significant and debilitating personal, social, and economic costs. We aim to explore the cognitive and associated behavioural consequences of FoF, in order to inform development of future interventions. Research highlights that OAs display difficulty integrating and re-weighting sensory inputs for balance control (Ramkhalawansingh, Butler, & Campos, 2018); a problem that may contribute to fall-risk. One proposed mechanism underpinning these age-related differences is altered attentional processing driven by a Fear of Falling (FOF). Heightened FOF is associated with an increased reliance on vision (Jacob, Redfern, & Furman, 1995; Ohno, Wada, Saitoh, Sunaga, & Nagai, 2004). Yet, the specific mechanisms driving this observation are unclear. The current study aimed to further scrutinise the link between anxiety and postural control, by investigating this process in two age groups (young adults [YAs; n=31] & OAs [n=31]) by inducing height-related threat using virtual reality. **METHOD**: Participants stood on a forceplate and viewed a virtual environment; either standing on a cliff (Threat condition) or at ground level (Baseline). During these trials, they experienced a small upward flow of the visual scene (visual perturbation) which created a disparity between visual and non-visual sensory input. Measurement of the resulting balance response (CoP displacement) allows us to quantify the degree to which participants prioritise vision over other senses. State anxiety and magnitude of postural sway was measured in both Threat and Baseline conditions following the visual perturbation. RESULTS: Both groups reported significantly increased anxiety during Threat, with these changes accompanied by significantly greater ranges of sway for both YA and OAs. However, a significant correlation of the magnitude of change in anxiety between Baseline and Threat and the associated sway response was only found in YAs, suggesting the significant effect of Threat was driven primarily by changes observed in YAs. CONCLUSIONS: While anxiety does appear to lead to increased reliance on vison to control balance, it does not fully account for greater reliance on vision in OAs. These results support previous findings that anxiety increases visual reliance for balance control in YAs, and elucidate age differences in how balance is maintained during increased anxiety. Research suggests that encouraging external focus during balance control tasks improves both motor learning and performance, while increased anxiety leads to an increase in internal focus and associated performance decrements (Chiviacowsky, Wulf, & Wally, 2010; Huffman, Horslen, Carpenter, & Adkin, 2009). We speculate that anxiety-related adoption of internal focus could exacerbate, and to a degree, mediate sensory re-weighting during balance control in OAs. Work is ongoing to explore the mechanisms through which anxiety increases reliance on vision.

P2-N-115 Effects of step direction and stimulus modality on step reactions during a prolonged motor-cognitive task in older adults

Eleftheria Giannouli¹, Wiebren Zijlstra¹

¹German Sport University Cologne





BACKGROUND AND AIM: The ability to conduct rapid and precise corrective steps in all directions in order to maintain balance during complex daily life activities is crucial for avoiding a fall. Falls often happen during dual-task conditions, e.g. when a mechanically challenging activity is combined with additional cognitive tasks. Such additional cognitive tasks frequently require reacting to multisensory stimuli. This study aims to compare reaction times (RTs) of steps in different directions as well as steps in reaction to different stimulus modalities in communitydwelling older adults in order to inform stepping interventions for falls prevention. **METHODS**: Data were collected during a prolonged motor-cognitive task. Thirty older adults stood on a force plate connected to an audio-visual display in front of them. They were instructed to step as guickly as possible to the direction indicated by visual (right, left, forwards, backwards) or auditory cues (step forwards for high-pitched tones and step backwards for low-pitched tones). Durations of step reactions (SRT) were assessed as the time between stimulus presentation and stepping on the required position. **RESULTS:** First results of 30 older adults with mean age of 67.6 ± 5.6 years show significantly slower step reactions and higher error rates for anteroposterior steps (20.5% errors and a mean SRT of 1094.4 ms) compared to mediolateral steps (12.9% and 958.6 ms) as well as for steps in response to auditory (29% and 1198.8 ms) compared to visual (12.5% and 973.6 ms) stimuli. **CONCLUSIONS:** These findings suggest that performance of sideways steps differs from forward and backward stepping and that stimulus modality has an effect of stepping reaction times in older adults. Thus, the choice of the direction of the steps and the secondary task at stepping exercise programs is not indifferent when aiming to improve overall stepping performance and prevent falls.

P2-N-116 Association of walk ratio during normal gait speed and fall in communitydwelling elderly people

Sho Nakakubo¹, Takehiko Doi¹, Kota Tsutsumimoto¹, Min-Ji Kim¹, Satoshi Kurita¹, Hideaki Ishii¹, Hiroyuki Shimada¹

¹National Center for Geriatrics and Gerontology

BACKGROUND AND AIM: Walk ratio (WR), calculated by dividing step length by cadence, can be used to represent the gait characteristics of human beings to maintain their gait speed. The aim of this study was to examine whether WR could distinguish fallers from community-dwelling elderly people. **METHODS:** We recruited 9205 elderly people (mean age: 73.7 ± 5.6 years, 4218 men and 4987 women) from the National Center for Geriatrics and Gerontology - Study of Geriatric Syndromes. Fall history was assessed by face to- face interview, and "fallers" were defined as people who had fallen at least once within the past year. WR was calculated as corrected step length divided by corrected cadence, and we divided the subjects into three groups according to the tertile of WR (T1, T2, and T3). We also stratified the participants by gait speed (< 1.0 or \geq 1.0 m/s). **RESULTS:** With reference to the T3 group, the T1 group had a higher odds ratio (OR) of falling in the past year [OR: 1.24, 95% confidence interval (CI): 1.09-1.41], even



after adjusting for other covariates. After stratification by gait speed, the same multivariate analyses were conducted. In the participants who walked at 1.0 m/s or faster, the T1 group had a higher OR [1.27, 95% confidence interval (CI): 1.10-1.48], while there was no significant association with fall rate among those who walked slower than 1.0 m/s. **CONCLUSIONS:** This study revealed that the smallest WR was independently associated with falling in the past year among community-dwelling elderly people, especially elderly people with no deterioration of gait speed. These results suggest that intervention regarding gait pattern, especially WR, would help to prevent falls.

P2-N-117 Validating the rate of perceived stability scale to measure balance training intensity among older adults

M Ann Reinthal¹, Debbie Espy¹, Lorenzo Bianco¹, Kathryn Kroszkewicz¹

¹Cleveland State University

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BACKGROUND AND AIM: About one third of individuals over the age of 65 fall each year, sometimes sustaining serious injuries; balance training programs are often recommended. Balance exercise prescription includes mode, frequency, duration, and intensity. Prescribing the correct dosage is essential for an intervention to be effective. However, there are no currently accepted clinical measures of balance training intensity, so determining the intensity dosage is problematic. We developed the Rate of Perceived Stability (RPS) scale which is a self-rating scale that measures the intensity of balance exercises. The purpose of this study was to validate the RPS scale among older adults, thereby allowing more effective balance training prescription. METHODS: The study consisted of 25 subjects who were community ambulators (male = 7 and female = 18) over the age of 50 (mean = 60.2 and SD = +/-7.61). They were taught to use the RPS scale and completed the Activities-Specific Balance Confidence Scale (ABC), the Berg Balance Scale (Berg), the Timed Up and Go (TUG), and cognitive TUG. Subjects were then randomly assigned four balance training conditions out of 16 possibilities. Conditions consisted of a specific Xbox 360 Kinect game played on a specific therapeutic balance training surface (floor, unstable foam, wobble board, and rolling surface). Each subject stated two RPS ratings during each condition (trial) and an overall RPS rating immediately after each trial. After all the trials were complete, the subject completed a direct ranking of the four trials from 1 (easiest) to 4 (most difficult). The rankings of the trials by sum of the RPS scores (RPS-based rank) for each trial were compared to the subject's direct overall ranking of the conditions afterwards (direct rank). **RESULTS**: The average ABC score was 94.01%. The average Berg score was 55.83. The average TUG time was 6.39 seconds, and the average cognitive TUG time was 8.90 seconds. Six subjects had a perfect match of RPS-based ranking to direct ranking, 12 had matches if ties were considered, and seven subjects had incorrect matches in at least two conditions. Fifty-one trials matched perfectly, 32 trials tied, and 17 trials did not match. The average of summed RPS scores for all games that were directly ranked as 1 (easiest) was 4.32; as 2 was 6.04, as 3 was 8.92, and

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as 4 (hardest) was 14.76. **CONCLUSION:** The RPS-based rankings of the balance training trials aligned well with the subjects' direct ranking of the trial difficulty. The scale can be used effectively to assess the intensity of balance training tasks for proper dosing in exercise prescription. This is essential both to prevent injury or discouragement from tasks that are too difficult as well as to prevent ineffective training from practice that is too easy. Acknowledgments and **FUNDING:** This project was supported by Cleveland State University's Undergraduate Summer Research Award program.

P2-N-118 Transfer and retention effects of perturbation-based treadmill training in older adults.

Markus Rieger¹, Selma Papegaaij², Mirjam Pijnappels¹, Frans Steenbrink², Jaap van Dieën¹

¹Vrije Universiteit Amsterdam, ²Motek Medical BV

BACKGROUND AND AIM, Falls are the leading cause of injuries in older adults1. In daily life, perturbations that demand changing the gait pattern to recover balance and to prevent a fall can occur in any direction. Perturbation training, which is known to positively affect reactive recovery1, is a promising approach in fall prevention in this group 2. With a treadmill, perturbations in anteriorposterior (AP) direction can easily be applied by accelerations or decelerations of the belt, but we don't know if training in this direction transfers to reactive recovery in medio-lateral (ML) direction. This study aimed to evaluate the transfer and retention effects of gait training with treadmill perturbations in AP direction to ML direction, which is important for developing a training protocol only allowing AP perturbations. METHODS, 30 community dwelling older adults aged 65+ from the Amsterdam area (The Netherlands) participated in this experimental trial. They were randomly assigned to a training session with either 16 AP perturbations (experimental group) or with treadmill walking (control group). The baseline, post-intervention and retention test (after 1 week) contained a perturbed walking trial with 4 AP and 4 ML perturbations. Deviations in trunk velocity from steady-state walking were summed over the first three strides after perturbation as a measure of recovery. Separate mixed design ANOVAs with planned comparisons were used to analyze recovery after AP and ML perturbations. **RESULTS**, For AP perturbations, both groups showed better recovery immediately and 1 week post-intervention. A group x time interaction indicated that the improvement was larger in the training group, but immediately post-intervention only (Fig 1a). For ML perturbations, both groups showed better recovery immediately and 1 week post-intervention and no group x time interaction was found (Fig 1b). CONCLUSION, Our results indicate that the baseline measurement with perturbations in ML and AP directions caused significant improvements that were retained after 1 week. Training with AP perturbations did cause a further improvement of recovery after AP perturbations only and this effect was not retained. These results suggest that short-term training can be effective, but do not exclude that multi-directional perturbations may be needed. Direction-specific training may cause specific anticipatory gait changes that allow better recovery after similar perturbations.

ACKNOWLEDGEMENTS AND FUNDING, This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 721577. 1 McCrum C et al., Eur Rev Aging Phys Act. 2017;14(1):3 2 Pai YC et al., JGerontol - Ser A Biol Sci Med Sci. 2014;69(12):1586-1594.

P2-N-119 Elderly fallers and non-fallers adjust their posture in anticipation of perturbations

Thomas Robert¹, Charlotte Le Mouel², Romain Tisserand³, Romain Brette⁴

¹Université de Lyon, ²Max Planck Institute of Intelligent Systems, ³University of British Columbia, ⁴Sorbonne Université, INSERM, CNRS, Institut de la Vision

BACKGROUND AND AIM: The ability to adjust one's standing posture according to the motor task has recently been suggested to be critical for mobility and balance, and young subjects have been shown to adjust their standing posture in anticipation of perturbations. Age-related decreases in this ability could result in balance impairments and higher risk of falling. The purpose of this study was to determine to what extent elderly fallers and non-fallers adjust their posture in anticipation of perturbations, and the influence it has on their ability to cope with external balance perturbation. METHODS: We retrospectively analysed the data of 21 elderly non-fallers, 18 elderly fallers and 11 young adults who participated in a waist-pull perturbation task (3 different directions, but always with a major forward component, proposed in a random order and at a random times) and in a Choice Stepping Reaction Time task (CSRT). Using force platform measurements, we determined the initial position of the centre of mass (CoM) relative to the toes in both tasks. We used the Mann-Whitney U-test to determine whether subjects changed their standing posture preceding the stimulus onset between the two tasks and a Hodges-Lehmann estimator to quantify it. We also used a Mann-Whitney U-test to compare the initial postures between perturbation trials where subjects recovered with a step and those where subject recovered without stepping. **RESULTS:** The initial posture was shifted slightly backward in the perturbation task compared to the CSRT task for all three groups to a similar extent: elderly fallers (p < 0.001, 2.0% limb length), elderly non-fallers (p < 0.001, 2.4% limb length) and young subjects (p < 0.001, 1.8% limb length). Elderly fallers leaned backward as much as the other groups in anticipation of a forward perturbation despite a higher fear of falling (ABC score of 76.3 vs. 90.0 for elderly fallers vs. non faller, p<0.01). Although small, this backward shift seems critical in order to resist the waist-pull because subjects leaned more backward in perturbation trials recovered without stepping (p < p0.001). CONCLUSIONS: Both elderly non-fallers and fallers adjust their initial posture in anticipation of forward perturbations, to an extent comparable to young subjects (respectively 2.4%, 2.0% and 1.8% of limb length). This study extends previous findings that young subjects adjust their standing posture to repeated backwards platform translations. It shows the preserved ability of elderly fallers to anticipate perturbations in a laboratory-based experimental setting. This ability may explain why such tests may fail to discriminate fall risk, as the literature shows



contradictory observations in on the performance of elderly fallers responding to perturbations. Therefore, studies aiming at predicting fall risk in elderly should carefully control for this postural adaptation, by interleaving perturbations of opposite directions for example. **ACKNOWLEDGEMENTS AND FUNDING:** grant ANR-16-CE19-0006-01.

P2-N-120 The influence of fear priming on whole-body reaching in young and older adults

Alexander Stamenkovic¹, Susanne van der Veen¹, James Thomas¹

¹Virginia Commonwealth University

BACKGROUND AND AIM: Anxiety associated with a Fear of Falling (FoF) is common among older adults and is a predictor of future falls risk. The influence of a perceived threat to balance for adults exhibiting high FoF manifest as changes in both static postural and dynamic locomotor behaviour. However, these studies often focus on alterations between groups already exhibiting high or low FoF prior to exposure of a given context. In contrast, less is known about the influence that acute FoF (e.g. through fear priming) has upon movement strategies, and whether these change as a function of age. By increasing the probability for falls to occur across a training period, this study aimed to examine the influence of fear cognition on motor planning and execution during a whole-body reaching task. METHODS: As part of a pilot, 10 young and older height and weight matched adults (21.5±1.7 vs. 58.1±2.2 years) were assessed for baseline perceptions of functional movement capacity and FoF. Whole-body reaching movements were made to a single target with distance and height normalized to the participant, such that it required a forward step and 15° of lumbar flexion to achieve. Movements were made under four postural conditions that altered stability by applying lubricant film to the floor; natural stance (Nat), unstable support limb, unstable landing limb, and unstable support + landing limb (UnStab). Movement behaviour was examined through changes in peak to peak joint excursions, as well as timing of bilateral trunk and lower limb muscle activity (i.e. EMG) relative to the initiation of reach. The analyses focus on the differences between the Nat and UnStab conditions. RESULTS: Visual analogue scales examining the likelihood and concern of falling showed scores that were similar across ages at baseline but that increased with FoF priming (p<0.001). Between conditions, joint motions displayed trends towards decreased flexion in the supporting limb (ankle: p = 0.053, knee: p=0.097) and increased flexion in the landing limb for older adults (knee: p=0.018, hip: p=0.077). Surprisingly, trunk motion increased in both age groups during UnStab reaching (p=0.008). Initial EMG analysis (n=12) also suggests that supporting limb muscle onsets are delayed, activating closer to arm movement onset in older adults during UnStab, while clear changes in the sequence of certain trunk and lower limb muscles are also evident between ages (see Fig 1 - rectus abdominis, gastrocnemius). Overall, total movement time increased between conditions for older adults (p=0.005). CONCLUSIONS: Despite sample size limitations, the current paradigm shows that fear priming has the capacity to differentially alter kinematic and EMG responses in older and younger adults. As such, this study provides a novel assessment of how fear primes change motor



behaviour in a healthy cohort with an initial low FoF and provides a method to examine how fear changes motor planning in older individuals.

P2-N-121 Fall risk and falls are related to spatiotemporal gait asymmetry in older adults: Effect of gait speed

Brian Street¹

¹California State University, Bakersfield

BACKGROUND: Increased fall risk and declining mobility threaten the health and independence of older adults. Falling is a multifactorial problem, but often falls occur during walking, suggesting that walking patterns may contribute to falls. Limb asymmetry while walking has been shown to increase with age and be an independent factor related to falling in older adults. Aim: The aim of this study was to investigate the relationship between spatiotemporal limb asymmetry while walking, fall risk and falls in older adults. METHODS: Twenty-two healthy older adults (mean age 73.6 years; SD 7.9) walked at their preferred (mean 108.8 steps/min; SD 14.4) and fast (mean 129.2 steps/min; SD 21.1) speeds, limb asymmetry ratios for step length, stance time, and swing time were also collected. Falls (total number reported in the previous 12-months), as well as function mobility (Timed-up to Go Test) and balance confidence (Activities-specific balance confidence scale) were collected from each participant. RESULTS: Correlation analyses revealed the relationships between gait asymmetry, number of falls and fall risk measures. At preferred and fast walking speeds, numbers of reported falls were significantly correlated with step length and swing time asymmetries (r = 0.50-0.84). Functional mobility was significantly correlated with step length and swing time asymmetries (r = 0.36-0.53). Balance confidence scoring was significantly correlated with step length, swing and stance time asymmetries (r = -0.68 - -0.57). CONCLUSIONS: Spatiotemporal gait asymmetry was more closely related to falls and fall risk at fast walking speeds, suggesting that limb asymmetry and the consequence of a fall may be more likely when older adults are forced to deviate away from their preferred walking patterns. Knowing that limb asymmetry is correlated with specific risk factors for falling, further work should investigate if interventions can be implemented, targeting limb asymmetry and these risk factors, specifically during altered gait patterns, to reduce limb asymmetry when walking and ultimately reduce the number of falls for older adults.

P2-N-122 Lateral balance capacity after external perturbation in persons with chronic stroke

Hideyuki Tashiro¹, YUI SATO¹, Naoki Kozuka¹

¹Sapporo Medical University





BACKGROUND AND AIM: Stepping responses to external perturbations are often impaired after stroke. Although most falls occur as weight is transferred laterally in persons following a stroke, little is known about balance responses to lateral perturbation. The aim of this study was to determine the capacity to recover balance from lateral perturbations and the behavioral characteristics of individuals after stroke. METHODS: Twelve chronic stroke survivors and 18 healthy controls participated. We determined the maximal lean magnitude (MLM) from which participants could be suddenly released sideways and still recover with maximally one step. MLM was described by the percentage of body weight (%BW) and was set at 2.5%BW increments. Five trials were conducted at MLM to both sides (paretic and non-paretic side in stroke patients, and dominant and non-dominant side in controls), and step types (lateral side step, crossover step, medial step, and no step) of each trial were recorded. MLM and step types were compared between groups (stroke and control) and perturbation direction. RESULTS: Post-stroke individuals had significantly lower MLM than controls, and the paretic side showed significantly lower MLM than the non-paretic side (Fig. A). A significantly high proportion of stroke survivors could not respond with a step when released toward the paretic side (48.3% of trials; Fig. B), and more frequently responded with a medial step when released toward the non-paretic side (68.3%; Fig. B). On the other hand, most of the controls responded with a lateral side step or crossover step toward lateral perturbation (38.8% and 55.5% toward the dominant side, and 38.8% and 50.0% toward the non-dominant side; Fig. B). CONCLUSIONS: Stroke survivors demonstrated remarkably limited capacity to recover balance from lateral perturbation compared with healthy controls, especially in perturbation toward the paretic side. Additionally, stroke survivors could not step effectively to recover balance from lateral perturbation. Capacity to recover balance from lateral perturbation may represent a contributing factor for falls among persons with stroke and should be considered in strategies to reduce the risk of falls.

P2-N-123 Do falls precede or follow changes in self-efficacy scores regarding falls and gait in community dwelling older adults?

Roel Weijer¹, Marco Hoozemans¹, Jaap van Dieën¹, Mirjam Pijnappels¹

¹Vrije Universiteit Amsterdam

BACKGROUND AND AIM: Self-efficacy of physical abilities was found to be an independent risk factor in fall prediction models for older adults. However, it is not known whether falls experienced lead to decreased self-efficacy, or if self-efficacy decreases independently of fall history and leads to falls. With this study, we aimed to clarify whether falls precede or follow changes in self-reported fall- and gait-efficacy in community-dwelling older adults. **METHODS:** 284 community-dwelling older adults (>= 65 years) participated in a one-year follow-up and extensive pre- and post-assessment. During the follow-up we recorded self-reported fall-efficacy (Falls Efficacy Scale) and gait-efficacy (modified Gait Efficacy Scale) as well as the occurrence of falls, by means of monthly questionnaires and telephone calls. During the pre- and post-assessments participants performed





the Quickscreen, an instrument for fall risk assessment, several tests designed to quantify selfperception of stepping abilities and filled out questionnaires about psychological traits and states. Furthermore, they wore an activity monitor with tri-axial accelerometer, gyroscope and barometer for seven days following the pre- and post-assessments. We will use cross-lagged structural equation modeling (SEM) to determine the order of falls and changes in fall and gait efficacy scores, all of which were measured monthly (fig. 1). **RESULTS:** Data collection is still in progress. During the congress we will present preliminary results of the SEM model. **CONCLUSION:** Our results may provide evidence for the direction of causality underlying the relation between falls and self-efficacy. If no associations between these two variables are found it could indicate that there is no direct relation, that the effects are only visible over a larger time frame than the one year follow-up, or that the sampling frequency of one month was too broad and effects of a fall on self-efficacy recover within this period. Finally, effects of falls on self-efficacy may be specific to the circumstances or consequences of the fall itself.

O - Habilitation & rehabilitation

P2-O-124 Mediolateral constraints during overhead unloading result in altered gait dynamics and balance regulation

Christopher Easthope¹, Niklas Ignasiak², Mathias Bannwart¹, Sara Bayer¹, Armin Curt¹, Georg Rauter³, Marc Bolliger¹

¹University Hospital Balgrist, ²Chapman University, ³University Basel

BACKGROUND AND AIM In gait rehabilitation of patients with central nervous system disorders, partial body weight support enables early locomotor training. Most commercially available systems are based upon overhead designs which dynamically unload the patient either from a single point or from a rail while walking overground or on a treadmill. New approaches in this area introduce body weight support robots that have a 3D workspace, enabling transparent mediolateral motion of the patient, however there is no evidence that this contributes to more natural gait under unloading. We investigated how reducing mediolateral transparency of a transparent 3D body weight support robot impacted gait patterns and balance regulation in a healthy, young cohort on a treadmill. We hypothesized that unloading per-se would induce changes of the gait pattern, however the effects on gait stability parameters could partially be removed by adding mediolateral transparency. Methods Kinematics of 20 healthy young subjects were recorded during treadmill walking at their preferred gait velocity wearing a body weight support harness. In randomized, counter-balanced order, the following conditions were applied: normal walking, 30% bodyweight unloading with full transparency, 30% bodyweight unloading with reduced mediolateral transparency. 10 minutes of data were captured for each condition after the subjects had acclimatized for 2 minutes. As measures of gait stability, maximal center of mass Lyapunov exponents (LyE), step width, margins of stability and various classical gait





parameters were compared between conditions. Embedding dimension and time lag of the LyE were optimized for each trial and then fixed to the median dimension to compare between conditions and subjects. Response groups of variables were detected in principle component (PC) space using K-means clustering and each group was tested via MANOVA. Results K-means clustering of the 21 input variables in 3-dimensional PC space yielded 3 distinct groups of response variables over the conditions (Fig. 1A). Applying 30% unloading force led to the typical gait alterations of increased step length and swing phase, and reduced step width (Fig. 1C). As expected, the vertical and anteroposterior LyE were reduced as was the absolute mediolateral center of mass motion. Increasing the damping of the robot reduced the maximal mediolateral LyE and variability of the step width, mediolateral center of mass excursion variability, and mediolateral body sway variability (Fig. 1B). Conclusions Damping mediolateral motion with overhead body weight support especially impacts the variability domain of gait, potentially complicating the transfer of gait relearning strategies from a rehabilitation setting to ecological settings. While damping mediolateral motion may increase patient confidence in early rehabilitation phases, additional benefits may be reaped by freeing this plane in the course of rehabilitation. Acknowledgements: Swiss Federal Commission of Technology and Innovation (CTI), Grant number 17567.2 PFLS-LS; Swiss Center for Clinical Movement Analysis, SCMA.

P2-O-125 Immediate effects of Voluntary-induced Stepping Response (VSR) training on protective stepping in persons with chronic stroke: A randomized control trial

Kristen Hollands¹, Pornprom Chayasit², Mark Hollands³, Rumpa Boonsinsukh²

¹University of Salford, ²Srinakharinwirot University, ³Liverpool John Moores University

BACKGROUND: Automatic protective stepping in response to perturbations may be impaired after stroke and could lead to falls. Training using complicated perturbation equipment has been found to improve protective stepping after stroke(1, 2); however, the cost and complexity of the equipment may limit clinical use. Alternatively, voluntary-induced Stepping Response (VSR) characterized by patients being asked to lean until they need to take a step (requiring no technical equipment) also promotes protective stepping but there is currently no evidence that VSR training can improve protective stepping after stroke. AIM: To examine immediate effect of VSR on protective stepping, compared to DynSTABLE perturbation training (DST), in stroke survivors (SS). METHODS: This 2 parallel-arm randomized controlled trial was conducted in a neurorehabilitation center (BASIC) in UK Participants: 34 SS able to stand and walk independently were randomly allocated to VSR (n=17) or DST (n=17). Persons in VSR and DST were not different in age (66.5±10.3 years vs 68±10.9 years), stroke duration (0.58 - 44 years vs 0.79 - 16.75 years) or severity (Fugl-Meyer motor score: 25.2±7 vs 25.9±7.2). Intervention: In VSR, participants were instructed to lean forward to induce balance loss to elicit protective steps. In DST, a support surface translation was used to elicit a recovery step. Baseline test (of step response to support surface translation) was carried out prior to 50 mins of practice with VSR/DST and then, immediate




post-test. Main Outcome Measures: Number of step and choices of first step leg in response to support surface translation, Step kinematics (step length and step width), and Center of mass relative to stability limits were assessed using Computer Assisted Rehabilitation Environment (CAREN) system. Kinematic and kinetic data were collected with Vicon. Chi-square and McNemar were used to compare nonparametric data between 2 groups, while Mixed ANOVA with Bonferroni comparison was used for comparing pre-post parametric data between 2 groups. **RESULTS:** Significantly fewer protective steps were taken after training in both groups. Single step increased 16.3% in VSR and 23.1% in DST. Multiple step decreased 16.3% in VSR and 22.5% in DST. Only participants in VSR generated protective steps with the affected leg in greater percentage of trials (27%) when compared with baseline (20.2%). While step width was increased in both groups, step length was longer and stability limit was larger only in DST (p<.05). **CONCLUSION:** With a single day of perturbation training, VSR could improve protective stepping in the same way as DST. Trial registration: This study was registered with Thai Clinical Trials Registry [identification number of TCTR20170827001]. Funding source: Thailand Research Fund through the Royal Golden Jubilee Ph.D. program [grant numbers PHD/0076/2558]. References 1.Kajrolkar et al J Biomech. 2014 Aug; 47(11): 2751-8. 2.Mansfield et al. Phys Ther. 2011 Jun; 91(6): 958-69.

P2-O-127 Effects of modified exercise programme for improving axial rigidity and turning dysfunction in individuals with Parkinson's disease

Fuengfa Khobkhun¹, Mark Hollands¹, Amornpan Ajjimaporn²

¹Liverpool John Moores University, ²Mahidol University

BACKGROUND AND AIM: Axial rigidity is a common symptom of Parkinson's Disease (PD) which contributes to mobility problems and leads to increased falls risk. One activity which is affected by axial rigidity is turning around. Specific turning deficits can be categorised into perpendicular deficits (taking more steps and shorter steps and an altered turn strategy) and axial deficits (segment rigidity, altered segment co-ordination and timing, reduced segment rotation and the effects of altered posture). Axial deficits may drive secondary responses in the perpendicular segments during turning in people with PD and therefore it has been suggested that specific focus should be place on rehabilitation of the axial deficits alongside those of the perpendicular body segments in the design of multi-modal treatment strategies to improve turning performance (Hulbert et al., 2015). Therefore, this pilot RCT study will investigate the effects of using a modified exercise programme aimed at improving axial rigidity on turning dysfunction in individuals with PD. METHODS: Twenty-two individuals with PD were randomised into two groups: exercise (n = 11) and control groups (n = 11). All participants were assessed for demographic data: the Hoehn and Yahr scale and the Unified Parkinson's Disease-Rating Scale (UPDRS). For assessments, all participants completed standing turns on level ground at 180°. Kinematics were recorded by the Inertial Measurement Unit (xIMU) and eye movements measured using a BlueGain





electrooculography system. They were assessed by the Functional Reach Test Scale (FRT), Fall Efficacy Scale International (FES-I), and Borg's Ratings of Perceived Exertion Scale (REP). Participants in both groups were assessed twice (at baseline (week 0) and post- (week 4)). The exercise group received a modified exercise programme, which the researcher conducted from the scoping review (Schenkman et al., 1998). The elements included within this modified exercise programme include deep breathing exercise, stretching exercise, rotation segments, and taskspecific training. It involves combinations of movements in all movement position. The exercise group received a four-week, nine-session by a physiotherapist. Independents t-test was used to compare the variables. **RESULTS:** There was no significant difference of the variables between the exercise and control groups in the baseline comparisons. The differences of each variable between groups comparisons demonstrated that exercise had a significant effect (p<0.05) on the following: decrease in UPDRS total score, UPDRS motor score, UPDRS rigidity score, FES-I, onset latency of body segments, total step and step duration, along with a significant increase (p<0.005) in the peak head-thorax angular separation, turn speed, FRT and step size. See table 1. CONCLUSION: The modified exercise programme had a positive effect on various markers of functional mobility and improved turning performance in individuals with PD. These preliminary results support the notion that targeting axial deficits and improving mobility and reducing falls in PD. ACKNOWLEDGEMENTS AND FUNDING: 1.Liverpool John Moores University Funding 2. Mahidol University's Academic Development Scholarship.

P2-O-128 Differences in lateral symmetry of muscle synergies between acute poststroke patients undergoing robot-assisted therapy and conventional therapy

Chun Kwang Tan¹, Hideki Kadone¹, Hiroki Watanabe¹, Aiki Marushima¹, Yasushi Hada¹, Masashi Yamazaki¹, Yoshiyuki Sankai¹, Kenji Suzuki¹

¹University of Tsukuba

[**BACKGROUND AND AIM**] Movement impairment is typically observed in patients with stroke. Therapy to allow patients to regain their mobility is one of the main focus, as it affects the quality of life. Recent studies showed that gait symmetry, calculated with spatiotemporal metrics, actually worsens after patients are discharged. Asymmetric gait also leads to further complications, like muscle and joint pains. Furthermore, recent studies also show that certain measure, like gait speed and motor function assessments are uncorrelated to gait symmetry, which may indicate a need for better metrics to study and understand gait symmetry. New therapy methods, like robot assisted therapy, show promise in speeding up the rehabilitation progress. Our study examines how such a therapy form influences gait symmetry. We are also interested in tracking the progress of the patients as they undergo therapy to observe how they would respond to the therapy sessions. [Methods] Muscle synergy analysis is used to study the muscle coordination patterns in the lower limbs of 2 groups of acute post-stroke patients, one undergoing robot-assisted gait training (HAL group)(Age: 57.16±10.24 yrs, Onset to training: 12.5±3.14 days) and one





undergoing conventional gait training (Conventional group)(Age: 68.83±4.79 yrs, Onset to training: 15.33±2.16 days). Gait training schedules are synchronized between two groups, with 9 sessions over 3 weeks (3 session per week). EMG was collected bilaterally from the adductors, vastus medialis, hamstrings, tibialis anterior, gastrocnemius, gluteus maximus. Heel strike and toe off events were determined with Vicon motion tracking for the HAL group, while foot events for the Conventional group were determined with foot contact sensors in the shoe. Data collection was conducted for all patients at 4 time points: 1) Before therapy, 2) After the 4th session 3) After the 7th session and 4) After the final session. [Results] Muscle synergy modules exhibit more symmetry as the therapy progressed in the HAL group (0.74±0.12 -> 0.85±0.09), as compared to the Conventional group $(0.79\pm0.16 \rightarrow 0.75\pm0.08)$. A linear regression fitted to the scalar product similarity of muscle synergy modules over the data showed an increasing trend in gait symmetry in the HAL group, while a decreasing trend in gait symmetry is noticed in the Conventional group. Stance percentages after all therapy were more asymmetric in the Conventional group (Paretic: 0.7±0.12, Non-paretic: 0.77±0.11), as compared to the HAL group (Paretic: 0.63±0.05, Nonparetic: 0.69±0.05). [Conclusions] Gait symmetry should be given more attention as a rehabilitation outcome. Our results show that gait symmetry changes, quantified with muscle synergies, can be observed within sessions. Future work could include a follow-up study on patients that were discharged after robotic therapy to evaluate whether the effects of gait symmetry can be sustained after therapy.

P - Modeling

P2-P-130 Expanding a model of the dynamic Margin of Stability to evaluate balance control following support-surface perturbations

Keaton Inkol¹, Lori Ann Vallis¹

¹University of Guelph

BACKGROUND AND AIM: Many research groups [1,2] have utilized the dynamic Margin of Stability (MoS), the location of the velocity-extrapolated centre of mass (CoM) within the base of support (BoS) [3], to explore balance recovery strategies evoked using support-surface (platform) perturbations. While important insight has been gained from these analyses, we would argue that the fixed nature of these perturbations should be accounted for in the underlying model given the influence of future states of platform motion on CoM control [4]. To this end, we expanded the linear inverted pendulum model from Hof et al. [3] to find a closed-form solution (the pMoS) that addressed the limitation posed by the MoS when modelling recovery responses following a translational, square-wave platform acceleration. **METHODS:** Support of the time-variant pMoS and assessment of the model's sensitivity to the no foot-ground shear force assumption [3] involved identification of the model's stable CoM position-velocity boundaries via trajectory optimization [4]. Calculated 3D root mean square (RMS) error quantified the difference between





said pMoS boundaries (within CoM position-velocity-time space) generated with or without footground shearing. Two factors and their relation to error were of interest: magnitude of the acceleration(s), duration of acceleration pulse. Lastly, comparisons of the pMoS and MoS involved use of kinematic data (CoM position and velocity, BoS position) from a previous experiment (N=3, [1]). Within [1], individuals were to maintain upright balance following forward or backward perturbations of the support surface. A change in support was required for some conditions (i.e. large compared to small magnitude perturbations [5]); MoS/pMoS was evaluated at the following instance within each condition: small = minimum in two second window; large = step initiation. **RESULTS:** The mean ± SD MoS via Hof et al. (2005) and the proposed pMoS were resolved for each perturbation condition as follows: backward small, MoS (-6.4±0.5 cm), pMoS (0.0±0.5 cm), backward large, MoS (-21.2±2.3 cm), pMoS (-6.9±5.4 cm), forward small, MoS (-1.6±4.1 cm), pMoS (0.8±0.3 cm), forward large, MoS (-14.8±2.3 cm), pMoS (-4.8±5.4 cm). Shear error had poor monotonicity with pulse duration but covaried exponentially with acceleration magnitude. Notably, RMS values were small, i.e., greater than 1 cm only for cases in which stepping would be expected. CONCLUSIONS: Unlike the standard MoS, the proposed pMoS model was successful in identifying appropriate positive (stable) and negative (unstable) outcomes for instances of balance recovery evoked via platform accelerations. Thus, the pMoS may be a more appropriate measure of dynamic stability for perturbation-based paradigms. Limitations of our model, such as perturbation specificity, will be addressed in future work. REFERENCES:[1] Inkol et al. (2018) Exp Brain Res, 236:1689-98; [2] Mansouri et al. (2016) Gait Posture, 43:24-30; [3] Hof et al. (2005) J Biomech, 38:1-8; [4] Pai et al. (2000) J Biomech, 33:387-92; [5] Maki et al. (1996) J Biomech, 29:343-53.

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P2-Q-131 Obstacle crossing in fallers with and without Parkinson's disease; influence of attentional demand

Lisa Alcock¹, Brook Galna¹, Richard Foster², Jeff Hausdorff³, Sue Lord₄, Lynn Rochester⁵

¹Newcastle University, ²Liverpool John Moores University, ³Tel-Aviv Sourasky Medical Center, ⁴Auckland University of Technology, ⁵Institute of Neuroscience, Newcastle University

BACKGROUND AND AIM: People with Parkinson's Disease (PD) are three times more likely to fall as a result of tripping compared to older adults[1]. PD demonstrate impaired gait during complex tasks such as dual task walking and obstacle crossing compared to controls[2]. Our recent work has shown that highly salient obstacles redirect visual attention to task-relevant stimuli[3] and may help to ameliorate gait deficits in PD. As such, gait deficits may be exacerbated further when obstacles are less visible and increased cognitive resources are required. The aims of this study were to determine whether (i) obstacle crossing deficits are exacerbated when





performing a dual task in PD. METHODS: Twenty people with mild-to-moderate PD (Mean[SD]age70.5[7.7]y), and 10 older adults (OA; Mean[SD]age77.2[7.2]y) with a history of falls took part. Participants began the walking trials with eyes closed and upon the word 'go' opened their eyes and started walking. Walking conditions included negotiating either a high or low contrast obstacle (HxWxD 15cmx60cmx2cm), performed under single or dual (Welscher digit span) conditions. Temporal-spatial gait was measured (GAITRite, 240Hz) during the approach to (A2, A1) and crossing over (Lead, Trail) the obstacle. General linear models evaluated the effect of task (single, dual), obstacle contrast (high, low) and group (PD, OA). RESULTS: PD were younger, had better global cognition (MoCA) and visual acuity (LoGMAR) and these differences were controlled for in our analyses. The groups were well matched for mobility, balance and physical function but people with PD reported a greater fear of falling (p=.029). People with PD walked with a shorter step length, although increased it to the level of controls for the lead crossing step (Figure 1) regardless of obstacle contrast or dual task. Step length was significantly reduced during the final crossing (trail) step in PD compared to OA. Dual task significantly increased single limb support (SLS) during the lead crossing step in PD compared to OA. There was a significant interaction between task and obstacle contrast; PD widened their step when crossing the low contrast obstacle under dual task. CONCLUSIONS: Gait hypokinesia was evident in PD during obstacle crossing regardless of obstacle contrast or dual task. When attentional demands were high during dual task, a prolonged SLS in PD may increase the risk of instability when crossing the obstacle. When visuo-attentional demands were greatest (low contrast obstacle, dual task), PD widened their step increasing the base of support and preserving upper body stability. Adaptive strategies in PD are selective to obstacle contrast and attentional demand, and provide insight into the complexity of fall risk in PD. ACKNOWLEDGEMENTS AND FUNDING: This research was funded by the V-TIME project (European Union 7th Framework Programme 278169) and supported by the NIHR Biomedical Research Unit based at Newcastle Hospitals NHS Foundation Trust and Newcastle University [1] Rudziñska et al., 2014 Neurologia i Neurochirurgia Polska [2] Maidan et al., 2016 Neurorehab & Neural Repair [3] Hunt et al., 2018 Behavioural Brain Research.

P2-Q-132 Parkinson's disease delays predictable visual cue processing although does not affect complex and non-predictable visual cue processing in postural control

Jose Barela¹, Caio Cruz², Flávia Doná³, Vitor Amaral⁴, Henrique Ferraz³, Ana Barela⁴

¹São Paulo State University (UNESP), ²University of São Paulo, ³Federal University of São Carlos (UFSCar), ⁴Cruzeiro do Sul University

BACKGROUND AND AIM: Parkinson's disease (PD) leads to several changes in sensory and motor functioning, compromising daily activities. There is evidence that people with PD have a greater reliance on vision to control actions, however, the basis for such evidence still has to be uncovered. The aim of this study was to examine the performance of postural control and the





coupling between complex and non-predictable visual information and body sway in individuals with PD. METHODS: Twenty-one individuals with idiopathic PD (62.1 ± 7.2 years old), stages 1 and 2 of Hoehn & Yahr scale and 21 individuals with no known orthopedic or neurologic impairment that could compromise balance (62.3 ± 7.1 years old) participate in this study. Participants stood inside a moving room and was asked to look at a target on the front wall, remaining as still as possible for 60 seconds, and no information about the room movement was provided. Each participant performed 10 trials. In the first trial, the room remained motionless, and in the following trials, the room moved continuously in the anteroposterior direction, distributed in 3 blocks of 3 trials each, with different conditions of complexity and predictability. In the first block, the room was moved back and forth at a frequency of 0.2 Hz ("periodic simple" condition); in the second block, the room was moved with combined periodic frequencies of 0.1, 0.3 and 0.5 Hz ("periodic complex" condition); in the third block, the room was moved with combined nonperiodic frequencies of 0.1, 0.3 and 0.5 Hz ("non-periodic complex" condition). Data from room displacement and trunk sway were acquired using infrared emitters (OPTOTRAK) fixed on the front wall and on the participant's back, respectively. Postural performance was examined using mean sway amplitude, and the relationship between visual information and body sway was examined using coherence, gain, and phase. **RESULTS:** With no visual manipulation, there was no group difference in the magnitude of body sway. With visual manipulation, individuals with PD presented larger magnitude of sway only in the non-periodic complex condition. Regarding the relationship between visual information and body sway, individuals with PD lagged behind the moving room, with larger phase values, compared to their peers, but only in the periodic simple condition. No group difference was found in the remained measurements. CONCLUSIONS: These findings indicate that individuals with PD can use complex and unpredictable visual information similarly to their peers during upright quiet stance. However, the larger delay observed between body sway and room displacement in the periodic simple condition suggests that PD might affect the processing of predictable visual cues.

P2-Q-133 Impact of attentional abilities on step initiation in patients with Parkinson's disease with and without freezing of gait

Madli Bayot¹, Aurore Braquet¹, Céline Tard¹, Luc Defebvre¹, Kathy Dujardin¹, Arnaud Delval¹

¹University of Lille - Inserm U1171-Degenerative and Vascular Cognitive Disorders

BACKGROUND AND AIM: Step initiation can vary according to attentional resources. More particularly, components of visuospatial attention (i.e. alerting, orienting, and executive control or conflict resolution) can specifically modulate anticipatory postural adjustments (APAs) and step execution phase [1], [2]. However, patients with Parkinson's disease (PD) with freezing of gait (FOG) present a deficit in executive control that could deteriorate step initiation [3]. The present study aims for a better understanding of the interaction between visuospatial attention and step initiation in PD with and without FOG. **METHODS:** Fourteen freezers (PD+FOG), fifteen non-





freezers (PD-FOG) and fifteen healthy controls (HC) performed an attentional task adapted from the Attention Network Test combined with step initiation. Step preparation and execution phases were assessed via two force plates and a video motion analysis system. RESULTS: Although step execution time was longer for PD patients compared to HC, the effects of cues and targets were not significantly different between groups. In each group, step execution time was shorter in trials with central cue compared to trials without cue (alerting effect), as well as in trials with congruent targets versus incongruent targets (effect of conflict resolution). Indeed, trials during which a conflict has to be resolved were related to a higher rate of APA errors (APAe) and multiple APAs (APAm) which lead to longer APA durations. The three groups showed the same rate of APA errors, while PD patients presented multiple APAs contrarily to controls. CONCLUSIONS: Tasks with attentional load such as conflict resolution lead to an alteration of step initiation (i.e. with longer step execution time and APA duration) in the same way in PD+FOG, PD-FOG and HC. This effect of conflict resolution is related to a higher occurrence of APAe and APAm. The rate of APAe seems to be modulated by the attentional condition rather than the disease, whereas multiple APAs seem to be associated with PD patients and their difficulty to couple preparation and execution of a step which might partly explain the global slowness of patients. FUNDING: "The project leading to this application has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie grant agreement No 721577". [1] C. Tard et al., « Attention modulates step initiation postural adjustments in Parkinson freezers », Parkinsonism Relat. Disord., vol. 20, no 3, p. 284-289, mars 2014. [2] K. Uemura, T. Oya, et Y. Uchiyama, « Effects of visual interference on initial motor program errors and execution times in the choice step reaction », Gait Posture, vol. 38, no 1, p. 68-72, mai 2013. [3] J. Vandenbossche et al., « Freezing of gait in Parkinson disease is associated with impaired conflict resolution », Neurorehabil. Neural Repair, vol. 25, no 8, p. 765-773, oct. 2011.

P2-Q-134 Postural biomechanical predictors of subjective and objective measures of severity of freezing of gait in Parkinson's disease

Daniel Coelho¹, Caroline Souza¹, Carla Silva-Batista¹, Andrea de Lima-Pardini², Alexandre Bastos², Luis Teixeira¹

¹University of São Paulo, ²Federal University of ABC

Freezing of gait (FoG) in Parkinson's disease (PD) is a phenomenon with pathophysiology not yet elucidated. It is known that the clinical balance scores are consistently lower in patients with PD and FoG when compared to those who do not have FoG. Its association with increased risk of falls suggests a relationship between FoG and deficit in body balance of these individuals. However, laboratorial measures of postural control as predictors of FoG measures are still unknown in the literature. The objective of this study was to test for a possible relationship between FoG severity and postural control. Twenty-two patients (age: 66 ± 8 years; Hoehn & Yahr stage: 3-4) assessed "on" state of medication completed the study. A subjective (New Freezing of Gait Questionnaire





P2-Q-135 Is mediolateral dynamic balance in Parkinson's disease similar between freezers and non-freezers?

Bauke Dijkstra¹, Moran Gilat¹, L. Eduardo Cofré Lizama², Sabine Verschueren¹, Alice Nieuwboer¹

¹KU Leuven, ²University of Melbourne

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BACKGROUND AND AIM: Postural instability in Parkinson's disease (PD) is associated with falls and a reduced quality of life. People with freezing of gait (FOG; freezers) exhibit more postural instability than non-freezers especially during dynamic tasks, sometimes expressing itself as a freezing-like weight-shifting deficit. To date, dynamic balance control in freezers and non-freezers has only been studied for gait-like tasks, such as stepping-in-place and turning. Therefore, we investigated the influence of FOG on patients' mediolateral (ML) weight-shifting during a task which imposed increasing speed and accuracy demands. We hypothesized that performance would drop below a set threshold at lower speeds in freezers than in non-freezers. METHODS: Seventeen freezers, 15 non-freezers and 15 age-matched controls performed the ML balance assessment (MELBA). MELBA was found to be more sensitive to age-related balance deficits than standard tools. In this study, we adapted the MELBA to accommodate for PD. Participants were instructed to follow a visual target with their center of mass (CoM) by shifting their weight from one leg to the other. The target and CoM were displayed in real-time on a projector screen in front of the participant. Target oscillations started at 0.1 Hz and increased with steps of 0.1 Hz to a final frequency of 1.2 Hz. Participants performed one practice trial and 3 actual ones. A cutoff point was determined, indicating the inability to follow the target movement, as either a phase shift > 90 degrees or an amplitude ratio <.5 between the target and CoM. The average cutoff score of the 3 trials was used an indicator for the breakdown of ML weight-shifting. RESULTS: The three groups were matched for age (F(2,44)=.669, p=.517)) and freezers and non-freezers were matched for motor symptom severity (U=78, p=.061). Freezers had lower Mini-BESTest scores than nonfreezers (U=65.50, p=.095). MELBA cutoff points were different between groups: controls=.84



(SD=.12), non-freezers=.76 (SD=.16), freezers=.71 (SD=.15); F(2,44)=3.63, p=.035. Post hoc Tukey HSD tests revealed that freezers did not have lower cutoff points than non-freezers (p=.549). Freezers showed lower cutoff points than controls (p=.027), whereas non-freezers did not differ from controls (p=.236). MELBA cutoff points were significantly correlated to Mini-BESTest scores (rs=.286). **CONCLUSIONS:** In contrast to our hypothesis, ML weight-shifting did not breakdown earlier in freezers than non-freezers, despite overall group differences in Mini-BESTest scores. These results may be explained by the visual control of the task, as it was previously found in cueing studies that freezers were more dependent of visual input than non-freezers. It is also possible, that not having to generate an actual step, reduced the interference between the neural control of ML balance and stepping, accounting for the lack of movement breakdown in freezers.

P2-Q-136 Factors related to unanticipated obstacle negotiation success: association with Parkinson's disease and motor planning

Irina Galperin¹, Eran Gazit², Ilan Kurtz¹, Topaz Sharon², Marina Brozgol², Nir Giladi², Anat Mirelman², Jeff Hausdorff²

¹Center for the Study of Movement, Cognition and Mobility, Neurological Institute, Tel Aviv Sourasky, ²Tel-Aviv Sourasky Medical Center

BACKGROUND AND AIM: Tripping over an obstacle is a common cause of falls in people with Parkinson's disease (PD). The ability to negotiate an obstacle is, putatively, related to motor function (e.g., if the obstacle is too high, it will be difficult to swing the leg over it) and cognitive function (e.g., planning ahead to prepare for the obstacle). If the obstacle is unexpected (and not seen well in advance), then processing speed and reaction time also might play a role. Here we aimed to examine these factors and how they relate to the ability to successfully negotiate unanticipated obstacles. METHODS: 29 people with mild to moderate PD (age: 67.9±5.5 yrs, Hoehn and Yahr stage: 2(1-3), 51.7% men) and 23 healthy adult controls (HC) (age: 72.2±8.6 yrs, 60.9% men) were studied. Balance (e.g., MiniBest test), cognitive function (MOCA, Stroop test, and Trails Making Test, TMT), Timed Up and go, and disease severity (MDS-UPDRS part 3, levodopa equivalent dose, LED) were assessed. An instrumented gait mat (Zeno walkway, ProtoKinetics) and an accelerometer quantified walking and gait initiation. Gait initiation metrics included: time to start of APA (time-to-APA), i.e., planning/ reaction time, time-to-first-heel-strike, and the % time planning (i.e., 100xtime-to-APA/time-first-heel-strike). Unanticipated obstacles (100 mm high) appeared during walking over a computer-controlled "real" obstacle course. The negotiating was considered successful if the subject crossed it without tripping. Pearson chisquare tests, Student's t-tests and Mann Whitney U tests compared groups. RESULTS: MiniBESTest scores tended to be worse in (PD: 21.7±3.0); p=0.054) than in HC (23±3 2.9). Many other factors were not significantly different (p>0.10) in the PD and HC (e.g., MOCA, TMT, gait speed, TUG). As expected, the success rate when negotiating the obstacle was lower (p=0.004)

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in the patients (41.2%) than in the HC (83.3%). Among the patients, many measures were similar in those who did not succeed and those who did including age, sex, disease duration, MDS-UPDRS part 3, LED, MiniBESTest, TUG, MOCA, TMT, gait speed and the time-to-first-heel-strike (p>0.10). Somewhat counterintuitively, time-to-APA was longer (p=0.048) in those who succeeded (307±136 msec), compared to those who did not (220±85 msec); similarly, the % time planning was also longer (p=0.032) in the PD subjects who succeeded (24±6%), compared to the PD subjects who failed to successfully cross the obstacle (19±6%). **CONCLUSIONS**: In this study of relatively mild patients with PD, we find that the ability to successfully negotiate unanticipated obstacles is markedly lower than that seen in healthy controls; as expected, the success rate in PD was about half that seen in the controls. This finding is not surprising, although it is more remarkable given that many measures of gait and balance were similar in the PD and control groups. Interestingly, among the patients with PD, patients who devote more to the planning segment of gait initiation, which could also be viewed as a form of reaction time, are more likely to succeed in obstacle negotiation. Future studies are needed to examine the nature of this relationship, underlying mechanisms, and how this changes in more advanced disease.

P2-Q-137 Oxygenated hemoglobin concentration levels during usual walking and obstacle course in people with Parkinson's Disease (PD)

Lilian Gobbi¹, Diego Orcioli-Silva¹, Priscila Sousa¹, Nubia Conceição¹, Victor Beretta¹, Ellen Lirani-Silva¹, Rodrigo Vitório¹

¹São Paulo State University (UNESP)

BACKGROUND AND AIMS: There is a strong evidence of the participation of the prefrontal cortex (PFC) during walking in neurotypical and PD older individuals as a compensatory mechanism to a lost of movement automaticity [1]. The PFC activity also increases during obstacle crossing in older adults. The aim of this study was to compare the PFC activation during continuous walking and obstacle course by means of the oxygenated hemoglobin (HbO2) concentration levels in right and left cortices in people with PD. METHODS: Sixteen individuals with PD in OFF medication state (69.23±5.6 years-old, MDS-UPDRS III=34.56±11.9 points), cognitively preserved (MiniMental=26.06±1.8 points), and without anxiety and depression symptoms (HAD-A=5.13±1.7 points, HAD-D=6.63±3.7 points) participated in this study. A functional near infra-red spectroscopy (fNIRS; OctaMon, Artinis Medical Systems, Netherlands) was used to register the HbO2 in the right and left prefrontal cortices during continuous walking and on an obstacle course (4 obstacles, 15cm height). In each trial (60s), individuals stand still for the first 30s (baseline) and performed the walking task in the last 30s. The average of maximum concentrations of HbO2 levels were analyzed in time windows and three phases were determined: 1. the last 10s of the baseline, 2. from the fifth to the fifteenth second (early), and 3. from the fifteenth to the twenty fifth second (late) of walking task. The differences from early and baseline and from late and baseline were than calculated by participant and by walking task. **RESULTS**:



Statistical analysis revealed interactions between walking task and phase (F1,15=4.93; p=0.042; np2=0.247) and between walking task and side of the prefrontal cortices (F1,15=5.943; p=0.028; np2=0.284). The increment in concentrations of HbO2 from early to late was larger during obstacle course than in continuous walking. Left PFC was always more activated than the right PFC, but the difference was larger in obstacle course than in continuous walking. **CONCLUSIONS:** The increased concentrations of HbO2 in the PFC in late phase of the obstacle course corroborates with the compensatory mechanism assumption for movement automaticity in people with PD. However, the increased left PFC activation was a surprise and it requires further investigation related to hemispheric impairment. ACKNOWLEDGE AND **FUNDING:** FAPESP (#2016/21499-1) and CAPES (Finance Code 001). **REFERENCES:**Stuart et al., Maturitas 113 (2018) 53-72.

P2-Q-138 Characterization of novel centre of pressure cyclogram measures during double support phase of gait in people with stroke

Sarah Gregor¹, Julie Vaughan-Graham², Kara Patterson¹

¹University of Toronto, ²Toronto Rehabilitation Institute

BACKGROUND AND AIM: People with stroke exhibit changes in various center of pressure (COP) measures during single limb support (SLS). Conversely little is known about COP changes during double support (DS). Weight transfer during DS is essential for rhythmical stepping and changing gait velocity. Cyclograms illustrate COP throughout the full gait cycle and have the potential to inform decision-making in post-stroke gait rehabilitation. This study aims to characterize 1) cyclogram measures of COP during DS in people with stroke and healthy adults, and 2) the relationship of cyclogram measures to clinical measures in people with stroke. METHODS: Preferred-pace walking of 29 people with stroke and 11 healthy adults was recorded using a pressure sensitive mat (Zeno mat). The mat software (PKMAS) plots cyclograms of COP during gait and calculates the following measures: the location of the cyclogram intersection point (CISP); where the lines of COP from toe-off of one foot to heel-strike of the other foot intersect with respect to the anterior-posterior (AP) and medial-lateral (ML) axes, and related CISP AP and ML standard deviation (SD) as measures of DS COP variability (see Fig. 1). Gait speed, swing time and step length symmetry ratios were also extracted. The stroke group was characterized using lower extremity proprioception, leg motor recovery scores, and as either household or community ambulators (cut-off speed 0.66 m/s). Between group comparisons were made with unpaired ttests. Relationships between the 4 cyclogram measures, gait speed and symmetry, and clinical presentation in the stroke group were determined using Spearman correlations. RESULTS: Stroke participants had larger values for CISP ML and AP SD compared to healthy adults (all p<0.01). CISP ML SD correlated with motor recovery (rs=-0.59 p<0.01), proprioception (rs=0.38 p=0.04), gait speed (rs=-0.75, p<0.01), and swing time symmetry (rs=0.68, p<0.01). Household ambulators had greater CISP ML variability (20.18 +/- 5.74) than community ambulators (10.97

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+/- 7.02; p<0.01). CISP AP SD correlated with gait speed (rs=-0.50), and swing time symmetry (rs= 0.56; all p<0.01), but not motor recovery or proprioception. Neither variability measures correlated with step length symmetry. Finally, the location of CISP (relative to (0,0); Fig. 1) in the ML direction was opposite to the foot individuals spent more time on during SLS, and the magnitude of CISP ML displacement correlated with swing time symmetry (rs=0.49 p<0.01). **DISCUSSION:** People post-stroke have increased variability in COP measures during DS compared to healthy adults. In addition, people post-stroke who walk slower and are more temporally asymmetric have greater DS COP variability. This increased variability may indicate reduced dynamic control during antero-lateral weight transfer between legs during DS. The correlations of CISP ML variability with leg motor recovery and proprioception seem to support this. Thus, these CISP measures may have clinical utility informing clinicians about weight transfer during DS which is noted as a suitable focus of therapy. Future research on changes in DS COP variability with different gait speeds and varying base of support is warranted.

P2-Q-139 Influence of ankle-foot orthosis with different type of joint on walking parameters in stroke patients

Naruhito Hasui¹, Naomichi Mizuta¹, Yasutaka Higa², Yasutada Yamamoto², Ayaka Matsunaga², Tomoki Nakatani², Masako Tsutsumi², Junji Taguchi², Yohei Okada³

¹Department of Neurorehabilitation, Graduate School of Health Sciences, Kio University, ²Takarazuka Rehabilitation Hospital, ³University of Kio

BACKGROUND AND AIM The Ankle-Foot Orthosis (AFO) improves walking parameters such as step length, shank movement, center of pressure (COP) movement, and muscle activities of lower limbs in stroke patients. Recently, the types of ankle joint of AFO have been increased and their characteristics are different. Nevertheless, the influence of the difference in the joint of the AFO on the walking parameters in the stroke patients has not been sufficiently examined. The aim of this study is to examine how the difference of joint conditions of AFO influence on walking parameters in stroke patients. Methods 13 stroke patients who can walk without assistance were included(age:67.0±13.0 years, stroke on set: 123±37.2days). They walked 6m straight at a comfortable speed in no-AFO condition and then walked in the 3 conditions (ankle joint plantardorsiflexion stop (Rigid: R), dorsiflexion free and plantarflexion stop (planter stop: PS), dorsiflexion free and plantarflexion oil damper (Oil damper: OD)) in random order. We assessed the severity of motor paralysis, the walking speed, step length, anteroposterior distance of COP movement in stance phase with a force platform, shank movement with a wireless gyro sensor, and muscle activities of lower limbs with the superficial electromyography. Results Walking speed, nonparetic step length, and anterior COP movements in the PS and R conditions was significantly higher than in the no-AFO condition. The influence of orthoses on the step length of non-paretic side is different depending on subjects. Therefore, we performed cluster analysis based on the degree of orthotic influence on the step length of non-paretic side and classified into two



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subgroups. The group in which the degree of improvement was higher in the PS condition than in the OD condition showed severe motor paralysis, the increased posterior tilting movement of the shank in the early stance phase in no-AFO condition. **Conclusions** The AFO with plantar-stop or rigid joint could improve walking speed, step length of the non-paretic side, and anterior weightshifting in the stance phase in stroke patients. The influence of AFO with different types of joints on the step length of non-paretic side varies depending on the patients. Stroke patients with severe paralysis and increased extension thrust knee pattern in the stance phase in the no-AFO condition could be better suited for the AFO with plantar stop joint.

P2-Q-140 Can quantitative gait parameters serve as progression marker of Parkinson's disease? A longitudinal study over 5 years

Markus Hobert¹, Susanne Nussbaum², Tanja Heger², Daniela Berg¹, Walter Maetzler³, Sebastian Heinzel¹

¹Christian-Allbrechts-University of Kiel, ²University of Tuebingen, ³Christian-Albrechts-University of Kiel

BACKGROUND AND AIM: Progression of symptoms in patients with Parkinson's disease (PD) is measured mainly with semiguantitiative assessments and questionnaires. Disadvantages hereof are that these methods are at least partly subjective and dependent on the experience of the examiner. With the technical development in recent years, sensors can be used to assess symptoms of PD objectively. Our study here investigates if gait parameters assessed with wearable sensors can serve as progression markers of PD. METHODS: In a longitudinal study we assessed 22 patients with PD in an early disease stage (E-PD), 18 patients in a medium disease stage (M-PD), and 24 healthy controls (HC) biannually over 5 years. Quantitative gait parameters were assessed with a wearable sensor (McRoberts Hybrid, The Hague, The Netherlands) worn at the lower back during walking on a 20m long walking path at convenient and at fast walking speed. Progression over the time was statistically compared between PD patients and HC with a Generalized Estimating Equations model. **RESULTS:** In the condition walking at convenient speed, we found a significantly higher increase in the parameter step number in E-PD compared to HC in the longitudinal analysis. The parameters step time variability and phase coordination index showed significant differences between E-PD and HC. The significant difference in this parameter was mainly caused by a decrease in HC compared to relatively stable values in E-PD over the observation period. Gait speed showed a significant reduction over the time without any group differences between E-PD and HC. M-PD and HC did not show any significant differences in progression of the gait parameters. In the condition walking at fast speed, we found no differences between groups. CONCLUSIONS: Out of the investigated gait parameters, step number seems to be the best progression marker in the condition walking with convenient gait speed. Variabilityassociated parameters of gait showed differences in the time course between PD patients and HC but it is not clear if this is a progression of symptoms in PD or the development of compensation



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mechanisms on HC. Slowing of gait speed over the observation period seems to be an unspecific age effect.

P2-Q-141 What can EMG tell us about the neuromotor control of gait in Parkinson's disease?

Aisha Islam¹, Lisa Alcock¹, Kianoush Nazarpour¹, Lynn Rochester², Annette Pantall¹

¹Newcastle University, ²Institute of Neuroscience, Newcastle University

BACKGROUND & AIM: Gait impairment is characteristic of Parkinson's disease (PD) and is associated with increased falls risk and mortality. However, the neural mechanisms underlying gait control in PD are unclear. Electromyography (EMG) evaluates muscle activity which presents a window into the terminal path of the motor network; EMG may provide insight into gait dysfunction in PD. This structured review aims to: (i) synthesise key findings of EMG patterns of gait in individuals with PD (ii) review methodologies of study design and signal processing. **METHODS:** A literature search was performed in four databases and the search strategy included four fields: measurement technique (surface/invasive EMG), population (PD), synonyms for gait initiation/termination/freezing) (excludina and synonyms for data analysis (muscle activity/coactivation). Data were extracted by one reviewer (AI), synthesised and formatted into a table, and confirmed by two reviewers (AP, LA). Data reviewed included study design, walking protocol, muscles recorded, electrode placement, EMG device, signal processing/normalisation techniques, EMG parameters, gait detection/parameters and key findings. RESULTS: The search strategy identified 726 studies. Data were extracted from 19 papers which satisfied the inclusion criteria (Fig.1). All studies used surface EMG. Ten studies neglected to report electrode placement and signal normalisation procedures. Study design for assessing lower limb muscle activity varied in signal filtering and time/amplitude normalisation techniques. PD exhibit altered temporal profiles of distal muscles, increased co-activation of proximal muscles, asymmetry and reduced variability compared to controls. Treadmill vs overground walking produced different patterns of muscle activity. Dopamine therapy (DT), subthalamic nucleus stimulation (STN) and auditory rhythmic stimulation improved clinical motor scores in some individuals with PD but only STN and DT altered muscle activity resulting in similar patterns to controls. No frequency analysis was undertaken. CONCLUSIONS: The studies in this review exhibit variation in study design, signal analysis and EMG parameters. methodological inconsistencies may lead to misinterpretation of results, and lack of normalisation procedures renders subsequent conclusions drawn from data analysis invalid. Distal muscles displayed more changes in amplitude and timing of EMG than proximal muscles. Increased co-activation in PD may indicate altered activity of nerve pathways such as the reticulospinal tract. Muscle activity was altered in response to walking surface and motor task, which should be considered when developing rehabilitative interventions. To conclude, studies analysing muscle activity during gait in PD is limited in comparison to gait kinematics. Underlying mechanisms of gait impairment in PD are still unclear despite

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consequences of immobility and death. **ACKNOWLEDGEMENTS & FUNDING:** Barbour Foundation.

P2-Q-142 Split-Belt Treadmill walking in people with Parkinson's disease: a systematic review

Jana Seuthe¹, Nicholas D'Cruz², Pieter Ginis², Burkhard Weisser¹, Daniela Berg¹, Günther Deuschl³, Alice Nieuwboer², Christian Schlenstedt¹

¹Christian-Allbrechts-University of Kiel, ²KU Leuven, ³University Hospital Schleswig Holstein, Christian-Albrechts University Kiel

BACKGROUND AND AIM: Split-Belt Treadmill (SBT) is an attractive tool to modulate asymmetric gait particularly in neurological conditions such as Parkinson's disease (PD) where asymmetry plays a key role due to the laterality of the disease. This study aims to summarize the literature on SBT in PD, discuss different SBT paradigms, methodological approaches and investigate gait adaptation in people with PD compared to healthy controls (HC). METHODS: A systematic literature search in the databases PubMED, PsychINFO and Web of Knowledge was conducted. Original research articles, published in English, which involved an SBT walking protocol in people with PD were included. RESULTS: Out of 925 studies identified, seven met the inclusion criteria and were selected for evaluation (n=118 people with PD of which n=44 with freezing of gait (FOG)). The SBT paradigms varied across studies with respect to the choice of SBT settings and definition of gait parameters. Some studies used disease dominance according to clinical rating scales whereas others used gait asymmetry to determine how to apply belt speed difference. Gait variability and bilateral coordination were found to adapt similarly in PD and HC. However, inconsistent results were found with respect to the response to asymmetry between PD and HC. Furthermore, the subgroup of PD with FOG showed reduced accuracy in detecting belt speed differences and slower adaptation to SBT. CONCLUSIONS: People with PD adapted to SBT walking similarly to HC in most of the gait variables. However, sub-groups with FOG showed deficits in adaptation and perception of belt speed differences. Further research is needed to determine whether belt speed differences should be applied according to the laterality of the disease whose definition (clinical ratings of disease laterality versus step length asymmetry) still needs to be investigated. Given the variety of methodological approaches used, we recommend to standardize the SBT protocols and the definition of gait parameters. SBT seems to be a promising tool to modulate gait asymmetry in individuals with PD. The effects of long-term interventions need to be investigated in future studies. ACKNOWLEDGEMENTS AND FUNDING This study was funded by the Jacques & Gloria Gossweiler Foundation.

P2-Q-143 Functional gait disorders and the broken escalator phenomenon





Diego Kaski¹, Denise Lin², Akila Ramamoorthy², Patricia Castro², Amy Edwards², Jan Coebergh³, Mark Edwards³, Adolfo Bronstein²

¹University College London, ²Imperial College London, ³St George's Hospital

BACKGROUND AND AIM: The 'broken escalator phenomenon', or locomotor aftereffect (LAE), describes the instability perceived by the majority of subjects when stepping onto a stationary escalator, and represents an inappropriate expression of a learnt motor programs used for stepping onto a moving escalator. Patients with Functional Gait Disorders (FGD) have gait difficulties which cannot be explained by an organic cause, and therefore the pathologic mechanism is still unknown. One possible hypothesis for the underlying deficits of patients with FGD is an abnormal sensorimotor scaling that may result in overcompensation to maintain balance, and lead to abnormal motor learning. To test this hypothesis, this study aims to investigate the subconscious LAE motor response in patients with FGDs and age matched controls when exposed to the "broken escalator phenomenon". METHODS: This experiment consists of 3 phases: a BEFORE phase where subjects step onto a stationary platform (5 trials), a MOVING phase where subjects step onto a moving sled (10 trials), and an AFTER phase that is identical to the BEFORE phase (5 trials). We obtained kinematic measures (linear trunk displacement, foot steps, gait velocity) and autonomic responses (electrodermal [EDA] galvanic skin response, respiratory rate, pulse) in addition to subjective questionnaires and task-related anxiety/instability scores for each trial. **RESULTS:** All patients had a significantly slower gait velocity in the BEFORE trials. During the MOVING phase, patients manifest a longer learning curve to adapt to the sled movement compared to controls. In the AFTER phase, all subjects (patients and controls) exhibited, as expected, LAEs, but these were more prolonged and substantial in patients compared to controls. Mean linear trunk displacement was higher, and gait velocity was lower in patients versus controls. Additionally, patients referred higher subjective levels of instability and anxiety than controls in all phases. CONCLUSIONS: Patients with FGDs showed a delayed motor adaptation to the exposed task and greater, longer-lasting LAEs compared to controls. Patients also perceived higher instability and anxiety. The results suggest an abnormality of sensorimotor scaling in patients with FDG that lead to enhanced gait after-effects.

P2-Q-144 Central cholinergic activity and risk of falls in patients with Parkinson's disease and freezing of gait

Giovanna Lagravinese¹, Gaia Bonassi¹, Martina Putzolu¹, Alessandro Botta¹, Carola Cosentino¹, Anat Mirelman², Elisa Pelosin¹, Laura Avanzino¹

¹University of Genoa, ²Tel-Aviv Sourasky Medical Center

BACKGROUND AND AIM: Freezing of gait (FoG) is a severe episodic gait disturbance in patients with Parkinson's Disease (PD), associated with higher risk of falls. A PET study documented that PD patients with FoG display cholinergic deficits selectively driven by nucleus basalis of Meynert





neocortical denervation (Bohnen et al., 2014). In humans, cholinergic activity can be also estimated by means of short latency afferent inhibition (SAI), a transcranial magnetic stimulation (TMS) technique that assesses an inhibitory circuit in the sensorimotor cortex and it is regarded as a global marker of cholinergic function in the brain. To date, only one study investigated if changes in SAI might be associated with the presence of FoG (Picillo et al., 2015) and it failed. On the other hand, we recently showed SAI impairment in PD patients and elderly at high risk of falls respect to non-fallers (Pelosin et al., 2016). Thus, in this study, we aimed at assessing whether changes in cholinergic function might be related to increased fall risk in PD patients with FoG. **METHODS:** A cohort of 31 PD patients with FoG (14 women; mean age 73.06 ± 4.23 SD) who participated in the V-Time study were enrolled in this sub-study. Patients were divided into two groups on the basis of number of falls (=2 or \geq 3 in the previous six months). Disease severity and FoG were evaluated by means of MDS-UPDRS and the New FoG questionnaire (NFOG-Q). respectively. Cholinergic activity was estimated by means of SAI. Global cognition was assessed by means of Montreal Cognitive Assessment (MoCA). RESULTS: Twenty (65%) participants reported ≥3 falls in the previous six months, whereas eleven (35%) participants reported 2 falls in the previous six months. The two groups were matched for age, gender distribution and disease duration (p always > 0.05). Results showed that SAI was reduced in recurrent FoG fallers than in PD patients with FoG who experienced 2 falls in the previous six months (p=0.02). Reduction in SAI indicates less inhibition i.e., less cholinergic activity. Furthermore, PD patients with FoG and recurrent falls showed increased disease severity (higher scores at total MDS-UPDRS; p=0.04), worse impact of FoG on daily life (higher score at NFOG-Q Part III; p=0.01), worse short-term memory performance (as tested with delayed recall test; p=0.03). CONCLUSIONS: Our results showed that patients with FoG who experienced recurrent falls in the previous six months, presented a significant impairment of SAI respect to FoG patients who reported two falls in the same period of time, suggesting reduced central cholinergic activity. This neurophysiological pattern was associated with cognitive dysfunction, related to short-term memory. SAI abnormalities and presence of cognitive impairment strongly support the hypothesis of cholinergic dysfunction in increasing fall risk in PD patients with FoG.

P2-Q-145 Why do asymmetric gait patterns persist after deep brain stimulation in Parkinson's disease?

Deepak Ravi¹, Michelle Gwerder¹, Niklas Ignasiak², Christian Baumann³, Mechtild Uhl³, William Taylor¹, Navrag Singh¹

¹ETH Zurich, ²Chapman University, ³University Hospital Zurich

BACKGROUND AND AIM: People with Parkinson's disease (PwPD) are commonly recognized with asymmetrical severity of clinical symptoms including bradykinesia, tremor and rigidity but also gait impairment (Johnsen et al. 2009). Deep Brain Stimulation (DBS) targeting subthalamic nucleus (STN) of the basal ganglia has shown therapeutic potential to alleviate impairment, albeit





not in all patients and not all motor features; an example of deterioration is dynamic postural control (Clerc et al. 2015). In clinical practice, bilateral implantation and asymmetrical stimulation demonstrate efforts to ensure functional symmetry. However, asymmetry either persists or in some cases it aggravates after surgery, the reasons might be multifactorial, including inherent lateralization (Lizarraga et al. 2017). Nonetheless, the interplay between clinical symptoms and gait function both before and after DBS is complex, and continues to remain elusive. Our study focuses on systematic clinical and experimental assessment of asymmetry in motor function, measured both pre-operatively and post-operatively, and compares these with healthy elderly. METHODS: We recruited 32 PwPD (mean age: 63 years) treated with STN-DBS bilaterally, 23 of these patients underwent 6-month post-operative testing and additionally 51 asymptomatic agematched controls. MDS-UPDRS scores were collected in the medication "on" state both pre- and post-operatively. 3D kinematic data were also collected while the participants performed 10 minutes of continuous walking to establish pre- to post-operative gait differences. We extracted step-length (SLA), step-time (STA) and swing time (SWA) asymmetry ratios and correlated these with asymmetry of clinical symptoms. **RESULTS:** Both experimental and clinical (Fig 1a & 1b) metrics of asymmetry increased (hinting worsening behavior) in PwPD after STN-DBS. The correlation between the two metrics are much less clear, presumably these are mediated differently and might represent distinct motor sub-features (Fasano et al. 2015). Interestingly, we found positive correlation (p < 0.05) between pre-operative STA and post-operative SWT with post-operative total UPDRS asymmetry (Fig1c). Increased asymmetry in gait after DBS might either suggest adaptation or compensation mechanism, currently under-recognized for gait in clinical practice, but extremely important for e.g. avoiding fall risk (Yogev et al. 2007). The relevance and significance of asymmetry in gait, however needs to be further explored in the context of its dynamic interplay with other features including rhythmicity, balance and fall risk. **CONCLUSIONS:** Our study demonstrate post-operative deterioration of motor symmetry after bilateral STN stimulation in PwPD. Future directions for the study will utilize this dataset for providing predictive information on the specific nature of different post-operative gait features including asymmetry, and to establish ways to improve pre-operative patient selection.

P2-Q-146 The effect of closed-loop tactile feedback on gait initiation in people with Parkinson's disease with Freezing of Gait

Christian Schlenstedt¹, Daniel Peterson², Martina Mancini³

¹Christian-Allbrechts-University of Kiel, ²Arizona State University, ³Oregon Health & Science University

BACKROUND AND AIM: Gait initiation and turning are recognized as triggers for Freezing of Gait (FOG) in people with Parkinson's disease (PD). In addition, people with PD and FOG show altered preparation (anticipatory postural adjustments (APAs)) and execution of the first step during gait initiation while dual-tasking. Recently, it has been shown that closed-loop tactile feedback (CL)





can be effective to improve turning performance in people with FOG [1]. The aim of this study was to determine whether the same sensory feedback impacts preparation and execution of the first step during gait initiation. METHODS: Eighteen subjects with PD and FOG (PD+FOG) and 18 without FOG (PD-FOG) were included and performed, OFF medication, self-initiated gait with or without CL under single and dual task conditions. Anticipatory postural adjustments and step kinematics were quantified with inertial measurement units (IMUs). Muscle activity of the right and left tensor fasciae latae (TFL) was measure with EMG recordings. Linear mixed models were applied to investigate the effect of group (PD+FOG vs. PD-FOG), condition (with vs. without CL) and Task (single vs. dual task) and the respective interaction effects. RESULTS: PD+FOG and PD-FOG did not differ in age, gender and disease duration and severity (p>0.05). A significant group effect was found for medio-lateral (ML) size of APA and TFL muscular co-contraction indicating that PD+FOG performed smaller APAs (F=4.559, p=0.04) with a higher amount of TFL co-contraction (F=6.034, p=0.02) compared to PD-FOG. CL had no effect on APAs but led to an increase in first step duration (F=7.921, p=0.008). CONCLUSIONS: PD+FOG had smaller APAs and higher TFL co-contraction during gait initiation confirming prior results with a different sample of participants [2]. CL feedback did not impact preparation of the first step but led to a slower execution of the first step. We speculate that CL feedback, similarly to what has been found for turning, might led to a more conscious execution of the first step. Acknowledgements. This study was funded by a Career Development Award 5R00HD078492-04 (PI Mancini). [1] M. Mancini, K. Smulders, G. Harker, S. Stuart, J.G. Nutt, Assessment of the ability of open- and closed-loop cueing to improve turning and freezing in people with Parkinson's disease, Sci Rep 8(1) (2018) 12773. [2] C. Schlenstedt, M. Mancini, J. Nutt, A.P. Hiller, W. Maetzler, G. Deuschl, F. Horak, Are Hypometric Anticipatory Postural Adjustments Contributing to Freezing of Gait in Parkinson's Disease?, Front Aging Neurosci 10 (2018) 36.

P2-Q-147 Clinical meaningful thresholds of temporal and spatial gait parameters in the context of the differential diagnosis in gait ataxia

Roman Schniepp¹, Max Wuehr¹, Julian Decker¹

¹Ludwig-Maximillians Universität München

BACKGROUND: Gait ataxia due to cerebellar or sensory deficits is characterized by increased levels of gait fluctuations. However, functional gait ataxia also mimics gait dynamics similar to those of somatic entities. Clinicians therefore strive for discriminant features of somatic and functional gait ataxia disorders in order to establish a profound differential diagnosis. Aim: Identification of distinctive spatial and temporal gait parameters in different gait examination conditions. **METHODS:** Exploratory analysis of spatial, temporal and gait fluctuation parameters based on data of a pressure sensitive carpet of 320 patients with cerebellar ataxia (CA), 145 patients with vestibular ataxia (BVF) and 111 patients with functional gait disorder (FGD) with ataxia. Gait was recorded during walking with slow, preferred, maximal speed, walking with eyes





closed and walking with cognitive dual tasks. We performed an ANOVA model in order to identify group differences in different gait conditions. Moreover, a receiver-operating curve analysis with reverse regression was used in order to identify useful parameter thresholds and their discriminant powers. RESULTS: Differentiation of gait ataxia due to somatic ataxia from functional gait disorders can be facilitated by the comparison of base of support (BOS) and the coefficient (CV) of stride time and stride length. Discrimination is best when gait is measured during fast walking and walking with eyes closed. During fast walking, base of support and CV of stride time is significantly higher in patients with CA compared to the other groups (p<0.01). During walking with eyes closed, CV of stride time further increases in patients with BVF and (less pronounced) in patients with CA. No increase was found in patients with FGD. BOS threshold for maximally fast walking was 13.17cm (sensitivity 0.8, specificity 0.84). CV of stride time threshold was 5.7% (sensitivity 0.72, specificity 0.81) for fast walking and 3.6% (sensitivity 0.79, specificity 0.83) for walking with eyes closed. CONCLUSIONS: Spatial, temporal and gait fluctuation parameters can help differentiating somatic from functional gait ataxia. We found typical patterns of gait fluctuation parameters and base of support that are modified by walking speed and sensory feedback conditions. The study provides clinical meaningful threshold values and their diagnostic values for this clinical scenario.

P2-Q-148 Quantity and quality of gait in PD, MS and healthy people in a community setting

Vrutangkumar Shah¹, James McNames², Patricia Carlson-Kuhta¹, Rebecca Spain¹, John Nutt¹, Mahmoud El Gohary³, Fay Horak¹, Carolin Curtze⁴

¹Oregon Health & Science University, ²Portland State University, ³APDM, ⁴University of Nebraska Omaha

BACKGROUND AND AIM: Gait assessment in the clinic may not reflect actual mobility during daily life. In this study, we investigated quantity and quality of gait in people with Parkinson's Disease (PD), Multiple Sclerosis (MS) and Healthy Control subjects (HC) over a week of continuous monitoring in daily life. The aims of the study are twofold: 1. To determine if quantity of walking is different among people with PD, MS and HC, and 2. To determine which gait metrics are different among PD, MS and HC. **METHODS:** We recruited 8 people with PD, 7 people with MS and 7 age-matched healthy control subjects to date. Subjects wore three inertial sensors (Opals, APDM) attached to both feet and the lumbar region for a week of continuous monitoring with an average of 8 hours per day. From the data, we derived about 40 gait metrics and 10 turn metrics using various algorithms. Student t-test was performed to detect significant difference among the three groups. We plan to enroll 40 subjects per group. **RESULTS:** Preliminary analyses of continuous monitoring of gait for a week showed that quantity of gait was different in people with MS and PD. Specifically, people with MS were less active compared to people with PD (p=0.003). Although gait speed was not different among the three groups, several gait metrics





were statistically significant. Specifically, stance duration (seconds) was smaller in HC than in people with MS (p=0.046), and PD (p=0.016). Further, single limb support percentage of gait cycle was lower in people with MS than HC (p=0.025), and people with PD (p=0.004). Variability in turn duration was also larger in people with PD than people with MS (p=0.040), and HC (p=0.019). Variability in coronal trunk range of motion was higher in people with MS than HC (p=0.045), and higher in people with PD than HC (p=0.040). **CONCLUSIONS:** The preliminary results show that people with MS were less active than people with PD. Despite similar gait speed among the three groups, quality of mobility (specifically gait and turning) over a week differed in people with MS or PD compared to healthy control subjects. After data collection is complete, quantity and quality of gait will be related to prospectively tracked falls. **ACKNOWLEDGEMENTS AND FUNDING:** NIA grant # 5R44AG055388, and NMSS Mentor Fellowship: MB 0027.

P2-Q-149 Antero-posterior foot placement is disturbed in people with Parkinson's disease: preliminary data

Lucas Simieli¹, Sjoerd Bruijn², Erwin E van Wegen³, Fabio Barbieri¹, Jaap van Dieën²

¹São Paulo State University (UNESP), ²Vrije Universiteit Amsterdam, ³Amsterdam Universitair Medisch Centrum

BACKGROUND/AIM: To maintain a stable gait pattern, the relation between the center of mass (CoM) position and the base of support (BoS) needs to be controlled. It has been suggested that this demands higher-order neural mechanisms, which could be compromised in patients with Parkinson's disease (PD). To better understand this, we performed this study to assess Com-BoS coordination in patients with PD. METHODS: Twelve patients (8 men) with PD (age 65.1±6.4 years; height 181±8.9cm height; weight 80.8±16.9kg) and eight (4 men) neurologically healthy older people (control group age 66.8±7.8 years; height 174±11.2cm; weight 76.3±11.2kg) participated in this study. All participants could walk independently, were free of signs of dementia (Mini-Mental State Examination- 28.9 pts) and muscle-skeletal disorders. Subjects were asked to walk on an instrumented treadmill while their gait kinematics were recorded by Vicon Bonita cameras (sample rate 100 samples/s). Participants walked for three minutes at the preferred speed, during three trials. We calculated basic gait parameters, such as stride time, stride width and variability (standard deviation) of these parameters. Moreover, we assessed stability in AP and ML directions by using a linear model predicting foot placement based on trunk CoM position and velocity in the preceding swing phase. The heel markers were used to determine foot placement position. The outcome variable of this model was the prediction error of foot placement. **RESULTS:** Participants with PD presented longer stride times and unexpectedly smaller step widths when compared to the control group. The foot placement control model indicated a less tight control in people with PD only in anteroposterior direction, i.e. a larger differences model predicted and actual foot placements. CONCLUSION: While mediolateral foot placement appeared to be largely intact in patients with PD, anteroposterior foot placement was less tightly

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controlled than in control subjects. It could be that impaired AP foot placement control reflects PD specific features in control of gait stability, such as (manifestations of) freezing of gait and, rather than global instability.

P2-Q-150 Predictors of subjective and objective measures of severity of freezing of gait in Parkinson's disease

Caroline Souza¹, Acacio Neto¹, Daniel Coelho¹, Andrea Lima-Pardini², Raquel Marquesini¹, Alana Batista¹, Egberto Barbosa¹, Carlos Ugrinowitsch¹, Luis Teixeira¹, Carla Silva-Batista¹

¹University of São Paulo, ²Federal University of ABC

BACKGROUND AND AIM: Freezing of gait (FOG) is a devastating symptom of Parkinson's disease (PD). The pathophysiology of FOG is poorly understood and is most likely associated with multiple brain regions. In the present study, we aimed to evaluate different predictors of FOG in PD patients using a subjective (New Freezing of Gait Questionnaire [NFOGQ] score) and an objective (instrumented turning task [FOG-ratio]) FOG measure. METHODS: Thirty-eight patients (age: 66.2 ± 9.1 years; Hoehn & Yahr stage: 3-4; severity of motor signs: 51.7 ± 12.8 ; years of disease: 8.8 ± 5.0; L-Dopa equivalent units: 793.1 ± 267.0) assessed "on" state of medication completed the study. FOG measures, fear of falling (Fall Efficacy Scale-International [FES-I] score), executive functions (Digit Symbol Substitution Test [DSST]), Stroop test III, Trail Making Test sections A and B [TMTA and TMTB], The Frontal Assessment Battery [FAB]), cognitive functions (Montreal Cognitive Assessement [MoCA]), anxiety and depression (Hospital Anxiety and Depression Scale [HADS]), and motor signs (Unified Parkinson's Disease Rating Scale part III [UPDRS-III]) were assessed. RESULTS: Results showed a significant correlation between the objective and subjective FOG measures (r=0.48, P=0.002). In a multiple regression analysis (forward stepwise method), fear of falling was found to be the strongest significant predictor of the NFOGQ score (P<0.001) and FOG-ratio (P=0.004), explaining 52% and 20% of the variance, respectively. Addition of the anxiety score significantly improved the prediction model, accounting for additional 11% of the variance in the NFOGQ score (P=0.002). Different executive functions entered into the regression model. Failure of inhibitory control (Stroop test III) accounted for additional 5% of the NFOGQ score variance (P=0.023), while poor mental flexibility (TMTB) accounted for additional 10% of the FOG-ratio variance (P=0.027). The other variables did not contribute significantly as predictors. CONCLUSIONS: Our results lead to the following **CONCLUSIONS:** (a) fear of falling was the common predictor for both objective and subjective measures of FOG, (b) anxiety only was a predictor for the subjective FOG measure, and (c) different executive functions contributed to the FOG predictive model variance. These results are consistent with the assumption that dysfunctional fronto-striato-limbic structures are associated to the manifestation of freezing of gait in individuals with Parkinson's disease.





P2-Q-151 Natural progression of gait impairment in early Parkinson's disease: A six-year prospective incident cohort study

Joanna Wilson¹, Alison Yarnall¹, Sue Lord², Lisa Alcock¹, Rosie Morris³, David Burn¹, Lynn Rochester⁴, Brook Galna¹

¹Newcastle University, ²Auckland University of Technology, ³Oregon Health & Science University, ⁴Institute of Neuroscience, Newcastle University

BACKGROUND AND AIM: Gait disturbance is an early and cardinal feature of Parkinson's disease (PD), yet the natural progression of gait impairment in early disease stages is not well characterised. Over time gait characteristics respond in a variable manner suggesting that discrete features are resistant to levodopa. Understanding progression is important to develop therapies to better manage gait disturbance and identify better outcome measures to capture dopa responsive and resistant gait characteristics. We have previously identified discrete gait impairments (variability of step time and step length) which progress more rapidly in PD compared to age matched controls over the first three years after diagnosis, in spite of optimal medication. However, the natural history of gait progression over longer periods has not been described. Here, we aimed to describe changes in gait in PD over the first six years of disease, and identify if changes were related to PD or ageing and levodopa medication. METHODS: 109 PD patients and 130 age-matched controls completed at least two gait assessments through the ICICLE-GAIT study. Participants were recruited a median of 4 months from diagnosis; additional assessments were completed every 18 months for up to six years. For assessment, participants walked continuously for 2 minutes around a 25m circuit, with gait repeatedly sampled as participants walked over a 7m X 0.6m instrumented walkway included in the circuit. Sixteen spatiotemporal gait characteristics were derived. Levodopa equivalent dose (LEDD) scores were additionally calculated at each time point for PD patients. Yearly rates of change were calculated for each gait characteristic using a linear regression slope for each participant. Wilcoxon sign-rank tests assessed whether yearly rates of gait change differed significantly within-group and ANCOVA (controlling for age and sex) between groups. Pearson correlations assessed yearly rates of gait change with LEDD change. **RESULTS:** Preliminary results indicate that, compared to controls, step velocity and step length declined more quickly in PD patients and variability of step time, swing time, step length and step width increased more quickly (p<0.01). There were no significant correlations between the rate of increase in LEDD and progression of gait impairment for any variables (p>.01). CONCLUSIONS: This study represents the longest longitudinal assessment of the natural progression of gait impairment in an incident PD cohort to date. Despite optimal medication, gait impairment in early PD progresses more quickly than in age-matched controls. Gait characteristics related to pace and variability progress at a faster rate over the first six years of PD than typical ageing, and may present as targets for intervention to improve gait features that are poorly controlled by current therapies. ACKNOWLEDGEMENTS AND FUNDING: This research was funded by Parkinson's UK and supported by the National Institute for Health





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P2-Q-152 MTBI and PTSD are dissociable using novel posturography assessments

W. Geoffrey Wright¹, Amanda Haskell², Labeeby Servatius², Justin Handy³, Richard Servatius²

¹Temple University, ²Veterans Administration Medical Center (VAMC), ³NSMRL

BACKGROUND AND AIM: Post-traumatic stress disorder (PTSD) and mild traumatic brain injury (mTBI) diagnoses are largely symptomatology-based, as no clear biomarkers yet exist for objective diagnosis. Return-to-duty decisions are largely based on self-report, with most individuals reporting fitness for duty within 7-10 days. Those not recovering in that period have persistent sequelae including balance and coordination problems. Some symptoms of PTSD and mTBI have been found to overlap, such as concentration and/or memory loss, depression, irritability/anger, anxiety, and dizziness and loss of balance. This lack of symptom exclusivity is further complicated by the fact that mTBI often occurs in the presence of a traumatic event that can cause psychological stress. Some evidence suggests that psychological factors may account for many postconcussive symptoms, however, how these two conditions interact remains unclear. Accurately dissociating etiology of signs and symptoms is a critical part of an effective health recovery plan. An assessment trial was designed to test veterans using novel virtual reality (VR) technology and a battery of tests to assess psychological, cognitive, and medical history. **METHODS:** Veterans (n = 36) were recruited to the Syracuse VA hospital and interviewed for lifetime mTBI history with Defense Veterans Brain Injury Center (DVBIC) mTBI screen and PTSD with the Checklist (PCL-5) using cluster criteria. Four groups were formed in a 2x2 matrix: mTBI-/PTSD- = 12, mTBI-/PTSD = 5, mTBI /PTSD- = 14, and mTBI /PTSD = 5. All individuals completed the Neurobehavior Symptom Inventory (NSI), and a battery of neurocognitive and reactivity tasks. Postural stability was assessed using a custom-designed portable VR device using 6 conditions: 3 visual (eyes-open, eyes closed, dynamic rotating scene) completed on firm and foam surface conditions. **RESULTS:** The center of pressure (COP) sway area revealed main effects of mTBI (p=0.001) and PTSD (p=0.023) and mTBI x PTSD interaction (p=0.022) wherein the mTBI /PTSD group showed greater sway than all others. There were also significant interactions for mTBI-bysurface-vision (p=0.021). Those with lifetime mTBI exhibited greater sway specifically during the DYN-FOAM condition. Those reporting lifetime mTBI did not differ in PCL-5, PHQ or NSI scores, V10 of the NSI (i.e. malingering) or the subset of NSI symptoms focused on balance compared to lifetime mTBI-, all p's > .25. CONCLUSIONS: The findings suggest that independent of the presence of PTSD, having a history of mTBI results in long-lasting postural signs despite being asymptomatic. Although veterans with PTSD exhibit modestly increased sway across all visual and surface conditions, lifetime mTBI was associated with an independent increase in sway during DYN-FOAM condition. None of the other assessments were sensitive to mTBI history. Premature return-to-duty can have myriad negative consequences on the injured service member and

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colleagues placing both at greater risk of injury (or death in high-risk combat environments). Furthermore, failure to identify deficits following mTBI and/accurately identify etiology (physiological, psychogenic) can result in ineffective or absent treatment.

P2-Q-153 Frailty status predicts falls in early Parkinson's disease

Alison Yarnall¹, Shauna Holland¹, Rosie Morris², Sue Lord³, Brook Galna¹, Lynn Rochester⁴

¹Newcastle University, ²Oregon Health & Science University, ³Auckland University of Technology, ⁴Institute of Neuroscience, Newcastle University

BACKGROUND AND AIM: Parkinson's disease (PD) is a syndrome in which postural control, falls and gait impairments dominate. PD also is present in the context of ageing in which ageing syndromes such as frailty and multi-morbidity coexist. Frailty has been defined as a state where multiple body systems lose their in-built reserves. To date there has been little exploration of falls risk with respect to frailty. The aim of this study was to establish whether there was an association between frailty and falls in early PD. METHODS: As part of the Incidence of Cognitive Impairment in Cohorts with Longitudinal Evaluation in Parkinson's disease (ICICLE-PD) - GAIT study, participants were classified as robust, pre-frail or frail according to the electronic frailty index, comprised of 36 health deficits. They were also categorised as fallers on non-fallers, depending on whether they had fallen in the previous 12 months. **RESULTS:** Mean age of the 119 participants was 66.9 (±10.5) years, 66.4% were male, with a disease duration 6.3 (±4.7) months, mean MDS UPDRS III score of 25.4 and Montreal Cognitive Assessment of 25.2. 37 (31.1%) were classified as robust, 52 (43.7%) as pre-frail, and 30 (25.2%) as frail. Of the 119, 26 (21.8%) had fallen in the prior 12 months. Those that were frail were more likely to have fallen (50% fallers were frail vs. 17.3% pre-frail and 5.4% robust, X2=20.4, p<0.001). CONCLUSIONS: Even at very early disease, a considerable proportion of PD patients are classified as frail. Frailty status was associated with retrospective falls, suggesting that these may form a different falls phenotype which requires a different approach to falls risk reduction. ACKNOWLEDGEMENTS AND FUNDING: This study was funded by Parkinson's UK and was supported by the National Institute for Health Research (NIHR) Newcastle Biomedical Research Centre based at Newcastle upon Tyne Hospitals NHS Foundation Trust and Newcastle University. The views expressed are those of the author(s) and not necessarily those of the NHS, the NIHR or the Department of Health.

R - Orthopedic diseases and injuries

P2-R-154 Collegiate athletes with a conservative gait strategy are more likely to sustain a lower extremity musculoskeletal injury following concussion

Jessie Oldham¹, David Howell², Christopher Knight³, Jeremy Crenshaw³, Thomas Buckley³



ispgr INTERNATIONAL SOCIETY OF POSTURE & GAIT RESEARCH

¹Boston Children's Hospital, ²Children's Hospital Colorado, ³University of Delaware

BACKGROUND AND AIM: An increased risk of lower extremity musculoskeletal (LEMSK) injury in the year following concussion has been observed in athletes from the high school to professional level. Gait has successfully identified lingering post-concussion impairments in postural control, which have been speculated as a potential contributor the elevated injury risk; however, the underlying mechanism has yet to be determined. Therefore, the aim of this investigation was to examine gait characteristics between collegiate athletes who did and did not sustain a LEMSK injury in the year following concussion. METHODS: Thirty-four NCAA Division I collegiate athletes who sustained a concussion were divided into two groups based on if they did (n=16;Age: 19.9±1.5 years;Height: 175.3±9.3 cm;Weight: 71.3±10.5 kg) or did not (n=18;Age: 21.1±1.5 years;Height: 173.4±12.6 cm;Weight: 73.5±14.2 kg) sustain a LEMSK in the year following concussion. Injuries were tracked using an electronic medical database. Participants were instrumented with three APDM Opal wearable triaxial accelerometers and performed five single-task (ST) and five dual-task (DT) gait trials. Participants began standing behind a starting line and, in response to a verbal cue, traversed a 10-meter walkway, turned around a specified endpoint, and returned to the original starting line at a self-selected pace. During DT trials, participants simultaneously walked and answered mini-mental style questions. All participants completed baseline testing prior to the start of the season and again at return to play following concussion. A linear mixed effects model was used to identify significant interactions and/or main effects between groups for gait speed, double support time, cadence, and stride length. **RESULTS:** There was a significant main effect between groups for both ST (p=0.03) and DT (p=0.02) gait speed. The LEMSK injury group had an overall slower gait speed (ST: 1.15±0.10 m/s, DT: 1.01±0.10 m/s) than the no LEMSK group (ST: 1.23±0.11 m/s, DT: 1.10±0.11 m/s) under both conditions. There was also a significant main effect between groups for both ST (p=0.02) and DT (p=0.02) double support time. The LEMSK injury group spent longer in double support (ST: 20.19±2.34%, DT: 21.92±2.13%) than the no LEMSK group (ST: 18.16±2.60%, DT: 20.00±2.32%). There were no significant interactions or main effects for cadence or stride length. **CONCLUSIONS:** There were significant differences in gait characteristics between those who did and did not sustain a subsequent LEMSK injury in the year following concussion. These results (slower gait speed, increased time in double support) are evidence of a conservative gait strategy that has been observed following concussion and suggest that lingering deficits in postural control may contribute to the elevated LEMSK injury risk. Future studies should focus on implementing strategies to reduce the number of post-concussion LEMSK injuries. ACKNOWLEDGEMENTS AND FUNDING: None.

T - Psychiatric disorders

P2-T-155 Short postural training affects stability in children with autism spectrum disorders





Simona Caldani¹, Maud Tisne¹, Paola Atzori¹, Hugo Peyre¹, Richard Delorme¹, Maria Pia Bucci¹

¹Hopital Robert Debré

BACKGROUND AND AIM: Autism Spectrum Disorders subjects (ASD) are well known to have deficits in postural control. The aim of this study was to explore whether a short postural training period could enhance or not postural instability in ASD children. METHODS: Two groups (G1 and G2) of 20 ASD children of IQ-, sex- and age- matched (mean age 11 ± 0.6 years) participated in the study. Posture was recorded by using the Balance Quest from Framiral on unstable platform in three different viewing conditions (eyes open fixating a target, eyes closed and eyes open with perturbed vision). Two postural recordings were done for G1 before (T1) and after (T2) a 6-minute postural training. Training consisted of two different games (3 minutes each) to reinforce the standing position. In contrast, for G2 the two postural tests were done at an interval of 6 minutes T1 and T2, respectively). RESULTS: At T1, postural instability was similar for both groups of ASD children (G1 and G2) in the three viewing conditions. At T2, the group G1 only (who did a 6-minute postural training) improved significantly their postural capability under the eyes closed and eyes open with perturbed vision conditions. In contrast, the changes reported for the group G2 in the T2 did not reach significance. CONCLUSIONS: Postural training could help ASD children to use in a more appropriate way their sensorial inputs. Cerebellar integration seems improve by postural training in ASD and could represent a therapeutic opportunity for cognitive rehabilitation.

P2-U-156 Bilateral reshaping of gait coordination in hemiparetic stroke patients after early robotic intervention

Sandra Puentes¹, Hideki Kadone¹, Hiroki Watanabe¹, Yasushi Hada¹, Tomoyuki Ueno¹, Aiki Marushima¹, Yoshiyuki Sankai¹, Kenji Suzuki¹

¹University of Tsukuba

BACKGROUND AND AIM: Stroke is a leading cause of acquired disability in adults. Hemiparetic gait is commonly found in stroke survivors, affecting importantly their quality of life. Despite rehabilitation, some patients cannot achieve a functional motor recovery. The Hybrid Assistive Limb (HAL) robot is an exoskeleton able to support and enhance the lower extremities performance of patients using their own bioelectrical signals. HAL intervention has been used before in early stages of stroke, showing improvement in gait performance; however, gait coordination has not been evaluated yet. This study wants to evaluate the effect of early HAL intervention in gait coordination of hemiparetic stroke patients. **METHODS:** Ten hemiparetic poststroke patients underwent 9 sessions of HAL intervention. A motion capture system (VICON MX, 100Hz) was used to record segmental kinematics regarding the elevation angles described for thigh, shank and foot segments before the first and after the last session. Data from 9 healthy volunteers was used for comparison. **RESULTS:** Planar covariation analysis showed a classic tear drop pattern for healthy volunteers (figure 1, left column). Stroke patients before intervention





showed shrunk and deformed loops bilaterally, which recovered to some extent after HAL intervention (figure 1, central and right column). Principal component analysis (PCA) was performed and changes before and after HAL intervention in the second component (PC2-SD, figure 2 left) were found suggesting enlargement of the loop size. A recovery tendency for both sides after HAL intervention (Paretic side before intervention (par-pre) Vs healthy volunteers (healthy): <0.01, OP: 96.1%; paretic side after intervention (par-post) Vs healthy: <0.01, OP: 96.3%; non-paretic (np)-pre Vs healthy: <0.01, OP: 99.5%; np-post Vs healthy: <0.01, OP: 89.4%). Additionally, reduction of the percentage of variance of the third PCA component (PV3) was observed for the paretic side of patients reaching similar levels to healthy volunteers (figure 2, right. P-value: par-pre Vs par-post: 0.039, par-pre Vs healthy: 0.018, par-post Vs healthy: 0.49). Tendency of recovery for the non-paretic side also was observed but was still significantly different from healthy group after HAL (P-value < 0.01). CONCLUSIONS: Early HAL intervention was able to improve gait coordination along to walking performance in hemiparetic stroke patients. This novel intervention offers a new approach to improve motor recovery in this population. ACKNOWLEDGEMENTS AND FUNDING: Authors thank Ms. Mayuko Sakamaki and Ms. Yumiko Ito of Center for Innovative Medicine and Engineering (CIME) of the University of Tsukuba Hospital for their assistance during HAL intervention. We also thank Dr. Eng. Luis Carlos Manrique Ruiz for his advice on statistical analysis. This study was supported by the Industrial Disease Clinical Research Grant of the Ministry of Health, Labour and Welfare, Japan (14060101-01).

V - Sensorimotor control

P2-V-157 Effects of ankle muscle fatigue and visual behavior on postural sway in young adults

Fabio Barbieri¹, Tiago Penedo¹, Lucas Simieli¹, Ricardo Barbieri², Alessandro Zagatto¹, Jaap van Dieën³, Mirjam Pijnappels³, Sérgio Rodrigues¹, Paula Polastri¹

¹São Paulo State University (UNESP), ²Graduate Program in Physical Education and Sport at School of Physical Education and Sport of Ribeir, ³Vrije Universiteit Amsterdam

BACKGROUND AND AIM: Assuming that the ankle muscle fatigue (AMF) increases body sway due to impaired proprioception, vision can reduce the increase in body sway with AMF, and body sway in quiet upright standing is reduced when saccadic eye movements (SE) are performed, the purpose of the present study was to investigate the effects of visual information manipulation on postural control during AMF (calf) in young adults. **METHODS:** Twenty young male adults performed 1) two 60-s trials in quiet bipedal standing with eyes open (EO), eyes closed (EC) and SE (eyes saccades directed to a target appearing on one side of a monitor, then disappearing and reappearing simultaneously on the opposite side of the monitor once per 2s); 2) maximum voluntary isometric contractions (MVIC) in a leg press device, custom-made to test ankle plantar flexion force (two MVIC with 2min rest between attempts); 3) AMF induced by a calf raise exercise





performed standing on top of a step (the speed of the exercise was controlled by a metronome at 0.5Hz); 4) items 1 and 2 were repeated. The following parameters expressing CoP trajectory were calculated for the anterior-posterior (AP) and medial-lateral (ML) directions separately: displacement and the root mean square (RMS). In addition, the sway area and the median frequency of sway were calculated. Gaze behavior (number of fixations, mean duration of fixations, normalized total duration of fixations, and the area of fixation displacement) was measured by a mobile eye tracker during EO and SE. The body sway parameters were compared through twoway ANOVAs. The MVIC parameter and gaze parameters (separately for EO and SE) were analyzed with a Student?s T-test for repeated measurements. RESULTS: The MVIC was reduced by 7% after AMF (p<0.03). ANOVAs indicated interaction effects between fatigue and vision condition (Figure 1). SE reduced AP displacement and RMS in the fatigued condition (p=0.005 and p=0.003, respectively) and in the unfatigued condition (p=0.006 and p=0.006, respectively), compared to the EO. Without muscle fatigue, closing the eyes increased AP displacement and RMS of sway (p=0.041 and p=0.05, respectively), compared to the EO, while during AMF closing the eyes reduced AP displacement (p=0.04) and had no significant effect on AP RMS (p=0.09). AMF had no effects on AP displacement and RMS in the EC (p=0.13 and p=0.06, respectively), while AMF increased AP displacement and RMS with EO (p=0.003 and p=0.002, respectively) and with SE (p=0.01 and p=0.026, respectively). In addition, SE coincided with increased frequency of AP sway in the unfatigued and in fatigued conditions (p=0.001 and p=0.01) compared to the EO fixed gaze condition. Closing the eyes similarly increased AP sway frequency in unfatigued and fatigued conditions (p=0.01 and p=0.002) compared to the EO. The frequency of ML sway increased during SE (p=0.03) and EC (p<0.001) relative to the EO fixed gaze condition in the fatigued condition only. CONCLUSIONS: The body sway increased after induction of AMF. SE consistently reduced postural sway in fatigued and unfatigued conditions. Surprisingly, closing the eyes increased sway in the unfatigued condition, but reduced sway in the fatigued condition. ACKNOWLEDGEMENTS AND FUNDING: CAPES; FAPESP; CNPg.

P2-V-158 Lightly gripping a motionless handle: Study of postural sway decrease and correlation between transient force changes applied to the handle and balance

Angélina Bellicha¹, Andrés Trujillo-León¹, Wael Bachta¹

¹Sorbonne Université - ISIR

BACKGROUND AND AIM: Lightly touching (<1N) a stable surface with a finger reduces postural sway magnitude [1]. Lightly holding a stick, i.e. Lightly Gripping (LG) it while it is touching the ground, also reduces postural sway magnitude [2][3]. As the light touch does not provide mechanical support, it is assumed that the Central Nervous System (CNS) integrates the light touch as a new sensory input to reduce postural oscillations. The transient forces at the point of contact may also be relevant to the CNS as estimates of postural sway and thus contribute to sway oscillations decrease [4]. Our first aim is to study the effect of lightly gripping a stable handle





on postural sway. The handle is motionless with respect to the environment. Our second aim, which is our main contribution, is to study the correlation of the forces applied to the handle and the sway in the Anterior-posterior (AP) direction. An experiment including No Grip (NG) and Light Grip (LG) conditions has been conducted to that end. METHODS: 11 healthy young (24 years old in average) adults took part in the experiment. The experimental setup consisted of a handle with embedded FSR sensors to check the LG condition. This handle was attached to the ground using a force sensor to monitor the forces applied on the handle. A Force plate was used to acquire the participants' Centre of Pressure (CoP). The participants, standing on the force plate, were asked to shut their eyes and to remain as still as possible. They repeated 3 times in random order the following conditions: - No Grip (NG): The subject's arms were alongside the body. - Light Grip (LG): The subject held lightly a handle in his dominant hand, the other arm was alongside the body. RESULTS: Ranksum tests showed a significant difference between the two conditions. Light Grip reduced all the CoP temporal characteristics of postural sway, especially in the AP direction. Secondly, the tangential AP force applied to the handle by the hand of the participant is correlated with the CoP AP sway with a median correlation of 0.67 (p-value < 0.05 for all trials) and the force is leading with a median lag of 200ms. CONCLUSIONS: Lightly gripping a stable handle reduces postural sway. The cross-correlation of the force applied on the handle with the AP CoP with the force leading with a median lag of 200ms shows that the forces cues are sway related. This reveals the possible integration of touch force cues by the CNS to reduce postural oscillations. Acknowledgments and **FUNDING:** This work was funded by the ANR within the project i-Gait, under reference ANR-16-CE33-0012. [1] J. Jeka et al. Exp. Brain Res. 1997 [2] I.M. Albertsen et al. Human movement Science. 2010 [3] S. Sozzi et al. Front. Neuroscience. 2018 [4] V. Krishnamoorthy et al. Exp. Brain Res. 2002.

P2-V-159 Dynamic reweighting of three modalities for sensor fusion after repetitive head impact

Jaclyn Caccese¹, Fernando dos Santos¹, John Jeka¹

¹University of Delaware

BACKGROUND AND AIM: The potentially detrimental effects of repetitive head impact exposure are a fundamental concern facing the sports medicine community and the United States military and has become recognized as a major public health issue. Following mild Traumatic Brain Injury (mTBI), there are significant impairments in sensorimotor function, but the effects of subconcussive head impacts (i.e. head impacts that do not result in the acute symptoms associated with mTBI) on sensorimotor function has been relatively understudied. The purpose of this study was to investigate the effects of subconcussive head impacts on sensory re-weighting in a PRE, POST-0H, POST-24H repeated measures design. **METHODS:** Participants were randomly assigned to a soccer heading (EXP; N=14, 8 males, 22.8±3.4 years, 172.2±6.9 cm, 72.0±8.2 kg) or a control group (CON; N=12, 8 males, 20.9±2.2 years, 172.4±10.2 cm, 71.3±14.2





kg). The EXP performed 10 headers in 10 minutes with soccer balls projected at a velocity of 25 mph (11.2 m/sec). To evaluate sensory re-weighting, we simultaneously perturbed upright stance with visual (i.e. a moving visual scene at 0.2Hz), vestibular (i.e. a ±1 mA bilateral monopolar galvanic vestibular stimulus (GVS) at 0.36 Hz), and proprioceptive stimulation (i.e. an 80 Hz vibratory stimulus to their bilateral Achilles tendons at 0.28 Hz). The visual stimulus was presented at different amplitudes (i.e. 0.2m, 0.8m in the anterior-posterior (AP) direction) to measure the legsegment AP displacement change in gain to vision, an intramodal effect; and change in gain to GVS and vibration, both intermodal effects. A repeated measures ANOVA was used to compare gains to each modality and sensory reweighting between groups and across sessions. **RESULTS**: There were no changes in gain to vision (i.e. session X group effect; F=1.414, p=0.263, $n^2=0.110$), gain to GVS (F=0.320, p=0.729, n²=0.027), or gain to vibration (F=1.749, p=0.196, n²=0.132). In addition, there were no changes in sensory reweighting for any modality (i.e. session X condition X group effect; vision, F=0.460, p=0.829, η²=0.127; GVS, F=0.312, p=0.923, η²=0.090; vibration, F=0.729, p=0.493, n²=0.060). **CONCLUSIONS:** These results suggest that there were no changes in sensorimotor function following our soccer heading paradigm of subconcussive head impacts. These findings support previous work that suggests that subconcussive head impacts result in few behavioral changes, despite changes in blood biomarkers and neuroimaging. Future research should try to describe the progression and manifestation of long-term behavioral impairments sometimes observed following years of repetitive exposure. head impact ACKNOWLEDGEMENTS AND FUNDING: This study was supported by NIH-NINDS R01 (NS102157-01) grant (J. Jeka, J. Park, Pls).

P2-V-160 Threat-related changes in postural control in virtual environments

Jernej Camernik¹, Sanja Kezic², Jan Babic¹

¹Institute Jozef Stefan, ²Jozef Stefan Institute

BACKGROUND AND AIM: Immersive virtual reality (VR) can be used as a tool to treat various medical conditions including psychiatric and motor control disorders. Since it enables a highly modifiable environment and difficulty, it has a large potential to be used as a research platform to study balance control. Otherwise hard to achieve extreme and dangerous experiences like standing on a very high ledge can be easily achieved with the immersive VR within the research lab. Furthermore, it has been shown that the level of immersion in VR is highly determined by the capability of the system to deliver an inclusive, extensive, surrounding, vivid and matching illusion of reality to the senses of a participant. Therefore, we prepared an immersive VR environment, coupled with a robotic device to further enhance the level of immersion. With this setup, we aimed to evaluate the threat related changes in postural control when using immersive VR with additional bodily gravity cues. **METHODS:** For this purpose, we created a faithful virtual environment scene of an extreme situation in combination with a vertically translating platform to emulate the forces during the elevator ride and the accompanying audio effects. The VR scene emulated standing





on a tiny platform 15 m above the ground and the robotic platform performed accelerations to mimic those we experience during the departure and the arrival of the real elevator ride. The accompanying audio effects made the immersion in VR even more complete by concealing noises from the lab and enhancing the overall experience of the elevator ride. Fifteen healthy, young participants stood on top of a movable platform synchronized with the VR environment by using the Oculus Rift system. During the three experimental conditions (eyes open in VR + platform movement, eyes closed + platform movement, eyes open without VR + platform movement), we tracked the participant's movement of the centre of mass (COM), centre of pressure (COP), lower limb muscle activity and stress-related changes appearing on the surface of the skin (GSR). Before the VR trial, participants completed a brief immersion period to familiarise with the new environment and equipment. RESULTS: Preliminary results suggest that the level of immersion significantly influences balance control seen in the differences of COP and COM displacements between all three experimental conditions. Furthermore, the results of GSR complement these findings, suggesting that the delivery of gravity cues enhances the effect of realism. CONCLUSIONS: Based on the results of this study we conclude that immersive VR can be an effective means for balance control research, and suggest using this technology to study motor learning in many situations and in more types of populations. However, to faithfully perform postural control experiments in young healthy adults using immersive VR technology the appropriate setup necessitates including inputs to the auditory and vestibular system of the participant. ACKNOWLEDGEMENTS AND FUNDING: This work has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 731540 (An.Dy).

P2-V-161 The effects of lighting level on balance in dancers

Elizabeth Coker¹, Terry Kaminski²

¹NYU/Tisch School of the Arts, ²Teachers College of Columbia University

BACKGROUND AND AIM: Elite dance performance requires controlled balance in low and unpredictable lighting. Removal of vision has been shown to negatively affect balance control (Day et al, 1993), but no study has looked at dance-specific balance in low lighting. While previous dance research has relied on standardized tests to measure postural control (Hutt & Redding, 2014; Notarnicola et al., 2014), several studies suggest balance proficiency is activity specific and not generalizable (Gerbino, Griffin, & Zurakowski, 2007; Guillou, Dupui, & Golomer, 2007). Thus, standardized tests may provide limited knowledge about the organization of balance during dance-specific tasks. Center of pressure (COP) excursion has been employed to measure static balance in dancers (Schmit, Regis, & Riley, 2005), but is unlikely to be a valid measure of postural stability for dynamic tasks requiring shifting from flat-foot to demi-pointe. COP mean velocity (COPv) provides an alternative measure as it is highly correlated with fluctuations of the center of mass (Masani, Vette, Abe, & Nakazawa, 2014). Lower COPv indicates more coordinated control





of the COM within the base of support (Thompson, Badache, Cale, Behera, & Zhang, 2017). The aim of this study is to examine dancers' balance during standardized and dance-specific balance tasks under full and low light visual conditions similar to studio training and onstage performance, respectively. It was hypothesized that low lighting would yield poorer balance control during both standardized and dance specific tasks. METHODS: Fourteen elite dance students were recruited from a collegiate arts conservatory. Subjects performed three trials each of a static and dynamic dance task under two visual conditions: full light (106 lumens) and low light (5 lumens). Test trials were performed on a force plate to record COPv, determined by calculating the mean absolute value of XY COP velocity at each sampling point. Trials of the Star Excursion Balance Task (SEBT) (Batson, 2009) were recorded by an infrared motion capture system under each visual condition and analyzed for leg reach distance normalized to leg length. RESULTS: Subjects demonstrated significantly shorter leg reaches on the SEBT and higher COPv during both the static and dynamic dance tasks in low light conditions. Pearson product-moment correlations revealed no significant relationship between SEBT performance and COPv during the static dance task. However, a significant negative correlation was found between SEBT and the dynamic dance task; shorter leg reach and higher COPv both indicated less stability. CONCLUSIONS: When visual information is limited, as under stage-like performance conditions, elite dance students move less smoothly and show difficulty approaching extremes of their base of support. The SEBT may be a useful measure of dynamic balance ability in dancers, but additional measures like COPv provide a more complete understanding.

P2-V-162 Gender and form of thin plantar retrocapital metatarsal bar stimulations influence on postural control.

Marc Janin¹

¹Université de Pau et des pays L'adour

BACKGROUND: The art of standing while being balanced relies on your body integrating multisensory information arising from the visual, vestibular and somatosensory systems (1). Afferent plantar skin expert holds a powerful influence on balance through the cutaneous receptors located in the skin (2). In addition, cutaneous feedback from the foot sole plays a role in balance (3-6) as well as in the modulation of lower muscle activity (7, 8). The most commonly observed reflex coupling lies between mechanoreceptors of the foot and the muscles acting about the ankle (7). Therefore forefoot stimulations and retro metatarsal head result in spatially oriented backward body tilts (5, 9). We find 4 different forms of bars: Anterior (A, 10), S (S, 11), Regular (R, 9) and U (U, 12). On the other hand, women have lower plantar perceptual thresholds than men (13, 14). Then cutaneous afferent stimulations responses could be different. To our knowledge, the effect of gender on postural responses by bars stimulations on plantar receptive fields has not been investigated. **METHODS:** Postural responses of 20 women/20 men, 2 without stimulations: (C) and heel off (CHO), and 4 with thin bars: A, S, R, U (2,8mm thickness, 18 ±4 mm²





area of stimulation, in EVA 70sh Crispin Flex®) were collected by Fusyo® barostabiloforceplate (40Hz, 30s, 2cm inter heels, 4 m cross fixed). RESULTS: Effects and interactions were observed using Anovas with Bonferroni adjustments (genre W/M x 5 conditions, data normal distributed (KS ns). **DISCUSSION:** All anterior bars stimulated the plantar skin receptor fields. They created sensory variation in regards of the retrocapital metatarsal heads and midarch where the perceptual threshold is the lowest compared with all other sites of the foot (2, 14). Then the reweighting of pressure induces postural oriented responses: backward and lateral body tilts around the ankle axis (9-12). It may due to the reflex modulation of ongoing whole muscle Tibialis Posterior receptive field of mechanoreceptor they stimulated mechanically (4, 6-7, 15). Reponses are different depending on gender and bar stimulation (8). Higher responses were observed for W than M in regard of their sensitivity. S and R induce high postural responses contrary to A and U depending of tactile afferents stimulation size (respectively lower and higher stimulating area). These last will be below or above the best threshold stimulation. Therefore postural responses depend on their sensorimotor characteristics (13, 14) and reinforce the sensorimotor implication of the foot sole on the balance control. 1 Takakusaki, 2017 2 Strzalkowski et al. 2015 3 Inglis et al. 1994 4 Perry et al. 2000 5 Kavounoudias et al. 1998, 1999, 2002 6 Mildren et al. 2016 7 Fallon et al. 2005 8 Spaich et al. 2004 9 Janin Toussaint, 2005 10 Viseux et al. 2016 11Loureau et Janin, 2014 12 Constantin et al. 2014 13 Hennig et Sterzing, 2009 14 Weerasinghe et al. 2017 15 Andersen et al. 2000.

P2-V-163 The role of the vestibular system in the preparation of arm movements

Michael Kennefick¹, Joel Burma¹, Paige Copeland¹, Paul van Donkelaar¹, Chris McNeil¹, Brian Dalton¹

¹University of British Columbia Okanagan

BACKGROUND AND AIM: In a simple reaction time (RT) task, the required movement is known prior to an imperative stimulus, allowing participants to optimally prepare forthcoming movements. Increasing the complexity of arm movements not only lengthens RTs, but also delays the onset of anticipatory postural adjustments. The performance of these complex movements requires the online preservation of posture, accomplished in part via the vestibulomotor pathway through the encoding of self-motion relating to the position of the head in space; however, it is unknown whether vestibular-evoked responses are present during the preparation of a reaching task by examining vestibular-evoked responses in the surface electromyographic (EMG) signals of upper and lower limbs prior to movement in both standing (postural; experiment 1) and seated while braced (non-postural; experiment 2) conditions. In addition to an increased vestibular-evoked response with movement complexity in both conditions, it was hypothesized that, while seated, this response would only remain in the upper limb, owing to decreased postural requirements. **METHODS:** Stochastic (0-25 Hz; RMS = 0.9 mA) binaural, bipolar electrical vestibular stimulation





(EVS) was delivered at the mastoid processes to elicit vestibular-evoked responses while participants performed 270 ballistic elbow extension/flexion movements to one, two or three targets with their right arm in each experiment. In experiment 1, participants grasped the right handle of the KINARM while standing shoeless with feet together and their toes and head pointed forward. In experiment 2, the participants sat with their torso immobilized by an inelastic strap that secured the chest to a chair to minimize balance requirements for the task. A cumulant density function (similar to cross-correlation) evaluated vestibulomyogenic coupling in the triceps and biceps brachii and bilateral medial gastrocnemii (MG). RESULTS: In experiment 1, EVS-EMG cumulant density values surpassed the 95% confidence limits in the upper and lower limbs for all subjects, which confirmed the presence of vestibular-evoked responses during the movement preparation phase while standing. Furthermore, this response increased by ~10% in both the biceps brachii and right MG, and ~18% in the left MG from simplest to most complex condition. **CONCLUSIONS:** When seated, the vestibular-evoked response was present in the upper limb, but absent in the lower limb. Moreover, the response in the upper limb did not increase with movement complexity, indicating this information was not required by the vestibular system for the task. This study demonstrates the vestibulomotor pathway is engaged during the preparation of arm movements, even when balance requirements are limited. ACKNOWLEDGEMENTS AND FUNDING: Natural Sciences and Engineering Research Council of Canada and the Canada Foundation for Innovation.

P2-V-164 Support Surface Translation - Sway responses of vestibular able subjects resemble those of vestibular loss subjects

Thomas Mergner¹, Emre Akcay², Vittorio Lippi¹, Lorenz Assländer³

¹Neurological University Clinics, Freiburg, ²Kocaeli University, ³University of Konstanz

BACKGROUND AND AIM Human sway responses to sagittal translational acceleration of the support surface (SS) are particular in that the body-space angle BS and the body-foot angle BF in the ankle joints are functionally equivalent (whereas they are different e.g. with SS tilt). One may therefore postulate that vestibular loss (VL) subjects use the proprioceptive BF signal as a substitute for the vestibular BS signal. In fact, previous work [e.g. 1] observed similar body sway responses in VL and vestibular able (VA) subjects. However, those studies used sinusoidal stimuli, which leaves open whether prediction played a major role. We therefore used the pseudorandom ternary sequence (PRTS) stimulus of [2] for SS translation to compare sway responses in simulations of a model that was trimmed to use only proprioceptive ankle stiffness information. **Methods** Seven VL subjects and seven VA subjects were presented, while standing upright on a motion platform with the eyes closed, with SS translations in the body's sagittal plane using two amplitudes (peak-to-peak 3.5 and 7.0 cm). Body sway responses were measured, using an optoelectronic device, in terms of °/cm and expressed in the frequency domain with gain, phase,





and coherence. Simulations were performed using the model proposed in [3]. **Results** Gain was close to zero below 0.1 Hz and developed a peak of approximately unity above 0.1 Hz, while phase showed an increasing lag - this similarly for both stimulus amplitudes. The results of both subject groups resembled each other closely. An exception was that VA subjects had larger trunk excursions above 0.1 Hz. The experimental data was reproduced by the model in computer and robot simulations, using only short and long latency proprioceptive negative feedback and passive stiffness. **Conclusions** Our main findings resemble those previously observed with sine wave stimulation, which excludes that the latter were determined to a major degree by prediction. The simulations indicate that the responses are determined mostly by proprioceptive stiffness mechanisms. References 1. Buchanan, J. J., & Horak, F. B. (2002). J. Vestibular Research, 11, 371-389. 2. Peterka R. J. 2002. J. Neurophysiol. 2002, vol. 88, pp. 1097-118. 3. Mergner, T. (2010). Ann. Rev. Control 34, 177-198.

P2-V-165 The effects of remote subthreshold stimulation on skin sensitivity in the lower extremity

Emma Plater¹, Ryan Peters², Leah Bent¹

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¹University of Guelph, ²University of Calgary

BACKGROUND AND AIM: Skin at the foot sole acts as an interface with the ground and can affect balance. In lower extremity amputation (LEA), the interface is between the residual limb and the prosthetic socket and is comprised of hairy skin, which has different sensory properties to glabrous foot sole skin. A technique called stochastic resonance (SR) improves sensitivity in glabrous skin by adding noise. The main objective of the current study was to determine if remote subthreshold stimulation of the hairy skin on the posterior leg (analogous to the skin of a transtibial residual limb) can improve sensation to vibrotactile input. Secondary objectives were to compare this effect between 1) stimulation profile - electrotactile and vibrotactile noise, 2) stimulation at the heel and calf, and 3) older and younger individuals. METHODS: 40 healthy subjects had a vibrotactile (test) input applied to the lower extremity at the same time that a second, noisy stimulus was applied more proximally. Subjects were divided into 4 groups of 10: Y-E-C (young adults + electrotactile noise + calf site), O-E-C (older adults + electrotactile + calf), Y-V-C (young + vibrotactile + calf) and Y-E-H (young + electrotactile + heel). For the calf site, the test input was applied 10 cm below the popliteal crease and the noisy stimulus was applied 10 cm above the popliteal crease. For the heel site, the test input was applied at the heel and the noisy stimulus was applied 15 cm above the calcaneus. Thresholds were determined for both stimuli prior to testing. A two forced-choice protocol was used to determine detection ability of the test input, set at 80% of threshold, with varying noise levels applied simultaneously (0, 20, 40, 60, 80, 100% of threshold). An SR effect was identified when a greater percent-correct value was seen at any level of noise above that seen at 0% noise. A greater percent-correct value indicated better detection of the input. **RESULTS:** In all 4 groups, approximately half of the subjects showed an SR effect.


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The SR effect did not have a clear distribution across noise intensities. There were significant interactions between noise intensity and age (p=0.045) and between noise intensity and stimulation profile (p=0.047), but no significant effects on location. This indicates that, on average, SR effects occurred at different noise levels between different ages and profiles. **CONCLUSIONS:** The SR effect was seen in all 4 groups. SR behaves differently between younger and older subjects and between stimulation profiles, but no differences were seen between glabrous and hairy skin sites. SR may be effective at improving skin sensitivity, but the intensity required varies between individuals and is seen approximately 50% of the time. Testing in LEA is the next step, with the goal of this cutting-edge research being to inform future technology in prosthetics to improve balance and prevent falls.

P2-V-166 Electrocortical dynamics related to ankle proprioception reweighting

Martin Simoneau¹, Catherine Bluteau¹, Anctil Noémie¹

¹Université Laval

BACKGROUND AND AIM: This study investigate if there is electrocortical evidence that withdrawing or adding ankle proprioceptive involve different cortical mechanisms. Further, we determine if balance control performance relates to larger theta and alpha bands power reduction or changes in the gain of the somatosensory pathways. METHODS: Participants (n=15) stood upright with their eye closed. Each trial was composed of three intervals lasting 10 s: pre-vibration, vibration and post-vibration. Ankle proprioception deprivation (vibration interval) resulted from Achilles tendon vibration. We recorded ground reaction forces and moments and electroencephalography (EEG) to assess balance control and brain oscillations, respectively. We applied independent component analysis to analyze EEG signals into maximally independent component processes and computed equivalent current dipoles for each independent component. Then, we clustered cortical source independent components, selected the cluster located in the somatosensory cortex and analyzed time-frequency plots immediately following Achilles tendon vibration onset and offset. In addition, we calculated the somatosensory-evoked potential (SEP) immediately following Achilles tendon vibration onset and offset. To assess balance control performance at Achilles tendon vibration onset and offset, we calculated the root mean square (RMS) value of the centre of pressure (CP) velocity 2.5 s following vibration onset and offset. Then, we classified good and poor balance control based on the RMS value of the CP velocity immediately following Achilles tendon vibration onset. Trials with RMS value of the CP velocity smaller than the participant's mean minus one standard deviation were classified as good balance control. In contrast, trials with RMS value of the CP velocity greater that the participant's mean plus one standard deviation were classified as poor balance control. RESULTS: The analysis of the COP velocity RMS value revealed that body sway was faster immediately following Achilles tendon vibration offset compared to onset (t = -5.22, df = 13, p < 0.001). The gain of the somatosensory pathway was larger following Achilles tendon vibration onset compared to offset

(t = 4.49, df = 13, p < 0.001). Electrocortical analysis showed that immediately following Achilles tendon vibration onset, time-frequency dynamics revealed a strong increase in the theta (4-8 Hz) activity and a slight suppression in alpha- and beta-bands activity (8-12 and 13-30 Hz, respectively). When ankle proprioception returned to normal, there was a slight increase in the theta activity and a slight increase in low-beta band activity and suppression in high-beta band activity. The comparison between vibration onset and offset revealed a significant increase in theta activity and a significant suppression in alpha activity. **CONCLUSIONS:** Our results provide evidence that controlling balance immediately after altering ankle proprioception implies different cortical mechanisms compared to the return of normal ankle proprioception. Furthermore, better balance control, following ankle proprioception deprivation, relates to suppression of alpha and beta bands power.

P2-V-167 Collision avoidance between two walkers: Reduced avoidance behaviour in previously concussed athletes

Natalie Snyder¹, Michael Cinelli¹, Victoria Rapos¹, Armel Crétual², Anne-Hélène Olivier²

¹Wilfrid Laurier University, ²University of Rennes / Inria

BACKGROUND: Despite adherence to return-to-play guidelines, athletes with previous concussion exhibit persistent deficits during visuomotor integration tasks such as collision avoidance months after returning to sport. Previous research in collision avoidance was conducted in a static setting, however less is known about visuomotor strategies utilized in dynamic scenarios, such as person-person interactions. When avoiding another walker, individuals make adjustments to their path and/or their velocity in response to a risk of collision. When walkers are on a perpendicular collision course with one another, both walkers contribute to the avoidance of the collision, however the walker who is second in passing order contributes more to the avoidance of collision. These adjustments ensure that the clearance distance created is large enough such that no collision occurs, and personal space is maintained. However, athletes with previous concussion (CONC) may demonstrate impaired performance during a collision avoidance task requiring path adjustments based on visual information. The purpose of this study was to investigate CONC and healthy athletes' (ATH) collision avoidance strategies when interacting with another walker. It was hypothesized that CONC would demonstrate altered individual contribution to the avoidance compared to ATH. METHODS: Sex- and age-matched (20-26 yrs) CONC and ATH were recruited. In pairs, participants walked along a 90° trajectory toward each other to induce a risk of collision, while avoidance behaviours were recorded. CONC and ATH interacted with each other as well as those of the opposite group to observe any interaction differences between the groups (Interactions: ATH-ATH, ATH-CONC [ATH passing first], CONC-ATH [CONC passing first], CONC-CONC). RESULTS: SPM analysis revealed CONC trajectory adaptation behaviours consistent with ATH and young adults from previous studies. However, CONC showed significantly reduced contributions (i.e. creating physical space) to the

avoidance of the collision (ATH-ATH: p<.001, CONC-ATH: p<.001, ATH-CONC: p>.05; CONC-CONC: p<.001, each at midpoint of interaction). **CONCLUSIONS:** ATH-ATH interactions replicated previous research such that the second walker contributed significantly more to the avoidance of the collision (Fig.1A). However, when CONC participated in an interaction, individual contributions were altered. During ATH-CONC interactions (Fig.1C), individual contributions were not significantly different, suggesting the CONC group were not contributing normally as the second walker. However, when CONC-CONC interacted, the first passer contributed very little to avoiding the collision, and the second passer had to contribute significantly more to compensate (Fig.1D). The difference in group behaviours during this task indicates that visuomotor impairments persist after the resolution of concussion symptoms, and CONC may be at an elevated risk of collision and possible injury.

P2-V-168 Virtual time-to-contact indicates deficits in state prediction in women with multiple sclerosis

Tyler Whittier¹, Sutton Richmond¹, Andrew Monaghan¹, Clayton Swanson¹, Brett Fling¹

¹Colorado State University

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BACKGROUND AND AIM: Postural control relies on the fast and accurate transmission of sensory information from the lower extremities to the central nervous system (CNS) in order to perceive, predict, and avoid states of instability. People with multiple sclerosis (PwMS) suffer from sensory impairments that lead to postural control deficits. Due to the slowed conduction of sensory information through the CNS inherent to PwMS, the ability to predict future instability is likely jeopardized. Virtual Time-to-Contact (VTC) is a quantitative measurement of one's ability to predict future states of stability. Static postural control is achieved when the center of pressure (CoP) is contained within the boundaries of the base of support (BoS), defined by the parameters of the feet. The VTC measurement uses the instantaneous position, velocity and acceleration of the CoP, to predict how long it would take the CoP to reach the boundary of the BoS for every data point in a trial. The purpose of this study was to quantify the ability of PwMS to predict future instability and furthermore, assess how this prediction of stability affects their motor control of balance. We hypothesized that because the VTC measurement indicates a prediction of instability, that prediction would be based off the ability to correct unstable situations; therefore, VTC measurements would be correlated with the motor response times to a balance perturbation. In addition, we hypothesized that this correlation would be reduced in the MS group indicating their inability to make motor predictions in time to avoid unstable states. **METHODS:** Thirty-three (14 healthy controls (HC) and 18 PwMS) adult women completed four static balance trials, each lasting thirty seconds, under varying sensory conditions. VTC was calculated for both groups in all static balance conditions. In addition, participants completed a dynamic balance test measuring their response times to horizontal translations of the support surface. **RESULTS:** Significant main effects of group (PwMS vs. HC) were found for both static and dynamic balance conditions. For

HC, significant negative correlations were observed between the VTC minima in three of the four static conditions and the response time to backward translations. Within the current sample, correlations between VTC and forward translations were also near significance in the HC group. No significant correlations were found between VTC and static or dynamic conditions in PwMS. **CONCLUSIONS:** Initial results indicate that PwMS are incapable of predicting future states of instability likely because they are receiving sensory feedback too late. Thus, by the time the sensory feedback indicating future instability is received, it is too late to provide a corrective movement, and the person is already unstable. Accordingly, VTC may not be indicative of a neural strategy to avoid instability but rather a reactive strategy to correct an already unstable state.

W - Tools and methods for posture and gait analysis

P2-W-169 Test-retest reliability of frequency-domain measures of balance among people with sub-acute stroke.

Raabeae Aryan¹, Andrew Huntley², Elizabeth Inness², Kara Patterson¹, Avril Mansfield²

¹University of Toronto, ²Toronto Rehabilitation Institute

BACKGROUND AND AIM: Force plate-based balance measures have been used to inform researchers with objective insights into the specific balance problems experienced by people with stroke.[1] Spectral analysis of force plate time series is usually used to understand relative contribution of different sensory systems to balance control.[2] Determining the dominant sensory systems for balance tasks can provide important information for improving stroke rehabilitation. Although the reliability of a few force plate-based balance measures have been reported in stroke,[3,4] the reliability of the frequency-domain measures of balance have yet to be established within the sub-acute stage of stroke. In this stage, patients are still receiving intensive rehabilitation, and their status may change quickly. Therefore, in the present study we aimed to determine the test-retest reliability of frequency-domain measures of balance in sub-acute stroke. **METHODS:** Participants with subacute stroke (n=25; age=61.0±12.6 years; time post stroke=39.9±21.6 days) completed 2 quiet standing trials in one session (mean time between trials=11.2±8.9 mins). Participants were asked to stand as still as possible with each foot placed on one of two adjacent force plates, with eyes open for 30s. Ground reaction forces and moments were collected at 256Hz, and centre of pressure (COP) under each foot separately and under both feet combined was calculated offline. The following spectral measures were calculated from the net COP time-series for the frequency range of 0-4.0 Hz: medio-lateral (ML) and anteriorposterior (AP) mean power frequencies, median power frequencies (ML & AP), and 80% and 95% power frequencies (ML & AP). Test-retest reliability was calculated using ICC3,1 and 95% confidence intervals. Reliability values <0.5, between 0.5 and 0.75, between 0.75 and 0.9, and >0.90 were considered as poor, moderate, good, and excellent, respectively. RESULTS: Reliabilities were 0.63 [0.32-0.82] for AP-95% power frequency, 0.60 [0.27- 0.80] for AP-mean



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power frequency, 0.58 [0.24-0.79] for ML-mean power frequency, 0.58 [0.25-0.79] for ML-95% power frequency, 0.52 [0.16-0.75] for AP-80% power frequency, 0.50 [0.14-0.74] for ML-80% power frequency, 0.46 [0.10-0.72] for AP-median power frequency, and 0.45 [0.07-0.71] for ML-median power frequency. **CONCLUSIONS:** Frequency-domain measures of balance have moderate-to-poor test-retest reliability among people with sub-acute stroke. Further research is needs to determine the clinical usefulness of these measures. Spectral analysis of the COP timeseries of more and less affected legs will be presented at the conference. **REFERENCES:**(1) Mansfield & Inness. Rehabilitation Process and Outcome, 2015; 4:7-15. (2) Palmieri et al. J Sport Rehabil, 2002; 11:51-66. (3) Gasq et al. J Neuroeng Rehabil, 2014; 11:39. (4) Lafond et al. Arch Phys Med Rehabil, 2008; 85:896-901.

P2-W-171 Development of a clinical scale to assess retropulsion in neurological disorders

Jeannine Bergmann¹, Carmen Krewer¹, Eberhard Koenig¹, Friedemann Müller¹, Klaus Jahn²

¹Schön Klinik Bad Aibling, ²Ludwig-Maximillians Universität München

BACKGROUND AND AIM: Lateropulsion or pusher behavior in the frontal plane and retropulsion in the sagittal plane both severely affect postural control and bear a substantial risk of falls. Retropulsion is characterized by a posterior displacement of the center of mass with respect to the base of support and active resistance to passive correction of this posture. Although retropulsion seems guite frequent and relevant for neurorehabilitation, research on this postural behavior is limited. One major problem is that there is no established tool available to assess and quantify the behavior. Thus, the aim of this study was to develop a scale to assess retropulsion. **METHODS:** A preliminary version of the Scale for Retropulsion (SRP) has been set up by a multidisciplinary team in Germany (Schön Klinik Bad Aibling and University of Munich). The scale was further developed through a Delphi process involving experts from different countries and professions. Inclusion criteria for experts were 1) working in the field of neurorehabilitation, neurology, and/or geriatrics for at least two years, 2) a minimum of two years of experience with topics related to postural control, and 3) regular contact with subjects who show altered postural control. The Delphi process was done via electronic questionnaires (Lime Survey). The experts were asked to indicate their level of agreement on a 9-point Likert scale ranging from strongly disagree (1) to strongly agree (9). **RESULTS:** The expert panel included medical doctors (n=3), physiotherapists (5), researchers (human movement science, biomechanics, psychologist) (3) and a kinesiologist from Europe (France, Germany, UK), America (Canada, United States), and Australia. Working experience in neurorehabilitation, neurology, or geriatrics was 22.5±10.0 years. The Delphi process comprised three rounds (Fig.1). All items reached consensus in the second round. Consensus on the final version of the SRP-V1.2 was high (median 9; IQR 1). The SRP-V1.2 includes four subscores: A) static postural control, B) reactive postural control, C) resistance, and D) dynamic postural control. All subscores are tested in a sitting and a standing (initial) position.

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The SRP is designed as a bedside test and does not require any specific materials. Depending on the severity of the behavior, it takes about 10 minutes to administer the whole scale. Each item is scored from 0 to 3 (higher score indicates more severe behavior). CONCLUSIONS: High level of international, multidisciplinary expert consensus was achieved for the SRP. The SRP assesses spontaneous posterior body tilt with the risk of backward falling, insufficient reactive postural response, and active backward pushing with resistance against passive correction. The SRP will help clinicians, therapists and researchers to evaluate postural instability in the sagittal plane and to study the epidemiology, the etiology, and the rehabilitation process of patients with retropulsion. The next stage is to evaluate the clinimetric properties of the scale. FUNDING: German Federal Ministry of Education and Research (BMBF IFB 01EO0901).

P2-W-172 The inter relations between arm-leg, arm-arm and leg-leg coordination during human walking

Maya Cohen¹, Uri Rosenblum², Desiderio Cano Porras¹, Oran Ben Gal², Meir Plotnik¹

¹Sheba Medical Center, ²Center for the Study of Movement, Cognition and Mobility, Neurological Institute, Tel Aviv Sourasky

BACKGROUND & AIM: The spinal mechanisms of arm-leg coordination during human gait are not fully understood. We hypothesize that the rhythmic phasing between arm and leg movements will be less stable and accurate as compared to leg-leg or arm-arm coordination. Aims: To quantify arm-leg coordination during walking using the phase coordination index (PCI)1, and to compare arm-leg PCI to arm-arm and leg-leg PCI values. METHODS: Twenty-five healthy young adults (age 27.08 ± 3.75 yrs, 13 males) walked on a treadmill (TM) in self-paced (SP) mode. Gait analysis was performed using data recorded by three-dimensional optoelectronic analysis system (Vicon Motion Systems, UK; sampling rate 120 Hz). We used vertical coordinates of the heel marker and anterior-posterior coordinates of the elbow marker to detect series of time-points for heel strikes (tHS) and maximal forward arm swinging (tFS) respectively (Fig. 1). These time-points, were references for extracting such parameters as the relative anti-phased stepping values for the legs $(\phi L-L)$, swinging values for the arms $(\phi A-A)$ and swinging-stepping values for left and right sides of the body (LoA-L, RoA-L, respectively). These parameters, in turn, allowed the calculation of four corresponding PCI values (PCIL-L; PCIA-A; PCI-RA-L, PCI-LA-L). We run two withinparticipants? analyses (repeated measures ANOVA), to compared the four different types of phase measures and the corresponding PCI measures. Correlations (Spearman's rho; Rs) were also computed among the PCI measures. RESULTS: All inspected inter limb coordination parameters were anti phased: mean (±SD) values of ϕ L-L, ϕ A-A, L ϕ A-L and R ϕ A-L were 179.5 ± 2.9°, 181.4 ± 10.6°, 182.9± 11.6° and 180.8 ± 13.1°, respectively (F3,69=0.40; p=0.66). The reduced variability of ϕ L-L was expressed in lower PCIL-L values (4.9± 1.8%) relative to the other types of phase measures: 12.2± 6.9%, 12.5± 5.3% and 12.6± 6.3%, for PCIA-A, PCI-RA-L, PCI-LA-L, respectively (F3,69= 22.85, p<0.001). PCIL-L and PCIA-A were moderately correlated

(Rs=0.43; p=0.03) as were PCIA-A and PCI-RA-L (Rs=0.52; p=0.01). No other pair of PCI values was significantly correlated (Rs≤0.37; p≥0.07). **CONCLUSIONS:** Our results support our hypothesis in part: leg-leg coordination has indeed the lowest PCI values, but all inter-limb coordination patters that involve the arms have roughly similar PCI values. This study suggests that spinal neuronal circuits responsible for limb rhythmicity during walking exhibit strongest coupling for the lower limbs (evidenced by lower values for PCIL-L). The fact that the anti-phased pattern of the lower limbs correlated with that of the upper limbs might reflect a governing left-right coordination, as compared to intersegmental coordination. Given the observed correlation between PCI-RA-L and PCIA-A, further research may investigate whether the inter-segmental pathways on the right side of the spinal cord are the primary drivers of upper-lower limb coordination.

P2-W-173 Can an Inertial Measurement Unit assess the Shank-to-Vertical Angle in healthy individuals?

Lysanne de Jong¹, Yvette Kerkum², Jeske Jansens¹, Noel Keijsers¹

¹Sint Maartenskliniek, ²OIM Orthopedie

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BACKGROUND AND AIM: For orthotic alignment the Shank-to-Vertical Angle (SVA) is a commonly used outcome measure. The SVA represents the orientation of the shank relative to the vertical in de sagittal plane. For measuring and adjusting the SVA, a 3D gait analysis (3D-GA) is considered as gold standard. However, this is time consuming and not easy to apply in the outpatient clinic. As an alternative Inertial Measurement Units (IMUs) attached to the shank can be used to assess the SVA. Therefore, the aim of this study was to investigate if an IMU on the shank can accurately assess the SVA during standing and walking in healthy adults. **METHODS:** Ten healthy participants (5m/5f, mean age: 35 ± 12 years) were recorded during guiet standing and barefoot walking with a 3D motion capture system (Vicon, Oxford, USA) and simultaneously with IMUs (APDM, Portland, USA) on the shank. The IMUs were anatomically placed at two different locations: anterior, in line with the tibial tuberosity and midline of the ankle (frontal alignment; fronIMU), and lateral, in line with the lateral epicondyle and lateral malleolus (sagittal alignment; sagIMU). The SVA of the 3D-GA was used as gold standard and calculated as the angle between two markers on the anterior side of the shank and the vertical in the global sagittal plane. Mean difference (±SD), correlation coefficient (r) and repeatability coefficient (RC) were calculated for the SVA between the 3D-GA and IMUs during standing with slightly bended knees and at midstance during walking (50% between heel strike and toe-off). RESULTS: The mean (±SD) SVA measured by 3D-GA was 12.7° (±3.1°) for standing and 13.3 (±2.9°) at midstance during walking. The difference of the SVA between the 3D-GA and fronIMU was -2.1° (±2.0°) for standing and -0.3° (±2.3°) for walking. The sagIMU had a difference in SVA of 6.0° (±3.0°) for standing and 7.9° (±2.7°) for walking compared to the 3D-GA. The correlation coefficient of the SVA between 3D-GA and fronIMU was 0.78 (p=0.008) for both standing and walking. For the



sagIMU the correlation coefficient was 0.62 (p=0.05) for standing and 0.75 (p=0.01) for walking. The repeatability coefficient for the fronIMU was 3.9° for standing and 4.6° for walking. The sagIMU showed a repeatability coefficient of 6.0° for standing and 5.2° for walking. **CONCLUSION:** A single IMU anatomically aligned at the anterior side of the shank can accurately assess the SVA during standing and walking with an accuracy within 5° compared to 3D-GA. Although future research should investigate the use of IMUs in orthotic gait, this study indicates an IMU to be a promising method to use for evaluation of orthotic alignment.

P2-W-174 Mobility disability in older adults through the eyes of the tandem walk

Natalie Ganz¹, Eran Gazit¹, Aron Buchman², Anat Mirelman¹, Jeff Hausdorff¹

¹Tel-Aviv Sourasky Medical Center, ²Rush Alzheimer's Disease Center

BACKGROUND AND AIM: In prior work, we developed and validated the automated extraction of Tandem walk (TW) metrics from wearable body-fixed sensor recordings of a supervised testing session. The aims of this study were to test if TW metrics are associated with mobility disability (MD) and if TW metrics contribute to the ability to identify those with MD, even when taking into account usual-walking and postural control metrics obtained in the same session. METHODS: 620 community-living older adults were classified into two groups based on the Rosow-Breslau scale: 553 subjects with 0 mobility scale (mobility) (mean age:71.76±10.94 yrs; 56% women), and 67 subjects a score of 2 or higher (disability) (mean age:73.25±yrs; 63% women). While wearing a 3D accelerometer on their lower back, subjects performed three different tasks: 1) TW, 2) usualwalking, 3) quiet standing to assess postural sway. Measures of TW, postural sway and usualwalking were extracted from 100 Hz raw acceleration data (e.g., High to Low frequency band ratio from the power spectral density from the ML axis [nu], step time[s], velocity[m/s], stride regularity [nu], acceleration path length[mm/s^2]). The number of missteps during the TW was also counted. To investigate associations with mobility disability, we used a one-way ANCOVA with age and gender as covariates. RESULTS: Measures of TW, postural sway and usual-walking were significantly different in the MD groups (see Table 1). For TW, the frequency ratio, a measure putatively reflecting the ability to make complex movement sequences, was significantly greater in the group with intact mobility. Furthermore, they walked faster (mobility:0.148±0.034 m/sec; disability:0.126±0.034 m/sec) and had fewer missteps compared to the MD groups (mobility:1.4±2.22;disability:2.34±2.39). For the usual-walking, the stride regularity, velocity and frequency ratio measures were greater in the group with intact mobility. For postural sway, the mean velocity and the acceleration path length from the AP and ML axis where lower in those with intact mobility. Support Vector Machine classification applied to combine measures in order to identify subjects with mobility disability resulted in 60%, 63% and 67% accuracy based on sway, TW, and usual-walking measures, respectively. When using just two measures based on TW, and usual-walking, the accuracy increased to 78%. CONCLUSIONS: The present results demonstrate that it is possible to extract meaningful measures of TW in older adults, and moreover, that these

measures are associated with an adverse health outcome, i.e., mobility disability. Interestingly, the TW measures are not strongly related to conventional measures of gait and quiet standing postural control, suggesting that the TW metrics are largely these other tasks. Consistent with this idea, the strongest classification model of mobility disability groups were found when combining TW and usual-walking gait measures together. ACKNOWLEDGEMENTS This work was supported in part grants from National Institute of Health R01AG17917, RF1AG22018 R01NS78009, R01AG56352. The older adults were participants in the Rush Memory and Aging Project.

P2-W-175 Thinking about walking: a new approach to quantifying gait initiation using a wearable sensor

Eran Gazit¹, Marina Brozgol¹, Pablo Cornejo Thumm¹, Robert Dawe², Thomas Curran², Anat Mirelman¹, Jeff Hausdorff¹, Aron Buchman²

¹Tel-Aviv Sourasky Medical Center, ²Rush Alzheimer's Disease Center

BACKGROUND AND AIM: Gait initiation (GI), the transition from a standing posture to walking, includes three phases: (a) Motor planning time, a cognitive process, (b) anticipatory postural adjustment (APA) that is used as preparation for walking and (c) motor implementation of the first step (end of APA to the first heel strike of the initiation leg). GI is usually evaluated using force plates or instrumented gait-mats. In order to assess GI in large-scale studies that are conducted outside the lab, we developed a new automated approach using a 3D accelerometer (Opal by APDM) worn on the lower back. METHODS: 27 older adults (age: 75.6±5.5, 26 females) and 41 young adults (age: 31.2±5.0, 27 females) arrived to the lab and underwent a GI protocol. Subjects were asked to start walking upon hearing an auditory cue. In the first 3 trials, subjects were not instructed with which leg to start walking (random condition). During the next three trials, subjects were instructed to start with the right leg and in the last 3 trials with the left leg. All the tests were recorded using the 3D accelerometer on the lower back and by an instrumented gait-mat (Zeno walkway by ProtoKinetics) which was used as a gold standard for the algorithm's validation as it provides measures of the center-of-pressure (COP). To investigate the age-related differences between the groups only data acquired from females were used (21 healthy young adults age: 30.9 ±4.8 and 27 older adults age: 75.4±5.5) in order to eliminate possible effects of differences in gender between the two age groups. Due to non-normal distribution of the data Mann-Whitney test was used when comparing the two groups. **RESULTS:** The measures extracted by the algorithm were highly correlated with those determined by the COP and instrumented mat. Intraclass correlation coefficient analysis results (Two way mixed, absolute, single measures) of APA start, initiation leg toe off, APA duration, and initiation leg heel strike were 0.76,0.91,0.85, and 0.92 respectively. All the measures differed significantly (P<0.01) between the older and young groups. APA duration was not significantly different whether the subjects were instructed to start with their dominant or non-dominant leg. When looking at the random condition, compared to trials with an instruction to start with a specific leg, for the young adults, the APA duration was

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longer at the random condition (dominant:457.7±73.4[ms], random: 523.9±76.2[ms], P=0.014). For the old adults, however, APA duration was not different in the random condition compared to the other conditions (dominant: 628.6±183.9, random: 634.1±222.1, P>0.44). **CONCLUSIONS:** The acceleration based algorithm of gait initiation shows promising results compared to the gold standard, instrumented gait-mat. It was also able to detect differences of planning and execution of gait initiation between the young and older adults. Future work should include validation of the algorithm on additional cohorts. **ACKNOWLEDGEMENTS AND FUNDING:** This work was supported by National Institute of Health [R01AG17917 (DAB), RF1AG22018 (LLB) R01NS78009 (ASB), R01AG56352 (ASB)]; the Illinois Department of Public Health (DAB); and the Robert C. Borwell Endowment Fund (DAB).

P2-W-176 The association between physical capacity, physical performance, and fall risk in young seniors

Katharina Gordt¹, Anisoara Paraschiv-Ionescu², Anna Mikolaizak³, Kristin Taraldsen⁴, Sabato Mellone⁵, Ronny Bergquist⁴, Jeanine Van Ancum⁶, Corinna Nerz³, Miriam Pijnappels⁶, Andrea Maier⁶, Jorunn Helbostad⁷, Beatrix Vereijken⁷, Clemens Becker³, Kamiar Am

¹Robert Bosch Medical Foundation, ²Ecole Polytechnique Fédérale de Lausanne (EPFL), ³Robert-Bosch-Krankenhaus, ⁴Norwegian University of Science and Technology, ⁵University of Bologna, ⁶Vrije Universiteit Amsterdam, ⁷The Norwegian University of Science and

BACKGROUND: In frail older adults, physical capacity (defined by the International Classification of Functioning, Disability and Health (ICF) as what they do when tested in a controlled environment) has been shown to be associated with physical performance (defined by ICF as what they do in daily life) and fall risk. Performance and fall risk can be further divided into perceived (subjectively experienced) or actual (objectively measured). However, the association between measures of physical capacity, physical performance, and fall risk has not been investigated in young seniors, despite the importance of this growing population for preventive interventions. As traditional tests of physical capacity likely are too basic for young seniors, we added advanced physical capacity measures and hypothesize that these are more strongly linked to physical performance and fall risk in this population. The study aimed to examine the association between both basic and advanced physical capacity measures, perceived and actual physical performance and fall risk in young seniors. **METHODS:** Young seniors (n=187) between 61 and 70 years of age underwent assessment of basic (habitual gait speed, Timed Up-and-Go) and advanced (fast gait speed, Community Balance & Mobility Scale) physical capacity measures. Perceived performance was assessed using the Late-Life Function & Disability Instrument. Actual performance was assessed using one-week sensor-based physical activity monitoring, with outcomes including percentage of walking time, average walking time at moderate to vigorous intensity/day, percentage of active time, and moderate to vigorous active time/week. Perceived fall risk was assessed by the Falls Efficacy Scale-International (FES-I), actual as number of falls in





the past six months. Associations between physical capacity, physical performance, and fall risk measures were calculated by Spearman correlation coefficients. **RESULTS:** Mean age was 66.3 ± 2.5 years of age (52.4% women). Basic capacity measures correlated from 0.35 to 0.54 (p<.001) with perceived performance, from 0.17 to 0.28 (p<.05) with actual performance, and from 0.24 to 0.25 (p<.001) with perceived fall risk, while no significant correlation was found with actual fall risk. Advanced capacity measures correlated from 0.52 to 0.58 (p<.001) with perceived performance, from 0.17 to 0.23 (p<.05) with actual performance, from 0.24 to 0.26 (p<.001) with perceived fall risk, while no significant correlation was found with actual fall risk. Advanced capacity measures correlated from 0.52 to 0.58 (p<.001) with perceived performance, from 0.17 to 0.32 (p<.05) with actual performance, from 0.24 to 0.26 (p<.001) with perceived fall risk, and from 0.19 to 0.23 (p<.05) with actual fall risk. **CONCLUSIONS:** In comparison to basic capacity measures, we found higher peak correlations between advanced capacity measures and physical performance and fall risk in young seniors, confirming our hypothesis. Furthermore, advanced capacity measures seem to be better indicators of young seniors' fall risk, as assessed by FES-I and number of falls. These findings are a first step towards a specific assessment framework of physical capacity and physical performance in young seniors.

P2-W-177 Gait analysis by the use of handy three-dimensional acceleration sensors

Kazuo Ishikawa¹, Aya Asari¹, Hiromoto Kimura¹

¹Japanese Red Cross Akita Hospital

Back ground and aim: Gait analysis is important in evaluating equilibrium functions and for substantiating a patient's feeling of gait instability caused by vestibular system disorders. So far, big machines using a large space have been utilized. For the clinical application, small, inexpensive, and reliable devices for the analysis of gait should be developed. From this point of view, it could be useful to use the recently developed handy three dimensional acceleration sensor instrument - Mimamori gait-. We have conducted gait analysis by using this device in patients with three different disease entities and have confirmed the usefulness of the device along with some characteristic findings caused by each disease entity. METHODS: The device is a 5x7x2 cm sized three dimensional acceleration sensor weighing 120g (LSI Medical Corporation, Japan). This was placed at the center of L4 level of the subject's back and free gait was performed back and forth with eyes open and then closed for a distant of 6 meters. Patients were those with vestibular neuronitis (VN) (9 cases), SCD(4cases), and Parkinson's disease (PD) (3cases). Data obtained were statistically compared with that of 13 healthy adults. Variables were gait time, cadence, gait velocity, CV of step time, step length, overall acceleration(AC) during gait performance, and horizontal and vertical movement. AS for the case with VN, comparisons were analyzed between the acute and recovery stage. RESULTS:1) VN cases:especially under gait with eyes closed, slower gait with greater horizontal sway in addition to a greater CV of step time was shown. With eye open, only CV was increased. At the recovery stage, all variables came back to the control level with the exception of CV of step time. 2) In cases with SCD and PD, instability of gait was not significantly changed under gait with eyes open and eyes closed except for a few variables. 3)The most striking change between SCD and PD were that of AC. Namely, lower acceleration of gait



performance was evident in cases with PD. Three dimensional movements of the instrument can also be drawn and were informative. This might also be shown. **CONCLUSION**:Gait analysis with the use of this three dimensional acceleration sensor could delineate the trait of different gait performance caused by different disease entities and substantiated the recovery process. Thus this device is expected to be used clinically for gait performance evaluation in dizzy patients.

P2-W-178 Development and content validity of a scale assessing lateropulsion in stroke patients: The SCALA

Dominic Pérennou¹, Anais Odin², Emmuelle Clarac², Andréa Kistner², Shenhao Dai², Maud Barbado², Emilie Chipon², Carole Vuillerot², Jean-Luc Bosson², Alexandre Moreau-Gaudry², Céline Piscicelli¹

¹University Hospital Grenoble-Alpes, ²Grenoble Alpes University Hospital

BACKGROUND AND AIM: Patients' misperception of earth vertical orientation and longitudinal body axis is known as the leading cause of the lateropulsion behavior, i.e. whole body lateral deviation. The current Gold Standard for lateropulsion evaluation is the Scale for Contraversive Pushing (SCP) which presents unsatisfactory metrological properties. The objective was to elaborate a new reliable and comprehensive tool: the SCAle for LAteropulsion: the SCALA. **METHODS:** A first draft was locally conceived and its face and content validity was submitted to 24 international lateropulsion experts through a Delphi process. At each round, experts' degree of agreement was recorded on Likert scales from 1 to 9 for each item and general procedure. The in-depth analysis of comments served to decide changes in the scale between rounds. **RESULTS:** The Delphi process was entirely completed by 21 experts. Three rounds were needed to reach consensus between them. While the first draft included 15 items arranged 3 sections, with a homogeneous four-grade scoring for a total 54 points scale, the final SCALA V1.1 is a one page matrix in which the 4 components - spontaneous lateral tilt, self-initiated lateral pushing, resistance to passive lateral tilting, lateropulsion unawareness - are scored for 10 different postural tasks, resulting in a 50 points scale. Each component is scored with a four-grade scoring except one with binary scoring. The overall degree of agreement by experts in the first, second, and third rounds was 7[5-7]/9, 7[7-8]/9, and finally 8[8-9]/9. CONCLUSIONS: Meaningful scores and enthusiast comments prejudge the success of this promising tool. The SCALA in its final form should be able to evaluate the severity of contraversive as ipsiversive lateropulsion. A forthcoming study will evaluate the validity and reliability of the SCALA in stroke patients.

P2-W-179 Impact of a thin plantar orthopaedic insert on posture and locomotion

Carole Puil¹, Anne Hélène Olivier², Armel Crétual³





¹Rennes University - IFPEK - M2S Laboratory, ²Rennes University -INRIA - M2S Laboratory, ³University of Rennes / Inria

Univ Rennes, Inria, M2S - EA 7470, F-35000 Rennes, France BACKGROUND AND AIM: EMI® (Medio-intern element) is a thin plantar insert used by podiatrists to treat postural deficiency. Janin and Dupui (2009) showed the influence of a 3 mm high EMI on Medio-Lateral (ML) displacement of the Centre of Pressure (CoP) of healthy participants in quasi-static standing [1]. Recently it has been demonstrated that EMI has an impact on eyes vergence, and especially in population with plantar postural dysfunction [2]. These effects were weakly assessed however and only using static tasks. Therefore, the objective of our study was to evaluate the effect of the EMI while performing a locomotor task. We expected a contralateral deviation of the trajectory when this insert was located under one foot. Indeed, in previous studies dealing with bottom-up control of locomotion, it was shown that a 30 min podokinetic stimulation leads to a ML deviation of the trajectory when participants were asked to walk in a straight line with eyes closed [3][4]. **METHODS:** 20 healthy participants volunteered for this study. They participated into 3 different sessions in random order: either without EMI, with EMI under the right foot or under the left foot. Each session involved first, static tasks (with and without vision) to compare with previous work, then, dynamic locomotor tasks 6 different conditions mixing trajectory (straight walking, 90° left or right turn) and vision (with and without vision) in random order. In static conditions, we computed the average ML position of the CoP. In dynamic conditions, we analyzed the difference in the final orientation of the locomotor trajectory with and without vision with a EMI with respect to this difference without the EMI. RESULTS: No significant effect of the EMI was observed for either static or dynamic conditions CONCLUSIONS: Our results do not confirm the previous work in static conditions. Future work is needed to better understand the effect of this insert. In particular, our participants were healthy and it could be interesting to evaluate this effect in participants with postural deficiencies. These results would have an application in the design of new clinical tests. REFERENCES:[1] Janin, M., & Dupui, P. (2009). The effects of unilateral medial arch support stimulation on plantar pressure and center of pressure adjustment in young gymnasts. Neuroscience letters, 461(3), 245-248. [2] Foisy A, et al. (2015) Controlling Posture and Vergence Eye Movements in Quiet Stance: Effects of Thin Plantar Inserts. PLoS ONE 10(12): e0143693. [3] Earhart, G. M., et al. (2002). Podokinetic after-rotation following unilateral and bilateral podokinetic stimulation. Journal of neurophysiology, 87(2), 1138-1141. [4] Earhart, G. M. (2013). Dynamic control of posture across locomotor tasks. Movement Disorders, 28(11), 1501-1508.

P2-W-180 Deterioration of specific aspects of gait during the instrumented 6-minute walk test among people with multiple sclerosis

Shirley Shema Shiratzky¹, Eran Gazit¹, Ruopeng Sun², Keren Regev¹, Arnon Karni¹, Jacob Sosnoff², Anat Mirelman¹, Jeff Hausdorff¹

¹Tel-Aviv Sourasky Medical Center, ²University of Illinois at Urbana-Champaign





BACKGROUND AND AIM: For people with multiple sclerosis (MS), prolonged walking becomes challenging and fatigue often get worse as the disease progresses. The 6-minute walk test (6MWT) is commonly used to assess fatigue and gait endurance. Typically, the distance walked is the single measure used to quantify 6MWT performance. However, it is unknown if different aspects of gait deteriorate similarly during this test. The aims of the present study are to evaluate which aspects of gait change during the 6MWT and to examine whether these changes are related to disability level. METHODS: Subjects with relapsing-remitting MS performed the 6MWT overground, while wearing sensors on the lower back and ankles (Opal APDM). The sensors include a 3D-accelerometer and a gyroscope, which were used to extract disparate gait features such as cadence, gait speed, gait regularity, and asymmetry. To explore changes over time, gait features were averaged over each 1-minute segment of the test. For the analysis, the cohort was stratified into mild and moderate disability groups, based on the Expanded Disability Status Scale (EDSS). Repeated measures ANOVA was performed on each gait feature to assess the effects of time (within-subject, 6 levels), group (between-subject, 2 levels) and time x group interaction. **RESULTS:** Fifty-eight patients with MS were studied (mean age 48.9±9.9 yrs, 71% female, mean disease duration 13.7±9.6 yrs). Thirty four subjects with mild disability (EDSS 2 to 3.5) were compared to 24 subjects with moderate disability (EDSS 4 to 6). Age, gender, disease duration and fatigue were similar (p>0.20) between the groups. As expected, the moderate-disability group covered a significantly shorter distance in the 6MWT compared to the mild group (291.0±102.3 m vs. 434.6±80.4 m, p<0.001, respectively). The moderate disability group walked slower than the mild group (p<0.003), with a lower cadence, and lower (i.e., worse) stride regularity (see Table 1). Cadence and stride regularity became significantly worse over time (p<0.001) in both groups. Interestingly, gait speed and asymmetry did not change over time. A time X group Interaction effect was seen for cadence (p=0.02); the mild disability group maintained their cadence during the entire test, whereas cadence decreased in the moderate group across time. CONCLUSIONS: The current findings confirm that multiple aspects of gait are related to disability level in people with MS, as expected. Somewhat unexpectedly, only specific gait features change over time during the 6MWT. Perhaps these disparate behaviors can be used to better assess disability, the effects of fatigue, and responsiveness to therapy. Instrumenting the 6MWT using wearable devices apparently provides information that cannot be obtained using just the distance walked. Future study of this method may help clinicians to better assess disease progression, treatment effects and perhaps even assist in distinguishing between different types of MS.

X - Vestibular function and disorders

P2-X-182 Body spatial representation in unilateral vestibular patients: Evolution before and after surgery

Liliane Borel¹, Mathilde Bachelard-Serra², Laurence Bernard-Demanze², Jean-Pierre Lavieille², Arnaud Saj³, Jacques Honoré⁴





¹CNRS & Aix-Marseille Univ, ²Hôpital de la Conception, AP-HM, ³Geneva University Hospitals, ⁴Université de Lille

BACKGROUND AND AIM: The unilateral vestibular syndrome results in postural, oculomotor, perceptive and cognitive symptoms. The present study was designed to investigate the body orientation representation of unilateral vestibular defective patients and its evolution after surgery. METHODS: The subjective straight ahead (SSA) was investigated using a method disentangling lateral shift and tilt components of error. Participants were required to align a rod moving either in the horizontal or in the frontal plane with bodily references. In the horizontal plane, the reference was the midsagittal plane; in the frontal plane, it was the midline of the head or trunk. Patients with right (RVN; n =14) or left (LVN; n=8) vestibular neurotomy or vestibular schwanoma resection were compared with 14 healthy controls. The patients were tested the day before surgery and during the recovery period, 7 days and 2 months after the surgery. **RESULTS:** In the early stage after surgery, all the patients showed an ipsilesional deviation in translation and in rotation. Before the operation and during the recovery period, the patients with LVN showed a contralesional translation of their SSA, whereas those with RVN had a deviation which did not change throughout the entire recovery period and did not differ from that of the controls. The deviation did not depend on the reference segment, head or trunk. CONCLUSIONS: This work constitutes the first description of body orientation representation of unilateral vestibular defective patients and of the recovery time-course after a unilateral vestibular surgery, which remains poorly considered in the vestibular patients. Interestingly, deviated body representations were mainly observed when the neurotomy was performed on the left side. These data again support the hypothesis of an asymmetric vestibular function in healthy subjects.

P2-X-183 The effect of roll circular vection on the subjective postural horizontal

Taylor Cleworth¹, John H. Allum², Emma Nielsen³, Mark Carpenter³

¹University of Waterloo, ²University of Basel Hospital, ³University of British Columbia

BACKGROUND AND AIM: Falls and related injuries are critical issues in aging, peripheral vestibular, and proprioceptive loss populations. The contribution of otolith sensory loss on these balance deficits remains unclear. Subjective postural horizontal (SPH) assessments have been proposed as a viable method for assessing otolith contributions to balance [1]. Previous assessments of perceived body alignment, including subjective visual vertical, have suggested that visual inputs are weighted more when vestibular information is less reliable during body tilt [2]. To date, no studies have examined the influence of visual stimuli on SPH. Therefore, this study investigated how dynamic visual cues, in the form of circular vection (CV), influence the perception of the support surface horizontal. **METHODS:** Ten healthy young adults (mean age: 22, 6 female), free of neurological and orthopedic impairments, wore a head mounted display (Oculus Rift, USA) while standing on a tilting platform. Participants were asked to remain upright





for 30s during which a) the visual scene rotated in roll (CV) at 60°/s clockwise (CW) or counterclockwise (CCW), b) the platform rotated in roll (SPH, 0.6°/s, 2°, CW or CCW), c) a combination of both occurred, or d) neither. During SPH trials, participants used a hand held device to adjust the position of platform at 0.8°/s to their subjective 'horizontal' position. Body roll angles (normalized to baseline conditions) were calculated from individual kinematic markers placed on the upper trunk, head, pelvis and anterior aspect of the tilting platform. **RESULTS:** Participants mean perceptions of platform horizontal position deviated from true horizontal by 0.20° collapsed across CW and CCW platform rotations. The pelvis deviated 0.19°, the trunk deviated 0.29°, and the head deviated 0.58°. When SPH and CV directions were congruent, participant's platform deviations increased (0.69°), as did pelvis, trunk, and head deviations (1.21°, 2.73°, and 4.24°, respectively) in the direction of the CV. When SPH and CV were incongruent, platform deviations increased from baseline but were smaller than congruent conditions (0.46°); however, pelvis, trunk and head deviations were similar to congruent conditions (1.15°, 3.01°, and 5.07°, respectively). **CONCLUSIONS:** Roll CV significantly effects the SPH of the support surface and body position during postural tasks. Perceived platform horizontal, pelvis, trunk, and head angular displacements were significantly different from baseline. In line with previous reports, young healthy adults are accurate in determining horizontal support surface position. This study supports the hypothesis of weighted multisensory integration during a postural task being dependent on the direction of additional visual cues. These techniques could be used to examine vestibular (otolith) and proprioceptive sensitivity during continuous visual perturbations within clinical populations. ACKNOWLEDGEMENTS AND FUNDING: Funded by NSERC. REFERENCES:[1] Beule & Allum, Audiol Neurotol, 2006; [2] Ward et al, J Neurophysiol, 2017.

P2-X-184 EEG correlates of postural dizziness of aging

Richard Ibitoye¹, Patricia Castro¹, Onur Guven¹, Amy Edwards¹, Qadeer Arshad¹, Adolfo Bronstein¹

¹Imperial College London

BACKGROUND AND AIM Dizziness affects 1 in 3 adults over 65 years and is associated with falls and reduced quality of life. Despite work-up this often remains unexplained and we refer to this as unexplained Postural Disequilibrium or Dizziness of Aging (PDA). Aetiology is not known but excess cerebral white matter hyperintensities (WMH) has been reported, a marker of small vessel disease (SVD). Recent work has shown postural task difficulty increases centroparietal EEG alpha desynchronization, with similar effects in theta; this likely reflects attentional demands. Changes are asymmetric with greater attenuation in the right hemisphere (for right-handers), compatible with known lateralisation of vestibulospatial functions. We explore the effect of age, and PDA on postural EEG, and consider pathophysiological implications. **Methods** 19 YOUNG controls (20-30yrs), 25 OLD controls and 18 with PDA (60-90 yrs) undertook 32 channel EEG in sitting and standing postures. Spectral power was analysed in theta (4-8Hz) and alpha (8-14Hz) bands. OLD





and PDA also undertook vestibulo-ocular reflex (VOR) thresholds and offline postural sway measures. Results Age - We normalise power (standing/sitting) and consider means by group. In YOUNG, occipital alpha power increases on standing with minor centroparietal theta desynchronization. Normal aging (OLD) is associated with the emergence of centroparietal alpha desynchronization, and more extensive theta desynchronization. PDA - Compared to OLD controls, PDA subjects have more spatially extensive attenuation of centroparietal alpha and theta power, the latter statistically significant (p<0.05 e.g. FC1, C3, CP1). Differences relate to postural challenge with no significant difference in baseline (sitting) power. Lateralisation - YOUNG and OLD controls show significant (p<0.05) left>right asymmetry to centrotemporal and centroparietal alpha and theta normalised power. In PDA, no significant asymmetry is seen. Sway and VOR thresholds do not differ significantly between PDA and OLD. Conclusions Standing is a challenge to stability, requiring cognitive/attentional resources for feedback control. Our results imply normal aging is linked to greater attentional demands in standing, even in the absence of symptoms. Greater alpha and theta desynchronization in PDA may thus reflect less efficient adaptation to postural challenge, requiring greater cognitive resource for the same degree of control. This is consistent with the proposition that excess SVD underlies this syndrome, as SVD impairs efficiency in functional brain networks. Loss of lateralisation in PDA may thus result from disruption of normal interhemispheric influences. In the absence of significant group differences in peripheral vestibular function and sway, our EEG findings support a cerebral basis to this syndrome. Analysis of MRI data will soon be available, directly addressing the SVD hypothesis.

P2-X-185 Quantitative gait analysis of acoustic neuroma patients using portable accelerometer

Koh Koizumi¹, Kazuo Ishikawa²

¹Akita University, ²Japanese Red Cross Akita Hospital

1)**BACKGROUND AND AIM** Gait analysis is useful as an experiment for patients who have dizziness or valance disorder. Various devices have been used for quantitative evaluation. However, due to the large size of the device, it had been carried out at limited facilities and hospitals. In recent years, technological advancements allowed us using portable devices, so clinicians can perform quantitative gait exam even in a corridor in the hospital. In this study, we carried out gait analysis for patients who had acoustic neuroma by using the portable accelerometer and examined whether it can evaluate gait abnormality of them. 2). **Methods** The subjects were 32 patients, including 13 males and 19 females, who had visited Akita university hospital and were diagnosed unilateral or bilateral acoustic neuroma. The triaxial accelerometer (Mimamori-gait system, LSI Medience, size: 8cm×6cm×2cm, weight: 120g) was fixed on the lumbar midline of the patient. The gait experiment was performed in a corridor in the hospital. Patients had 10m walk test, which is the commonly used balance test in clinical practice. Data were collected at a sampling frequency of 100 Hz and stored on a Secure Digital memory card





inserted into the device for later analysis. The basic gait characteristics (cadence, speed, step length) and coefficient of variation (CV%) for the step were calculated by using dedicated analysis software. 3)**results** The gait parameters obtained were following: cadence; 114.1 \pm 9.5 / min, speed; 64.3 \pm 13.6 m/min, step length; 56.2 \pm 10.5 cm, coefficient of variation for the step; 4.5 \pm 3.0 % (mean \pm standard deviation). There is positive correlation between the maximum tumor diameter and CV% (r = 0.62). CV% were significantly higher (Student t-test, p<0.05) in large tumor size group (>15mm) than small tumor size group (\leq 15mm). In some cases, we have measured improvement of gait parameters after treatment, for example surgical operation or radiation. 4)**conclusions** The data obtained from this device are consistent with the results obtained from other large devices we have used before. Typically, length and speed of gait tend to be small and slow, and CV% is higher in patients with big size tumor. Quantitative evaluations of 10m walk test by using portable device is useful for the patients with acoustic neuroma.

P2-X-186 Phase- and speed-dependent modulation of vestibulo-ocular reflexes during walking

Max Wühr¹, Haike Dietrich¹

¹Ludwig-Maximillians Universität München

BACKGROUND AND AIM Gaze stabilization during locomotion is likely mediated by a weighted summation of sensory (mostly vestibular) feedback and motor feed-forward commands (MacNeilage and Glasauer, 2017). It has been shown that in the vertical plane, amplitude and timing of sensory, vestibulo-ocular reflexes (VOR) are modulated with locomotor speed (Moore et al., 1999). On the other hand, the contribution of feed-forward mechanisms likely increases with locomotor speed, as head movements become more predictable (MacNeilage and Glasauer, 2017). Vestibulo-spinal reflexes for balance control are similarly modulated with walking speed, but additionally depend on the phase of the gait cycle (Dakin et al., 2011). Here we tested whether vertical VOR responses also display a speed- and phase-dependency during locomotion and whether this correlates with changes in head motion predictability. METHODS Eve and head movements of healthy subjects (n=10) were recorded using video-oculography during walking and running at 0.4 to 2.4 m/s on a pressure sensitive treadmill. Trials were performed in darkness or in light, where subjects fixated a red point in front of them. Pitch angular VOR gains (eye/angular head velocity) were calculated in dependence of gait cycle phase (local gains) and correlated with the predictability of the head angular pitch velocity (residual variance, Vres). RESULTS Vertical angular VOR responses are comparable in light and darkness and change with increasing locomotor speed from compensatory to synergistic eye vs. head movements. Average predictability of pitch head velocity increases (i.e., Vres decreases) with faster locomotor speed. During slow walking, pitch VOR gain remains around unity, independent of gait cycle phase. During faster locomotion, pitch VOR gain changes throughout the gait cycle such that local VOR gain peaks correspond to peak Vres. Thus, pitch VOR gain is highest, i.e., sensory feedback is

maximal during phases of low head motion predictability. **DISCUSSION** As shown for balance control, these results demonstrate a phase- and speed-dependent modulation of vestibular contributions to oculomotor control during locomotion. The observed correlation between VOR gain and head motion predictability further suggests that this modulation results from a selective suppression of sensory cues by an intrinsic feedforward mechanism.

P2-X-187 Optimal treatment period for vestibular balance rehabilitation in patients with chronic unilateral vestibular dysfunction

Toshiaki Yamanaka¹

INTERNATIONAL SOCIETY OF

Posture & Gait

RESEARCH

ispgr

¹Nara Medical University

BACKGROUND AND AIM: Some patients with uncompensated vestibular hypofunction have a long-term history of a persistent severe problem in their posture and mobility that is refractory to any treatment. Vestibular balance rehabilitation therapy (VBRT) is effective for balance problems and increases the safety and independence in such patients. However, it is unclear when to quit the VBRT program in those with chronic balance disorders following unilateral vestibular loss. In this study, long-term VBRT was administered to determine the optimal period of the training program for patients with chronic balance dysfunction caused by vestibular balance deficit that is refractory to any treatment. METHODS: A total of 87 subjects (35 men and 52 women aged 31-83 years, median age 62 years) with unilateral vestibular loss, determined based on significant unilateral caloric canal paresis, were administered VBRT. They were treated with pharmacotherapy for more than 6 months and exhibited persistent chronic dizziness and postural imbalance. Our VBRT comprised vestibular/visual-ocular motor-related training and vestibular spinal-related training to promote vestibular adaptation and improve the laterality of the vestibular system. All the subjects completed 15-minute training sessions 2-3 times every day for 12 months. The Dizziness Handicap Inventory (DHI) and functional gait assessment (FGA) were used to evaluate the severity of the subjects' balance problems and dynamic stability or gait function at 1, 3, 6, 9, and 12 months after training initiation. DHI and FGA were considered to indicate improvement when the subject scored \leq 30 and \geq 23 points, respectively, on these scales. The subjects' condition was regarded as having improved when both, the DHI and FGA scores showed improvement. RESULTS: A total of 44 (50.5%) of the 87 subjects showed improvements in their DHI and FGA scores after the 1-month training period. Furthermore, 12 subjects showed improvements, and at 3 months, the condition of 64.4% of all the subjects had improved. This improvement percentage increased by 8.0% to reach 72.4% at the end of 6 months of training. However, the improvement at 9 months and 12 months was 74.7% and 71.3%, respectively; thus, there was no further improvement during 6-12 months of the training period. CONCLUSIONS: VBRT was able to achieve marked improvements in the balance ability of subjects with intractable chronic balance dysfunctions caused by vestibular deficits and increased their ability to perform daily activities after 3 month of training. Although an improvement of 8% was observed between



3 and 6 months from the start of the training period, no further improvement was observed in the patients after 6 months of training i.e., between 9 and 12 months from the start of training. Therefore, we recommend that the training should be administered for at least 3-6 months.

P2-X-188 The utricular hypofunction of patients with type 2 diabetes mellitus has a subtle influence on the static postural control with neck extension.

Kathrine Jáuregui-Renaud¹, Catalina Aranda-Moreno¹, Julio Villaseñor-Moreno¹, María Giraldez-Fernandez¹, Martha Gutierrez-Castañeda¹, Ignacio Figueroa-Padilla¹, Ana Saucedo-Zainos¹

¹Instituto Mexicano Del Seguro Social

BACKGROUND AND AIM. The prevalence of diabetes mellitus and its complications is increasing, with an impact on balance decline. To assess the influence of subclinical utricular hypofunction on the static postural control (with/without head extension) of patients with type 2 diabetes mellitus. Methods. Participants. 39 patients with type 2 diabetes mellitus participated in the study (58 ±10 y.o., 10 men, BMI 28.7± 4.4). All of them denied having a history and have no medical record of otology, neurology, psychiatry, or orthopedic disorders, foot injuries, peripheral artery disease, renal failure, postural hypotension, or exposure to ototoxic medication or unsafe noise levels. Procedures. Vestibular function was assessed by sinusoidal rotation (0.16 Hz &1.28 Hz, 60°/sec peak velocity), static visual vertical and dynamic visual vertical during unilateral centrifugation (300°/sec at 3.85 cm) (I-Portal-NOCT-Professional, Neuro-Kinetics). Peripheral neuropathy was assessed by electromyography (Nihon Kohden MEB 9400). Static posturography was recorded during 8 conditions (Posturolab 40/16, Medicapeturs): hard surface eyes open/closed, hard surface without/with 30° neck extension, soft surface eyes open/closed and soft surface_without/with 30° neck extension. Statistical analysis was performed using "t" test and multivariate analysis of covariance, including repeated measures (Statistica, Statsoft Inc.), with a significance level of 0.05. Results. Utricular hypofunction was evident in 16 patients (58 ±11 y.o., BMI 28.4± 4.1), 11 unilateral and 5 bilateral, 7 of them had peripheral neuropathy; while no utricular hypofunction was observed in 23 patients (58±10 y.o., BMI 28.6 ± 4.4), 6 of them had peripheral neuropathy. The 2 groups had similar gain to rotation at 0.16Hz/ 1.28 Hz. Posturography recordings showed that utricular hypofunction interacted with neuropathy and polypharmacy on the anterior-posterior position of the center of mass while standing on soft surface, either with the eyes closed or with neck extension. Across conditions, polypharmacy had influence on sway velocity, and the body mass index had influence on the medio-lateral position of the center of mass. CONCLUSIONS. In patients with type 2 diabetes mellitus, an effect of subclinical utricular hypofunction on the anterior-posterior position of the center of mass may remain silent, unless sensory distortion/ deficit is provoked; while polypharmacy may interfere with their postural control, even when standing on hard surface with their eyes open.





P2-X-189 Detecting alterations in head movements in individuals with vestibulopathy of varying etiology

Lee Dibble¹, Brian Loyd¹, Annie Fangman¹, Janie Savier-Steiger¹, Mark Lester², Serene Paul³

¹University of Utah, ²Army-Baylor University, ³University of Sydney

BACKGROUND AND AIM: Populations with peripheral vestibular dysfunction (i.e., vestibular schwannoma resection [PwVSR]) may reduce the amplitude and velocity of head movements during dynamic movement. However, it is unclear if those with central vestibular dysfunction (i.e., multiple sclerosis [PwMS]) experience similar declines. Additionally, little data exists quantifying pitch plane head movement during dynamic activity. We hypothesized that pitch plane head kinematics would be most impaired in PwVSR relative to PwMS and healthy controls (HC). We also hypothesized that PwMS would demonstrate reduced head kinematics compared to HC. METHODS: Forty-three participants (13 PwVSR, 14 PwMS, 16 HC) performed the Functional Gait Assessment (FGA) while wearing 3-D inertial measurement units (IMUs) on the head, over the sternum, and on the low back. Peripheral vestibular hypofunction was confirmed with vHIT testing in PwVSR while central vestibular dysfunction was confirmed in PwMS through oculomotor testing including saccades, smooth pursuitsm and vestibulo-ocular reflex cancellation. Custom written MATLAB algorithms were used to extract and analyze pitch plane angular velocity and amplitude of head nods performed during the FGA-4 task (self-selected gait speed with vertical head nods). Average peak amplitude and velocity were calculated for each participant. Additionally, FGA total scores were calculated for each participant (scored 0-30, with 30 indicating no impairment). Oneway ANOVAs were used to determine between group differences for all outcomes. If significant (p<0.05), pair-wise t-tests were performed to determine specific group differences. RESULTS: Significant between group differences in average peak velocity and amplitude were present head nods. PwVSR had significantly reduced amplitude of pitch plane head movements compared to PwMS and HC (mean[ISD = 52.1]16.3 deg vs. 72]22.7 deg vs. 85.4]20.9 deg; p<0.05). PwVSR performed head turns significantly slower than people with MS (19.605.6 deg/sec vs. 30.1012.3 deg/sec, respectively), but no differences were observed between PwVSR and HC (mean SD = 19.605.6 deg/sec vs. 21.605.2 deg/sec), or PwMS and HC. FGA total scores significantly differed between all three groups. PwMS scores (17.105.4) were significantly lower than PwVSR (20.403.8) and both were significantly lower than HC (29.9^[]0.3). Vestibulopathy may result from a peripheral dysfunction (e.g., vestibular schwannoma resection) or from demyelination induced damage of central vestibular pathways (e.g., multiple sclerosis), both impairing gaze and postural stability. The use of wearable sensors and a gait task requiring pitch plane movements, revealed that people with vestibulopathy of varied origins alter their head pitch plane head movements. Localized peripheral damage resulting in asymmetrical vestibular input drives PwVSR to restrict head movement in order to control symptoms. However, in PwMS, the altered kinematics may be a result of motor and multi-sensory dysfunction experienced by PwMS, relative to PwVSR who may be more specifically impacted by dynamic activities requiring head movements.





P2-X-190 Can the vestibulocollic response be modulated by optic flow?

Yawen Yu¹, Emily Keshner²

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¹Colorado State University, ²Temple University

BACKGROUND: Maintaining upright stance requires continuous updating of sensory information to estimate the current state of postural orientation. While each sensory system is responsible for unveiling a specific aspect of body motion, changes in one sensory system can alter the influence of the input from another sensory system. This process of adjusting sensory contributions to balance control is referred to as sensory reweighting. Sensory reweighting would explain why the magnitude of the postural response due to galvanic vestibular stimulation (GVS) is dependent on non-vestibular sensory signals; when visual information is unavailable, GVS can elicit a much greater postural response. Individuals standing quietly in an immersive virtual environment with a continuous moving visual surround exhibit postural sway in the direction of visual flow. Thus, vestibular reafference could be modulated as much by visual flow as it is by fear of falling. This study aimed to explore whether vestibular reafference was modulated by visual field motion. METHODS: Eight healthy adults (28.0±6.0yrs) with no neurological or sensory deficits were tested. Cervical vestibular evoked myogenic potential (cVEMP) elicited by 500Hz 125dB-SPL tone-bursts at 5Hz delivered monaurally via in-ear earphone, was recorded over the sternocleidomastoid (SCM) ipsilateral to the tone-burst while standing. For the left cVEMP, participants looked over the right shoulder to face the front screen with their body parallel to the left screen and actively contracted the left SCM for 20s during which visual field motion was kept either stationary (EO) or continuously rolling about the nasion-to-inion axis (RU) at 30°/s. SCM background muscle activity was examined to avoid a potential confounding effect. Amplitude and latency of p13 and n23 were compared between EO and RU. RESULTS: No visual motion effect was found in SCM background muscle activity (p>.05). The p13 amplitude was significantly reduced by the RU visual field motion (p<.02; EO:21.1±4.2uV; RU:17.7±3.7uV; Fig1). No significant visual scene differences emerged in n23 amplitude or latencies of p13 and n23. CONCLUSIONS: Changes in magnitude of the cVEMP suggest that vestibular reafference was modulated by visual field motion in the virtual environment. The source of this vestibulocollic modulation could be cerebellar projections through Purkinje cell axons to the vestibular complex. To our knowledge, this is the first study to elicit and record VEMPs during upright stance with different conditions of visual field motion thus providing a baseline for future studies examining vestibulo-myogenic responses in neurological populations (e.g., MS, CP). Vestibulomyogenic responses as a function of self-motion illusion due to visual field motion could provide a physiological interpretation for changes in the postural response due to visual field motion.



Poster session 3: Thursday July 4, 2019

A - Activity monitoring

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P3-A-1 Associations between laboratory-based assessments and daily physical activity in patients with Parkinson's disease: Can one replace the other?

Inbar Hillel¹, Ira Galperin¹, Silvia Del Din², Esther Bekkers³, Alice Nieuwboer³, Giovanni Abbruzzese⁴, Laura Avanzino⁵, Freek Nieuwhof⁶, Bastiaan Bloem⁶, Lynn Rochester⁷, Ugo Della Croce⁸, Andrea Cereatti⁸, Nir Giladi¹, Anat Mirelman¹, Jeff Hausdorff¹

¹Tel-Aviv Sourasky Medical Center, ²Newcastle University, ³KU Leuven, ⁴University of Genova & IRCCS San Martino Teaching Hospital, ⁵University of Genoa, ⁶Radboud University Medical Center, ⁷Institute of Neuroscience, Newcastle University, ⁸University of Sassari & Interuniversity Centre of Bioengineering of the Human Neuromusculoskeletal

BACKGROUND AND AIM: Recent work suggests that wearables can augment conventional measures of Parkinson's disease (PD). We evaluated the relationship between laboratory-based measures of gait and balance, conventional measures of disease and motor severity (e.g., MDS-UPDRS part III), and daily-living physical activity measures in patients with PD. METHODS: 125 patients (age: 71.7±6.5 years, Hoehn and Yahr: 1-3, 60.5% men) were studied. The MDS-UPDRSpart III was used as the gold standard of motor symptom severity. Gait and balance were quantified in the laboratory. Daily-living physical activity metrics were extracted from an accelerometer worn on the lower back for 7 days. RESULTS: In univariate analyses, daily-living physical activity was not (r<0.20) strongly correlated with laboratory-based measures of gait, balance or with the MDS-UPDRS (parts I-III). In multivariate analyses, daily-living physical activity metrics, laboratory-based balance, demographics and subject characteristics together explained 46% of the variance in MDS-UPDRS-part III scores(Figure 1a). Daily-living measures accounted for 62% of the explained variance, laboratory measures 30%, and demographics and subject characteristics 7% of the explained variance. Conversely, demographics and subject characteristics, laboratory-based measures of gait symmetry, and motor symptom severity together explained less than 30% of the variance in total daily-living activity. MDS-UPDRS-part III scores accounted for 13% of the explained variance, i.e., <4% of the variance in total daily-living activity (Figure 1b). **CONCLUSIONS:** Our findings suggest that conventional measures of motor symptom severity do not strongly reflect daily-living activity. Daily-living measures apparently provide important information that is not captured in a conventional one-time, laboratory assessment of gait, balance or the UPDRS. ACKNOWLEDGEMENTS: We thank the study participants and all of those who help and contributed to the V-TIME project. This work was funded in part by a grant from the European Commission.





P3-A-2 Comparison among PD, MS and healthy people between prescribed gait test and continuous monitoring of gait in a community setting

Vrutangkumar Shah¹, James McNames², Patricia Carlson-Kuhta¹, Rebecca Spain¹, John Nutt¹, Mahmoud El Gohary³, Fay Horak¹, Carolin Curtze⁴

¹Oregon Health & Science University, ²Portland State University, ³APDM, ⁴University of Nebraska Omaha

BACKGROUND AND AIM: The assessment of gait in the clinic at a singular moment may not adequately reflect functional, everyday mobility. In this study we investigated the quality of mobility among people with Parkinson's Disease (PD), Multiple Sclerosis (MS), and Healthy age-matched Control subjects (HC) over a week of continuous monitoring in the home and how daily-life measures relate to clinical gait tests. The aim of the study is to compare the quality of gait metrics between a prescribed gait test and continuous monitoring among PD, MS and HC in a community setting. METHODS: We recruited 8 people with PD, 7 people with MS and 7 age-matched healthy control subjects to date. In the clinic, subjects wore three inertial sensors (Opals, APDM) attached to both feet and the lumbar region; and performed a 3-minute walking task (PD subjects tested in the on medication state). At home, subjects wore three inertial sensors (Opals, APDM) similar to the clinic but for a week of continuous monitoring with an average of 8 hours per day. We derived about 40 gait metrics and 10 turn metrics. We plan to enroll 40 subjects per group. RESULTS: Differences between gait in clinic and community were largest in PD cohorts. Preliminary analyses show that some gait metrics worsened in community setting compared to prescribed test in the clinic among all the groups. Specifically, gait speed, cadence, single limb support percentage of gait cycle, and swing percentage of gait cycle decreased in community setting compared to gait test in the clinic. Further, variability metrics (double support, cadence, gait speed, step duration, strider length, and stride duration) increased in community setting compared to gait test in the clinic. CONCLUSIONS: Preliminary analyses show that quality of gait metrics were different between prescribed gait test in the clinic and continuous monitoring in a community setting particularly for people with PD. Further, quality of gait metrics were more variable relating fluctuations in a daily life compared to prescribed gait tests in the clinic, thus, providing evidence that continuous monitoring might more accurately capture gait fluctuations in a daily life. ACKNOWLEDGEMENTS AND FUNDING: NIA grant #5R44AG055388, and NMSS Mentor Fellowship: MB 0027.

B - Adaptation, learning, plasticity and compensation

P3-B-3 Examining neural plasticity for slip-perturbation training: An fMRI study

Tanvi Bhatt¹, Patel Prakruti¹, Shamali Dusane¹, Sophie DelDonno¹, Scott Scott Langenecker¹







¹University of Illinois at Chicago

BACKGROUND: Perturbation-based balance training has shown to induce adaptation of reactive balance responses that can significantly reduce longer-term fall risk in older adults. While specific cortical and subcortical areas in control of posture and locomotion have been identified, little is known about the training-induced plasticity occurring in neural substrates for challenging tasks involving reactive balance control. The purpose of this study was to use functional neuroimaging to examine and determine the neural substrates, if any, involved in inducing adaptation to slip-like perturbations experienced during walking over three consecutive training days. We used a mental imagery task to examine the neural changes accompanied by slip-perturbation training. **METHODS:**Ten healthy young adults were exposed to increasing magnitude of displacements during slip-like perturbations while walking, with an acceleration of 6 m/s2 on a motorized treadmill for three consecutive days. Brain activity was recorded through MRI while performing imagined slipping and imagined walking tasks before and after the perturbation training. The number of compensatory steps and center of mass state stability at compensatory step touchdown were recorded. RESULTS: As compared with day 1 (first trial), on day 3 (last trial) there was a significant reduction in number of compensatory steps and increase in stability at compensatory step touchdown on the mid and highest perturbation intensities. At baseline, imagined slipping showed increased activity in the SMA, parietal regions, parahippocampal gyrus and cingulate gyrus compared with rest. After perturbation training, imagined slipping showed increased activation in DLPFC, superior parietal lobule, inferior occipital gyrus, and lingual gyrus. Perturbation training was not associated with decline in activity in any of the brain regions. **CONCLUSION:** This study provides evidence for learning-related changes in cortical structures while adapting to slip-like perturbations while walking. The findings reflect that higher-level processing is required for timing and sequencing of movements to execute an effective balance response to perturbations. Specifically, the CNS relies on DLPFC along with motor, parietal and occipital cortices for adapting to postural tasks posing a significant threat to balance.

P3-B-4 Modulation of H-reflex; effect of age and surface stiffness

Leila Alizadehsaravi¹, Sjoerd Bruijn¹, Huub Maas¹, Jaap van Dieën¹

¹Vrije Universiteit Amsterdam

BACKGROUND AND AIM: To improve the conceptual basis for the development of diagnostics and interventions for balance problems in older adults, we investigated balance control in different mechanical environments. Specifically, the aim of this study was to investigate the excitability of the spinal reflex circuitry during a unipedal balance task on surfaces varying in stiffness. **METHODS:** 20 healthy adults (10 aged 18-30 years and 10 aged 65-80) were recruited. Before the unipedal balancing task, the soleus muscle H-reflex recruitment curve was assessed during bipedal stance on a stiff surface. Subsequently, H-reflexes were elicited using the Hmax



stimulation current, during unipedal stance on a robot-controlled balance platform, which can rotate in the frontal plane with various levels of rotational stiffness. 12 trials of 140 seconds each were performed, grouped into three identical blocks, each consisting of four levels of surface stiffness (10%, 20%, 40% and 100% of body weight multiplied by center of mass (COM) height, in random order within blocks). Electromyographic (EMG) and full body 3D kinematics data were collected. EMG data were analyzed in terms of the Soleus H-response amplitude and the corresponding background EMG (bEMG) activity 100 ms prior to the stimulation. RESULTS: The H-reflex amplitude during unipedal balancing on the stiffest surface tended to be smaller than in bipedal stance (P=0.057) while the bEMG activity was higher (P=0.005) and consequently, the H/bEMG ratio was lower (P = 0.006). A trend towards higher H-reflex amplitudes in older adults was found for non-normalized amplitudes only (P = 0.076). The H-reflex amplitude during unipedal balancing was not different between surface conditions but was higher in older than in young adults (P=0.037). The H/bEMG ratio and bEMG were not significantly different between groups or surface conditions, in unipedal balancing. Center of mass (COM) velocity confirmed the successful manipulation of task difficulty, as it was significantly higher at lower stiffnesses (P =0.004). In addition, it was higher in older participants (P < 0.001). CONCLUSIONS: The H-Reflex was modulated between bipedal and unipedal standing, but not between surface stiffnesses in unipedal balancing. Our result may suggest that H-reflex is down-modulated by task difficulty but this is offset by increased bEMG activity associated with the increased task difficulty. Age effects on H-reflex amplitudes appeared to be mediated by bEMG (Figure 1). ACKNOWLEDGMENTS AND FUNDING The authors want to thank Cassandra Thompson for her helpful advice on H-reflex measurements. This project was funded by Keep Control, an EU-funded industrial academic initial training network.

P3-B-5 After-effect magnitude predicts retention in split-belt gait adaptation

Tom Buurke¹, Claudine Lamoth¹, Lucas van der Woude¹, Rob den Otter¹

¹University Medical Center Groningen

BACKGROUND AND AIM: Current gait rehabilitation programs are aimed at improving gait performance and increasing rehabilitation efficiency. However, it is difficult to predict who is more likely to benefit from specific training (e.g. robot assisted gait training) and who is not. A possible indicator of sensitivity for gait rehabilitation is the amount of adaptation people show in gait. Yet, we do not know whether initial gait adaptation is an indicator for retention after repeated exposure. Therefore, the aim of this study is to explore whether performance on repeated exposure to a locomotor task is related to first exposure after-effect magnitude. A split-belt paradigm, in which people walk on a split-belt treadmill, with one leg faster than the other, will be used in this study. Parameters of spatial and temporal gait symmetry [1] and dynamic balance control [2] will be extracted to assess performance. **METHODS:** Fourteen healthy young adults followed a gait protocol of 5 min tied-belt warm-up (1.5 m s⁻¹), 5 min tied-belt baseline (0.5 m s⁻¹), 10 min split-





belt adaptation (1.5 m s⁻¹: 0.5 m s⁻¹), and 5 min tied-belt washout (0.5 m s⁻¹). All participants repeated the protocol on second exposure, three weeks later. An instrumented split-belt treadmill was used to measure 3D ground reaction forces (N), 3D moments of force (N m), center of pressure (m) and (extrapolated) center of mass (m), from which step length symmetry, double support symmetry [1] and bilateral margins of stability [2] were calculated. The magnitude of adaptation (difference between last and first 10s of the adaptation phase) and magnitude of aftereffects (first 10s of the washout phase) were calculated for both exposures. Pearson correlation coefficients were calculated between 1) first exposure adaptation magnitude and first exposure after-effect magnitude and 2) first exposure after-effect magnitude and second exposure adaptation magnitude. **RESULTS:** First exposure adaptation magnitude was positively correlated to first exposure after-effect magnitude in step length symmetry (r=0.73, p<.05). Furthermore, first exposure after-effect magnitude was positively correlated to second exposure adaptation magnitude (r=0.66, p<.05). No significant correlations were found for double support symmetry or margins of stability. CONCLUSIONS: These results indicate that participants who showed more adaptation, showed larger after-effects on step length symmetry. In addition, participants who showed large after-effects also showed more adaptation on second exposure. As no relation was found on double support symmetry and margins of stability, these findings suggest that step length symmetry is retained on repeated exposure. In conclusion, after-effects on initial exposure may be a predictor for performance on repeated exposure to a locomotor task. REFERENCES:[1] Reisman et al. (2005) [2] Hof et al. (2005).

P3-B-6 Combined study of segmental movements and motion of the centre of mass during adaptation on a split-belt treadmill

Luigi Catino¹, Chiara Diletta Malloggi², Luigi Tesio²

¹Università degli Studi di Milano, ²Istituto Auxologico Italiano, IRCCS

BACKGROUND AND AIM: Walking on a split-belt treadmill (each of the two belts running at different speed) has been proposed as an experimental paradigm to investigate the flexibility of the neural control of gait and as a form of therapeutic exercise for hemi-paretic patients[1]. However the scarcity of dynamic investigations both for segmental aspects and for the entire body system, represented by the Centre of Mass (CoM), challenges the validity of the available findings on split-gait. Thus, the aim of the present study is to describe the dynamic adaptation of healthy subjects in terms of segmental and CoM motion, using Gait Analysis on Force Treadmill [2]. The study intends to clarify the effect of "split-gait", underlining its differences with pathologic claudication. **METHODS:** Ten healthy adults walked on a split-belt treadmill mounted on force sensors, with belts running either at the same speed ('Tied Condition', TC) or at different speeds ('Split Condition', SC, 0.4 vs 0.8 m/s). For the study of segmental motion, the surface Electromyography (sEMG), sagittal power and work provided by ankle, the main engine of body propulsion, were simultaneously recorded. For the study of the CoM motion, the Total Energy





(Etot) and the percentage of Recovery (%R), the index of efficiency of the pendulum-like mechanism, were simultaneously analyzed. Various tied/split walking sequences were requested. The study was approved by the Local Ethic Committee. **RESULTS:** In the SC, the segmental motion analysis revealed a marked asymmetry between the two sides. The work provided by the ankle was 4.8 times higher (in the 0.4 vs 0.8 m/s conditions, respectively) compared with the slower side, and 1.2 times higher compared with the same speed in the TC (0.6 m/s) [3]. Paradoxically, the analysis of the CoM revealed an increased efficiency of the pendulum mechanism, with a higher %R in SC with respect to the TC at the same speed. **CONCLUSIONS:** Split gait entails its own pattern of locomotion, very different from pathologic claudication. The faster leg mimics the paretic limb temporally, but the unimpaired limb from the spatial and dynamic point of view[3]. This must be considered when a therapeutic application is designed. **REFERENCES:**1. Helm et al. Phys Med Rehabil Clin N Am. 2015;26(4):703-13. 2. Tesio et al. Am J Phys Med Rehabil. 2008;87(7):515-26. 3. Tesio et al. Int J Rehabil Res. 2018;41(4):304-315.

P3-B-7 Perceptions of induced temporal gait asymmetry in healthy adults

Lucas Crosby¹, Jessica Grahn², Joyce Chen¹, Kara Patterson¹

¹University of Toronto, ²Brain & Mind Institute - Western University

BACKGROUND: Nearly 60% of individuals with stroke walk with temporal gait asymmetry (TGA); an inequality of time each foot spends in swing phase of gait. A previous study showed that about half of post-stroke individuals with TGA are unable to correctly identify the presence or direction of their asymmetry. If patients are unable to perceive gait errors, it is less likely they will be able to correct errors to improve their gait pattern. Perception of gait pattern error may be affected by the stroke itself; therefore, the purpose of this study was to determine if young healthy adults could correctly perceive direction and magnitude of an induced TGA during an overground locomotor adaptation experiment. METHODS: After baseline symmetry was assessed with a pressure sensitive mat, healthy adults walked for 15 minutes overground with cuff weights (7.5% of body weight) on their non-dominant leg to induce TGA. Magnitude and direction of actual and perceived TGA (single limb support (SLS) ratio > 1.06) were measured at the beginning (early adaptation (EA)) and end (late adaptation (LA)) of the 15 minutes. Direction and magnitude of perceived TGA was measured with a self-report questionnaire that asked participants which leg they stood on more and the percent of total walking time on each leg. Differences between perceived and actual asymmetry were calculated. **RESULTS:** Seven participants were included in this preliminary analysis. During EA, all participants walked asymmetrically (mean (SD) SLS ratio=1.17 (0.03)) and spent more time on the unloaded limb. All participants perceived this TGA, however four incorrectly perceived the TGA direction. At LA, two participants returned to baseline symmetry however both reported the presence of TGA. Only one participant correctly identified TGA direction at both EA and LA. At EA, participants consistently over-estimated TGA magnitude (mean perceived SLS ratio was 1.39 times greater than actual [min=1.03, max=1.96]). At LA, three

participants perceived a return to baseline symmetry, but remained asymmetric resulting in both under- and over-estimations of TGA magnitude with a much larger range (mean perceived SLS ratio was 1.49 times greater than actual [min=0.83, max=2.76]). **DISCUSSION:** Preliminary results suggest that when initially walking with a unilateral loaded leg to induce asymmetry, most participants do not correctly perceive the direction of asymmetry, and grossly over-estimate the magnitude of asymmetry. Perceptions of gait symmetry performance do not appear to improve after the individual has adapted to the leg weight. After stroke, altered perception of motor performance may have explained some of the decreased ability to recognize TGA; however, these preliminary findings indicate that estimating an altered gait pattern is a difficult task even for healthy young adults.

P3-B-8 Retention of entrained auditory fractal patterns during gait

Vincenzo Di Bacco¹, Jeevaka Kiriella¹, Kristen Hollands², William Gage¹

¹York University, ²University of Salford

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BACKGROUND AND AIM: There is a growing body of literature showing that human gait demonstrates inherent fractal characteristics, or long-range correlations in the stride-to-stride fluctuations [1]. Fractality of the inter-stride duration signal is associated with gait adaptability and stability [2]. Healthy individuals are able to shift their fractal pattern of stride time to match various fractal patterns generated by an external stimulus [1,3], and can retain an entrained fractal pattern for up to 10 minutes after cueing to a visual fractal metronome has ceased [4]. However, it is currently unknown how long the retention effects last with the use of an auditory fractal metronome. This experiment assessed the duration of retention following entrainment to three auditory fractal metronomes. **METHODS:** Sixteen young healthy adult volunteers (n=8 females, age: 29±3 years, height: 1.71±0.08m), participated in the study. Each participant visited the laboratory once and walked on a motorized treadmill (Bodyguard Fitness, Quebec, CA) at a selfselected comfortable walking speed (CWS: 1.05±0.09m/s), timing right heel contact to each of three metronomes (MET: white noise (WN), pink noise (PN), and red noise (RN), presented in random order). Participants also completed an uncued condition trial during which the metronome was not active. Each trial lasted for a total of 1024 strides (~20 continuous minutes), which was separated into four blocks (PHASE) of 256 strides. The metronome was active during the first 256 strides (entrainment phase: ENT); the last three phases (post-entrainment: POS1, POS2, POS3) consisted of normal walking without the metronome. The fractal scaling index (FSI) was compared across the four phases for each condition to assess retention. A two-factor ANOVA was used to assess any differences between conditions. RESULTS: A significant interaction effect of MET and PHASE (p=0.004) was found for FSI (Figure 1). Post-hoc analysis revealed that the FSI was significantly greater for RN compared to WN and PN during ENT; no other differences were found. A main effect of MET (p=0.03) was found for FSI. Post-hoc analysis revealed that FSI for UN and WN were significantly less than for RN. No main effect of PHASE (p=0.34) was revealed.



CONCLUSIONS: The results of this experiment demonstrated a trailing off of the entrained fractal pattern, over time after the metronome was inactivated. Participants demonstrated FSI values that converged toward that of the uncued condition (Figure 1). Additionally, this experiment demonstrates that walking to an auditory fractal stimulus may be a viable option for inducing specific fractal patterns as the type of fractal pattern (i.e., WN, PN, RD) impacted the FSI during ENT. Future work will investigate the effect of longer entrainment periods to determine the association between entrainment and retention duration. **REFERENCES:**[1] Hunt N, et al. (2014), Nature Science Reports, 4(5879), 1-8. [2] Hausdorff JM. (2007), Hum Mov Sci, 26:555-589. [3] Rhea C.K, et al. (2014), PLOS ONE, 9(9), 1-10. [4] Rhea C.K, et al. (2014), Hum Mov Sci, 36, 20-34.

P3-B-9 A new approach using electrical muscle stimulation to elucidate sensorimotor adaptation in human postural control system

Shota Hagio¹, Anvar Azat¹, Daichi Nozaki¹

¹University of Tokyo

Human standing posture is inherently unstable, but we can stably keep balance on various conditions, such as on the flat, ice, or the moving surfaces. Conventionally, the mechanisms of posture control based on the visual, proprioceptive and vestibular system have been investigated by analyzing responses to diverse perturbations (Fitzpatrick and McCloskey, 1994). However, little is known about the flexible adaptability of postural control system to various unexpected conditions. Here, we proposed a new method that flexibly changes the postural dynamics to elucidate the adaptation ability of the human postural control system. The underlying idea is that toppling torque, i.e., ankle dorsiflexion torque, is externally produced using electrical muscle stimulation (EMS) applied to tibialis anterior muscle (TA) (see Figure). This technique makes it possible to flexibly and easily modulate the dynamics of postural sway depending on the position and/or velocity of a center of body mass (CoM).
br> Subject-specific parameters of EMS were first determined by estimating the relationship between EMS intensity and the induced ankle dorsiflexion torques. To this end, subjects lied on their back with their both feet attached to a force transducer. Ankle joint torgues were measured, while the intensity of EMS (biphasic pulse train, pulse width: 500 µsec, 20 Hz) applied to TA was gradually increased to 30 mA. Next, we tested if the EMS can dynamically produce the desired torque. Here, we used the previously-measured data of CoM fluctuations as the reference signal to determine the intensity of EMS (I) as follows: I = Cp p + Cv p + C (eq. 1), where p is the displacement of CoM. Cp and Cv represent the constant coefficients in the displacement and velocity of CoM, respectively. C is the constant. We confirmed that the desired ankle torque was produced by EMS under various combinations of the constant coefficients.
 After that, the subjects were instructed to keep upright standing. After the baseline standing task for 60 s, EMS was applied to TA for 10 min following eq. 1. During the task, 14 sets of catch trials where EMS was set to constant, i.e., Cp = Cv = 0, were interleaved to

measure the adaptive change of postural sway and response, such as displacement of center of foot pressure (CoP). The series of the postural tasks was repeated under different combinations of the constant coefficients, Cp and Cv. As a result, the amplitude of CoP fluctuations corresponding to the forward displacement and velocity of CoM was gradually changed depending on the body dynamics with the different constant coefficients.
br> In conclusion, the simple modulation of EMS intensity could produce the ankle dorsiflexion torque required to alter the body dynamics and the postural response was reasonably changed to adapt to the novel dynamics. The experimental system we proposed here is a powerful tool to investigate the flexible adaptability of human postural control system.

P3-B-10 Cortical correlates of gait adaptation to walking with a transfemoral dummy prosthesis

Vera Kooiman¹, Vivian Weerdesteyn¹, Helco van Keeken², Natasha Maurits², Teodoro Solis-Escalante¹

¹Radboud University Medical Center ²University of Groningen, University Medical Center Groningen

BACKGROUND AND AIM: After transfemoral amputation, patients must adapt to walking with a prosthesis for regaining safe and independent ambulation. This adaptation process may be reflected in the cerebral cortex as modulations of intrinsic cortical rhythms. Identifying cortical correlates of gait adaptation is important for the development of neuroprosthetics and novel EEGbased parameters for monitoring rehabilitation progression. Here, our aim is to identify differences in cortical rhythms of able-bodied individuals between walking without and with a dummy mechanical-knee prosthesis. METHODS: Fourteen naïve participants walked (0.9 m/s) on a treadmill without (one block, 4 min) and with a dummy prosthesis (three blocks, 3 x 4 min), while 32-channel EEG was recorded. Independent component analysis isolated brain-related activity from distinct anatomical sources. The source-level data were segmented into gait cycles and analyzed in the time-frequency domain to reveal relative enhancement or suppression of intrinsic cortical oscillations. The average power spectral density across gait cycles during walking without prosthesis served as common baseline for walking without dummy prosthesis, and the first, and last block with dummy prosthesis. Statistical comparisons were conducted at group-level, according to estimated locations of source-level data. Differences between walking conditions were evaluated with one-way ANOVA and (post-hoc) paired t-tests. Statistical significance was determined by non-parametric permutation statistics (n=200, α =0.05). RESULTS (Figure 1): Source-level activity was localized to prefrontal cortex (PFC) and posterior cingulate cortex (PCC). Significant effects were indicated in PFC β (19-25 Hz) and PCC α (9-12 Hz) rhythms, and in θ (3-7 Hz) and y (PFC: 34-44 Hz; PCC: 30-70 Hz) rhythms for both cortical areas. In PFC and PPC, first dummy prosthesis use (cf. walking without prosthesis) elicited θ rhythm enhancement preceding heel strikes with dummy prosthesis and during subsequent stance phase. In PFC, β rhythm



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> suppression preceded heel strikes of either body side, but γ rhythm enhancement only preceded heel strikes with dummy prosthesis. With further use, PFC and PPC θ rhythm enhancement only occurred around heel strikes with dummy prosthesis, and first enhancement of PFC γ (heel strikes with prosthesis) and PCC θ rhythms (heel strikes without prosthesis) were significantly reduced. Additionally, dummy prosthesis use elicited PCC γ rhythm enhancement throughout the gait cycle, which was significantly different between walking conditions(strongest during first use, reduced afterwards). **CONCLUSIONS:** Modulations of θ and γ rhythms from PFC and PCC may correspond to top-down gait cycle adaptation for correct stabilization of the dummy prosthesis, including proper (un)locking of the mechanical knee and/or proper placement. **FUNDING:** ERC-H2020 Project MyLeg(#780871). All data collected at Center of Human Movement Sciences, UMCG.

P3-B-11 Retention, savings and interlimb transfer of reactive gait adaptations in humans following unexpected perturbations

Christopher McCrum¹, Kiros Karamanidis², Paul Willems¹, Wiebren Zijlstra³, Kenneth Meijer¹

¹Maastricht University, ²London South Bank University, ³German Sport University Cologne

BACKGROUND AND AIM: Reactive adaptations in gait are vital for safe mobility but how these occur, are retained and if they can be transferred across tasks and lower limbs is not well understood. In this study, we aimed to determine if reactive gait adaptations to sudden, unexpected perturbations can be retained, if savings on re-exposure one month later are present and if interlimb transfer of these adaptations occurs. METHODS: Eighteen healthy adults participated in this study (eight males, 10 females; age: 24.4±2.5y; height: 174.9±7.4cm; weight: 74.6±15.2kg). The Computer Assisted Rehabilitation Environment Extended (CAREN; Motekforce Link, Amsterdam, The Netherlands) was used. Participants experienced 10 unilateral treadmill belt accelerations on one day and returned approximately one month later (28.4±3.4 days) and repeated this protocol. The first and last perturbed the right leg, while the second to ninth repeatedly perturbed the left leg. The gait perturbation protocol was conducted at a stabilitynormalised walking speed based on trials of unperturbed walking at various speeds for each individual, to ensure that all participants were walking at comparable stability levels. To quantify stability, we determined the anteroposterior margins of stability (MoS) at the moment of foot touchdown as defined by Hof et al. (2005). RESULTS: We found significant improvements in MoS and in the number of steps to recover to baseline MoS during the perturbations to the left leg on Day 1, and these improvements were retained during the first perturbation to the left leg on Day 2. Savings were also confirmed as the rate of recovery to MoS baseline was significantly faster on Day 2 for the first perturbation to the left leg. Additionally, the number of steps to reach baseline MoS following each perturbation on Day 1 was reached more quickly on Day 2, and subsequently improved upon. No clear difference between MoS during the two right leg perturbations on Day 1 were seen, but improvements in the recovery during the right leg perturbations on Day 2 were

found. However, we could not conclusively determine if the gait adaptations observed during the right leg perturbations on Day 2 were strictly due to interlimb transfer or to independent or combined effects of interlimb transfer, perturbation repetition, and task awareness. **CONCLUSIONS:** Our results show that humans demonstrate both retention and savings in reactive gait adaptations to benefit gait stability, but that interlimb transfer may not be exclusively responsible for improvements following perturbations to the untrained limb. **REFERENCES:**Hof et al. (2005) J Biomech 38, 1-8 **ACKNOWLEDGEMENTS AND FUNDING:** CM was funded by the Kootstra Talent Fellowship awarded by the Centre for Research Innovation, Support and Policy (CRISP) and by the NUTRIM Graduate Programme, both of Maastricht University Medical Center+.

C - Aging

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P3-C-13 Effect of postural training in age-related macular degeneration subjects

Hortense Chatard¹, Laure Tepenier², Talal Beydoun², Olivier Offret², Sawsen Salah², José-Alain Sahel³, Saddek Mohand-Said³, Maria Pia Bucci⁴

¹INSERM, ²Department of Ophthalmology, Assistance Publique-Hôpitaux de Paris, Paris Descartes University, ³Sorbonne University, Institut de la Vision, Centre Hospitalier National d'Ophtalmologie des Quinze-V, ⁴Hopital Robert Debré

BACKGROUND AND AIM: The goal of this study was to explore the impact of unilateral versus bilateral age-related macular degeneration (AMD) on postural sway with a temporal analysis, the influence of ocular dominance on postural sway in different visual conditions, and the effect of a short postural training on postural stability in AMD subjects. We hypothesized that unilateral or bilateral AMD subjects had specific compensatory strategies, and that a short postural training could improve postural performances in AMD subjects. **METHODS:** Three groups participated to a short postural training: 13 elderly unilateral AMD subjects (mean age: 72.47 ± 1.89 years), 18 elderly bilateral AMD subjects (mean age: 74.0 ± 1.02 years), and 16 healthy age-matched control subjects (mean age: 70.3 ± 1.36 years). Postural performance was recorded before and after postural training with a force platform (Framiral®) in seven visual conditions (eyes open fixating a target (both eye viewing (BEV), dominant eye viewing (DEV) and non-dominant eye viewing (NDEV)), eyes closed (EC) and eyes open with perturbed vision by optocinetic stimulation (both eye viewing (B-OPTO), dominant eye viewing (D-OPTO) and non-dominant eye viewing (ND-OPTO)). We analyzed the surface area and the mean speed of the center of pressure, the postural instability index, as well as the number of collision during postural training. RESULTS: Unilateral and bilateral AMD subjects are more instable than healthy age-matched subjects. Postural performances are normalized after training in AMD subjects, and such normalization is more evident for the bilateral AMD group. There is a correlation between postural instability and the severity of AMD, and not of visual acuity values. CONCLUSIONS: Visual inputs are important for postural control. Short period of postural training is able to improve postural stability in AMD



subjects, most likely due to adaptive mechanism. Further studies combining postural and imaging measures before and after postural training will be necessary to improve knowledge on such issue.

P3-C-14 Normative data of turning parameters in a large cohort of older adults using wearable sensors a four-year longitudinal study

Morad Elshehabi¹, Minh Pham², Clint Hansen¹, Elke Warmerdam², Susanne Nussbaum³, Daniela Berg², Walter Maetzler¹

¹Christian-Albrechts-University of Kiel, ²Christian-Allbrechts-University of Kiel, ³University of Tuebingen

BACKGROUND: Turning is a complex phase of gait, and is linked with higher risk of e.g. falling especially in older adults. Recent studies have focused on understanding the mechanical and biological aspects of turning. However, to our best knowledge, normative data of quantified turning parameters to define "normal" turning in older adults and gender-specific differences is not yet available. METHODS: We measured turning parameters (direction, duration, angular velocity and peak angular velocity) in adults 50y+ from the TREND study, every two years (three biannual visits from 2012 to 2016; 1017, 957 & 877 participants). Participants walked a 20m long, 3m wide, cleared hallway, in convenient pace for one minute back and forth making a 180° turn every 20m. Participants did not receive any instructions on to which direction they should turn. Participants wore inertial measurement units (IMUs, Mobility Lab®). Data from the lower back IMU are currently extracted. Turns have been detected and quantified using an in-house validated algorithm (Pham et al, Frontiers Neurology, 2017) to the following parameters: angle, duration, angular velocity, peak angular velocity, angular velocity at the start, middle and end of turns. We split our cohort based on gender and on age groups (<60y, 60-69y, 70y+) Cross sectional analysis (student t- & ANOVA tests) were performed on different gender and age groups on data from baseline. Longitudinal analysis using the generalized estimating equation (GEE) will be applied to test the effect of aging on turning (not yet done). RESULTS: In the currently available dataset from the first visit, 520 participants (f=268) performed a total of 1733 turns, 1284 (74%) of which were to the left and 449 (26%) to the right. Peak angular velocity was higher in men than women, angular velocity at the start of the turn was higher in women than in men. The total duration of turn did not differ. An ANOVA analysis with post-hoc analysis showed a deterioration in duration, angular velocity, peak angular velocity, angular velocity at the beginning, middle and end of turns in the 70y+ group without significant difference between genders. Results of the GEE model will also be provided in the presentation. Conclusion and outlook: Older adults turn more often to the left (74%). Men turn with higher peak velocity than women, and women have higher start turn velocity. Turning parameters slow down significantly in both genders starting from the 8th decade. A longitudinal data analysis of the three visits will be provided using the GEE model. This normative





database on turning behavior in older adults can serve as a reference for detailed studies on turning in diverse diseases.

P3-C-15 Regional associations of grey matter volume with gait variability-the Tasmanian Study of Cognition and Gait

Oshadi Jayakody¹, Monique Breslin¹, Richard Beare², Velandai Srikanth², Helena Blumen³, Michele Callisaya¹

¹University of Tasmania, ²Peninsula Health, Monash University, ³Albert Einstein College of Medicine

BACKGROUND: Cerebral grey matter atrophy is common in older age and associated with slower gait speed. Few studies, however, have examined whether such atrophy is associated with intra individual gait variability. This study aimed to examine the regional relationships of grey matter atrophy with gait variability in a population-based sample of older people. METHODS Participants (n=351) were randomly selected from the Southern Tasmanian electoral roll. Step time, step length, step width and double support time (DST) at usual gait speed were measured using a GAITRite walkway. Variability was calculated as the standard deviation of each gait measure averaged across all steps of 6 walks. Structural MRI scans were obtained using a single 1.5T Generic Electric scanner and segmented into 68 brain regions (34 per hemisphere) using FreeSurfer (version 5.3) software. Two measures were adopted as markers of grey matter atrophy, 1) regional areas of pial (outer) surface of the cortex 2) relative regional cortical thickness (regional thickness/mean thickness). Bayesian analysis was performed to determine the associations between each marker of atrophy and gait variability measure. Covariates included age, sex, education and height. RESULTS: The mean age of participants was 71.9 ± 7.1 and 56.1% of were males. Smaller cortical surface area of widespread regions, including bilateral inferior parietal, middle frontal, right medial orbitofrontal and right middle temporal areas were associated with greater variability in DST and step length. Smaller surface area in bilateral inferior parietal and right middle temporal regions were associated with greater step time variability. Smaller surface areas in temporal and right superior parietal regions were associated with base of support variability. Smaller relative regional thickness in bilateral precentral, right inferior parietal, left middle and transverse temporal areas was associated with greater variability in most measures. In contrast, greater relative regional thickness in bilateral anterior cingulate, bilateral isthmus of cinqulate, right pars triangularis and right middle temporal regions were associated with greater variability in most measures. **CONCLUSION:** This study adds to the evidence that smaller cortical surface area and thickness in dispersed brain regions important for integration of sensory and multiple cognitive functions are related to greater gait variability. The association of greater variability with greater thickness in some regions, may represent a compensation in the face of impaired cortical control of gait.





P3-C-16 Healthy older adults regulate lateral stepping in destabilizing environments

Jonathan Dingwell¹, Meghan Kazanski¹, Joseph Cusumano¹

¹Pennsylvania State University

BACKGROUND & AIM: Falls in the elderly occur frequently, with high injury rates and high morbidity / mortality (Robinovich et al., The Lancet, 2013). Falls to the side greatly increase hip fracture risk (Kannus et al., Bone 2006) and walking humans are less stable laterally (Kuo et al., Int. J Robotics Res., 1999). Increased fall risk may result from increased lateral variability and/or adjustments in stepping control. When walking on a path, healthy humans regulate lateral stepping movements to maintain primarily step width, but also absolute lateral body position (see companion abstract). Here, we characterized lateral stepping variability and control strategies of older adults walking unperturbed and in laterally destabilizing virtual environments. **METHODS**: 17 healthy Older adults (OH; aged \geq 60) and 17 healthy Young adult controls (YH; aged 18-35) walked in a virtual environment and completed two, 3-minute trials for each of three conditions: walking with no perturbations (NOP), or with pseudorandom, mediolateral oscillations of either the visual field (VIS) or treadmill platform (PLAT) (McAndrew, J Biomech, 2010). For each trial, stepto-step time series of step width (w) and absolute lateral body position (zB) were computed from motion capture data. Stepping variability was guantified as standard deviations. Step-to-step control was guantified from Detrended Fluctuation Analysis (DFA), as a scaling exponent that quantifies degree of statistical persistence (Dingwell et al., PLoS Comput. Biol., 2010). We also quantified how deviations from mean w and zB values were corrected on subsequent steps (Dingwell & Cusumano, PLoS ONE, 2015). RESULTS: For both groups, mean w values were significantly higher (p < 0.0005) in the presence of VIS and PLAT perturbations, while mean zB were not significantly different. Standard deviations for w and zB were significantly higher (p < p0.0005) for VIS and PLAT perturbations, compared to NOP. OH adults exhibited slightly higher w standard deviations for VIS perturbations than YH adults (p < 0.05). Across conditions and groups, DFA exponents were smaller (and closer to 0.5) for w than for zB. DFA exponents for w and zB were significantly lower (p < 0.0005) for VIS and PLAT perturbations, compared to NOP. However, there were no group differences for w (p = 0.80) or zB (p = 0.31). **DISCUSSION:** VIS and PLAT perturbation conditions significantly destabilized both groups, as indicated by higher w and zB standard deviations. Participants in both groups increased their mean w in response to these destabilizing conditions. Older adults were more destabilized in the presence of visual perturbations than Young adults. The DFA values for w compared to zB reflect tighter step width control for both populations and all conditions. Thus, these healthy Older adults, while slightly more variable, adopted similar stepping control strategies as Young adults across all conditions. ACKNOWLEDGEMENTS & FUNDNG: NIH R01-AG049735.




P3-C-17 Do falls or fragility predict fracture in Māori and non-Māori in advanced age; LiLACS NZ

Ngaire Kerse¹, Ruth Teh¹, Leah Palaper¹, Oliver Menzies¹, Catherine Bacon¹

¹University of Auckland

Kerse N1, Teh R1, Palaper L1, Menzies O2, Moyes SA.1 Bacon C1 1School of Population Health, University of Auckland, Auckland, New Zealand 2Auckland District Health Board, Auckland, New Zealand. BACKGROUND AND AIM: Falls and fractures are closely related and lead to poor outcomes for older people. The balance of risk factors for fracture related to falls and osteoporosis have not been studied in the very old nor in indigenous people. METHODS: A cohort study of Māori 80-90 years and non-Māori 85 years at inception in 2010 was used to establish 7 year incidence of fractures. Falls were ascertained by self-report. Fractures were ascertained from hospitalisation records and publicly funded accident insurance data available on all participants. Osteoporosis and falls risk factors related to all fractures were established by univariate and then multivariable regression techniques adjusting for deprivation, education and age for Māori and non-Maori separately. RESULTS: Over 7 years 66 (17%) Maori sustained 86 fractures and 135 (27%) non-Maori sustained 189 fractures. Non-Maori women had significantly more fractures that other subgroups. For Maori previous fracture, and use of antidepressants were risk factors for any fracture and prior fracture was independently associated in the fully adjusted. For non-Maori prior fracture, height loss since age 25 years were significant at the univariate level and in the fully adjusted model sex (women higher OR 1.9 (1.15, 3.16)), number of comorbidities (per additional condition OR 1.79 (1.08, 2.97)) and use of antidepressants (OR 2.00 (1.04, 3.82)) remained independently associated with future fracture. Repeated fracture risk presented differing risk factor associations. CONCLUSIONS: Fracture occurrence was greatest in non- Maori women and risk factors for fractures differ between these ethnic groups. Ethnic specific preventive strategies may be needed. ACKNOWLEDGEMENTS AND FUNDING: Funding for this study was contributed from the Health Research council of New Zealand, the Ministry of Health, the Auckland Medical Research Foundation.

P3-C-18 Adherence to a programme has greater impact on function and behavioural complexity improvement than group allocation in young seniors at risk of functional decline

A. Stefanie Mikolaizak¹, Kristin Taraldsen², Elisabeth Boulton³, Beatrix Vereijken⁴, Chris Todd³, Anisoara Paraschiv-Ionescu⁵, Kamiar Aminian⁵, Andrea Maier⁶, Mirjam Pijnappels⁶, Katharina Gordt¹, Jorunn Helbostad⁴, Clemens Becker⁷

¹Robert Bosch Medical Foundation, ²Norwegian University of Science and Technology, ³University of Manchester, ⁴The Norwegian University of Science and Technology (NTNU), ⁵Ecole Polytechnique Fédérale de Lausanne (EPFL), ⁶Vrije Universiteit Amsterdam, ⁷Rob





BACKGROUND AND AIM There are numerous intervention programmes to promote mobility (physical performance and activity) with ageing. However, adherence to interventions, a recognised treatment-effect moderator, is a challenge, especially over longer periods. The ECfunded PreventIT project adapted the lifestyle-integrated exercise programme (LiFE) to recently retired seniors to include activities that are more challenging and a strong underpinning behavioural change framework (aLiFE). aLiFE was subsequently transferred to an ICT platform to offer the intervention via smartphones and smartwatches (eLiFE). We aimed for an a priori subgroup analysis to identify the determinants of adherence to a tailored home-based intervention and the impact of adherence on outcome measures. METHODS: A multicentre, three-armed feasibility RCT was conducted in three European cities comparing aLiFE and eLiFE against a control group, who received written general physical activity advice only. Participants, aged 61-70 years old, were encouraged to integrate the interventions throughout their day. The primary outcomes were the Late-Life Function and Disability Instrument (LLFDI) and a physical behaviour complexity measure that quantifies variation in physical activity and intensity using wearable sensor-derived physical activity data. After the six months intervention period, adherence levels were measured using the Exercise Adherence Rating Scale (EARS). Determinants of adherence, collected prior randomisation, were identified using linear multivariate analysis. Linear regression was used to calculate treatment effect depending on predicted adherence levels. RESULTS: 180 participants (66.3±2.5 years, 92 females) were included. Baseline functional LLFDI scores were 73.4±12.2 and the one-week mean complexity value was 0.362±0.095. 156 participants were reassessed after six months. Intention-to-treat analysis showed no difference between treatment groups on the main outcome measures. Mean EARS score in the intervention groups (aLiFE/eLiFE) was 16.1±5.1 and was significantly, negatively, influenced by total number of medications taken, depression level and individual's risk of function decline. Predicted adherence was significantly associated with improved LLFDI basic lower extremity function (1.24 points/per EARS point increase, F(3,152)=78.76, p=.02) and behavioural complexity (B=0.011, F(3,132)=4.00, p=.037), regardless of group allocation. Advanced lower extremity function was significantly better with higher adherence, however treatment effect appeared to be moderated by group allocation. CONCLUSION: When offering evidence-based interventions, adherence to the protocol is significantly associated with better lower extremity function and behavioural complexity above and beyond the intervention components. Barriers to adherence such as depressive symptoms or polypharmacy should be addressed as part of a pre-intervention to achieve the best treatment effect possible.

P3-C-19 Gait speed assessed by a 4-meter walk test is not representative of daily-life gait speed in community-dwelling adults

Mirjam Pijnappels¹, Jeanine Van Ancum¹, Kimberley van Schooten², Nini Jonkman¹, Bas Huijben³, Rob Van Lummel³, Carel Meskers⁴, Andrea Maier¹





¹Vrije Universiteit Amsterdam, ²Neuroscience Research Australia, University of New South Wales, ³McRoberts, ⁴Amsterdam UMC, Vrije Universiteit Amsterdam

BACKGROUND AND AIM: Standardized gait speed tests are regarded clinically valuable, but are typically performed under optimal conditions, and may not reflect daily-life gait behavior. The aim of this study was to compare 4-meter gait speed to the distribution of daily-life gait speed. METHODS: We included 254 community-dwelling participants ranging from 20 to 91 years (median age 66.7 years [IQR 59.4 - 72.5], 66% female), from the cross-sectional Grey Power cohort. A timed 4-meter walk test at preferred pace from a standing start was assessed with a stopwatch. Daily life gait speed was obtained from tri-axial lower back accelerometer data over seven consecutive days and the distribution of gait speed over all gait episodes >10sec was attained. Pearson's correlations were used to compare gait speed assessed using a timed 4-meter walk test at preferred pace, and different percentiles from the daily-life gait speed distribution. **RESULTS:** Participants had a mean 4-meter gait speed of 1.43 m/s (SD 0.21), and a mean 50th percentile of daily-life gait speed of 0.90 m/s (SD 0.23). Ninety-six percent had a bimodal distribution of daily-life gait speed, with a mean 1st peak of 0.61 m/s (SD 0.15) and 2nd peak of 1.26 m/s (SD 0.23). The percentile of the daily-life distribution that corresponded best with the individual 4-meter gait speed had a median value of 91.2 (IQR 75.4 - 98.6). The 4-meter gait speed was very weakly correlated to the 1st and 2nd peak (r=0.005, p=0.936 and r=0.181, p=0.004), and the daily-life gait speed percentiles (range: 1st percentile r=0.076, p=0.230 to 99th percentile r=0.399, p<0.001; 50th percentile r=0.132, p=0.036). CONCLUSION: The 4-meter gait speed is only weakly related to daily-life gait speed. Clinicians and researchers should consider that 4meter gait speed and daily-life gait speed represent two different constructs.

P3-C-20 The effect of optic flow stimuli on standing balance in young and older people with low and high fall risk

Daina Sturnieks¹, Matthew Brodie¹, Brandon Chen Yi Tan², Michela Persiani³, Stephen Lord¹

¹Neuroscience Research Australia, University of New South Wales, ²University of New South Wales, ³Sede di Fisiologia Università di Bologna

BACKGROUND AND AIM: Optic flow stimuli can destabilise posture, especially in older individuals with increased visual field dependence. This may contribute to an increased risk of falls in older people. This study aimed to investigate the differing effects of optic flow stimuli on postural stability between younger and older adults with low- and high-fall risk. **METHODS:** 76 participants were recruited into 'young' (20-40 years, n=25), and 'old' ($_{i}$ Ý65 years, n=51) groups. The latter was stratified into 'old-LFR' (low fall risk, n=27) and 'old-HFR' (high fall risk, n=24). Participants stood on a force platform in a dark room with motion capture markers on the head, torso and lower limbs and EMG electrodes on lower limb muscles. Optic flow stimuli were projected onto a large screen encompassing the participants field of view as moving white dots.





Following 30 seconds of static white dots (no flow), one of four optic flow stimuli were presented for 30 seconds: radial expansion and contraction, circular (roll vection) anticlockwise and clockwise. Postural control was calculated from centre of pressure (COP) and lower limb joint and trunk angles. Repeated measures ANOVAs determined if optic flow stimuli influenced postural control, and if effects differed between groups. RESULTS: Optic flow stimuli led young and older participants to shift their COP in the expected direction for each stimulus condition (forward for expansion, backward for contraction, left for anticlockwise, right for clockwise). For radial expansion, significant stimuli by group interaction effects for AP path length (Fig 1a), total path length (Fig b) and AP mean peak frequency resulted from increases in old-LFR and old-HFR (p<0.001) but not in young (p<0.17). Similar results were seen for radial contraction. For circular clockwise, significant interaction effects for ML path length resulted from increases in old-HFR (p=0.002) but not in young (p=0.912) or old-LFR (p=0.749). Results differed for circular anticlockwise, with greater changes seen in AP path length compared with ML, particularly in old-HFR. Young females had larger increases in path length compared with males, however, this was not true for older participants, with old-HFR men having greater changes in sway than women. No stimuli by group interaction effects were seen in body kinematics. CONCLUSIONS: Optic flow stimuli led to significant increases in path length variables, predominantly in AP. Larger optic flowinduced increases in sway were seen in older compared with younger participants, most prominently in the old-HFR group. Results suggest that optic flow plays a more significant role in reducing postural stability in older than younger adults, particularly those at increased risk of falling. Analyses of participant lower limb muscle activity during the experimental conditions is currently underway. ACKNOWLEDGEMENTS AND FUNDING: National Health and Medical Research Council of Australia.

P3-C-21 Associations between mobility and dementia subtypes in nursing home residents

Karen Sverdrup¹, Sverre Bergh², Geir Selbæk¹, Pernille Thingstad³, Gro Tangen¹

¹Norwegian National Advisory Unit on Ageing and Health, ²Innlandet Hospital trust., ³Norwegian University of Science and Technology

BACKGROUND AND AIM: Most nursing home residents have dementia, and residents with dementia fall more frequently than residents without dementia. In community-dwelling elderly there are some studies indicating differences in mobility between dementia subtypes, while for nursing home residents this remains unknown. In this study we aimed to explore differences in mobility between dementia subtypes in nursing home residents. **METHODS:** Residents with an expected stay of more than four weeks were recruited at admission to the nursing home. The Short Physical Performance Battery (SPPB) and the Nursing Home Life Space Diameter (NHLSD) was used as outcome measurements of mobility. Dementia diagnosis was set by two experienced old age psychiatrists. Bivariate and multiple regression analyses were used to analyse differences





between groups. **RESULTS:** Preliminary. Of the 696 participants, 583 (83.8%) had dementia and 540 (76%) had a specific dementia diagnosis (Alzheimer's dementia (n=414), vascular dementia (n=57), frontotemporal dementia (n=47) or Lewy bodies dementias (n=22)). Mean age was 84 years and 64% were women. Median score on SPPB was 4. In total 61% achieved a score of 1 or more on balance, 81% on gait, but only 41% achieved a score of 1 or more on the chair stand. The mean NHLSD semi and NHLSD total were 25.7 and 41.4. We found no significant differences in mobility between residents with different subtypes of dementia in neither bivariate analyses, nor in analyses controlled for age, sex and degree of dementia. **CONCLUSIONS:** Nursing home residents with differences between residents with different dementia subtypes emphasises the importance of individual mobility assessments at admission to prevent falls and to preserve mobility in this population.

P3-C-22 Consistency and test-retest reliability of stepping tests designed to measure self-perceived and actual physical stepping ability in older adults

Roel Weijer¹, Marco Hoozemans¹, Jaap van Dieën¹, Mirjam Pijnappels¹

¹Vrije Universiteit Amsterdam

BACKGROUND AND AIM: Older adults with an incorrect perception of their physical abilities may fall more often, suggesting a need for tests to quantify self-perceived and actual abilities. We aimed to determine between-test consistency and test-retest reliability of three tests that measure self-perceived and actual stepping ability in older adults. METHODS: Older adults performed three stepping tests, covering high (bar test) and far steps (river and step tests). We studied between-test consistency in the perceived ability and actual ability of 269 participants at each task and in the difference between these two (degree of misjudgment). We also studied test-retest reliability in 21 participants. **RESULTS:** Perceived ability showed moderate consistency (r = 0.46 to 0.55, p < 0.001) and moderate to strong reliability (ICC(2,1) = 0.42 to 0.63, p < 0.03) for all tests. Actual ability showed strong consistency (r = 0.77, p < 0.001) and strong to excellent reliability (ICC(2,1) = 0.68 to 0.93, p < 0.001). Degree of misjudgment was weakly consistent between two stepping far tests (r = 0.32, p < 0.001), but not consistent between stepping far and high tests (r = 0.05 and 0.06, p > 0.3). Test-retest reliability of the degree of misjudgment was poor to moderate $(ICC(2,1) = 0.38 \text{ and } 0.50, p < 0.05 \text{ on the two stepping far tests and ICC(2,1) = -0.08, p = 0.63 \text{ on}$ the stepping high test). **CONCLUSIONS:** Actual and perceived ability can be consistently and reliably measured across tests, whereas the degree of misjudgment is less reliable and consistent within individuals.





D - Biomechanics

P3-D-23 Stiff-knee gait: effects of knee restriction in the gait of non-impaired individuals

Ana Barela¹, Odair Ramirez¹, Dinah Santana¹, Melissa Celestino¹, Valeriya Gritsenko², Sergiy Yakovenko², José Barela³

¹Cruzeiro do Sul University, ²West Virginia University, ³São Paulo State University (UNESP)

BACKGROUND AND AIM: Stiff-knee gait is characterized by diminished peak knee flexion during the swing period of the gait cycle, and it is common in individuals with stroke. Although, the cause of stiff-knee gait is unknown, it leads to an inefficient gait pattern; therefore, understanding the consequences of stiff-knee gait can help to develop effective gait interventions. The purpose of this study was to investigate the effects of knee restriction in healthy individuals during walking. **METHODS:** Ten individuals with no known gait impairment (53.7 ± 7.9 years old) walked with and without an orthotic knee constraint (maximum of 40 degrees knee flexion) on a 10-m walkway with two force plates embedded in the middle of it. Passive reflective markers were placed bilaterally on specific body landmarks to define low-limb segments. Motion capture data were used to compare multiple parameters of gait between the limbs ipsilateral and contralateral to knee constraint and between control and restricted-knee conditions. These parameters were the angular displacement and velocity of the knee at the beginning of swing, the time of peak knee flexion during swing, the magnitude of the second vertical peak of ground reaction force (pushoff), walking speed, step length, and stance duration of both limbs. **RESULTS:** We found that participants reduced ipsilateral knee angle and velocity at beginning of swing, anticipated the peak of ipsilateral knee flexion, and reduced the magnitude of push-off force of both limbs in the restricted knee condition. Participants walked slower, with reduced step length and shortened stance duration of both limbs in the restricted knee condition. However, the ipsilateral limb had longer step and shorter stance duration than the contralateral limb. **CONCLUSIONS:** Healthy individuals walking with restricted knee showed gait alterations that were similar to a gait pattern of individuals with post-stroke hemiparesis. In future experiments, we will compare both groups (stroke and non-impaired) and investigate the muscle activity of agonist and antagonist knee flexors to better understand the effects of stiff-knee gait. This may lead to an innovative therapy aimed at reducing gait deficits in individuals with stroke.

P3-D-24 The effects of varying midsole cushioning in footwear on gait in females with multiple sclerosis

Andrew Monaghan¹, Sutton Richmond¹, Clayton Swanson¹, Daniel Peterson², Brett Fling¹

¹Colorado State University, ²Arizona State University

BACKGROUND AND AIM: Multiple sclerosis (MS) is a chronic and progressive neurodegenerative disease affecting 2.5 million people worldwide. It is a female dominant (4:1) disease



and principally results in the breakdown of myelin sheaths surrounding axons in the nervous system. In the US alone, there is an estimated 500,000 people affected by MS, and approximately 75% of those individuals suffering from walking impairments. These walking impairments result in an elevated fall risk, decreased quality of life, and increased morbidity. Indeed, more than 50% of people with MS (PwMS) suffering a fall-related injury within any 6-month period. To combat these mobility impairments, PwMS exhibit a cautious gait strategy characterized by prolonged double support phase, a shorter single support phase, and a truncated swing phase. However, these gait adaptations, along with shorter length and height of strides, may have detrimental effects that increase the likelihood of falls. Footwear can have a pronounced impact on gait in healthy and MS populations, thus altering gait characteristics and fall risk. Although previous studies have examined spatiotemporal measures of gait in various shoe types such as high heels, slippers, and typical shoes during running, it remains unclear how different midsole characteristics of shoes influences gait in PwMS. Therefore, this study investigated the effects of two different shoe midsole conditions on the spatiotemporal parameters of gait in females with MS. METHODS: 18 females (41 ± 9 years, 1.72 ± 0.1 m, 71.97 ± 20.97 kg) diagnosed with MS performed a two-minute walk test in two different shoe conditions in random order; a medium-cushion shoe (New Balance 85V1) and a high-cushion shoe (Hoka One One Clifton 3). Spatiotemporal changes in gait were assessed using the Opal (APDM Inc., Portland, OR) wireless inertial sensors. RESULTS: There were no significant differences in stride length (Left P = 0.425; Right P = 0.917) or elevation between conditions (Left P = 0.917; Right P = 0.651). There were significant differences in the composition of the gait cycle, with decreased time spent in double limb support (Left P = 0.004; Right P = 0.004) and stance phase (Left P = 0.05; Right P = < 0.001) and increased time in single limb support (Left P = < 0.001) and swing phase (Left P = 0.05; Right P = < 0.001) in the Hoka One One shoe (high-cushion midsole) compared to the New Balance shoe (medium-cushion midsole). **CONCLUSIONS:** Despite not seeing changes in stride length and elevation at midswing, spending less time with both feet on the ground may mediate the inadvertent increased fall risk associated with prolonged double support phase. This has the potential to be directly applicable for patients, as the acquisition of a high-cushion midsole shoe could improve gait performance and reduce the risk for a fall by returning the double support phase of the gait cycle to a normal proportion.

P3-D-25 Anticipatory postural adjustment for an accurate step

Masahiro Shinya¹, Hiroki Yamada¹

¹Hiroshima University

BACKGROUND AND AIM: Anticipatory postural adjustment (APA) is known to serve an appropriate body state for upcoming voluntary focal movements such as forward step. It has been reported that various task requirements (step length, velocity, location, etc.) influenced APA parameters. However, little is known about how APA parameters are regulated when different step





accuracy is required. Based on the classical "speed-accuracy trade-off" theory, two hypotheses for making accurate step were presented. One is the motor control before the take-off, i.e., to reduce the variability of center of mass (CoM) state by taking a long time for APA. The other is the step leg control after the take-off, i.e., to precisely control the foot in the air by taking a long step time. METHODS: Twelve healthy young male participants were asked to make a forward step to locate the foot thumbs at targets placed on the floor. Two target distance (20% and 40% of body height) and two target size (2 cm square and 10 cm square) conditions were made. The participants repeated 40 trials for each condition. Ground reaction forces and 3D motion data were measured. As APA parameters, the location of the center of mass (CoM), the velocity of CoM, and duration of APA were analyzed. As step parameters, time to complete the step and variability in the placement of foot thumbs were analyzed. These parameters were compared between conditions by using two-way repeated measures ANOVA. **RESULTS:** The participants took a longer time to complete the step task to reduce the variability in the foot placement in the small-target conditions. This can be explained by the speed- accuracy tradeoff theory, which was consistent with the previous study (Duarte and Latash, 2007). A longer APA duration and a smaller variability in anterior-posterior CoM position at the instance of take-off was observed in the smalltarget condition comparing with the large-target condition. These results might be interpreted as a speed-accuracy trade-off in the control of APA. The CoM was located more at the support-foot side at the take-off under the small-target condition. The shift of CoM toward the support foot was regarded as a preparation for the following longer single-support step phase. The result suggests that the participants prepared for the planned long single-stance phase. **CONCLUSIONS:** Speedaccuracy trade-off was observed in the stepping task when the target size was manipulated. APA parameters were controlled so that the participants could make a slow and accurate step.

P3-D-26 Motion patterns that cause the increase of integrated knee muscle torque in individuals with knee osteoarthritis

Moeka Sonoo¹, Tsutomu Fujino², Keisuke Kubota¹, Shunsuke Kita¹, Hiroki Hanawa¹, Keisuke Hirata¹, Takanori Kokubun¹, Naohiko Kanemura¹

¹Saitama Prefectural University, ²University of Human Arts and Sciences

BACKGROUND AND AIM: To prevent the progression of knee osteoarthritis (KOA), it is important to reveal the relationship between progression factors and motion patterns. The effect of progression of KOA factors such as increased muscle activity and external knee joint torque is gradually being revealed. However, it is unclear how the motion pattern causes an increase in the progressive factors. This study attempted to determine the muscle torque that is generated from the knee muscle using a method called torque decompose. Muscle torque is different from joint torque because it is separated from the torque generated due to inertial force or gravity. To clarify how motion patterns induce increase muscle torque, we also performed an induced acceleration analysis (IAA), which can divide knee angular velocity into components generated from each joint





torque. **METHODS:** A KOA group (N=7; age: 69 years, 85.7 bmale) and control group (N=7; age: 66 years, 100 bmale) participated in this study. Sit-to-stand (STS) motion was captured using motion capture system, and it was divided into three phases: (1) sitting to lift-off, (2) to the instant of the peak ankle dorsiflexion, and (3) to standing. We calculated the knee muscle torque and the knee angular velocity generated from each joint torque by expanding the equation of motion on the 3-segment model (HAT: head, arm and trunk, thigh, and shank) into torgue decompose and IAA. The results were compared between the two groups using the non-paired t-test. The Pearson correlation coefficient between the integrated knee muscle torque (iMUS) during phase 3 and knee angular velocity at the start of phase 3 was calculated. RESULTS: KOA group has a significantly larger iMUS during phase 3 than the control group (56.1 ± 14.9 Nm/kg, 32.5 ± 11.2 Nm/kg, respectively). Decreasing knee extension angular velocity at the start of phase 3 was related to increasing iMUS (r = 0.75). Knee angular velocity in the KOA group was smaller than the control group. The result of IAA showed that knee angular velocity generated from the knee joint torque was significantly smaller in the KOA group than the control group at the start of phase 2 and 3. CONCLUSION: We demonstrated that the increased iMUS in the KOA group during phase 3, which may cause progression of the disease, was caused by decreased knee angular velocity at the start of phase 3. Smaller knee angular velocity generated from the knee joint torque in KOA group at the start of phase 2 may have been caused by different hip movement patterns between the groups because hip movement which is dominant during phase 1 generates knee extension joint torgue through chair reaction force. Continued smaller angular velocity generated from the knee joint torgue at the start of phase 3 supports the importance of hip movement during phase 1. The findings of the relationship between motion patterns and increased iMUS have implications on the rehabilitation for individuals with KOA.

P3-D-27 The effect of self-paced and fixed speed treadmill walking on the energetic cost of transport

Kyra Theunissen¹, Guy Plasqui¹, Peter Feys², Annelies Boonen¹, Annick Timmermans², Pieter Meyns², Kenneth Meijer³

¹Maastricht University Medical Center, ²Hasselt University, ³Maastricht University

BACKGROUND AND AIM: Self-paced treadmill walking enables natural variation in walking speed, as reflected in daily life conditions. This fluctuating walking speed leads to more variation in the step-to-step transition costs, compared to fixed speed treadmill walking. Although differences in kinetic and kinematic gait parameters between self-paced and fixed speed treadmill walking are negligible, the variability in walking speed is expected to increase the energetic cost of transport. Higher variation in forces for braking and propelling the body's Centre of Mass are likely to reflect increased walking speed variability in self-paced treadmill walking. The aim of this study is to identify the effect of self-paced and fixed speed treadmill walking on the cost of transport, spatiotemporal parameters and braking and propulsion ground reaction forces in





healthy adults **METHODS**: Eight healthy participants performed two bouts of walking on an instrumented treadmill with embedded force plates for continuously measuring ground reaction forces (Caren Motekforce Link). The first bout consisted of ten minutes self-paced; the second bout consisted of ten minutes fixed speed treadmill walking in which the speed was set to the mean self-paced speed. O2-consumed and CO2-produced gasses were measured via indirect calorimetry (Omnical, Maastricht University) and converted to cost of transport presented in J/kg/m. Fore-aft ground reaction forces were presented in N*s/kg and the following spatiotemporal parameters were measured: step time (s), step width (m), step length (m). RESULTS: No significant difference were found in all parameters between both conditions, yet the variation in walking speed was slightly higher in self-paced treadmill walking (1.38±0.07m/s) compared to fixed speed treadmill walking (1.37±0.01m/s). A small but not significant difference in step length (0.71±0.02m, 0.62 ±0.01m) and step time (0.51±0.01s, 0.45±0.01s) was found between self-paced and fixed speed treadmill walking, respectively. Cost of transport was 2.43 J/kg/m in both conditions. CONCLUSIONS: Self-paced treadmill walking seems a feasible setting for conducting clinical walking assessments, allowing for natural walking speed variability. Although step length and step time are important determinants of the cost of transport, this small but not significant difference could be strengthened by including a bigger sample size or multiple walking speeds. ACKNOWLEDGEMENTS AND FUNDING: This double-degree PhD funding is established thanks to a cooperation sponsored by Maastricht Universitair Medisch Centrum and Hasselt University.

P3-D-28 Are a few millimeters added under the big toe enough to improve postural control in elite handball players?

Frédéric Viseux¹, Philippe Villeneuve², Rodolfo Parreira³, Franck Barbier⁴, Antoine Lemaire⁵, Sebastien Leteneur¹

¹LAMIH - University of Valenciennes - France, ²Posture Lab - Paris, ³LaNEx - University of Southern Santa Catarina - Brazil, ⁴Université de Valenciennes, ⁵CETD - Centre Hospitalier de Valenciennes - France

BACKGROUND AND AIM: Handball players need efficient postural control to combine running, sprint across the field, jump performed in flexibility, and shoot of great accuracy. The foot is the direct interface between the body and the ground during practice and plantar cutaneous information contributes to postural control [3, 4]. This cutaneous feedback is provided by low-threshold mechanoreceptors that are highly sensitive to low mechanical stimuli applied to the skin of the foot [1, 5]. Studies showed that additional thickness under the foot [2, 6] could be used to improve upright balance. The purpose of the present study was to evaluate the effect of a low additional thickness placed under the big toe on the CoP measures in elite women handball players. **METHODS:** Fourteen elite women's handball participated in this study. Postural oscillations were recorded for each participant using a force plate (AFP / APE85, 40 Hz/16-bit, Win-posturo, Médicapteurs, France) and analyzed with the software (v; 1.8, Win-posturo) coupled





to the force plate. The subject's task was to stand as still as possible during the trial. Two randomized conditions were compared: additional thicknesses under the big toe (TUBT) 0 (control) and 0.8 mm. Five parameters were computed from the CoP displacements: (i) the surface of CoP excursions; (ii) the length of CoP excursions; (iii) the frontal (X) mean position of CoP; (iv) the sagittal (Y) mean position of the CoP and; (v) the average speed of CoP. The mean of three consecutive measurements was performed with a sampling frequency of 40 Hz over 51.2 s. RESULTS: A significant decrease in TUBT 0.8 compared to control condition was observed for three of the five variables: the surface of CoP excursions, the length of CoP excursions and the average speed of CoP. CONCLUSIONS: This study evidences that Low additional thicknesses placed under the big toe has an effect on the CoP measures used to assess postural control. These postural reactions are consistent with previous reports that used mechanical stimulation of the plantar sole to facilitate the tactile cutaneous sensation [2-4, 6]. In conclusion, cutaneous information arising from the toes plays an important role in controlling posture. This way of facilitating the sensory feedback of plantar receptors is guite simple and it is possible to insert a low additional thickness on a customized sole. In this context, this brings perspectives in the management of athletes to prevent injury risk and optimize performance. REFERENCES:[1] Inglis et al, 2002 [2] Janin & Toussaint, 2005 [3] Kavounoudias et al, 2001 [4] Kavounoudias et al, 1999 [5] Kennedy & Inglis, 2002 [6] Viseux et al, 2018.

E - Brain imaging/activation during posture and gait

P3-E-29 The effect of walking speed on cortical activity in young and older adults

Lisa Alcock¹, Rodrigo Vitório², Samuel Stuart³, Lynn Rochester⁴, Annette Pantall¹

¹Newcastle University, ²São Paulo State University (UNESP), ³Oregon Health & Science University, ⁴Institute of Neuroscience, Newcastle University

BACKGROUND AND AIM: Walking speed has been described as the "sixth vital sign" as it is reflective of overall health status and physical function [1]. Walking speed reduces with age [2] and is predictive of life expectancy and mortality [2, 3]. Fast walking is considered to reflect maximal capacity and may be more useful than preferred gait speed when understanding age-related changes in the neural control of locomotion. Previous studies have identified an increased cortical activity with faster walking speeds [4] however the effect of age is unknown. **METHODS:** 17 young adults (YA; Mean age [SD] 20.3[1.2] years, 8 males) and 18 older adults (OA; Mean age [SD] 72.6[8.0] years, 9 males) walked on a motorised treadmill for five minutes. Oxygenated haemoglobin (HbO2), an indicator of cortical activity, was measured using a tethered 40 channel functional near-infrared spectroscopy (fNIRS) system (LABNIRS, Shimadzu, Japan 23.8Hz). The following regions were monitored for each hemisphere; prefrontal cortex (PFC), premotor cortex (PMC), supplementary motor area (SMA) and primary motor area (M1). Treadmill speed was altered every 30-seconds between a preferred and fast (120% preferred) speed for five trials.





fNIRS signals were filtered, detrended to remove physiological noise and normalised to the signal amplitude for each participant. Linear mixed effect models evaluated the effect of task (preferred vs. fast speed), group (YA vs. OA) and trial repetition (Trial 1-5) on HbO2 whilst controlling for preferred walking speed. Significance was accepted at p<.05. RESULTS: The OA walked significantly slower than YA (group mean speed; 2.8km/hr vs. 3.8km/hr, p=.001). There was a main effect of Task such that a significantly higher HbO2 was observed in the RSMA, LM1 and RM1 (p<.006) during fast walking compared to preferred walking regardless of age group (Table 1). There were no significant main effects of Group or Trial on HbO2. Significant Task x Group interactions were identified for all cortical regions except for RM1, indicating that a greater increase in HbO2 was observed in the older adult group in response to walking faster. **CONCLUSIONS:** Walking faster is associated with greater activity in the motor cortex regardless of age. A greater increase in HbO2 was observed from preferred to fast walking in the older adults, despite walking significantly slower than the young adults. Considering age-related changes that occur in brain structure and function and the greater increase in HbO2 in the older adults when walking faster, one factor that may restrict walking speed in older adults is limited cortical capacity. This enhances our understanding of one of the many factors influencing a reduced walking speed in older age. ACKNOWLEDGEMENTS AND FUNDING: The authors acknowledge the contribution of Ellen Lirani-Silva, MSc, with data collection. This research was supported by Sao Paulo Research Foundation (FAPESP 2016/00518-8; postdoctoral fellowship to Rodrigo Vitorio). REFERENCES [1] Fritz & Lusardi 2009 Journal of Geriatric Physical Therapy [2] White et al., 2012 Journal of Gerontology; Med Sci [3] Studenski et al., 2011 JAMA [4] Vitorio et al., 2017 Neurosci **Biobehav Reviews.**

P3-E-30 Parkinson's disease affects neural activation during continuous alterations to the split-belt treadmill: An [18F] FDG PET Study

Dorelle Hinton¹, Alexander Thiel¹, Laurent Bouyer², Jean-Paul Soucy¹, Caroline Paquette¹

¹McGill University, ²Université Laval

BACKGROUND AND AIM:Split-belt (SB) treadmill walking, where each leg is driven at a different speed, highlights the nervous system's ability to quickly alter both stride length and phasing. Interestingly, adults with Parkinson 's disease (PD), who experience reduced automaticity of gait and difficulty in step-to-step changes, are also able to adjust to SB treadmill walking. The neural correlates underlying these rapid gait changes are emerging. Direct evidence of cat cortical activity during complex walking shows increased activity of motor planning and sensory integration areas. Coupled with evidence of SB treadmill walking impairments in adults with cerebellar lesions, it is hypothesized that a parieto-cerebellar network is required during SB treadmill walking. Here, we compared whole brain activity during SB treadmill walking with continuous belt speed changes to typical treadmill walking to identify how areas activated by continuous asymmetrical gait speed changes are altered by healthy aging and by PD. **METHODS**:





Ten young adults (23±3y), 4 older adults (64±6y) and 8 adults with PD (65±5y) performed SB treadmill walking for 30 minutes on 2 occasions: 1) Control- both belts at comfortable walking speed, and 2) Continuous Change- speed ratio between belts changed every 15 (Young Adults) or 30 seconds (Older Adults, Adults with PD). A bolus injection of 18F-fluorodeoxyglucose (FDG) tracer (a glucose analog) immediately prior to walking measured whole brain glucose metabolism, or activation, during each trial. Upon uptake in the brain (~20mins), FDG is held within the cell, where it can be imaged using Positron Emission Tomography (PET) before it decays (halflife:109mins). PET images of metabolism from each condition were compared to assess for increases when continuous gait pattern changes are required and to determine the effects of aging or PD. RESULTS: During continuous belt speed changes, similar to young adults, older adults and adults with PD increased activity in bilateral supplementary motor areas, right posterior parietal cortex, right anterior cingulate cortex and left bilateral anterior cerebellum compared to typical treadmill walking. Age-related increased activity was present in pre-frontal (BA8,10) and temporal cortex (BA20) and caudate nucleus, whereas adults with PD further increased activity in primary sensory areas (BA3), insula (BA13), lateral globus pallidus. CONCLUSIONS: Adults with PD required a broader neural network to adjust to continuous asymmetric belt speed changes. Compared to typical treadmill walking, older adults (healthy,PD) activated areas for motor planning, sensory integration, task directed attention and updating a locomotor plan. With age, these activations widened to include areas for working memory and subcortical motor processing. The presence of PD required further activation of primary sensory and sensory integration areas, and excess subcortical motor processing. This widespread use of cortical and subcortical neural networks may help to explain why more complex walking tasks, such as dual tasking or turning, show detriments with aging and progression of PD. ACKNOWLEDGEMENTS AND FUNDING: NSERC Discovery Grant (CP), Parkinson Canada New Investigator Award (CP) and Graduate Student Award (DH).

P3-E-31 Readiness potential of gait initiation recorded with mobile EEG

Nadine Jacobsen¹, Stefan Debener¹

¹University of Oldenburg

BACKGROUND AND AIM. Impairments of gait initiation, such as freezing of gait, are a hallmark of Parkinson's disease (PD). The initiation of voluntary movements, such as gait, is accompanied by the readiness potential (RP). Alterations of the RP have been reported in PD patients. The recent advent of mobile electroencephalography (EEG) technology as well as wearable motion capture sensors allows us to record gait-related brain activity with a minimal setup on off-the-shelf smartphones, tablets or laptops. This facilitates recordings in clinicals settings and natural environments. As a starting point, we investigated the RP of gait initiation in healthy subjects in the present study. **Methods.** Mobile 64-channel EEG will be recorded of N = 20 healthy and young participants while they initiate walking with either their left or right leg. In total each subject





performs 100 initiations. Acceleration signals from the participant's shoes are used for the detection of gait initiation and synchronized with the EEG. So far, data of n = 4 participants (3 females, 19-28 years old) have been recorded. Preprocessing of EEG data was performed using EEGLAB. Artifacts were attenuated using independent component analysis. Subsequently, data was filtered between 0.1 and 40Hz, epoched from -2.5s to 1s and baseline corrected from -2.5 to -2s before gait initiation. Improbable epochs containing residual artifacts were automatically rejected. On average 85 trials (range 83-91) remained for further analysis. RP data were then rereferenced to common average and submitted to source modelling in Brainstorm using default parameters. RP source estimates were obtained with dynamical statistical parametric mapping and constrained dipoles. The RP ERP was analyzed within an a priori defined region of interest (ROI) around the vertex (s. Fig. 1a). A comparison between left and right leg gait initiation will be provided once the full dataset is acquired. **Results.** All participants displayed a negative deflection at the ROI showing two peaks: one at -950ms and another at -300ms prior to gait initiation. The onset of the negative slope of the RP occurred approximately at -2s. Topographically, the negativity over vertex channels was source localized in or near the central sulcus, the interhemispheric cleft and the supplementary motor area. Conclusions. Seizing the possibilities of mobile EEG and wearable sensors, the present study is to our knowledge the first one to assess EEG patterns of gait initiation with both legs and a fully mobile setup. The preliminary RP of gait initiation could be identified in each participant. The temporal course and the topographies as well as the modelled sources are in accordance with previous studies. The present study reflects an important step towards measuring RPs of gait initiation in impaired populations, such as PD patients with mobile setups anywhere. This could provide further understanding of the nature of gait impairments in this population.

P3-E-32 Single-session transcranial direct current stimulation alters the cortical response to dual task walking in functionally-limited older adults-a pilot study

Azizah Jor'dan¹, Hagar Bernard-Elazari², Anat Mirelman², On-Yee Lo³, Jeffrey Hausdorff², Brad Manor³

¹Havard Medical School, ²Tel-Aviv Sourasky Medical Center, ³Harvard Medical School

BACKGROUND & AIM: Dual task walking (DTW) is important for many activities of daily living. DTW is associated with increased prefrontal cortical activation, as measured by oxygenated hemoglobin (HbO2) using functional near-infrared spectroscopy (fNIRS), in healthy older adults. Transcranial direct current stimulation (tDCS) can noninvasively modulate cortical excitability. Our prior research reported that in older adults, a single session of tDCS targeting the left dorsolateral prefrontal cortex (dIPFC) improved dual task performance when tested immediately after stimulation. However, the underlying mechanisms of these acute effects of tDCS on cognitivemotor performance remains unclear. We therefore conducted a secondary analysis to test the hypothesis that in older adults with cognitive-motor impairment, a single session of tDCS targeting





the left dIPFC, compared to the sham, will improve prefrontal cortical activation (i.e., reduce HbO2) in response to DTW immediately after stimulation. METHODS: A double-blinded, blockrandomized, sham-controlled trial was completed in 18 older adults with functional limitations (i.e., walking speed of <1.0 m/s and mild-to-moderate executive dysfunction determined by the Trail Making Test) within the parent study. Participants were randomized into an intervention group (i.e., tDCS or sham stimulation). Stimulation consisted of a 20-minute session with the anode over the left dIPFC and cathode over the right supraorbital region. In a subset of 14 participants (mean age 80±11 years, n=7 per group), HbO2 was measured during normal walking and walking while serially subtracting 3's using an fNIRS system consisting of two probes placed over the forehead. HbO2 and walking outcomes were measured immediately before and after the first stimulation. Data Analysis: Due to the small sample size and individual intrinsic differences, Matched Pairs ttests were used to assess changes in HbO2 and walking outcomes. RESULTS: Before stimulation, there was a task-related decrease in walking speed (0.68 to 0.55 m/s, p=0.002) and an increase in HbO2 (0.05 to 0.14 µM, p=0.03) from normal to DTW. After a single session, tDCS, compared to sham, increased walking speed from 0.71 to 0.76 m/s (p=0.03) for the normal walking condition, but not for the DTW condition. tDCS had no effect on the dual-task cost to walking speed. tDCS, compared to sham, reduced HbO2 levels from 0.17 to 0.04 µM (p=0.02) in the DTW condition only. CONCLUSIONS: A single-session of tDCS targeting the left dIPFC increased normal walking speed and separately induced prefrontal cortical activation changes (i.e., HbO2 decrease) in response to DTW in older adults with functional limitations. However, results should be interpreted with caution as the small sample may not be sufficient to elucidate the physiological mechanisms of the acute effects of tDCS on DTW. Larger trials are warranted to decipher this connection to optimize cognitive-motor rehabilitative treatments.

P3-E-33 Activity in the sensorimotor cortex during action observation of walking combined with motor imagery

Naotsugu Kaneko¹, Hikaru Yokoyama², Yohei Masugi³, Katsumi Watanabe⁴, Kimitaka Nakazawa¹

¹University of Tokyo, ²Tokyo University of Agriculture and Technology, ³Tokyo International University, ⁴Waseda University

BACKGROUND AND AIM: For gait rehabilitation after neurological disorders, action observation (AO) and motor imagery (MI) of walking are often used in addition to motor practice. Neurophysiological studies have shown that AO- and MI-related brain activities are partly different, but both contribute to improvements in gait function. In order to examine whether AO combined with MI (AO MI) would be more effective than AO or MI alone, we have recently shown that AO MI facilitates corticospinal and spinal reflex excitabilities more than AO or MI independently. In this study, we examined how AO MI of walking changes the brain activity in the sensorimotor cortex. **METHODS:** Twelve males participated. Each participant sat in a chair placed 1m away from a treadmill, where another person walked with a fixed speed of 3.6 km/h, and performed AO





and AO MI in separate sessions. In the AO session, the participants simply observed the person's right leg. In the AO MI session, they observed the person from the AO session, and were instructed to also imagine that they were walking alike the person. Electroencephalogram (EEG) signals were recorded with 63 electrodes and separated into brain activity, blink, eve movement, and other artifacts by using independent component analysis. For each component related to brain activity, an equivalent current dipole location and event-related spectral perturbations (ERSP), which are frequency power modulations related to an observed walking phase were computed. Brainrelated components were clustered across participants based on their dipole location, power spectra, and ERSP to identify sensorimotor areas involved. For each sensorimotor area, the average power spectra and ERSP were calculated. RESULTS: Three clusters were identified in the central, left, and right sensorimotor cortices. In the left sensorimotor cluster, the alpha band power (8-12 Hz) significantly decreased in AO MI compared to AO. For ERSP of the left sensorimotor cluster, a significant modulation depending on an observed walking phase was found in both AO and AO MI. During AO, the beta band power decreased in the terminal stance phase and increased in the terminal swing phase. During AO MI, the alpha and beta band power (15-30 Hz) increased in the terminal stance phase while the beta band power decreased in the terminal swing phase. In the cluster of the central sensorimotor cortex, the modulations of power spectra, and ERSP were similar to those in the left sensorimotor cluster. The cluster of the right sensorimotor cortex showed no modulation. CONCLUSION: The present study demonstrated that activity in the sensorimotor cortex during AO MI depends on an observed walking phase and is comparable to the activity during walking. The findings have elucidated the underlying neural activities induced during AO, MI, and combined processes, which would lead to better neurorehabilitation strategies for patients with neurological gait dysfunctions.

P3-E-34 Functional near infra-red spectroscopy neuroimaging of prefrontal cortex in Parkinson's disease during cognitive tasks under different postures.

Graham Kerr¹, Mark Muthalib², Roger Pegoraro¹, Luisa Roeder¹, Ian Stewart¹, Simon Smith³

¹Queensland University of Technology, ²University of Montpellier, ³University of Queensland

BACKGROUND AND AIM: In Parkinson's disease reduced executive function is associated with poorer quality of life, decreased activities of daily living, and increased balance and gait disturbance. Neural circuits involving dorsolateral prefrontal cortex (DLPFC) and involved in executive function are critical for control of balance and gait. The objective of this study was to determine how prefrontal cortex activation is affected during concurrent cognitive and balance tasks. **METHODS:** Bilateral DLPFC alterations in concentration of oxy- (O2Hb) and deoxy-haemoglobin (HHb) in cerebral microcirculation blood vessels were recorded using fNIRS. Four optode receivers were placed 40mm from a central transmitter optode over the frontal lobe of each hemisphere. Participants performed a cognitive task (phonemic verbal fluency) involving executive function under both seated and standing (force plate) conditions. Early stage PD (N=14;





64 yrs), healthy age matched controls (N=17; 64.8 yrs), and young participants (N=12; 25 yrs) were assessed according to the following protocol repeated 5 times during sitting and standing: Baseline - Rest -no activity (30s), Rest (30s), Verbal Fluency (30s), Rest (30s), Recital of days of the week (30s), Rest (30s). Test conditions were counterbalanced. PD participants were optimally medicated. **RESULTS:** All groups had similar performance in the verbal fluency and the week day recital tasks. In the young group, neuronal activation during the verbal fluency task (relative to baseline) was characterised by an increase in O2Hb and a decrease in HHb in the right DLPFC while seated and in the DLPFC bilaterally during standing. Similar, but reduced changes were observed for the older control group. For the PD group there was a bilateral increase in DLPFC O2Hb for the verbal fluency task during the seated condition but this was greatly reduced in amplitude; right hemisphere HHb decreased. During standing there was negligible change (relative to baseline) in DLPFC O2Hb in both hemispheres for PD participants and a slight bilateral decrease in HHb. There was negligible change in O2Hb or HHb during the week day recital task for all groups. CONCLUSIONS: These changes in O2Hb indicate that PD participants have reduced activation of the DLPFC during the performance of cognitive tasks involving executive function when sitting and standing. During standing activation of the DLPFC is further reduced, in contrast to young and control participants who have increased bilateral activation. This indicates that people with PD have either reduced activation of the same neural circuits or utilise different neural circuits to complete these cognitive tasks.

P3-E-35 Brain activation during real-time walking post-stroke: systematic review

Shannon Lim¹, Dennis Riley Louie¹, Janice Eng¹

¹University of British Columbia

BACKGROUND: With the advance of technology, the ability to record brain activity while an individual completes large movements, such as walking, has become increasingly achievable. Recent systematic reviews (Hamacher et al 2015; Vitorio et al 2017) have consolidated 45 discrete studies focused on measuring brain activity during various walking tasks; however, these reviews non-specifically grouped neurological populations together. As neurostimulation and individualized interventions are receiving increasing attention to improve walking in the post-stroke population, it is important to identify areas of activation during walking specific to the post-stroke brain. **METHODS:** Two independent reviewers assessed search results from 6 databases and relevant references. Search categories included terms for stroke, ambulation/stepping, brain activation during actual upright walking or stepping (e.g. simulated walking or seated stepping) were excluded. **RESULTS:** From the 937 papers identified, 12 studies (156 individuals post-stroke, 73% chronic) were included for review. Eight studies utilized functional near-infrared spectroscopy (fNIRS), while 4 studies utilized electroencephalography (EEG) to measure brain activity. Real-time walking tasks varied: initiation of walking (N=2) or stepping (N=1), overground

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walking (N=3), treadmill walking (N=2), body weight-supported walking (N=3), or robotic-assisted walking (N=1). Four fNIRS studies recorded solely along the prefrontal cortex (PFC), while 2 research groups also recorded over premotor cortex (PMC), supplementary motor area (SMA), and sensorimotor cortex (SMC). The majority of fNIRS studies did not utilize techniques for precise localization of probes, nor account for individualized brain anatomy, or task-related systemic changes. Further, recordings were often over a limited area, and were not compared to an age-matched healthy group. Significant heterogeneity in task and analysis techniques also resulted in varied findings. Several studies showed increased PFC activation and decreased ipsilesional SMA activation during walking, and greater PFC and pre-SMA activation associated with greater stroke severity. Studies using EEG recorded from the central to prefrontal areas and generally found event-related potentials prior to task initiation. **CONCLUSIONS:** While the ability to record brain activity during walking has become increasingly feasible, numerous limitations hinder the interpretation of current results. Although some patterns within the PFC and SMA are beginning to emerge, future work would benefit from more rigorous methods suggested within this presentation.

P3-E-36 Resting state functional connectivity of normal and dual-task walking in healthy older adults

On-Yee Amy Lo¹, Mark Halko², Victoria Poole¹, Junhong Zhou³, Lewis Lipsitz¹, Brad Manor³

¹Hebrew SeniorLife / Harvard Medical School, ²Beth Israel Deaconess Medical Center / Harvard Medical School, ³Harvard Medical School

BACKGROUND AND AIMS: Walking performance, especially when simultaneously engaged in additional cognitive tasks (i.e., dual-tasking), has been linked to interconnected brain regions. The integrity of and interaction between functional networks can be evaluated with resting-state fMRI. We aimed to investigate the associations between resting-state functional connectivity and dual task gait performance in healthy older adults. **METHODS:** Twelve healthy older adults (aged 75±8 years, 4M) completed laboratory-based assessments of gait and cognition, and within one week, MRI brain scans. The gait assessment comprised five walking trials under single- (i.e., walking quietly at preferred speed) and dual-task (i.e., walking with verbalized serial subtractions) conditions. Gait outcomes included average gait speed (m/s) in each condition and the percent change in gait speed from single- to dual-task conditions (i.e., dual task cost). Resting-state functional connectivity was analyzed with a custom-built software package. Based upon a previously-defined and highly-replicated parcellation, seven functional brain networks were identified including the visual, somatomotor, dorsal attention, ventral attention, frontoparietal, limbic and default networks. BOLD signals from each voxel within each network were extracted to calculate the strength of the within- and the between-network functional connectivity. Descriptive statistics were used to summarize participant characteristics and study outcomes. Bivariate analyses with and without age adjustment were used to test the correlation between gait





performance and functional connectivity. The level of statistical significance was set at p=0.05 for all tests. RESULTS: Older adults with lower dual-task cost to gait speed (better dual-task performance) exhibited greater strength of functional connectivity within the dorsal attention network (R2=0.43, p=0.02, Fig. 1). Older adults with faster dual-task gait speed exhibited greater strength of functional connectivity within the default network (R2=0.43, p=0.04). A similar trend was observed between single-task gait speed and connectivity within the default network (R2=0.36, p=0.08). In addition, gait speed within both single- and dual-task conditions was correlated with the strength of functional connectivity between multiple network pairs, especially those pairs involving the somatomotor, frontoparietal, and default networks (R2 from 0.30 to 0.62, p from 0.001 to 0.05). Finally, dual-task gait speed was correlated with the strength of function connectivity between the dorsal attention network and several other networks including the frontoparietal and ventral attention networks (R2 from 0.33 to 0.45, p from 0.01 to 0.04). CONCLUSIONS: In healthy older adults, dual-task gait speed correlated to the strength of connectivity within the default network. Moreover, the integrity of the dorsal attention network, as well as its functional connectedness with other brain networks, appears critical to maintaining gait performance when dual tasking.

P3-E-37 Prefrontal and motor cortical activity during stepping tasks in older people at low and high risk of falling

Paulo Pelicioni¹, Stephen Lord¹, Nigel Seng¹, Bethany Halmy¹, Daina Sturnieks¹, Rui Liu¹, Jasmine Menant¹

¹Neuroscience Research Australia, University of New South Wales

BACKGROUND AND AIM: Impaired stepping and reduced cognitive functioning are fall risk factors in older people. Understanding neural mechanisms may assist in elucidating mechanisms underpinning these relationships. The aim of this study was to investigate prefrontal and motor cortices activity during stepping tasks using fNIRS (functional near-infrared spectroscopy) in older people. We hypothesised those with a high risk of falling would display greater prefrontal and/or motor cortical activation when performing a complex stepping task as a compensatory mechanism for reduced cortical capacity. METHODS: Fifty-eight older adults first undertook a fall risk assessment; the Physiological Profile Assessment (PPA) which includes five sensorimotor and balance tests (simple reaction time, proprioception, knee muscle strength, visual contrast sensitivity and postural sway), and for which a weighted summary score provides a composite measure of fall risk. Participants who reported 1+ fall in the past year or a PPA score > 1 were classified as high fall risk (n=22). Cortical activation in prefrontal and motor brain areas was determined as relative changes in oxygenated and deoxygenated haemoglobin concentrations during a complex stroop stepping task relative to a simpler choice-stepping reaction time task, performed on a computerised step mat. ANOVA two-way examined interaction between groups (high fall risk versus low fall risk) and tests (stroop stepping task versus choice-stepping reaction





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time task). **RESULTS:** ANOVA interactions revealed the high fall risk group exhibited significantly decreased haemodynamic activity in the prefrontal cortex, supplementary motor area and premotor cortex and the low fall risk group exhibited significantly increased primary motor cortex activity in the stroop stepping task compared with the choice-stepping reaction time task. In the sample as a whole decreased prefrontal cortex activity was correlated with high stroop stepping task response time variability (coefficient of variation) (r=0.351; p=0.01). **CONCLUSIONS:** Instead of demonstrating older people at high fall risk require greater cognitive input to perform complex stepping tasks (our primary hypothesis), we found those at high fall risk had decreased cortical activity in the prefrontal and motor areas when performing the stroop stepping task. This may indicate that older people with a high physiological fall risk have limited cognitive resources, and/or reduced capacity to recruit motor neurons to perform challenging balance tasks. The significant association between decreased prefrontal cortex activity and increased stroop stepping task response time variability complements previous research that has found reduced executive function is associated with poor gait adaptability in older people [1]. Reference 1. Caetano et al. J Gerontol (Med Sci) 2017;72:1257-63.

P3-E-38 The neural correlates of discrete gait characteristics in ageing: A structured review

Joanna Wilson¹, Liesl Allcock², Riona Mc Ardle¹, John-Paul Taylor¹, Lynn Rochester³

¹Newcastle University, ²Hexham General Hospital, ³Institute of Neuroscience, Newcastle University

BACKGROUND AND AIM: Gait is complex, described by diverse characteristics that are underpinned by widespread central nervous system networks sub served by both motor and cognitive functions. Despite this, we do not know how discrete gait characteristics map to defined neural networks, limiting understanding of gait impairment in ageing and disease. This structured review aimed to understand what was already know from the literature and mapped gait characteristics, defined from a pre-specified model reflecting independent gait domains, to brain imaging parameters in older adults. **METHODS:** Three databases were used for the search: Medline, PsycInfo and Scopus. Terms relating to gait, neuroimaging and older adults were included within each search; the search was limited to full journal articles, written in the English language between 1990 and April 2018. Articles were included if they quantitatively assessed gait in healthy older adults under single task conditions, utilising at least one of the characteristics within the model of gait, and used at least one brain imaging technique. Both cross-sectional and longitudinal study types were included. RESULTS: Fifty-two studies of 38,029 yielded were reviewed. Gait impairments typically associated with brain deterioration, specifically grey matter atrophy and white matter integrity loss. Gait velocity, a global measure of gait performance, was the only gait characteristic frequently assessed. Slower gait velocity was associated with grey matter atrophy and white matter integrity loss within frontal and basal ganglia regions, and its





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decline was predicted from white matter volume and integrity measurements. Only ten studies used functional imaging techniques to derive brain imaging parameters; the only replicated finding from these demonstrated that increased amyloid beta burden was associated with slower gait velocity. **CONCLUSIONS:** Studies showed inconsistent approaches when mapping gait characteristics to neural substrates, limiting conclusions. Although global associations have been more concretely assessed, an emerging specificity of associations between discrete characteristics of gait and neural networks is evident. Future studies mapping regional neuroanatomical and functional correlates of a wide range of gait characteristics are needed, including those which take a multi-process network perspective, to better understand mobility in health and disease. **ACKNOWLEDGEMENTS AND FUNDING:** This research was supported by the Wellcome Trust and the NIHR Newcastle Biomedical Research Centre awarded to the Newcastle upon Tyne Hospitals NHS Foundation Trust and Newcastle University.

P3-E-39 Cortical muscle synergy representations reveal functional modulation as a function of short-term balance training

Coen Zandvoort¹, Jaap van Dieën¹, Nadia Dominici¹, Andreas Daffertshofer¹

¹Vrije Universiteit Amsterdam

BACKGROUND AND AIM: In neuromotor control, the dimensionality of complex muscular activation patterns is effectively reduced through using muscle synergies. Muscle synergies are tailored to task-specific biomechanical needs. Traditionally, they are considered as lowdimensional neural output of the spinal cord. As such, they have particularly been evaluated as spinal output leaving their coherent cortico-muscular pathways underexplored. Here, we investigated whether synergies have a higher-order origin in the brain and, especially, whether they are manifest in the cortical motor network. We focused on cortical muscle synergy representations involved in balance control and examined changes in cortico-synergy coherence accompanying short-term balance training. **METHODS:** Fifteen healthy young adults participated in a longitudinal study including intra-individual pre/post training comparisons. Participants performed a unipedal right-legged balance task in which they had to react to perturbations imposed by rotations of the support surface in the frontal plane. Pre/post recordings were intermitted by a balance-training program of 30 minutes in which participants practiced their balance on unstable wobble boards. Before and after balance training, 64-channel electroencephalography and electromyography of nine key muscles of the stance leg were coregistered. The muscular activity of the nine leg muscles was decomposed into three muscle synergies using non-negative matrix factorization. Coherent cortico-spinal sources of the muscle synergies were cortically localized and reconstructed using adaptive spatial filters. Corticosynergy coherence between the source-reconstructed activity of the left paracentral lobule and decomposed activation patterns was estimated as a measure of functional cortico-spinal connectivity. **RESULTS:** We found comparable muscle synergies pre- and post-training. These





muscle synergies were significantly active during the balance task as rendered by time-locked amplitude modulation. Broad-band oscillatory activity of the muscle synergies was cortically localized in primary motor cortex and neighboring areas. The resulting cortico-synergy coherence was most pronounced at the left paracentral lobule and revealed a phase-locked gamma-band activity around 40 Hz, i.e., at the Piper rhythm. The Piper rhythm was significant for the cortico-synergy coherence estimates of the three muscle synergies. Short-term balance training revealed a decrease of the cortico-synergy coherence at this Piper rhythm. **CONCLUSIONS:** Our results clearly showed that muscle synergy representations are present in the motor cortex. We concluded that neural oscillations propagate between the motor cortex and spinal motor neuron pools representing muscle synergies. The corresponding cortico-synergy coherence, in particular around the Piper rhythm, highlights modulation in the course of short-term balance training.

F - Cognitive impairments

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P3-F-40 Gait as a potential marker of cognitive decrements in Type 2 Diabetes (T2DM): Early results from the ENBIND study

Adam Dyer¹, Isabelle Killane², Benjamin Campbell², Killian Tobin², Richard Reilly¹, Isabella Batten¹, Nollaig Bourke¹, James Gibney¹, Sean Kennelly¹

¹Trinity College Dublin, ²Dublin Institute of Technology

BACKGROUND AND AIM: Type 2 Diabetes (T2DM) in midlife represents a potent risk factor for the development of dementia in later life. Early indicators to highlight particular individuals with T2DM who are at risk of cognitive decline are lacking. Subtle abnormalities in gait (and particularly dual-task gait with a cognitive task) have emerged as a potential predictor of cognitive decline in older adults, but have not been investigated in patients with T2DM. The ENBIND Study (Exploring Novel Biomarkers of Brain health IN Diabetes) aims to assess patients with T2DM in midlife without cognitive impairment and follow participants over the course of several years to establish early predictors of cognitive decline in this poorly characterised yet high-risk group. METHODS: Patients with midlife T2DM (45-60 yrs) were recruited at the time of their diabetic clinic appointment. Patients were excluded if they had a diagnosis of peripheral neuropathy, peripheral vascular disease, musculoskeletal disease, previous stroke, any form of diagnosed cognitive impairment or any form of diabetic retinopathy/nephropathy. Patients underwent medical/diabetes assessment and examination by a physician. Cognition was screened using the Montreal Cognitive Assessment (MoCA) and assessed using a computerised cognitive battery designed for prodromal Alzheimer's Disease (CANTAB®). Gait was then assessed using both a raw clinical measure (stopwatch) and Shimmer® Inertial Measurement Units (IMUs) across four tasks: (i) 30 metre walk at a normal pace (turn at 15m), (ii) 30 metre fast walk (turn at 15m) (iii) dual cognitivegait task (reciting alternate letters of the alphabet) and (iv) a long walk at a self-selected pace. Between group differences were assessed using t-tests and appropriate non-parametric





equivalents **RESULTS**: 20 participants with T2DM (52.05 yrs ± 2.13) and 10 matched healthy volunteers (mean age 52.2 yrs ± 2.74) were recruited. T2DM was associated with a significantly lower score on the MoCA (29.2 vs 27.6; p=0.0452). Participants with T2DM had slower but non-significant self-selected (0.87 ms-1 vs 0.8ms-1) and fast gait speed (0.66 ms-1 vs 0.59 ms-1). On the dual-cognitive task, participants with T2DM made more errors (1.1 vs 0.6), and had higher dual-task cost (9.17% vs 2.7%, p=0.014). Dual-task cost (the percentage decrement in walking speed due to **Introduction** of the cognitive task) was significantly correlated with total MoCA score (R2 = 0.17, p =0.031). **DISCUSSION**: Otherwise healthy participants with midlife T2DM display significantly poorer scores on MoCA. Performance on the dual-cognitive gait task was significantly correlated with MoCA score. Our study adds evidence to the presence of cognitive decrements in midlife T2DM, in-keeping with its role as a potent risk factor for the later development of dementia. We provide early data to support the utility of simple clinical gait analysis, particularly where a dual-cognitive paradigm is employed. Expansion of the sample size of patients in this study as well as longitudinal follow up should afford more detailed insight into using gait as a potential marker for cognition in this high risk cohort.

P3-F-41 Gait as a signature of cognitive impairment and dementia disease subtype

Riona Mc Ardle¹, Brook Galna¹, Alan Thomas¹, Lynn Rochester²

¹Newcastle University, ²Institute of Neuroscience, Newcastle University

BACKGROUND: Distinguishing dementia disease subtypes can be difficult due to clinical and pathological similarities and may hinder accurate diagnosis, particularly between Alzheimer's disease (AD) and Lewy body disease (LBD). Effective treatment and disease management is reliant on diagnostic accuracy. Gait analysis may be a potential clinical tool to aid differential diagnosis as gait impairments are closely associated with cognitive impairment. Discrete gait characteristics are also associated with specific cognitive domains. Therefore, gait may indicate underlying disease pathology in the brain, and disease subtypes may have unique signatures of gait relating to subtype-specific pathology. This study aims to assess if gait analysis can distinguish people with cognitive impairment from age-matched controls, and differentiate people with AD and LBD. METHODS: 110 participants were recruited across three groups; 36 AD ((mean±sd) Age: 77±6; sMMSE: 23±4), 45 LBD (Age: 77±6; sMMSE: 24±4) and 29 controls (Age: 74±9; MMSE: 29±1). Dementia disease subtypes ranged in severity from mild cognitive impairment to moderate dementia. Gait was assessed using an instrumented walkway (GAITRite) under single-task walking conditions. A battery of cognitive tests were employed. One-way ANCOVA controlling for age, sex and height were used to identify group differences ($p \le .01$) and backwards multivariate regression explored which cognitive variables explained discrete gait impairments across disease subtypes. **RESULTS:** Both AD and LBD groups walked slower ($p \le .001$), with shorter ($p \le .001$) steps and greater variability (swing, step and stance time, step length; $p \le .01$ for all) compared to controls. Participants with LBD also had greater step velocity variability ($p \le .001$), wider steps ($p \le .001$),

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longer step time (p = .010) with greater asymmetry for step (p = .006) and swing time (p = .003) compared to controls. The LBD group could be distinguished from AD with greater step time (p = .003) and length variability (p≤.001), and greater step (p≤.001), stance (p = .008) and swing time asymmetry (p≤.001). In LBD, executive function (measured by FAS test) explained 10.8% and 11.3% of the variance for step and stance time variability respectively, while in AD, global cognitive impairment (measured by sMMSE) explained 13.5% of the variance in step velocity variability. **DISCUSSION:** Gait impairment can distinguish cognitive impairment from normal ageing and differentiate dementia AD and LBD disease subtypes. Gait variability are somewhat explained by global cognition and executive function, functions mediated by the prefrontal cortex. This area of the brain is affected early in LBD and later in AD; therefore gait impairment in LBD may support suggestions of prefrontal involvement in the facilitation of gait. Greater gait asymmetry in LBD may be due to the unilateral onset of the disease, reflecting an asymmetrical neurodegeneration. Future research is required to establish gait's specificity, in addition to sensitivity, as a diagnostic tool. Acknowledgements: This research was supported by the Alzheimer's Society and the NIHR Newcastle BRU/BRC based at NUTH & Newcastle University.

P3-F-42 Association of gait domains and incident falls in mild cognitive impairment: Results from the gait and brain study

Frederico Pieruccini-Faria¹, Yanina Sarquis-Adamson¹, Manuel Montero-Odasso¹

¹University of Western Ontario

Background - Mild Cognitive Impairment (MCI) is an intermediate state between normal cognition and dementia. In addition to rapid cognitive decline, older individuals with MCI also present with worse gait performance and have double the risk of falls with injuries compared to cognitively normal older adults. Although the association between falls and gait performance in aging has been relatively well established, it remains unclear how and whether gait performance is associated with falls, particularly falls with injuries, among older adults with MCI. Aims - To investigate associations between gait domains and incident falls in MCI in a study with up to 5years follow-up. Methods - A total of 133 older adults diagnosed with MCI with a mean age of 74.09 ±6.46 years (47.4 % women) were assessed for 11 spatiotemporal gait variables, including variabilities, using a 6-m instrumented walkway (Zeno® mat) at baseline. Falls and their consequences (i.e. injuries), and the time-to-event when the fall occurred were computed using falls calendars. Principal component and factor analyses using "varimax" rotation procedure for factor score extraction were applied to group gait parameters with highest loadings in each gait domain. Only gait parameters with the highest loadings from each gait domain were included into regression models. Multivariable linear regression and Cox-proportional regression models were both used to investigate associations between gait parameters and incident falls within a 6 to 60 months follow-up period (mean of 30.69 ±23.66 months). Statistical analyses were adjusted for age, sex, years of education, number of comorbidities, global cognition, history of falls within the

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previous 12 months at baseline and individuals' follow-up duration. Results - Four components (gait domains) emerged from the factor analysis: pace, rhythm, variability and postural control that accounted for 83% of the variance in baseline gait performance. A total of 127 falls were reported during the follow-up period, and 47 of them (37%) caused injury. Multivariable linear regression analyses revealed that only the variability domain was significantly associated with falls, specifically the total number of injurious falls during the follow-up period (p=.007). Stride length variability was the highest loading individual variable within the variability domain and it was also associated with total number of incident injurious falls (Beta = .43; 95% CI .05 to .41; p=0.01). These associations remained statistically significant after controlling for potential confounders. No statistically significant associations between gait domains and total number of falls without injuries were found. Associations between gait domains and risk of incident falls (Hazard ratios) were not statistically significant. Conclusion - This study demonstrated that the occurrence of incident injurious falls in MCI are exclusively associated with the gait variability domain. Specifically, this association suggested that injurious falls in MCI may be caused by abnormal regulation of stride length dynamics while navigating. Efficacy of falls prevention interventions in MCI populations may be optimized by acting on mechanisms of stride length regulation.

P3-F-43 Older people with dementia have reduced daily-life activity and impaired daily-life gait when compared to age-sex matched controls

Morag Taylor¹, Matthew Brodie¹, Kimberley van Schooten¹, Kim Delbaere¹, Jacqeline Close¹, Narelle Payne¹, Lyndell Webster¹, Jessica Chow¹, Garth McInerney¹, Susan Kurrle², Stephen Lord¹

¹Neuroscience Research Australia, University of New South Wales, ²University of Sydney

BACKGROUND AND AIM: Understanding the characteristics of daily-life activity, such as gait, in older people with dementia may assist in identifying people at risk of negative health outcomes and could highlight opportunities for targeted interventions. The study aims were to (a) compare daily-life activity and gait between community-dwelling older people with mild to moderate dementia and age-sex matched cognitively healthy controls, and (b) examine daily-life activity and gait correlates (self-reported physical activity [PA], history of falls and cognitive function) in older people with dementia. METHODS: Forty-five participants with mild to moderate dementia (mean age 81±6 years, 42% female) and 90 age-sex matched cognitively healthy controls (1:2) wore a tri-axial accelerometer (DynaPort MoveMonitor, McRoberts) on their lower back for 7-days. Participants were also assessed on self-reported PA (Incidental and Planned Exercise Questionnaire) and cognitive (Montreal Cognitive Assessment or mini-Addenbrooke's Cognitive Examination, Trail Making Test A and B and phonemic fluency) and physical performance (gait speed assessed under standardized conditions and the Timed-Up-and-Go). RESULTS: Compared to age-sex matched controls, participants with dementia demonstrated reduced daily-life activity (fewer steps per day [Kruskal-Wallis H(1)=25.18, p<0.001], fewer [H(1)=17.77, p<0.001] and shorter walking bouts [H(1)=4.05, p=0.044] and lower daily walk time [H(1)=17.65, p<0.001];





Figure 1), gait intensity (reduced speed [H(1)=16.63, p<0.001], stride length [F(1, 126)=12.47, p=0.001] and cadence [F(1, 133)=8.07, p=0.005]; Figure 1) and between-walk adaptability (reduced vigor interquartile range [H(1)=15.52, p<0.001]; Figure 1). Participants with dementia also had increased within-walk variability (stride time [H(1)=11.61, p=0.001]; step peak [F(1, 133)=15.92, p<0.001]; Figure 1) and less regular gait (higher sample entropy: vertical [H(1)=5.10, p=0.024] and anteroposterior [H(1)=12.90, p<0.001]; Figure 1). Within the group of participants with dementia, daily-life activity was significantly correlated with self-reported PA, executive function and clinical physical performance measures. Daily-life gait characteristics (e.g. walking speed) were significantly correlated with clinical physical performance measures, and fallers (1+ falls past year) had significantly reduced daily-life activity and walking speed compared to nonfallers in participants with dementia. CONCLUSIONS: People with dementia are less active in daily-life and present with significant multi-domain daily-life gait impairments when compared to age-sex matched controls. To address these deficits, potential interventions could target daily-life activity and include bouts of sustained walking with feedback to encourage increased speed and reduced variability. The effect of these interventions need further evaluation, particularly with respect to fall outcomes while considering activity exposure.

G - Cognitive, attentional, and emotional influences

P3-G-44 The effects of virtual reality-induced postural threat on performance of a walking balance task.

Amir Boroomand-Tehrani¹, Andrew Huntley², David Jagroop², Jennifer Campos², Kara Patterson¹, Luc Tremblay¹, Avril Mansfield²

¹University of Toronto, ²Toronto Rehabilitation Institute

BACKGROUND AND AIM: Rapid motor learning may occur in situations where injuries are a consequence to making a motor error. Perceived threat may stimulate the body to mobilize resources to optimize motor performance and shift attention to the most vital information. These adaptive reactions may lead to more errorless practice, potentially facilitating the rapid motor learning that is observed in threatening situations. As a first step towards understanding the role of perceived threat on motor learning, the purpose of this study is to determine if performance of a balance task is affected by different levels of perceived threat. Virtual reality (VR) technology provides a safe technique for experimentally introducing perceived threat of injury. We hypothesized that perceived threat of injury introduced within a virtual environment (VE) will result in improved motor performance in a balance beam walking task (i.e., higher frequency of successful steps and reduced trunk movement variability). **METHODS:** In this study, healthy young adults were asked to walk on a beam under 3 conditions: 1) low-threat real environment (RE); 2) low-threat VE; and 3) high-threat VE. Threat was introduced by virtually simulating a balance beam elevated over heights that appear to be dangerous. Performance was evaluated by





assessing frequency of successful steps and variability of trunk movements. Physiological arousal and state anxiety were characterized using electrodermal responses and questionnaire scores in order to evaluate the intended effect of increasing perceived threat in a VE. **RESULTS:** Preliminary data from 8 participants suggests that step success was higher in the high-threat VE (median (M)=54.1%) than the low-threat VE (M=45.4%). Trunk movement variability was highest in the RE (M=32.2cm) and similar across the 2 VEs (M=28.9cm and 29.5cm for high-threat and low-threat VEs, respectively). Although electrodermal responses were similar across all conditions (M=0.18µS, 0.17µS, and 0.16µS in the RE, low-threat VE, and high-threat VE, respectively), state anxiety scores were greatest in the high-threat VE (M=43, 49, and 56 in the RE, low-threat VE, and high-threat VE, respectively), providing support that our methods were sufficient to induce perceived threat. Data from the full sample will be presented at the conference (target n=24). **CONCLUSIONS:** Higher perceived threat appears to optimize walking balance performance. Differences in performance and state anxiety between the 2 low-threat environments may indicate a need for design improvement and/or reflect inherent differences between VR and realenvironment walking. These findings can provide guidance for similar studies, as well as studies that investigate the effects of threat on long-term motor learning. Learning in VR may be beneficial in situations where the consequences of error in the real world, particularly pertaining to balance errors and falls, are high. ACKNOWLEDGEMENTS AND FUNDING: This work is supported by the Natural Sciences and Engineering Research Council of Canada and the Ministry of Research and Innovation (Ontario). The authors acknowledge the support of the Toronto Rehabilitation Institute.

P3-G-45 Move aside: Approach-avoidance theories scrutinized

Daniëlle Bouman¹, John Stins¹, Peter Beek¹

¹Vrije Universiteit Amsterdam

BACKGROUND AND AIM: Approach and avoidance motivations stem from our emotions and make us more inclined to approach pleasant and avoid unpleasant stimuli. This disposition forms the basis for many studies on movement and emotion. But how should approach and avoidance behavior be conceptualized? The Distance Regulation (DR) account holds that the change in bodily distance relative to the stimulus determines whether behavior is approach- or avoidance-oriented: Increasing the distance between oneself and a stimulus represents avoidance, and decreasing the distance represents approach. In contrast, the Evaluative Response Coding (ERC) theory emphasizes the cognitive labelling of the movement as an approach or avoidance response: If a movement is mentally classified as 'towards', it constitutes an approach movement, but if the same movement is classified as 'away from', it constitutes an avoidance movement. Both the DR and the ERC account are supported by empirical evidence (for an overview, see Beatty et al., 2016). We aim to directly compare the two theories, and to see which theory is supported by the evidence, using a whole-body movement approach-avoidance task. **METHODS:** In a series of





three experiments, participants step sideways (left or right) on a force platform in response to two faces presented laterally on the screen in front of them. One of the faces always has a neutral facial expression, while the other is either happy or angry. Previous research has shown that happy faces generally elicit an approach response, while angry faces often elicit an avoidance response. To compare the two theories, both distance and response labels are manipulated by varying instructions in a within-subjects design. Half of the trials instruct participants to step 'towards' one of the two faces on the screen, and the other half of the trials instruct them to step 'away from' one of the faces. By varying the location of the neutral and emotion faces (left or right), both the 'towards' and 'away from' instructions lead participants to decrease the distance to happy and angry faces just as often as it leads them to increase the distance, thereby facilitating different predictions of the DR and ERC paradigms. Dependent variables include reaction time, peak velocity, step size, and anticipatory postural adjustment, derived from the center-of-pressure time series. **RESULTS:** Experiments are ongoing and we expect to have results in the Spring. Both the DR and the ERC have specific predictions regarding reaction times. With these series of experiments we will be able to tease apart the aforementioned theories. CONCLUSIONS: This is, to our knowledge, the first series of experiments that explicitly compares two theories of approach-avoidance behavior to see what constitutes approach-avoidance behavior: physical distance change or mental response labels. ACKNOWLEDGEMENTS AND FUNDING: This research is funded by the Netherlands Organisation for Scientific Research (NWO). Grant number: 406-14-077. REFERENCE: Beatty, GF, Cranley, NM, Carnaby, G, & Janelle, CM. (2016). Emotions predictably modify response times in the initiation of human motor actions: A meta-analytic review. Emotion, 16(2), 237-251.

P3-G-46 Priming distorts sense of instability during postural control

Adolfo Bronstein¹, Patricia Castro¹, Sami Mahmoud², Efstratia Papoutselou¹, Constanza Fuentealba³, Qadeer Arshad¹

¹Imperial College London, ²Technische Universität München, ³Universidad San Sebastian

Purpose: Previous studies have suggested a link between anxiety and postural control. Additionally, providing information to participants before a postural task has proven to modulate their performance. Previously, we have shown that subjective instability correlates well with anxiety and with postural sway in healthy individuals. Here, we investigated whether it is possible to modulate these correlations by changing expectations via visual and verbal priming. **METHODS:** Experiment 1: 30 healthy participants (19-36yr) performed a postural task standing moving sled. Before performing the task, subjects were randomly allocated into one of two groups and watched a video of a person having a stable performance (Group 1) or the same person on an unstable performance (Group 2) in the task. Objective measures of body sway were recorded and subjective measures of instability and anxiety. Experiment 2: 25 healthy volunteers performed the postural task on the moving platform but this time they completed 6 trials, half of these without





previous verbal information but with different sled movement amplitude and half with the same sled amplitude but three different previous information. Objective and subjective measures of instability and anxiety were obtained. **RESULTS:** Experiment 1: We observed a strong correlation (r=.531; p=.042) between upper trunk sway and subjective instability ratings in Group 1. This relationship was abolished in Group 2 (r=.213; p=.447). No significant between-group differences were found in measures of sway, subjective instability or anxiety. However, in Group 1 anxiety was significantly higher after the task (p<.05). Experiment 2: There was a different perception of instability with different sled amplitudes, even when no information was given, which confirms previous findings. However, we observed a difference in the subjective instability perception in the trials with different previous information even when the objective platform movement was the same for all trials. **CONCLUSION:** We showed that it is possible to distort the perception of instability, which usually correlates with objective instability measures, by changing expectations using visual and verbal priming. This finding highlights the prominent influence that expectation and anxiety can have on the perception of self-stability.

P3-G-47 Patterns of dual-task interference at hospital discharge post stroke

Jody Feld¹, Prudence Plummer¹

¹University of North Carolina at Chapel Hill

BACKGROUND AND AIM: Community ambulation requires negotiation of complex, dynamic environments, often while simultaneously performing cognitive tasks (i.e., dual-tasking). Dual-task interference in chronic stroke survivors usually presents as decrements in both gait and cognitive performance (mutual interference) or in gait performance only (gait interference). Further, poststroke dual-task interference has been primarily studied in chronic stroke (>6 months). The aim of this study was to examine the patterns and magnitude of dual-task interference at hospital discharge post stroke. METHODS: Thirty-two adults (66% male) with median age of 62.0 years (IQR=52.3-65.0) and 9.0 days post stroke (IQR=3.5-17.0) completed 4 walking trials; 2 each of single and dual-task walking (category-fluency task). Subjects were not specifically instructed to prioritize either task. The category-fluency task was completed twice while seated (single-task). The order of the single-task cognitive and dual-task walking trials was randomized. Walking trials involved continuous 1-minute passes over an instrumented walkway, turning off the walkway at each end, so that only steady-state strides were acquired for analysis. Verbal responses during category-fluency were recorded with a wireless headset. The gait variables were gait speed (m/s), stride time (s), stride time variability (coefficient of variation, %), stride length (m), and cadence (steps/min). The cognitive variable was correct response rate (words per minute, WPM). Dualtask effects on gait speed (DTEg, %) and correct response rate (DTEc, %) were calculated. Differences between the single- and dual-task conditions were examined using paired sample ttests. A performance operating characteristics (POC) curve was used to examine dual-task interference patterns and tradeoffs between gait speed and cognitive task performance in dual-

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task conditions. **RESULTS:** There were significant differences between single and dual-task gait speed, stride length, stride time, stride time variability, and cadence, but not correct response rate, suggesting overall that participants displayed gait interference, but not cognitive interference. However, we observed mutual interference patterns in 38% of subjects, gait interference in 25%, and cognitive priority trade-off in 25%. Thus, there was greater variability in the dual-task effect on cognitive performance than gait performance. Average DTEg was -21.7% (SD=15.2) whereas average DTEc was 0.3% (SD=42.0). **CONCLUSIONS:** The predominant patterns of mutual inference and gait interference in subacute stroke survivors suggest inadequate attentional resources for dual-task walking, which is consistent with previous findings in chronic stroke. Insufficient attentional resources for dual-task walking may impede functional mobility and community participation. Overall, stroke survivors placed a higher priority on the cognitive task despite their gait deficits, possibly increasing their risk for falls. **ACKNOWLEDGEMENTS AND FUNDING:** This work was supported in part by a Promotion of Doctoral Studies (PODS) - Level II Scholarship from the Foundation of Physical Therapy and Philanthropic Educational Organization Scholar Award.

P3-G-48 The effect of age and anxiety on objective and subjective instability

Patricia Castro¹, Diego Kaski², Richard Ibitoye¹, Marco Schieppati³, Michael Furman¹, Qadeer Arshad¹, Adolfo Bronstein¹

¹Imperial College London, ²University College London, ³Lunex University

BACKGROUND AND AIM: Objective and subjective instability have been observed to be well correlated when measured under static conditions. The aim of this study is to investigate the relationship between objective and subjective instability and to determine the effect of age and anxiety in this relationship when measured using dynamic challenging conditions. METHODS: 50 healthy participants (aged 18-83 years) stood on a moving platform. Six back and forth oscillatory stimuli of different magnitude were delivered with and without a fall-preventing harness (aimed at reducing task-related anxiety). We measured sway path, hip angular velocity, foot-lift counts and subjective instability and task-related anxiety **RESULTS**: The subjective perception of stability accurately matched objective body sway, following a logarithmic function profile (r2=0.72, p<0.001). This function did not change significantly with age, harness or task presentation order. A strong relationship was observed between the subjective measures of stability and task-related anxiety (r=0.812, p<0.001) Higher anxiety levels were associated with increased subjective unsteadiness in the older subjects. Preliminary data suggest that this relationship could be changed in patients with balance disorders. CONCLUSIONS: Subjects accurately rate their own instability during dynamic postural challenges, irrespective of age and anxiety. However, patients with balance disorders would show a significant difference in this relationship compared to healthy subjects. The influence of anxiety upon subjective instability showed to be greater for the older group and could be even bigger in patients with balance problems.





P3-G-49 The nature of motor-cognitive relationship beyond age and disease

Inbal Maidan¹, Preeti Sunderaraman², Eran Gazit¹, Anat Mirelman¹, Yaakov Stern², Jeff Hausdorff¹

¹Tel-Aviv Sourasky Medical Center, ²Columbia University Medical Center

BACKGROUND AND AIM: There is compelling evidence that motor function such as gait and cognition are interrelated. However, both gait and cognition are multifaceted - gait can be quantified using pace, rhythm, asymmetry, and variability, and cognition using domain-specific functions including executive functioning, memory, language, and processing speed. Moreover, this association can be influenced by the task complexity (simple vs. dual tasking (DT)) and by the manner in which cognition is measured (paper and pencil tests vs. computerized tests). Therefore, the aim of the study is to better understand the specific nature of motor-cognitive relationship in a cohort of healthy adults spanning the developmental lifespan from age 20 to 80. **METHODS**: One hundred and twenty four healthy adults (age: 61.5±11.9 years, 56% females) completed a comprehensive cognitive battery consisting of various cognitive domains, while gait was measured under various task conditions including usual walking, DT walking, and the Time Up and Go (TUG) that were performed while wearing a three-axis accelerometer on the lower back. The gait measures were divided into six motor domains: 1) transitions and 2) turns from the TUG, and 3) variability, 4) asymmetry, 5) rhythm, and 6) pace. Spearman's rank correlations between each pair of motor and cognitive variables were calculated after adjusting for age and gender. First, all pair of motor-cognitive variables were screened according to their family's Simes p-value. Each family consisted of correlations of cognitive domain with one motor variable. P-values within each family that passed the screening stage were adjusted for multiple comparisons to control for false discovery rate at level 0.05. **RESULTS:** Executive function was correlated with turn duration (p<0.013), range of sit to stand (p=0.003), DT stride time variability (p=0.004), and DT step asymmetry (p=0.003). Language was correlated with DT stride time variability (p<0.006) and processing speed was associated with DT step regularity and stride regularity (p<0.007) and turn duration (p=0.003). Rhythm was not significantly associated with any of the cognitive domains. Notably, about half of the motor-cognitive associations involved cognitive measures using traditional paper-and-pencil based tests. CONCLUSIONS: Executive function, perceptual speed, and language were associated with distinct and overlapping facets of gait, suggesting that different combinations of cognitive systems are responsible for different gait features. Across most facets of cognition, the cognitive-gait association was primarily observed during the DT conditions, indicating that in healthy individuals the association between cognition and gait depends on the task condition. Perhaps in the single task condition, gait is more automatic and less cognitively demanding at least among healthy adults. However, with a cognitive load, both gait and cognitive processes become involved.





P3-G-50 Fear of heights saturates 20 to 40 meters above ground

Max Wühr¹, Katharina Breitkopf¹, Julian Decker¹, Gerado Ibarra¹, Doreen Huppert¹, Thomas Brandt¹

¹Ludwig-Maximillians Universität München

BACKGROUND AND AIM: One-third of the general population suffers from a more or less disabling visual height intolerance (vHI) with relevant impact on quality of life. Acrophobia, the most severe form of vHI, has a life-time prevalence of around 5%. Although it is commonly believed that fear of heights should continuously aggravate with increasing elevation, this issue has not been systematically investigated yet. Here, we examined this topic by using immersive virtual reality, an established tool in therapy for fear of heights, that allows to flexibly manipulate height stimuli. **METHODS:** In a comprehensive cohort (insusceptible and vHI up to acrophobia) vHI severity was graded by an established metric scale (vHISS). Participants were randomly exposed to different virtual elevations using a head-mounted display. RESULTS: Behavioral responses to virtual height exposure were analogous to exposure in vivo. Participants exhibited increased anxiety and musculoskeletal stiffening with enhanced high-frequency body sway, to an extend that corresponded to individual vHISS ratings. All behavioral responses saturated above a certain altitude. Body sway and musculoskeletal stiffening became maximal at 20 m above ground, whereas anxiety saturated above 40 m. CONCLUSIONS: These results suggest, that fear of heights is characterized by a nonlinear stimulus-response relationship and a dissociation between visual-height-induced bodily and emotional reactions.

P3-G-51 The influence of virtual height on visually evoked balance responses

Emma Nielsen¹, Taylor Cleworth², Mark Carpenter¹

¹University of British Columbia, ²University of Waterloo

BACKGROUND AND AIM: While postural threat associated with standing on elevated support surfaces has been shown to influence both vestibular and proprioceptive processes [1,2], its influence on visual contributions to balance is less understood. Virtual reality (VR) provides a unique platform for delivering visually-perturbing stimuli in a safe and immersive manner, while simultaneously manipulating the environment to impose a state of postural threat [3]. In this project, we aimed to evaluate balance responses during visual perturbations in VR and the influence of virtual height on these responses. **METHODS:** Eleven young healthy adults (9 female) stood on a force plate while immersed in a virtual environment produced with a head mounted display (Oculus Rift). A randomly generated continuous signal ranging from 0-1Hz was used to deliver oscillatory movements of the visual scene in the antero-posterior (AP) direction (max. amplitude = 5cm). Participants completed four individual 5-minute standing trials with the continuous visual perturbations, alternating between the LOW (ground level) and HIGH (7m





elevated) conditions (order of trials: LOW1, HIGH1, LOW2, HIGH2). Electrodermal activity (EDA) recorded from the palm of the left hand and self-reported measures of fear, anxiety and confidence were collected. Electromyography (EMG, 1000 Hz; Noraxon) was recorded from unilateral Soleus, Tibialis anterior and medial Gastrocnemius, as well as full body kinematics (100 Hz; Optotrak, NDI). Ground reaction forces and moments (1000 Hz; AMTI) were used to calculate center of pressure (COP). All data were concatenated within each height condition and used to calculate coherence and cross-correlations between the visual stimulus and key outcome measures (COP, body displacement and EMG). **RESULTS:** Significant changes in fear, anxiety, and confidence were observed when standing in HIGH compared to LOW conditions (p<0.05). Preliminary evidence demonstrated significant coherence between COP and the visual stimulus between ~0.09 and 1 Hz in both conditions, with larger coherence in the lower frequency range for HIGH compared to LOW conditions. Cross-correlations from the concatenated data show positive and negative peaks at ~0.6s and 2.6s, and a larger peak-to-peak response for the HIGH condition. CONCLUSIONS: The novel application of a stochastic visual stimulus reveals that visually-evoked balance responses are sensitive to a range of input frequencies. Preliminary evidence suggests that there may be differences in the coherence and amplitude of visually evoked balance responses when standing under conditions of increased postural threat. The results of this study provide further evidence for increases in multi-sensory gain during a threat to balance [1,2,4]. REFERENCES:[1] Horslen BC et al. (2018) J Physiol; [2] Naranjo EN et al. (2015) Neuroscience; [3] Cleworth TW et al. (2012) Gait Posture; [4] Horslen et al. (2013) J Neurophys. ACKNOWLEDGEMENTS AND FUNDING: Funded by NSERC.

H - Coordination of posture and gait

P3-H-52 Tumors of cerebellum effect on saccadic system and gait

Alina Aizenshtein¹, Marina Shurupova¹, Vladimir Kasatkin¹, Dmitriy Skvortsov², Alexander Karelin¹

¹Dmitry Rogachev National Research Center of Pediatric Hematology, Oncology and Immunology, ²Federal Research and Clinical Centre of Russia's Federal Medical-Biological Agency (FNKC FMBA)

BACKGROUND AND AIM: Motor system of human body has two subdivisions: gross (for example, gait) and fine (ocular system) which are controlled by motor cortex, basal ganglia, cerebellum and some others regions. The most important part of ocular system for everyday life is saccadic eye movements. In clinical practice for evaluation gait and posture usually use tandem gait (counting number of steps taken and time of walking). However applying 3-D analysis is more informative for diagnostic in patients. Aim of present study was to compare parameters of saccadic eye movements and kinematics characteristics of tandem gait in children survived after cerebellum tumors. **METHODS:** Research was conducted on 15 patients (8 males, 7 females, 9-17 years old, M=13.4±2.5) who survived cerebellar tumor. We used optical system Optitrack





Motion Capture (12 cameras Flex 13, 120 Hz) for estimating kinematics of tandem gait. A set of 26 reflective markers were placed on anatomical landmarks of subject body (fig. 1). As soon as reflective markers were attached subjects were asked to walk 4.5 meters, heel-to-toe, without spaces between feet along the straight white line marked on the floor. Patients were tested with eyes open in sock-covered feet on covering. For present research, we used data from only one marker on heel. Visual 3D software was used to calculate kinematics of heel motion (trajectory) within full gate cycle for left leg: length of step (L), amplitude of step (A), their relation L/A and step time. For correlation analysis between motor and ocular systems we took coefficient of variation (CV) of L, A and relation L/A as a measures of gait variability. Also we used eye tracker Arrington Research 60 Hz for estimating saccades parameters. Patients were asked to perform 20 visually guided saccades to the tops of the square demonstrated on the computer monitor. We calculated percent of hypermetric saccades (saccades which overshoot the target and are incorrect) (PHS) and scanpath (S, sum of the all saccades amplitudes). RESULTS: According to Spearman's correlation analysis strong correlations between tandem gait and ocular parameters were revealed. High percent of hypermetric saccades associated with high CV of major tandem gait parameters: with length (r=0.539), amplitude (r=0.526) of steps and their relation (r=0.548). Moreover, elongate scanpath was related to high CV of step length (r=0.629). All p<0.05. However, no significant relation between step time and ocular parameters was found. CONCLUSIONS: We investigated to relationship between two different motor systems: gross (tandem gait) and fine (saccadic). After comparing saccade and tandem gait parameters it was discovered strong regularity that cerebellum lesions (as tumors) impair both systems: high variability of tandem gait linked to big amount of inaccurate hypermetric saccades. Thus, cerebellum plays important role in saccadic system and gait and posture. These results open new horizons for the diagnosis of CNS lesions.

P3-H-53 Daily variation in executive function predicts daily variation in dual task walking performance in older adults

Sarah Allen¹, Junhong Zhou², Alexa Ludington², Bonnie Wong¹, Brad Manor²

¹The Harvard Medical School, ²Harvard Medical School

BACKGROUND AND AIMS: The ability to walk safely while dual tasking (walking while doing a cognitive task such as speaking or thinking) is dependent on cognitive "executive" function. In older adults, dual task cost to gait speed, the reduction of gait speed from normal to dual task conditions, is predictive of future falls and cognitive decline. Despite evidence that both motor and cognitive performance vary from day to day, dual task walking is commonly assessed during only a single baseline visit. We therefore aimed to quantify the intra-subject daily variation in dual task walking performance in healthy older adults and establish the relationship between this variation and performance on a test of executive function (the Stroop test). **METHODS:** Thirty-three older adults free of overt illness or disease (74±7 years, 20 F) completed four study visits at the same





time of day, separated by at least five days. On each visit, participants completed a walking paradigm in which gait speed was measured during two, 25-meter walking trials in each of two conditions: walking quietly (normal) and walking while doing verbal serial subtractions of three from a random number between 200 and 999 (dual task). Executive function was assessed by the Stroop testing battery. Participant were asked to 1) read the names of colors printed in black ink, 2) read the names of colors in colored ink mismatched to the printed word, and 3) read the color of the ink ignoring the word written. Different versions of the Stroop test were used for each visit to minimize confounding. Primary outcomes included the dual task cost (% reduction) to gait speed and the Stroop interference score calculated using recommended procedures. **RESULTS**: Across all visits, the average dual task cost to gait speed was -11.6±2.2% (i.e., 11.6% reduction of gait speed from normal to dual task walking). The inter-subject daily variance in dual task cost was 26.9±40.2%. The average Stroop interference score was 3.5±7.8 and its daily variation was 0.08±1.6. Participants with greater Stroop interference scores (i.e., better executive function) tended to have smaller dual task cost to gait speed ($r^2=0.40$, p=0.003). Those with greater daily variation in Stroop interference score also had greater daily variation in dual task cost to gait speed (r²=0.34, p=0.004). All analyses were adjusted for age. **CONCLUSIONS:** In this cohort of relatively healthy older adults, dual task walking performance was highly variable across days, even when assessed at the same time of day within controlled laboratory conditions. The magnitude of daily variation in dual task performance was associated with the magnitude of daily variation in executive function. These results highlight the need for higher-frequency monitoring of functional outcomes within research studies, and potentially that fall prevention strategies may be optimized by intervening in periods of relatively poor dual task performance.

P3-H-54 Effects of discrete visual cues on anticipatory eye movement and segment rotation during walking turns in neurotypical young adults and persons with Parkinson's disease

Tyler Baker¹, Jenna Pitman², Adam Johnston¹, Andrew Godbout¹, Rebecca Reed-Jones¹

¹University of Prince Edward Island, ²University of Guelph

Aim and **BACKGROUND:** Anticipatory eye movement promotes cranio-caudal sequencing during walking turns, reducing the risk of falls. Individuals with Parkinson's disease (PD) have difficulty producing anticipatory eye movements which may limit cranio-caudal rotation sequencing during turning. Visual cues have the potential to promote anticipatory eye movement and cranio-caudal sequencing by guiding the eyes into the turn. The purpose of this study was to examine if discrete external visual cues could train anticipatory eye movement and cranio-caudal rotations during walking turns. We hypothesized that visual cues would have limited effects on a sample of neurotypical young adults (NYA), but would improve anticipatory eye movement and cranio-caudal sequencing in a sample group with PD. **METHODS:** 10 NYA (20-30 years) and 6 PD (45-75 years; Hoehn and Yahr 1-3) completed three blocks of walking trials with a 90-degree left turn.





Trials were blocked by visual condition: non-cued baseline turns (5 trials), visually cued turns (10 trials), and non-cued retention turns (5 trials). A Delsys Trigno (Delsys, Boston, MA) captured horizontal saccades at 1024 Hz via electrooculography (EOG). Two Optotrak cameras (Northern Digital Inc., ON, Canada) captured head, trunk, pelvis and feet kinematics at 120 Hz. Timing of segment rotation with respect to ipsilateral foot contact (IFC1) prior to the turn was calculated using angular displacement and velocity about the vertical axis. RESULTS: As expected NYA produced typical cranio-caudal rotation sequences during baseline walking turns. Eyes led (407 ms prior to IFC1), followed by the head (99 ms prior to IFC1), and trunk (151 ms after IFC 1). Onset time between adjacent segments was significantly different (p = 0.018 and p = 0.021respectively). Effects of visual cues in NYA were minimal with some coupling of the eyes and head occurring (210 ms and 237 ms prior to IFC1) due to requirements to follow visual targets on approach to the turn. Trunk segment rotation remained significantly later (p = 0.001; 149 ms after IFC1). In contrast, PD produced no anticipatory eye or segment movement in baseline trials. Head rotation began 57 ms after IFC1 followed by the eyes and trunk (97ms and 323 ms after IFC1) with no significant differences between segments. However, following visual cue training (during retention trials), PD produced cranio-caudal rotation with anticipatory eyes movement at 161 ms prior to IFC1, followed by the head 106 ms prior to IFC1 and trunk 289 ms after IFC1 with a significant difference between head and trunk segments (p=0.048). CONCLUSIONS: Results suggest discrete external visual cues during walking turns assist PD in producing cranio-caudal rotation sequencing in trials following visual cue training. Interestingly, when visual cues are present, greater coupling between the eyes and head occur with the head often leading eye movement. Therefore appearance of visual targets and instructions to follow visual targets are critical to consider when evaluating their use for turning movements. These findings provide an interesting starting point for the use of visual cues to specifically promote cranio-caudal segment coordination during walking turns to reduce risk of falls.

P3-H-55 Modification of gait intralimb coordination: objective comparison of hip-knee cyclograms of individuals with incomplete spinal cord injury vs healthy subjects

Maude Barreau¹, Manuel Jose Escalona Castillo¹, Alexandre Tapin¹, Martin Vermette², Dany H. Gagnon¹, Cyril Duclos¹

¹Université de Montréal, ²IRGLM

BACKGROUND AND AIM: Gait training is a key element of intensive functional rehabilitation to improve mobility and participation after an incomplete spinal cord injury (iSCI). Gait performance after iSCI is generally reduced due in part to deficits of lower-limb coordination that is associated with a higher risk of fall. No objective method has been proposed to date to determine where coordination, when represented as a hip-knee cyclogram, is altered in the gait cycle and whether various gait training approaches improve intra-limb coordination. This study aimed to define normative points in hip-knee cyclograms of healthy subjects and determine intralimb gait




coordination deficits in individuals with iSCI. METHODS: Thirty-two healthy participants and 4 individuals with iSCI (AIS D, gait speeds of 0,2; 0,4; 0,85; 1,3 m/s) walked on a Bertec dual-belt instrumented treadmill, for at least 30 seconds. Lower limb kinematics during gait was recorded with a three-dimensional motion analysis system. Hip/knee cyclograms were calculated for every participant. Normative data (mean ± 1 standard deviation (SD)) for time in the gait cycle (in percent), joint angles at the right hip and knee were obtained at 18 specific gait events (floor contacts, toe-offs, maximal flexion and extension hip and knee angles, 45° up, 45° down, 0 and 90° slopes of the cyclogram) totalizing 60 specific data points in healthy participants and used to determine coordination deficits in iSCI individuals. **RESULTS:** Within-group variability at each considered gait event was generally low in the cyclograms of healthy participants for timing in the gait cycle (SD \leq 3.5% of gait cycle), except for the time of maximal hip flexion (SD=15.4%) and maximal knee extension (SD=17.7%). Variability was also low for joint angles $(4.4^{\circ} < SD < 7.2^{\circ})$. except for the knee angle at maximal hip extension, hip flexion at ipsilateral heel contact and at maximal knee extension (SD \geq 8.9°). Cyclograms of the participants with incomplete spinal cord injury showed values outside the normative data in 26 and 28/60 points for the two fastest participants, and 42 and 47/60 points for the two slowest. In addition, one of fastest participants had mostly problems in timing of the events evaluated during stance phase, and in durations of subphases of gait cycle, while the other showed mostly deficits at the hip during most of the gait cycle, and to a lesser extent at the knee. The cyclograms of the two slowest iSCI participants differed from the healthy both in timing and joint angles along most of the cycle. **CONCLUSIONS:** The objective characterization of intralimb gait coordination deficits in individuals with iSCI using normative points in hip-knee cyclograms of healthy subjects is possible and could be useful to determine where in the gait cycle coordination is affected. Further studies are necessary to test the sensibility of this method to detect improvements in intra-limb coordination with gait training programs. FUNDING : Craig H Neilsen Foundation.

P3-H-56 Walking speed choices among married couples: Middle-aged and older adults walk slower when walking with their partner

HyeYoung Cho¹, Anna Forster¹, Samuel Hatala¹, Manuel Ochoa¹, Sharon Christ¹, Melissa Franks¹, Elizabeth Richards¹, Shirley Rietdyk¹

¹Purdue University

BACKGROUND AND AIM: Walking is the most common physical activity for older adults [1], and this activity is facilitated by support of a partner [2]. However, males walk faster than females across their lifespan, and young adult males reduced speed when walking with their romantic partners [3]. Habitually walking at reduced speed may adversely affect critical health outcomes [4] and gait quality [5]. The purpose of this study was to determine whether and how middle-aged and older adult married partners change gait when they walk together versus alone. **METHODS:** Thirty-nine married couples (N=78; male: 64 yrs, female: 62 yrs) walked 50 feet in three different





walking conditions (walking alone, walking together without holding hands, and walking together while holding hands). Inclusion criteria: Married, at least one partner older than 50 years, living together, and neither partner used a mobility aid. Walking conditions were block randomized, and two trials for each condition were collected. Couples were instructed not to talk during walking trials. Speed was measured with a video camera, step length and step width were measured with a smartphone based system (SmartGait®). RESULTS: No interactions of sex by condition were observed ($p \ge 0.12$). Male speed was not different from female speed in the three conditions (p=0.69, Fig.1A). Both males and females reduced speed and step length when walking together (p≤0.01, Fig.1A); speed was further reduced while holding hands (p=0.03, Fig.1A). Males had wider step width in all walking conditions (p<0.001), and step width was significantly increased when holding hands compared to walking alone (p=0.02, Fig.1B). The wider step width is likely an adaptation to the medio-lateral perturbations imposed by the partner's motion. CONCLUSION: Males walked at the same speed as females in this cohort, which likely reflects that some of the males in this study were in poorer health than the females. Analyses for the conference will examine the effect of age and health status on the gait speed in males versus females. Adapting to a partner's speed is not consistent across the lifespan: young adult males reduced speed to match females [3], while middle-aged and older males and females both slowed down when walking together, which may reduce health benefits [4] and gait quality [5]. Nevertheless, more walking activity at a slower speed with a partner will be better than not walking. Interventions should consider how to increase gait speed of the slower partner, in order to optimize health benefits of walking for both partners. REFERENCES [1] DiPietro, J Gerontol A Biol Sci Med Sci, 56A, 13-22, 2001. [2] Victor et al. Arch Gerontol Geriatr, 67, 1-6, 2016. [3] Wagnild & Scheffler. PLoS One, 8(10), e76576, 2013. [4] Studenski et al. JAMA, 305(1), 50-8, 2011. [5] Huijbena et al. Gait & Posture, 65, 112-6, 2018.

P3-H-57 Variability of the inter-joint coordination during grade walking

Arthur Dewolf¹, Patrick Willems¹

¹Universite catholique de Louvain

1) **BACKGROUND AND AIM** In 2018, Dewolf et al. hypothesized that the changes in walking pattern on slopes was tuned, among others, to counteract toppling moment and maintain stability. The control mechanism of slope locomotion may be indirectly investigated by analyzing the continuous relative phase (CRP) between lower-limb joints. We expected that (1) walking at slow speed would induce greater variability of the CRP than walking at fast speed, and that (2) the effect of slope on CRP variability would be greater at slow than at fast speed. 2) **METHODS** Ten subjects walked on an instrumented treadmill at slopes of 0, \pm 3, \pm 6 and \pm 9° and at speeds of 2, 5 & 8 km h-1. The lower-limb segment orientations in the sagittal plane were measured by means of a BASLER piA640-210 camera using reflective markers glued on the joints. The phase portrait of the ith joint throughout a gait cycle was computed by plotting its normalized angular velocities,





wi, as a function of its normalized angular positions, θi (Stergiou et al., 2001). Then, the phase angle φ of the joint motion was computed as: φ = tan-1 (ω i/ θ i). The CRP angles between hip-knee and knee-ankle were calculated by subtracting ϕ at the distal joint from ϕ at the proximal joint. The mean value of the CRP (mCRP) was computed by averaging the values of the ensemble curve points. When mCRP moved away from 0°, the two joints evolved more and more out-of-phase. The variability of the inter-joint coordination, namely the deviation phase (DP), was assessed by averaging the standard deviations of CRP. 3) RESULTS Both hip-knee and knee-ankle mCRP increase with speed of progression and slightly change with slope (Fig. 1). Between -9° to +9°, the hip-knee mCRP becomes more negative, suggesting a more out-of-phase joint motion on positive slopes, whereas the knee-ankle mCRP tends towards zero, suggesting a more in-phase kneeankle motion on positive slopes. At all slopes, the joint coordination variability (DP) decreases when speed increases. Furthermore, DP is greater on negative slopes than on the level, especially at slow speed. On positive slopes, DP is not statistically different than at 0°. 4) **CONCLUSION** The change in mCRP with speed and slope shows that these variables significantly alter the coordination of lower limb-joints during walking. The low DP observed at high walking speeds on all slopes indicates a less changeable coordination between joints (Stergiou et al., 2001). The high DP observed at slow speeds, especially on negative slopes, corroborates the results obtained by Dewolf et al. (2018), which suggest that a greater effort is required to maintain the dynamic balance during downhill walking. 5) REFERENCES [1] Dewolf, A. H., Ivanenko, Y., Zelik, K. E., Lacquaniti, F. & Willems, P. A. (2018). J Appl Physiol 125: 642-653. [2] Stergiou, N., Scholten, Jensen, J.L. & Blanke, D., (2001). Gait & Posture 13: 210-220.

P3-H-58 Effect of voluntary gaze movement on gait steering control

Felix Dollack¹, Monica Perusquia-Hernandez¹, Hideki Kadone¹, Kenji Suzuki¹

¹University of Tsukuba

BACKGROUND AND AIM: Humans exhibit anticipatory gaze and head movements during locomotion [Grasso et al. 2008, Kadone et al. 2010]. These anticipatory movements are independent of visual cues [Authie et al. 2015]. Voluntary rotations of the head do not influence the steering control in case of a visible target [Cinelli et al. 2012] but they seem to have a significant effect when there is no explicit visual target [Vallis et al. 2004]. However, the effect of voluntary gaze movement in the steering of gait has not yet been investigated. **METHODS:** Five participants were asked to walk in a straight line while performing voluntary head and gaze rotations. We investigated the influence of five separate eye and head movements on walking direction with eyes open and eyes closed. The movements were head to both sides while keeping the gaze aligned with the walking direction, moving only the eyes to the side while keeping the head aligned with the walking direction and keeping gaze, head and walking direction aligned. Locomotion trajectory and path deviation angles were analyzed from motion tracking data. Gaze direction was estimated from electrooculography (EOG) to ensure participants followed the instructions.



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RESULTS: Voluntary rotations of the head with eyes open led to path deviations up to 2 degrees. With closed eyes and turned head, deviations were up to 20 degrees. Gaze rotation with eyes open led to path deviations between 0.7 and 1.4 degrees. In the eyes closed condition with gaze rotation, deviations were up to 18 degrees. Deviations represented themselves in the same or opposite direction as the head and gaze rotations. **CONCLUSION:** The results with eyes open and turned head are comparable to the results from [Cinelli et al. 2012]. Gaze rotation leads to path deviations of similar magnitude as induced by head rotation both with eyes open and eyes closed. The direction of the deviations has different explanations and builds on the gaze angle strategy [Warren et al. 1998], a more general target-heading angle strategy [Fajen et al. 2003] and attentional capture.

P3-H-59 How much does pregnancy affect female's gait pattern?

Wanda Forczek¹, Yury Ivanenko², Marcin Salamaga³, Agata Maslon¹, Marta Curylo¹, Barbara Fraczek¹, Agnieszka Suder¹

¹University of Physical Education, ²IRCCS Santa Lucia Foundation, ³Cracow University of Economics

1) **Background**. The woman's body is subjected to a lot of changes during pregnancy, including musculoskeletal alterations that affect gait and the lower extremities. Despite the numerous investigations on gait biomechanics during gestation in recent years, only a few focused on the longitudinal assessment of pregnancy and the kinematics of walking pattern. Therefore the aim of the study was to identify pregnancy-related adjustments in the kinematic parameters of gait in women throughout gestation period. 2) Methods. A longitudinal study involved 36 pregnant women (mean age 30.3 ± 3.4 years, body height 167.0 ± 4.4 cm, body mass 61.5 ± 6.7 kg, and BMI 21.96 ±2.01 kg/m2). Because of some complications and medical contraindications 6 women resigned from the participation in the study and 30 women were finally enrolled in all experimental sessions: 19 - primigravid, 8 - second pregnancy and 3 - third pregnancy. Three experimental sessions were arranged according to the same protocol: (P1) at the end of the first trimester of pregnancy (12 week of gestation), (P2) at the end of the second trimester (25 week of gestation) and (P3) at the end of third trimester (36 week of gestation). First, the anthropometric measures were taken. Then, we recorded the kinematics of overground walking at a self-selected speed at 120 Hz with the Vicon 250 system (Oxford Metrics Ltd.; Oxford, UK) consisting of five video cameras. 3) **Results**. The spatiotemporal parameters of gait (speed, stride length, cadence) did not show significant differences between sessions (p> 0.05). However, the ANOVA revealed a significant effect of pregnancy on the size of the base of support (inter-ankle distance (IAD) and inter 5th metatarsal distance (IMD)), that significantly increased from P1 to P3 (p<0.05). In regard to the ankle and knee joint range of motion (RoM), no significant differences were found between the experimental sessions. However, mobility of the hip joint in the transverse plane and the pelvis in the sagittal plane increased as pregnancy progressed (p<0.05). As to the angular changes



throughout the gait cycle, the hip joint and pelvis angles in the sagittal plane were significantly different over the whole gait cycle throughout gestation. The remaining joints were only slightly affected by the gravid conditions. 4) **Conclusions**. Overall, our study revealed adjustments in the gait kinematics throughout pregnancy. Wider base of support can be considered as a way to improve gait stability in the course of pregnancy. Pelvis and hip joints seem to be the most affected segments during adaptation to growing fetus and increasing body mass.

P3-H-60 Looking downward while walking is more challenging than looking forward for ambulatory chronic stroke patients

Yu-Chu Hsueh¹, Pei-Yun Lee², Pei-Yun Lee², Chih-Hung Chen¹, Hui-Yu Tseng³, Sang-I Lin¹

¹National Cheng Kung University, ²National Taiwan University Hospital Bei-Hu Branch, ³Tainan Hospital, Ministry of Health and Welfare

BACKGROUND AND AIM: Gait impairments are common after stroke and often manifested by decreased walking velocity, atypical movement and poor balance. These impairments may persist into chronic stage and could be accompanied by other changes in walking patterns. Looking downward while walking can be observed among patients after stroke. It is unclear if adopting such a walking pattern would affect gait for ambulatory chronic stroke patients. METHODS: Twenty-nine stroke patients (age=61.93±10.57 years; onset=3.14±2.44 years) participated in this study. Subjects were instructed to walk at their preferred speeds on an eight meter walkway in two conditions, looking forward or downward, with each repeated twice. A six-camera SIMI motion analysis system was used for the recording of full body kinematics. The Matlab computer language was used to calculate stride characteristics and peak joint angle of the affected side lower limb, and estimate the center of mass (COM) location in relation to the base of support (i.e. the distance along the sagittal axis between the ground projection of COM and heel marker during each gait phase). The means of the two repeated trials were used for data analysis. Six repeated measures multivariate analyses were used separately for temporal and spatial stride characteristics, step characteristics, COM, and peak joint angle in stance and swing phase, to determine the betweencondition differences. The p-value was adjusted to 0.0083 with Bonferroni correction. RESULTS: In terms of stride characteristics, looking downward showed significant decreases in velocity (p= 0.032), percentage gait cycle of single limb support phase (p= 0.008), and heel clearance (p= 0.006), and increases in step width (p= 0.003). The between-condition differences in step time, step length and toe clearance were not significant. In terms of peak joint angles, looking downward had significantly smaller peak hip extension during the swing (p= 0.004) phase, but not peak hip flexion, knee flexion, or ankle dorsiflexion/extension angles during the stance and swing phases. Furthermore, no significant differences were found in the location of the COM relative to the base of support. **CONCLUSIONS:** For ambulatory chronic stroke patients, looking downward during walking was accompanied by cautious gait, including slower walking speed, shorter single leg stance phase and greater step width. In addition, there was a significant decrease in the heel

clearance, making tripping more likely. These changes were not likely to be the result of changes in walking posture, since the COM location in relation to the base of support did not differ between the two conditions. It is possible that subjects might pay greater attention to the environment and/or their legs but less to walking while looking downward, making walking more challenging. Because looking downward is necessary when navigating uneven terrains, patients should be reminded of the related risks. Further studies are needed to determine if increased cognitive demands are associated with changes in gait pattern when looking downward. **ACKNOWLEDGEMENTS AND FUNDING:** This study was supported the Ministry of Science and Technology, Taiwan (MOST 105-2314-B-006-011-MY).

P3-H-61 Postural sway in young adults with and without chronic low back pain

Karen Lomond¹, Nick Paselk², Nilanthy Balendra², Burkhardt Zachery², Phillion Brooke², Jennifer Sansom²

¹Ithaca College, ²Central Michigan University

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BACKGROUND AND AIM: Impaired postural control for people with low back pain has been associated with: altered sway during quiet stance, altered anticipatory postural adjustments, and diminished stability. Most studies profiling postural control in patients with chronic low back pain (CLBP) have focused on middle-aged or elderly populations, despite more than half of the population experiencing low back before the age of 20. Thus, the purpose of this project was to determine the differences in postural sway in young adults with and without CLBP during stable and unstable standing postural tasks. **METHODS:** Nineteen young adults with CLBP (18-26 y/o) and 19 matched controls participated. Reflective markers defined segments of a whole-body model and were recorded using a 12-camera Vicon System (Oxford Metrics Ltd., UK). Subjects completed 3 trials of 3 balance tasks: Romberg, sharpened Romberg and unilateral stance, eyes open on a firm, stable surface (S) and unstable surface (US) (BOSU© ball). Custom Matlab scripts (Mathworks Inc, USA) were used to compute whole-body center of mass (COM) for determination of COM area, path length, and antero-posterior (AP) and mediolateral (ML) range of motion. For each outcome measure, 2x2 repeated Measures ANOVAs (group x stability condition) were performed with Holm-Sidak post hoc tests. Significance was set at p<<0.05. RESULTS: Significant Interaction effects indicated that in the unstable condition, the CLBP group had larger AP sway and larger area in Romberg and sharpened Romberg tasks, and longer path length for the sharpened Romberg task. Interaction effects also indicated that within groups the US condition had larger AP sway range in all conditions, larger sway area in Romberg and sharpened Romberg tasks, and longer path length in the sharpened Romberg task. Condition main effects, indicating more sway during unstable conditions across groups, were observed in range of ML sway for all tasks, path length during Romberg and unilateral stance task, and sway area for the unilateral stance task. CONCLUSIONS: Emerging results demonstrate significant increases in postural sway, represented through whole-body COM, in young-adults with chronic LBP during static

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clinical balance assessments. The increases in postural sway were only apparent during more challenging balance conditions on an unstable surface and appear to be primarily related to increased sway in the AP direction. These findings may signal the beginnings of larger problems with postural control, which are often reported in older groups with chronic LBP. Given the relative difficulty current treatment programs have demonstrated in treating altered postural control in this population, future work should examine sensory weighting and muscle activation patterns in younger populations with CLBP to better understand and treat this condition.

P3-H-62 Effect of arm motion on postural strategies during uphill and downhill walking

Mary Elise MacDonald¹, Allen Hill¹, Julie Nantel¹

¹University of Ottawa

BACKGROUND AND AIM: Human gait has two primary goals: forward progression and maintenance of postural stability. Postural stability is maintained by keeping the body's center of mass (COM) aligned above the moving base of support. While forward progression is primarily driven by the legs, the motion of the arms and torso contribute to gait stability by creating a smoother translation of the COM. Arm swing has been shown to play an active role in gait and gait stability during level walking. Daily walking, however, involves changes in elevation that impose different demands on the body's postural system. Therefore, the aim of this study is to investigate the effects of arm motion and surface slope on postural strategies and gait stability. METHODS: Fifteen healthy adults (18-30yrs of age) were tested using the Computer Assisted Rehabilitation Environment (CAREN). Walking trials were performed at self-paced speed. The hilly condition was composed of sums of sin waves, which imparted both incline and decline conditions. This was repeated under three arm swing conditions: held, natural, and active. **RESULTS:** Outcome measures will include spatiotemporal gait parameters as well as trunk and head stability measures such as: mean position of head, torso, and head relative to torso, and mean velocity and acceleration of torso and head. A two-way mixed ANOVA will be used to examine the effect of the two slope conditions and the effect of the arm swing conditions. Statistical significance will be set at p <0.05 with a Bonferroni correction on post-hoc analyses. **CONCLUSION:** The results of this study will add to the body of knowledge concerning the role of arm motion in gait stability on terrain beyond level walking. Identifying the adaptations made in spatiotemporal gait parameters under these combinations of conditions in healthy young adults will allow for better understanding of the risks of trips and falls in daily life. These results may also provide a baseline of comparison when further investigating populations with gait and postural balance deficits. Additionally, the present study will provide further insight into the functional prioritization of the body when adapting to a new environment.





P3-H-63 The path curvature of the body centre of mass during walking as an index of balance control in patients with Multiple Sclerosis

Chiara Diletta Malloggi¹, Luigi Catino², Viviana Rota¹, Laura Perucca¹, Stefano Scarano¹, Luigi Tesio¹

¹Istituto Auxologico Italiano, IRCCS, ²Università degli Studi di Milano

BACKGROUND AND AIM: The path curvature of the centre of mass (CM), mechanically representative of the whole body system, may provide hints to detection of fall risk during walking. Here, an example is taken from results of an ongoing controlled study. It shows the comparison between the CM path in a healthy subject and in a fully autonomous patient with Multiple Sclerosis (MS). METHODS: A representative healthy subject (woman, 26 years, 1.55 m tall) and a MS patient (woman, 34 years, 1.65 m tall, with very mild left hemiparesis) are presented. Subjects walked on a force-sensorized treadmill (1) at 0.6 m/s. Data were averaged across 6 subsequent strides. The 3D displacements of the CM were computed via double integration of the ground reaction forces (Cavagna's Method). The path curvature of the CM during one stride was computed according to the Frenet-Serret formula (2). The instantaneous efficiency of the kineticpotential, pendulum-like energy transfer of the CM was also computed (percent recovery, R: 100%=complete recovery, i.e. fully passive CM translation) (3). **RESULTS:** The left and right panels refer to the control and the MS subject, respectively. In the upper set of panels the human sketches on top of the figure help identifying the stride phases (% cycle) and give a frontal and a sagittal perspectives. The first and second rows of curves from the top give the instantaneous R and the path curvature of the CM during one stride. Each step begins with the single stance of the front leg (R=right; L=left). The horizontal bars under the curves mark the double and the single stance phases (continuous and dashed lines, respectively; grey tract=left step). The lower set of panels (closed curves) gives the planar projections of the CM path during the same stride. The space-time correspondence between the 2 sets of curves is facilitated by the shared A-D labeling of peak curvatures and the shared graphic conventions (dashed line=single stance; gray tract=left step). In both steps the curvature is peaking when R suddenly drops from 100 to 0, demonstrating that the passive pendulum-like mechanism of translation is briskly substituted by a short lasting, fully muscle-driven, propulsion. The highest peaks (A and C) are coincident with the lateral redirection during single stance. Of note, the patient's CM path is characterized by a 10-fold higher C peak (single stance, paretic-to-unaffected side redirection). This may be interpreted as a feature of "escape" limp, barely perceivable by clinical observation, when seen from the perspective of the body CM on the horizontal plane (bottom curves). CONCLUSIONS: Increased curvature peaks may reveal the attempt to shorten the stance on the affected side yet, placing at risk the lateral stability of the body. REFERENCES:[1] Tesio L, Rota V, Am J Phys Med Rehabil 2008;87:515-526 [2] Tesio L et al, J Biomech 2011;44:732-740 [3] Cavagna GA, J Appl Physiol 1975;39:174-179.





P3-H-64 Older adults adopted a more conservative strategy to step into a hole when compared to the task of stepping down a curb

Renato Moraes¹, Luciana Santos¹, Rosangela Batistela¹

¹University of São Paulo

BACKGROUND AND AIM. There are two strategies to deal with a hole in the ground while walking: avoid it by changing step length/width or step into it. When stepping into a hole with one foot, the first part of this action is similar to stepping down a curb for the lead limb; however, in the sequence of this movement, the trailing limb does not move to a lower level, and the lead limb has to overcome an obstacle when the foot is leaving the hole. This asymmetrical behavior may impose additional challenges for older adults because of their known balance deficits. We investigated the forces applied on the ground by the lead and trail limbs when walking and stepping into a hole and stepping down a curb in older adults. Methods. 15 older adults (71.1±3.7 years-old) walked on a pathway under three conditions: stepping into a hole 60-cm long; stepping into a hole with a length corresponding to 1.3 times the foot length (critical point, CP); and stepping down a curb. The CP was based on a previous study that we conducted to identify the transition point between stepping or not into a hole. The height was 12 cm in all three conditions. We positioned a force plate in the region corresponding to the foot placement into the hole or when stepping down the curb (lead limb). We placed another force plate in the region of the trail limb placement before the hole/curb. Based on the anterior-posterior (AP) component of the ground reaction force, we divided the support phase in braking (from foot contact on the ground to zerocrossing force) and propulsive (from zero-crossing force to toe-off) periods. For each of these periods, we integrated the area under the time-force curve to compute the impulse. Results. For the lead limb, the braking impulses for both hole conditions were larger than for the curb condition (p<0.002; Figure 1A). The propulsive impulse for the lead limb reduced for both hole conditions in the AP direction compared to the curb condition, whereas in the vertical direction it reduced only for the CP condition (p<0.001; Figure 1B). For the trailing limb, the braking impulse in the AP direction was larger for the CP condition than for the 60-cm hole and curb conditions (p<0.008; Figure 1C). There was no difference among conditions for the propulsive impulse for the trailing limb. CONCLUSIONS. When stepping into the hole, older adults increased the braking and reduced the propulsive impulses compared to the curb condition for the lead limb. These changes represent a more conservative strategy to step into the hole, which contributes to reduce the gait speed and ensure the safety while performing this task. For the trailing limb, there was only one difference in the AP direction, and it occurred for the most challenging condition. In the CP condition, the length of the hole was slightly longer than the foot length, and the older adults increased the braking of the trailing limb to facilitate foot placement into the hole. FUNDING: CAPES/Brazil.

P3-H-65 Differences in pre-season postural control based on sport type





John Palazzolo¹, Daniel Goble², Jeff Labban¹, Scott Ross¹, Donna Duffy¹, Christopher Rhea¹

¹University of North Carolina, Greensboro, ²Oakland University

BACKGROUND AND AIM: The BTrackS Balance Test is an objective and reliable way to measure postural control with low cost force plate technology, which can be used to help make return-toplay decisions if an athlete receives a concussion. BTrackS Balance Test results from many test administrators have been uploaded as deidentified data to the BTrackS database allowing "big data" research questions to be pursued. One such question focuses on the postural control of athletes playing different types of sports. Sport type can be classified into four categories based on the level of contact associated with each sport. These categories are non-contact (no contact allowed; e.g., tennis), limited contact (contact may occur, but it is not part of the sport; e.g., baseball), contact (contact is part of the sport, but in a restricted manner; e.g., basketball), and collision (contact is required as part of the sport; e.g., football). Normative databases used for postural control assessment typically do not take the sport type into account, but it is plausible that athletes participating in different sports exhibit different postural control characteristics, which may be meaningful when making return-to-play decisions after a concussion. This study used the BTrackS database to examine differences in postural control in athletes playing different types of sports. It was hypothesized that athletes participating in collision sports would exhibit the poorer postural control than the other three sport types. METHODS: BTrackS data from high school and college-aged athletes (14-22 years old) were included in this study (N = 9093; 2998 female, 6095 male). This included 1933 non-contact, 1459 limited contact, 2840 contact, and 2861 collision sport athletes. The dependent variable was the average Center of Pressure (CoP) displacement (cm) across three 20-second trials while standing on the BTrackS force plate with eyes closed, hands on the hips, and feet shoulder width apart. Higher displacements indicated worse postural control. A one-way ANOVA with a Bonferroni post hoc test was used to compare CoP displacements between sport types. RESULTS: A significant difference was observed between sport types, F(3,9089) = 42.4, p < .001. The post hoc test indicated that collision (M = 25.0, SD = 7.6) sport athletes had a significantly higher CoP displacement compared to the contact (M = 23.4, SD = 7.4), limited contact (M = 22.9, SD = 6.9), and non-contact (M = 23.0, SD = 7.4) sport athletes. There was no difference between the contact, limited contact, and non-contact sport athletes (p > .20). CONCLUSION: Collision sport athletes exhibited worse postural control in the preseason relative to athletes in other types of sports. This may be due to cumulative head trauma, body type differences, and/or the ratio of males to females in each group. These data suggest that normative postural control data for collision sport athletes should be derived from similar sport athletes.

P3-H-66 Walking with large axial pelvis rotations causes changes in axial thorax-pelvis coordination as observed in low back pain

Maarten Prins¹, Luca Cornelisse², Onno Meijer², Peter van der Wurff¹, Sjoerd Bruijn², Jaap van Dieën²





ispgr International Society of Posture & Gait Research

¹Military Rehabilitation Centre 'Aardenburg', ²Vrije Universiteit Amsterdam

BACKGROUND AND AIM: The relative timing of axial thorax and pelvis rotations can be affected by low back pain 1. In these patients, axial thorax and pelvis rotations are more in-phase (i.e., synchronous rotation in the same direction) than in healthy controls, who demonstrate more outof-phase thorax-pelvis coordination. In-phase thorax-pelvis coordination can be caused by reduced arm swing amplitude and increased axial trunk stiffness 2. However, these mechanisms do not seem to be the main cause for in-phase thorax-pelvis coordination in low back pain patients 2. Possibly, the relatively large movement excursion of axial pelvis rotations, as has been observed in these patients in previous research, causes more in-phase thorax-pelvis coordination 3. The objective of this study was to evaluate whether increased axial pelvis rotations result in more inphase axial thorax-pelvis coordination during gait. EMETHODS: 12 Healthy volunteers walked on a treadmill with real-time visual feedback on axial pelvis rotations. Kinematics and kinetics were obtained during normal walking and during walking with large axial pelvis rotations. **RESULTS**: Walking with large axial pelvis rotations resulted in significantly more in-phase thorax pelvis coordination compared to walking with normal axial pelvis rotations. Arm swing amplitude was not significantly different between conditions and apparent axial trunk stiffness was lower in the large pelvis range of motion trial, which can be shown to have attenuated the effect of increased pelvis rotational amplitude on thorax-pelvis coordination. see CONCLUSIONS: We conclude that walking with large axial pelvis rotations causes more in-phase axial thorax-pelvis coordination, that is not mediated by axial trunk stiffness or arm swing amplitude. 1. Lamoth, C. J. C. et al. Pelvis-thorax coordination in the transverse plane during walking in persons with nonspecific low back pain. Spine (Phila Pa 1976) 27, E92-E99 (2002). 2. Prins, M. R., et al.. Thorax-Pelvis Coordination During Gait: the Effect of Apparent Trunk Stiffness and Arm Swing. Under Review. 3. Huang, Y. P. et al. Gait adaptations in low back pain patients with lumbar disc herniation: Trunk coordination and arm swing. Eur. Spine J. 20, 491-499 (2011). Figure Caption: Individual example of pelvis and thorax kinematics while walking with normal and large axial pelvis rotations. E Each graph displays segmental movements averaged over strides of each trial. The horizontal axis runs from right heel strike (0%) to right heel strike (100%). The vertical axis displays the angle of pelvis and thorax around the global vertical axis. In this subject, thorax and pelvis are more in-phase while walking with large axial pelvis rotations.

P3-H-67 Negative effects of cognitive interference and altered sensory input on balance in Huntington's disease

Nicollette Purcell¹, Jennifer Goldman¹, Bichun Ouyang¹, Bryan Bernard¹, Joan O'Keefe¹

¹Rush University Medical Center

BACKGROUND AND AIM: As an individual with Huntington's disease (HD) progresses through the early, middle, and late stages of the disease, they typically exhibit a loss of automaticity. This





motor dysfunction contributes to progressive balance deficits, falls, mobility disability, and increased morbidity. Additionally, HD patients have cognitive deficits, especially difficulty holding, shifting, and dividing their attention. However, the extent to which cognitive deficits exacerbate balance dysfunction in HD is not well elucidated. Dual-task (DT) cognitive-motor paradigms have the capacity to reveal impairments not present under single-task (ST) conditions by creating competition for limited neural resources. Also, information collected from DT and other environmentally challenging balance assessments, such as conditions of altered sensory input, in conjunction with knowledge of how cognition impacts balance, may provide important information about fall risk in HD patients. Therefore, the goals of this study were to 1) determine the impact of DT cognitive interference and altered sensory input on postural control in HD. METHODS: Seventeen HD participants (55 +/- 9.7 years), with UHDRS-TMS ranging from 7-39, and 17 agematched controls (56.5 +/- 9.3 years) underwent quantitative balance testing with APDM inertial sensors. Postural sway was assessed in 30 second trials during conditions of the cognitive DT, manipulated stance and altered visual and proprioceptive input. The DT was a concurrent verbal fluency task, the Controlled Oral Word Association test. The modified Clinical test of Sensory Integration and Balance (mCTSIB) using the inertial sensors was used to assess the impact of altered sensory input on postural control. Neuropsychological assessments testing multiple cognitive domains were also administered. RESULTS: HD subjects demonstrated greater total sway area, total jerk, and sway variability under ST and DT conditions compared to controls (p = 0.0002 to < 0.0001). They also exhibited significantly greater dual-task costs (DTC) during eyes closed conditions for total sway area (p = 0.01) and sway variability (p = 0.02). Significantly worse postural control was observed in HD with vision removed and proprioception reduced (p = 0.001to 0.01). Low performance on the Judgement of Line Orientation test, a visuospatial test, correlated with greater total sway area (p = 0.0097) and total jerk (p = 0.0087) under eyes closed conditions. CONCLUSIONS: HD participants have worse postural stability than controls under the DT, greater DT interference with a narrowed base and no visual input, and on conditions of the mCTSIB with limited proprioception, vision, or both. These findings highlight the difficulty HD participants have with a cognitive dual-task while balancing, as well as when they are required to predominantly utilize vestibular information for balance control. Additionally, employing wearable inertial sensors is feasible to objectively assess balance deficits in clinical and research settings in HD.

P3-H-69 Analysis of center of mass velocity during dual-task in fallers and non-fallers elderly: Gait combined with prehension task during avoidance of an obstacle

Natalia Rinaldi¹, Janine Carvalho Camargos¹, Leticia Avellar¹, Anselmo Frizera¹

¹Federal University of Espirito Santo

BACKGROUND AND AIM: Postural stability during gait is dependent on the dynamics of the movement itself. Changes in postural stability are even more evident during adaptive strategies



such as avoidance an obstacle or when two motor tasks are combined, such as gait and prehension task in older adults with history of falls. A more appropriate analysis of postural stability during adaptive locomotion associated with reach-to-grasp task should take into account the velocity of center of mass (CoM), which will help in understanding changes in the postural stability during these both tasks combined. Our aim was to investigate the CoM velocity in a dual-task, gait in the presence of an obstacle and prehension in the older adults with and without a history of falls. METHODS: Twenty subjects distributed in two groups (n=10) participated in this study: older adults without history of falls (OA) and older adults who suffered at least one fall in the 12 months before data collection (FOA). Participants were instructed to walk through a walkway and avoidance an obstacle on the ground combined to reach-to-grasp task. The obstacle on the ground was placed in the step corresponding to the dowel to be grasped (Fig 1A). Moreover, the support with the dowel was positioned to the right side of the subjects adjusted to the height of the greater trochanter of the participants' femur and with a lateral distance corresponding to 50% of the length of the right upper limb. We used a system composed of a group of RGBd cameras (three Kinets v2) to compute the CoM velocity in the step before avoidance the obstacle (N-1), during avoidance (N) and after avoidance (N+1) in antero-posterior (AP) direction (Fig. 1A). **RESULTS:** The MANOVA revealed step (p<0.0001), group (p=0.007) and interaction (p=0.034) effect between step and group for CoM velocity. FOA presented a lower CoM velocity than OA for obstacle avoidance combined to grasping for steps N and N+1, respectively (Fig. 1B). In relation to step effect, CoM velocity was lower in step N than steps N+1 and N-1 (Fig.1B). **CONCLUSIONS:** Both groups modified the CoM velocity in three steps, with more evidence at the moment of grasping the object and during avoidance. The presence of the obstacle combined with the prehension task made the avoidance step more challenging, leading to a decrease in CoM velocity when compared to the first step. History of falls may challenge the postural stability in function of a more conservative locomotor pattern adopted by the older adults to divide attention between walking during avoidance obstacle and prehension task due to neuromuscular problems.

P3-H-70 Motor flexibility during locomotion: an important component of functional mobility in older adults

Noah Rosenblatt¹, Christopher Hurt², Nils Eckardt³

¹Rosalind Franklin University of Medicine and Science, ²University of Alabama, Birmingham, ³University of Oldenburg

BACKGROUND AND AIMS: Motor flexibility - enacting numerous movement patterns to solve a motor problem while limiting variance in an important performance variable - may facilitate mobility in older adults (OA), particularly during complex tasks. For example, when walking on uneven vs. even surfaces, OA increase kinematic variability more so than younger adults (YA), but in a manner that promotes step-to-step consistency in the relative motion of the limbs,





ensuring balance. This study aims to: 1) further demonstrate that OA rely on motor flexibility more than YA during demanding gait tasks; 2) evaluate the relationship between motor flexibility and functional mobility. **METHODS:** We analyzed data from 10 YA and 45 OA (≥65 years). Participants walked on a treadmill at 80% of self-selected velocity (SSV) under 2 conditions: 1) baseline normal gait; 2) cue - during each step, participants targeted lighted cues projected onto the treadmill belt at locations corresponding to mean baseline gait. Motion capture data was entered into an uncontrolled manifold (UCM) analysis. The analysis partitioned the total step-to-step variance in 7 lower-limb segment angles (VTOT) into a component that did (VUCM) and that did not (VORT) affect step-to-step variance in the position of the swing limb relative to stance limb. UCM measures were log-transformed and entered into ANOVAs to test for condition x group interactions. Motor flexibility within the UCM analysis was operationalized as an increase (baseline to cue) in VTOT due either to a decrease or increase in VORT and a greater absolute increase in VUCM (ΔVUCM). OA participants also completed: Timed Up and Go (TUG), maximum speed 10 m Walk (10mW), Single-leg Stance (SLS), Four Square Step (4SS) and Figure of Eight Walk (F8W) and performance was correlated with Δ VUCM. **RESULTS:** There was a significant condition x group interaction for VTOT (p<0.01; n2=0.16) reflecting a 20% increase during cue for OA (p=0.02) and a 34% reduction for YA (p=0.01). Effects were nearly identical for VUCM (Figure 1). However, regardless of group, VORT was ~50% lower during cued walking (p<0.01;n2=0.36). There were significant associations between $\Delta VUCM$ and SLS (r=0.44; p<0.01), SSV (0.31; 0.04), and F8W (-0.31; 0.04), but not 10mW, 4SS, or TUG. CONCLUSIONS: To complete cued walking, YA reduce kinematic variability. This is logical as the task does not directly challenge balance and requires only reducing step-to-step variance in foot placement. In contrast, due to age-related motor changes, e.g., increased motor noise, OA may be less able to reduce VTOT, requiring an alternative strategy - reliance on motor flexibility. The association of $\Delta VUCM$ with performance of complex rather than simple mobility tasks (e.g., F8W vs. TUG) may indicate the former relies more on motor flexibility and the ability to increase VUCM may be a biomarker of healthy aging. Exercises fostering exploration of motor solutions during complex tasks may improve existing (re)habilitation. ACKNOWLEDGEMENTS AND FUNDING: This work was partially supported by the National Institute of Arthritis and Musculoskeletal and Skin Diseases award number 1R03AR066326-01A1. The funding source had no role in the study design, collection, analysis or interpretation of data.

P3-H-71 Landing under conditions of height-induced threat

Bénédicte Schepens¹, M J Luu², Mark Carpenter²

¹Universite catholique de Louvain, ²University of British Columbia

BACKGROUND AND AIM: Landing on the ground involves a tuned anticipatory control to allow for soft and safe contact with the ground. Fearful situations are known to affect the control of posture during standing, but it is unclear how fear interferes with the control of a more dynamic





voluntary task requiring coordination between posture and movement. Our goal was to investigate the effect of height-induced threat on the motor control of landing after hopping down from a small box. We expected that threatening conditions will involve a stiffer touchdown, leading to the deterioration of the energy absorption mechanism necessary to avoid rebound and eventually to a less stable balance behavior. Likewise we expected that greater threat-related changes in arousal, balance confidence and fear of falling will be correlated with greater modifications to landing mechanics. **METHODS:** Twenty-three young healthy adults volunteered for the study (29.5± 6.1 years, 15 males). Subjects began each trial standing on a 44 cm box, fixed to the top of a hydraulic platform that could be elevated from a LOW height (0.75 m above ground) to a HIGH height (3.2m above ground). Subjects performed blocks of 15 trials in which they were instructed to stand still on a forceplate, then hop off the box, land naturally and safely on 2 forceplates, and return to a stable upright posture. After a familiarization session and practice blocks at ground level, subjects repeated the blocks at LOW and HIGH conditions (counterbalanced across subjects). Electrodermal activity (arousal) and self-reported measures of fear, anxiety and confidence were used to confirm the threat manipulation. Kinetic (forceplate) and kinematic (Optotrak) measures were used to calculate biomechanical changes during different phases of the take-off, landing and stabilization periods of the task performed at LOW and HIGH heights. **RESULTS:** Arousal, anxiety and fear significantly increased, while confidence significantly decreased when performing the hop-down landing task at HIGH compared to LOW conditions. The general pattern of the landing was not drastically modified when comparing HIGH and LOW conditions. But at HIGH, the impact on the ground and its loading rate were reduced. In addition the landing duration and the time to stabilization increased while the vertical index of stability decreased. In particular, participants who were less confident of doing the task showed a slower landing and a longer time to stabilize, as well as a diminished vertical stability index. CONCLUSIONS: Landing under threatening conditions seems to be made with caution and the participants who were more fearful landed more carefully. This confirms the ability of the central nervous system to change the overall mechanical properties of the lower limbs during landing, taking into account the potentially augmented risk of falling for all individuals (fearful and nonfearful). Acknowledgements & FUNDING: UCL & FNRS (BE), NSERC (CA).

P3-H-72 The modulation of trunk coordination for various step widths

Hai-Jung (Steffi) Shih¹, Kornelia Kulig¹

¹University of Southern California

BACKGROUND AND AIM: Modulating step width requires active control for stability. The trunk is the most efficient mechanical controller of the body's center of mass. Within the trunk, refined and recognizable modulations occur between the thorax and the pelvis especially during a well-practiced task such as walking. Upon varying step width, our pilot study discovered two emerging within-trunk modulations: one predominantly in the transverse plane and the other predominantly





in the frontal plane. This may support the clinically observed phenomenon, stating that when motion is introduced in one plane the available motion in other planes will be reduced. The purpose of this study was to investigate how young adults modulate trunk coordination in the transverse and frontal planes to accommodate different step widths. METHODS: Eight young adults (1 male, 7 female, age 26.1 ± 2.6 years) participated in the study. After giving informed consent, the participants walked on a treadmill with a speed of 1.25 m/s, and performed 30-second trials of walking using 5 different step widths: 0.33, 0.67, 1, 1.33, and 1.67 times their preferred step width. Real time step width feedback was presented in front of the treadmill at participants' eye level. Participant was instrumented with a lower extremity, trunk, and head marker set, and an 11-camera motion capture system was used to capture kinematic data. Vector coding analysis was used to quantify trunk coordination for each step width condition. The relationship of the thorax and pelvis motion for every instant in time throughout the gait cycles were quantified and categorized into in-phase, anti-phase, pelvic-only, and thorax-only patterns. Participants were then categorized as either transverse or frontal plane modulators depending on the relative amount of change in the pelvic-only pattern as a function of step width, confirmed by least squares lines and visual inspection. RESULTS: The test-retest reliability of thorax-pelvis kinematic coordination was excellent (ICC=0.98). There were 4 transverse modulators and 4 frontal modulators. The transverse modulators predominantly modulated their trunk coordination in the transverse plane, with decreased duration of the pelvic-only pattern (least squares line slope = -12.37) and increased duration of in-phase, anti-phase, and thorax-only patterns as step width increased from narrow to wide. The frontal modulators predominantly modulated their trunk coordination in the frontal plane, with increased duration of pelvic-only pattern (slope = 13.57) and decreased duration of the other three coordination patterns as step width increased. Both groups have minimal modulation in the non-dominant plane (Fig 1). CONCLUSIONS: Young adults varied their trunk coordination based on different step widths. In both transverse and frontal modulators, the modulation is predominantly in one plane whereas the other plane is marginally represented. ACKNOWLEDGEMENTS AND FUNDING: This work is supported by the International Society of **Biomechanics Matching Dissertation Grant.**

P3-H-73 Can a fractal visual motion cue modulate postural sway complexity?

Harris Sotirakis¹, Nicholas Stergiou², Dimitrios Patikas¹, Vassilia Hatzitaki¹

¹Aristotle University of Thessaloniki, ²University of Nebraska at Omaha

Abstract **BACKGROUND AND AIM** The complexity present in the temporal structure of movement variability is important for adaptable gait and posture. In gait, the complexity of stride duration variability can be modulated when synchronising steps to a fractal auditory metronome[1]. Sensorimotor entrainment to complex stimuli is less studied regarding postural sway despite the relevance of weight shifting in fall incidence[2] and the more challenging nature of voluntary sway compared to walking. We have previously shown that young adults entrain their





voluntary sway to a complex visual target with the same accuracy they couple to a periodic one[3]. In this study, we asked whether such entrainment also modulates the complexity of the spatial and temporal components of voluntary sway. Methods Fifteen healthy young adults (age: 25.5±8.9y, mass: 59.12±10.1kg, height(cm): 169.5±10.4cm) performed a voluntary rhythmic sway task (128 cycles) on a force platform (1kHz) in the anteroposterior direction in 3 conditions: a) self-paced sway while fixating a static dot on a TV screen (NF), b) self-paced sway with Centre of Pressure feedback shown as a vertically moving dot (FB) and c) sway guided by a variable visual cue. The variable visual cue was created to serve as a complex target to be followed while both its motion's duration and amplitude were constructed to represent PINK noise (Fig1a). The variability and complexity of the postural sway time series were assessed using Coefficient of variation (CV) and Detrended Fluctuation Analysis (DFA) of sway cycle duration (T) and amplitude (A). Results One-way ANOVA showed a significant effect of condition on CV(A) (F=21.64, p<0.01), DFA(A) (F=44.04, p<0.01) and DFA(T) (F=10.64, p<0.01). Post-hoc analysis revealed that CV(A) increased in the PINK compared to NF (p<0.01) and FB condition (p=0.031) (Fig 1b). DFA(A) increased for PINK compared to NF (p<0.01) and FB (p=0.024) and also increased for FB compared to NF(p=0.008). DFA(T) increased for FB compared to NF (p<0.01) and PINK (p=0.001). Conclusions Postural tracking of the variable pink-noise based visual target modulated the amplitude but not cycle duration complexity of voluntary sway in contrast to previous evidence showing modulation of gait cycle duration by a fractal auditory metronome[1]. This discrepancy is explained by the visual nature of the target because vision dominates spatial perception[4]. It could also be attributed to the presence of feedback since feedback alone increased the complexity of both sway duration and amplitude. Variable pink-noised visual cues may be a more relevant stimulus for modulating the complexity of voluntary sway especially in older adults who show greater spatial than time deficiencies when coupling posture to external stimuli[3]. ACKNOWLEDGEMENTS AND FUNDING Haralampos Sotirakis is supported by the General Secretariat for Research and Technology and the Hellenic Foundation for Research and Innovation [1]Hunt et al. Sci. Rep.(2014) [2]Robinovitch et al. The Lancet(2013) [3]Sotirakis et al. Neurosci. Lett.(2017) [4]Hove et al. J. Exp. Psychol. (2010).

P3-H-74 Muscle activity in the affected leg of stroke patients can be manipulated by altering guidance offered to the unaffected leg during Lokomat walking

Sylvana Weiland¹, Heleen Reinders-Messelink², Annemarijke Boonstra², Lucas van der Woude¹, Rob den Otter¹

¹University Medical Center Groningen, ²Rehabilitation center 'Revalidatie Friesland'

BACKGROUND AND AIM: The Lokomat, a robotic exoskeleton, offers the possibility to train asymmetrically and to study the neuromuscular linkage between the legs during gait. A previous study in healthy young participants [1] showed that ipsilateral muscle activity can be influenced by asymmetrical settings of movement support, or 'guidance': (1) ipsilateral muscle activity



increased when contralateral guidance was lowered and (2) ipsilateral muscle activity decreased when contralateral guidance increased. By providing asymmetrical guidance during Lokomat therapy in stroke patients, the capacity of the unaffected leg might be utilized to evoke a higher muscular output in the affected leg. To test this idea, we examined the effects of asymmetrical guidance levels on gait related muscle activity in hemiplegic stroke patients. METHODS: Ten chronic hemiplegic stroke patients walked in the Lokomat at two treadmill speeds (1 and 2 km/h), while guidance to the legs was offered symmetrically (both legs received 30% or 100%) or asymmetrically (one leg receiving 30% and the other leg 100%). Surface electromyography (EMG) was recorded from Biceps Femoris, Rectus Femoris, Vastus Medialis, Medial Gastrocnemius and Tibialis Anterior. Repeated Measures ANOVA's were conducted to assess the effects for each muscle at both speed levels separately. RESULTS: At 1 km/h, the amount of muscle activity in the affected leg depended on the level of guidance offered to the unaffected leg (see additional graphical material). Muscle activity (Vastus Medialis and Medial Gastrocnemius) in the affected leg increased when guidance to the unaffected leg was lowered. Conversely, muscle activity of these muscles in the affected leg decreased when more guidance was offered to the unaffected leg. At 2 km/h, however, no such effects could be observed. CONCLUSIONS: This study shows that, for specific speed settings, muscle activity in the affected leg of stroke patients can be influenced by contralateral guidance levels. The effect in Medial Gastrocnemius might be particularly desirable in training settings for stroke patients, since weakness in this muscle has been shown to be a main limiting factor for functional gait performance [2,3]. As the results point out, effects of asymmetrical guidance levels could only be observed in selected muscles at 1 km/h and not at 2 km/h. These results are in line with a previous study in healthy participants [1]. A possible explanation might be related to the inertia characteristics of the Lokomat exoskeleton. The results of this study urge further research on strategies for rehabilitation of stroke patients in which the capacity of the unaffected leg can be exploited to evoke a higher muscular output in the affected leg. ACKNOWLEDGEMENTS AND FUNDING: The authors wish to thank Emyl Smid for his technical support and the physiotherapists Steven Floor, Matthijs Dijkema and Geke van der Heide for their help with the recruitment and data collection. Lastly, the authors wish to thank 'het Revalidatiefonds' for providing financial support to this project.

I - Development of posture and gait

P3-I-75 The motor control of running in children and their development

Margit Bach¹, Andreas Daffertshofer¹, Nadia Dominici¹

¹Vrije Universiteit Amsterdam

BACKGROUND AND AIM: Muscle synergies are generally considered as the overall neural output of the central nervous system to evaluate motor control tasks like locomotion. The development of walking in children has been described using muscle synergies and it was shown





that the number of muscle synergies increases from the neonate to the toddler [1]. In adults, the major difference between walking and running has been related to the shift to an earlier phase in the gait cycle of one of the temporal activation patterns as an effect of a reduced duration of the stance phase [2]. We hypothesise that running follows a similar course of development as walking does. This implies a gradual maturation to resemble that of the adult pattern, i.e. increased number of synergies accompanied by a temporal shift related to a reduced stance phase. **METHODS:** In this cross-sectional, observational study, we investigated comfortable overground and treadmill walking and running in twenty-four healthy children (2-8 yrs) and seven young healthy adults (22-28 yrs). We collected kinematics and ground reaction forces (GRF) from the treadmill trials, accelerometer data from the tibia, and 30 bilateral limb, trunk, and arm muscles. Step events were determined based on kinematics and vertical GRF for treadmill trials and accelerometer data for overground trials. A muscle synergy analysis was carried out using non-negative matrix factorisation. A maximum of 20 strides were analysed per participant per modality. Full-width halfmaximum (FWHM) was determined for the medial gastrocnemius muscle (MG). RESULTS: Children younger than 6.5 years managed the running condition on the treadmill with a walk-run strategy. There, we observed strides with the presence of double support phase and strides with flight phase. During overground running, only the children younger than 4.5 years showed the same walk-run strategy. The FWHM of MG showed that there were no differences between overground and treadmill running for the adult group and children older than 4.5 years. We particularly considered the MG because we show that its burst duration is reduced with maturity of the walking gait pattern. However, the children younger than 4.5 years had a longer burst duration of the MG for the running treadmill trials compared to the overground trials. The muscle synergy analysis revealed a similarity in the activation pattern representing the MG muscle with a shift corresponding to the reduced stance phase for running compared to walking. There were fewer muscle synergies needed to explain 90% of the variance accounted for in children younger than 4.5 years old across all modalities. CONCLUSION: The preliminary results of this study confirmed our hypotheses: the older the child the more the muscle synergy patterns resemble that of the adult pattern. Moreover, the development of running in children appeared gradual as the youngest children had to make use of a combination of a walk-run strategy in order to manage a running task. 1. Dominici, N., et al., Locomotor primitives in newborn babies and their development. Science, 2011. 334(6058): p. 997-9. 2. Cappellini, G., et al., Motor patterns in human walking and running. J Neurophysiol, 2006. 95(6): p. 3426-37.

P3-I-76 Spatiotemporal gait characteristics in adolescent idiopathic toe walkers

Rahul Soangra¹, Richard Beuttler¹, Caprice Hollandsworth¹, Shewta Chheda¹, Afshin Aminian², Marybeth Grant-Beuttler¹

¹Chapman University, ²Children's Hospital of Orange County





BACKGROUND AND AIM: Idiopathic toe-walking is a childhood condition of unknown cause characterized by persistence of toe-to-toe gait pattern without evidence of neurologic, orthopedic, or psychiatric disease. Gait analysis and step counting for toe-toe gait and heel-toe gait are important objective diagnostic tools for understanding gait characteristics in idiopathic toe walking (ITW). The objective of this experimental study was to investigate gait in ITW using motion capture camera system. Further the amount of walking throughout day was measured using body fixed wearable sensor for 3-days. **METHODS:** Six adolescents (4 males and 2 female) of mean age, 13.5 years participated in this study. Participants walked on a 10 m walkway with embedded forceplates for gait analysis. To assess daily step counts, a small, light- weight sensor (DynaPort Hybrid, McRoberts, The Hague, Netherlands; 87 ×45 ×14 mm, 74 g) was attached to a belt and worn on their lower back for 3-days in their home environments. The device housed a triaxial accelerometer (sensor range and resolution: ±6 g and ±1 mg, respectively) and a triaxial gyroscope (sensor range and resolution: ±100 °/s and ±0.0069 °/s, respectively) which allowed longitudinal assessment of free-living activities and walking behavior is important but currently not clinically feasible for monitoring children who toe-walk. RESULTS: We found that adolescents who toe walk reduced the percentage of double limb support times to 9.0±4.9% of the gait cycle. When the participants were asked to walk with their best heel strike, they increased their double limb support time to 30% of the gait cycle. During the most stable period of gait, this reduction in double limb support time during toe-walking may reduce proprioceptive input. We also found 10% increase in gait cycle time and 19% decrease in mean step width when the participants were cued to produce a heel-to-toe gait. Step width and double support are both representative of balance control and their increase while producing a heel strike in these participants shows a disruption of the automatic stepping mechanism and poor balance control. Through longitudinal tracking using wearable sensor, we found that the average number of steps walked by adolescent ITW was 6555±3515 steps with average walking time 1.2 hours/day which was far less than their agematched counterparts (≥12000 steps). This reduced locomotion duration may be attributed to their less efficient gait pattern. CONCLUSIONS: We acknowledge the results of this study are limited due to small sample size of six subjects. In this study, we found that the adolescents who ITW exhibit different spatial-temporal gait characteristics when walking toe-toe gait (participant's typical gait) to that of best heel strike condition (cued heel-to-toe gait). Future interventions targeted to increase the frequency of heel-to-toe gait in adolescents who toe walk is important and tracking information on gait variables and step counts in their home environments can help design new targeted interventions and dosages.

P3-I-78 Balance and postural control in healthy children under 12 years of age: A systematic review

Prasath Jayakaran¹, Katie Bromley¹, Hayley Foster¹, Nikko Kim¹, Karaitiana Smith¹

¹University of Otago





BACKGROUND: Vision, vestibular and somatosensory system are the three key sensory systems required for an effective postural control. Typically, the function of these sensory systems improve progressively from birth to adulthood. However, these sensory systems mature at different rates as we age. The time it takes for each system to fully mature and therefore become integrated in postural control is still not known. This systematic review aims to review and collate data on postural control in children under 12 years of age, specifically relating to sensory information and organization, as measured by the Sensory Organization Test (SOT) using a Computerized Dynamic Posturography and/or modified Clinical Test of Sensory Interaction on Balance (mCTSIB). The SOT and mCTSIB measures were specifically targeted in this review, as they effectively manipulate the available sensory information and thereby inform the individuals' sensory integration for balance. METHODS: An electronic search was conducted in multiple databases using search strategies appropriate to the respective databases. Articles investigating postural control in children aged 12 years and under using SOT or mCTSIB were considered for inclusion in this review. Studies on children with a health condition such as cerebral palsy, strabismus and amputation were excluded from the review. However, if those studies had provided data on healthy control children were then considered for inclusion. The data extracted from the included studies were categorized into the following three age groups: 3-5 years (Group 1), 6-9 years (Group 2) and 10-12 years (Group 3). Data from the studies were pooled to find a mean data (weighted) across the included studies for the three age groups. RESULTS: A total of 29 articles were finally included in this review. SOT of the NeuroCom Equitest® was used to measure postural balance in 24 of the included studies. The SOT includes six sensory testing conditions with standing eyes open or closed on a sway-referenced force platform and visual surround, with the difficulty of the conditions progressively increasing from condition 1 to 6. The review found that the Equilibrium scores of the children increased progressively with the age groups for the six conditions. All three age groups had obtained higher scores in SOT-condition 1 (80.6, 88.94 and 92.84) and a lower equilibrium score in SOT-condition 6 (29.87, 38.56 and 57.57). The mCTSIB had been used in the remainder of the five studies. The mCTSIB includes four testing conditions, with standing eyes open or closed on a firm or a foam surface. Generally, the centre of pressure (COP) area for the mCTSIB decreased with the age groups. COP measures for Condition 4 (eves closed on foam surface) was observed to be lowest in Group 3 (10-12 years old - 22.00 mm²) and highest in Group 1 (3-5 years old - 28.40 mm²). CONCLUSION: The data provides a better understanding of postural control in children as they age, in altered sensory conditions. The measures of balance/postural control were progressively increasing until the age of 12 years, in all sensory testing conditions. The findings of the review may be useful to compare the postural control of children with balance deficits due to a health condition.

P3-I-79 Modular control of the leading and trailing limbs during obstacle clearance in children: Preliminary results

Michael MacLellan¹





INTERNATIONAL SOCIETY OF POSTURE & GAIT RESEARCH

¹University of Prince Edward Island

BACKGROUND AND AIM: A large proportion of the variance observed in muscle activity during locomotion can be explained by four to five temporal activation patterns. Children present a similar modular control of locomotion and studies have shown a refinement of these activation patterns throughout development. Locomotor adjustments such as obstacle clearance can be executed through a modulation of these temporal patterns, however it is unknown if developing children also use this mechanism of control. The purpose of this study was to determine if children exhibit modular control of the leading and trailing limbs during obstacle clearance. **METHODS:** To date, eight healthy children (age range: 2.3 - 6.1 yrs from onset of upright locomotion) performed overground walking and obstacle clearance over a piece of wood (0.1 m height, 1 m length, 0.01 m depth), which was placed 5 m from the start position. Full body 3-dimensional kinematics and activities from ten lower limb muscles on the right side of the body were recorded. During obstacle clearance, children repeated the task until a minimum of five trials for each of the leading and trailing limbs were obtained. All muscle activities were normalized to the peak activation observed during over-ground walking. Non-negative matrix factorization was applied to the amplitudenormalized muscle activations in order to identify the underlying temporal patterns and muscle weighting coefficients for over-ground walking, as well as in the leading and trailing limbs during obstacle clearance. **RESULTS:** The analysis identified 3-4 patterns that explained 94.3%, 93.8%, and 92.4% of the muscle activity variance for the over-ground, leading, and trailing limbs, respectively. As seen in heathy young adults, an additional burst was presented in the temporal pattern associated with the biceps femoris and semitendinosus muscles around toe-off. This burst is indicative of the increased knee flexor activation required to elevate the lower limb over the obstacle. In six of eight children in the leading limb, and three of eight children in the trailing limb, an additional burst at mid to late swing was observed in the temporal pattern associated with the medial and lateral gastrocnemius muscles. In some children, this additional burst appeared to be associated with decreased dorsiflexion of the descending foot prior to ground contact. **CONCLUSIONS:** These data indicate that children present modular control of muscle activation patterns when stepping over obstacles, similar to that seen in adults. However, some children presented an additional burst in the ankle plantarflexor temporal pattern, suggesting an altered landing strategy following clearance of the obstacle. Further investigation with a greater population of children may illustrate how children transition from this altered pattern to the mature pattern presented in adults.

P3-I-80 Development of postural control during single-leg standing in children aged 3-10 years

Hiroki Mani¹, Saori Miyagishima², Naoki Kozuka², Kenji Taneda¹, Takahiro Inoue¹, Kenta Takeda¹, Tadayoshi Asaka¹

¹Hokkaido University, ²Sapporo Medical University





BACKGROUND AND AIM: The ability to control the center of mass (COM) during single-leg standing (SLS) is imperative for individuals to walk independently. Furthermore, SLS skill is an indicator of anticipatory control and needs anticipatory postural adjustments. However, detailed biomechanical features of postural control during SLS performed by children remain to be comprehensively investigated. Therefore, the purpose of this study was to investigate the development of postural control during SLS in children aged 3-10 years. METHODS: Forty-eight healthy children (26 boys and 22 girls) aged 3-10 years and 11 young adults participated in this experiment. The child population was divided into four groups by age: 3-4, 5-6, 7-8, and 9-10 years. The SLS task included standing on a single leg as long and as steady as possible for up to 30 s. A three-dimensional motion capture system and two force plates were used for calculating the COM and center of pressure (COP). The task was divided into three phases (accelerated, decelerated, and steady) on the basis of the relationship between COM and COP. The root means squares (RMSs) of COP-COM distances in each phase were calculated. A one-way ANOVA was used with the factors Group (3-4 years, 5-6 years, 7-8 years, 9-10 years, and adults) for analysis across group differences. Additionally, Pearson's correlation coefficient was used to examine the relationships between COP-COM distances in accelerated phase and decelerated phase in each group to assess postural control strategies during the age frames. RESULTS: COP-COM distances in the 5-6 years' and 7-8 years' groups were significantly increased during the accelerated phase when compared with those in the adult group. Furthermore, COP-COM distances during the decelerated phase were significantly higher in all children's groups compared with those in the adult group. Lastly, COP-COM distance during the steady phase was significantly higher in the 3-4 year age group than in the 9-10 year age and adults groups. In addition, significant correlations between COP-COM distances in accelerated phase and decelerated phase were found at 7-8 years (r = 0.71; p = 0.01) and at adulthood (r = 0.85; p < 0.01). Conversely, no significant correlations were found at 3-4 years, 5-6 years, and 9-10 years groups. **CONCLUSIONS:** Postural control during the accelerated and steady phases mature at a minimum of 9 years of age. Conversely, children ~10 years of age did not attain adult-like levels of postural control during decelerated phase. Anticipatory control gradually becomes gradually effective at about 7-8 years of age during the transition phase. Children between the ages of 6 and 8 years produce excessive anticipatory control when compared with those aged 9-10 years and adult subjects. The developmental process for postural control at each phase possibly plays a significant role in the basic biomechanics of movement and does not display a monotonic pattern.

J - Developmental disorders

P3-J-81 Feedforward motor control in developmental dyslexia and developmental coordination disorder: Does comorbidity matter?

Christine Assaiante¹, Fabien Cignetti², Marianne Vaugoyeau¹, Aurelie Fontan¹, Marianne Jover³, Brigitte Chabrol³



¹CNRS, ²CNRS, TIMC-IMAG UMR 5525, ³AMU

BACKGROUND AND AIM: Children with developmental coordination disorder (DCD) experience difficulties in predictive motor control. It is hypothesised that these difficulties result from a deficit to use properly internal models. Several studies also reported poor motor abilities in children with developmental dyslexia (DD), which are grouped under the term sensorimotor syndrome. Thus, impaired motor control related to internal model deficits may not be specific to DCD but may constitute a hallmark of developmental learning disorders. However, it is imperative to address this issue by considering (i) the fact that models of motor control divide movements into two components, namely a feedforward component and an online component, and (ii) the cooccurrence of developmental learning disorders. Feedforward and online controls are two facets of predictive motor control from internal models, which is suspected to be impaired in learning disorders. In the present study we sought to determine whether children with DD and/or DCD demonstrate impaired feedforward control in the task of bimanual unloading, compared to typically developed (TD) children. This task requires anticipating for a perturbation in one hand that is the result of a volitional action of the other hand. **METHODS**: Children (8-12 years) underwent a bimanual unloading paradigm during which a load supported to one arm, the postural arm, was either unexpectedly unloaded by a computer or voluntary unloaded by the subject with the other arm. RESULTS: All children showed a better stabilization (lower flexion) of the postural arm and an earlier inhibition of the arm flexors during voluntary unloading, indicating anticipation of unloading. Between-group comparisons of kinematics and electromyographic activity of the postural arm revealed that the difference during voluntary unloading was between DD-DCD children and the other groups, with the former showing a delayed inhibition of the flexor muscles. These results demonstrated that only children with both DD and DCD were impaired in bimanual unloading (Cignetti et al, 2018). CONCLUSION: Although all children with learning disorders were able to implement anticipatory control, internal modelling deficit as evidenced through delayed muscle inhibition was found in DD-DCD children only. This outcome questions the common hypothesis of impaired internal models in DCD children and suggests that it may apply to comorbid subtypes only, as here DD-DCD. The development of a comprehensive framework for performance deficits in children with learning disorders will only be achieved by dissociating key components of motor prediction and focusing on subtypes and comorbidities. Cignetti, F., Vaugoyeau, M., Fontan, A., Jover, M., Livet, MO., Hugoneng, C., Audic, F., Chabrol, B., Assaiante, C. (2018) Research in Developmental Disabilities, Volume 76, May 2018, 25-34.

P3-J-82 Use of cluster analysis for gait classification of patients with syndrome of Dravet

Ann Hallemans¹, Lore Wyers¹, Karen Verheyen¹, An-Sofie Schoonjans¹, Berten Ceulemans², Patrica Van de Walle¹

¹University of Antwerp, ²Antwerp University Hospital



BACKGROUND AND AIM: Dravet syndrome is one of the most severe genetic epilepsies, representing 3-6% of epilepsy cases in infancy[1]. A recent survey showed that Dravet syndrome should be considered as a disease of the central nervous system with far reaching effects. Characteristic symptoms, next to epileptic seizures, include gait disturbances, ataxia, hypotonia and cognitive delay. Gait disturbances were common in the 1- to 3-year old group and the frequency of gait disturbances increased steadily reaching nearly 90% in 16- to 25-year olds[2]. The gait pattern has been described as a progressive crouch pattern arising in 80% of 13+ year old patients [3]. However, the clinical picture suggests gait disturbances are diverse. Therefore, the aim of this study is to classify gait patterns of patients with Dravet syndrome using cluster analysis. METHODS: Twenty-six patients (14.3 ± 5.4 years) with genetically confirmed diagnosis of Dravet syndrome were included. Gait was characterised during overground walking at selfselected walking speed by instrumented gait analysis (Vicon, PlugIn Gait). Non-hierarchical (kmeans) cluster analysis was performed on the spatiotemporal and kinematic parameters of gait, selected from previous research as characteristic for gait deviations in Dravet [3-5]. Repetition of calculations with varying number of clusters was performed and evaluated by the silhouette plot and silhouette value. Univariate analysis of variance were used to compare spatiotemporal and kinematic parameters between clusters (α =0.05). All analyses were performed in Matlab R2017a (for Windows). RESULTS: Three clusters of gait patterns were identified. The ANOVA revealed differences between the clusters in anterior pelvic tilt, hip rotation, knee flexion angle at initial contact, ankle rocker and foot progression angle. Cluster 1 (16/26 patients) is characterised by mild anterior pelvic tilt (16.3 ± 0.9°), external hip rotation (-11.4 ± 1.6°) and external foot progression angle (-17.4 ± 1.9°). Cluster 2 (7/26 patients) is characterised by only mild gait disturbances suggesting a fairly functional gait pattern. Cluster 3 is characterised by increased anterior pelvic tilt (19.6 \pm 2.0°), increased knee flexion at initial contact (24.3 \pm 2.6°) and a horizontal ankle rocker. Clusters do not differ in age or in spatiotemporal parameters of gait. **CONCLUSIONS:** The results from this cluster analysis confirm the clinical picture of diverse gait disturbances. Contrary to what is reported previously, the majority of patients appear to have gait disturbances in the transverse plane while only a minority fits the crouch gait pattern. ACKNOWLEDGEMENTS: This study was funded by FWO (TN003116N) 1. Al-Baradie, R.S., Neurosciences, 2013. 18(1): p. 11-7. 2. Villas, N., M.A. Meskis, and S. Goodliffe, Epilepsy Behav, 2017. 74: p. 81-86. 3. Rodda, J.M., et al., Arch Neurol, 2012. 69(7): p. 873-8. 4. Verheyen, K., et al., Gait & Posture, 2018. 65: p. 323-324. 5. Spagnolo, E., et al., Gait & Posture, 2016. 49: p. S10-S11.

P3-J-83 Concurrent validity of the Clinical Test of Sensory Interaction of Balance (CTSIB) Kids-BESTest criteria with laboratory center of pressure measures in children with and without cerebral palsy

Leanne Johnston¹, Rosalee Dewar¹, Kylie Tucker¹, Andrew Claus¹, Rob Ware²





¹University of Queensland, ²Griffith University

BACKGROUND AND AIMS: Laboratory data shows that children with Cerebral Palsy (CP) have postural control deficits in standing due to dysfunctional anticipatory mechanisms, adaptive mechanisms, musculoskeletal components and sensory strategies. However, current clinical assessments lack psychometric evidence, particularly for assessing sensory deficits. The aim of this study was to evaluate the concurrent validity of the Clinical Test of Sensory Integration of Balance (CTSIB) criteria from the new Kids-BESTest, against simultaneously collected laboratory measures of postural control. **METHODS:** Participants were 17 children with CP (aged 7-17 years; GMFCS I=11, II=6; Diplegia=4, Hemiplegia=13; 11 males) and 41 age and gender matched typically developing (TD) children. Standing balance was assessed using CTSIB-Firm and CTSIB-Foam conditions with eyes open (EO) and eyes closed (EC). Clinical scores were allocated using Kids-BESTest criteria: '0=unable', '1= <30sec', '2=30sec unstable', and '3=30sec stable'. Duration was measured by stopwatch. 'Stability/instability' was observed as 'leaning' or using a 'hip strategy' according to Kids-BESTest instructions. Simultaneous to real-time assessment, children stood on a Bertec forceplate and centre of pressure (COP) measurements were collected to derive 'duration' (before step recovery), 'velocity' (path length/ duration) and 'displacement' in anteroposterior (AP) and medio-lateral (ML) directions. Spearman's rank correlation coefficients were used to examine relationships between Kids-BESTest scores and COP variables. RESULTS: TD children achieved Kids-BESTest scores of 2-3 for all conditions. Children with CP found Foam-EC the most difficult (scores 0-1) and Firm-EO the easiest (scores 1-3). Kids-BESTest scores showed excellent agreement with COP duration (e.g. children scoring '0=unable' demonstrated a COP duration of 0 seconds; those scoring '1= <30sec' had a duration of <30sec). 'Stable/unstable' posture was associated with several COP variables. Excessive 'leaning' was related to larger COP displacement (AP: Foam-EO p=0.001; ML: Firm-EO p=0.005, Firm-EC p=0.05, Foam-EO p<0.001). Use of 'hip strategy', or excessive 're-adjusting', was detected by higher COP velocity (AP: Firm-EO p=0.05, Foam-EO p=0.001; ML: Firm-EO p=0.02, Foam-EO p=0.003). An additional strategy of 'constraining' was observed in some children as smaller COP displacement and/or velocity. CONCLUSION: Our data shows that Kids-BESTest criteria for CTSIB-Firm and CTSIB-Foam conditions is accurate and easy to apply for duration of standing balance in children with CP. 'Postural stability/instability' could be identified from COP data, but was not related to just one COP dimension. We recommend that the Kids-BESTest guide to possible 'instability' strategies be extended to include excessive 're-adjusting' or 'constraining', alongside 'leaning' or using a 'hip strategy'. This may assist novice raters to identify instability more reliably.

P3-J-84 Postural control in young adults with high-functioning Autism Spectrum Disorder (ASD): Distinguishing between general and sensory channel-specific impairments

Rebekah Knox¹, Mihalis Doumas¹

¹Queen's University Belfast





BACKGROUND AND AIM: Postural control deficits in Autism Spectrum Disorder (ASD) are wellestablished, yet their aetiology remains unclear. Postural control depends on the integration of information from proprioceptive, visual and vestibular channels, which is utilised by a feedback mechanism to generate motor output to maintain upright stance. Peripheral, sensory information is relatively intact in ASD, but sensory integration is impaired across various tasks (e.g. Stevenson et al., 2014) including postural control especially when sensory integration demands increase (e.g. Doumas et al., 2016). This evidence suggests that sensory integration impairments may be at the crux of postural control deficits in ASD. However, it is uncertain whether such impairments are general, or specific to certain sensory channel(s). To date, no studies have systematically examined postural adaptation to inaccurate sensory information pertinent to balance. The aim of this study was to assess the nature of these sensory integration difficulties by examining how individuals with ASD adapt to inaccurate visual and proprioceptive information, individually and simultaneously. METHODS: 13 individuals with ASD (age range 20-39 years) and 13 typically developed (TD) individuals (age range 19-31 years) with IQ>80 participated in this study. All participants completed an IQ test and sensory profile. Individuals with ASD also completed an ADOS-2 assessment of ASD severity. Participants stood on a balance platform and body sway was measured using motion capture. Postural adaptation was assessed by introducing inaccurate visual, proprioceptive, or both visual and proprioceptive information, using sway referencing of the surround, support or both. Each condition comprised 2 minutes of standing in an unperturbed environment (baseline), 3 minutes in the inaccurate environment (adaptation) and a further 2 minutes in an unperturbed environment (reintegration), in order to measure any after-effects. **RESULTS:** Neither visual nor proprioceptive perturbations in isolation revealed differences between ASD and TD groups. However, when both perturbations were applied simultaneously, group differences emerged. More importantly, in the simultaneous condition both groups initially exhibited a similar degree of increased sway, but the sway for the TD group subsequently decreased and plateaued whereas sway for the ASD group did not decrease throughout the adaptation period. CONCLUSIONS: Our results support previous evidence implicating sensory integration impairments in the aetiology of postural control deficits in ASD, as group differences in sway adaptation only emerged during the condition which posed the greatest sensory integration demands. Future research should also perturb the vestibular channel in order to probe the possible contribution of vestibular channel discrepancies to postural control deficits in ASD. ACKNOWLEDGEMENTS AND FUNDING: This work was supported by a Department of Employment and Learning PhD studentship to R. Knox. This study was carried out in preparation for a Doctor of Philosophy dissertation. The authors would like to thank Dr Katherina Dounavi and all participants who took part for their input to this study.

K - Devices to improve posture and gait

P3-K-85 A development of a bicycle-simulator-balance trainer with a novel system that provide customized unexpected perturbations during bicycling (the PerStBiRo system)



Shani Batcir¹, Yaakov Livne¹, Rotem Lev Lehman¹, Guy Shani¹, Amir Shapiro¹, Itshak Melzer¹

¹Ben-Gurion University

BACKGROUND AND AIM: The reactive balance control mechanism is the only recourse to recover from unexpected loss of balance. Recent studies show that participating in unexpected Perturbations Based Balance Training (PBBT), a novel approach that challenged the dynamic stability mechanisms, older adults reduced rate of falls. However, so far, the PBBT devices and programs were designed only for the healthiest independent older subjects while fall rates are higher in frail and pre-frail older adults. Thus, there is a critical need to provide the PBBT principles accessible to a wider range of the elderly population. Firstly, we conducted a preliminary study on 20 older adults aged 65-85 who regularly ride bicycles and 30 age- and gender- matched nonbicycle riders. We found Bicycling regularly preserves the reactive balance control and speed of voluntary stepping in older adults, both related to risk of falling. Secondly, in a laboratory study, using 3D kinematic analysis, we found that after unexpected loss of balance, trunk and hip movements are highly involved in the reactive balance reactions. Finally, we aimed to incorporate the PBBT principles, with the bicycle characteristics that require balance and with the well-known health advantages of bicycling to create a novel balance rehabilitation device - the first mechatronic system that challenges the reactive balance control in older adults during bicycling in safe sitting position, suitable for elderly at different levels of functioning. METHODS: Interdisciplinary collaboration at Ben-Gurion University between The Rehabilitation Laboratory (Physical Therapy Department), the Robotics Laboratory (Mechanical Engineering Department) and the Software and Information Engineering Department. RESULTS: The PerStBiRo system has three main parts that communicate with each other: 1) the servo roll-angle motor that is powered by a motion control system and connects to the mechatronic-bicycle device - the mechanical basis of the system that produce the perturbations; 2) the motion detection camera that detect both, the natural subject's body amplitude (the "base noise" of upper body sway) and the personal balance reactions - the basis information the system rely on for returning the device to its neutral position after a perturbation; 3) the computer controller program that control online the exact position of the bicycle, the subjects' balance reactions and the perturbation parameters - allowing the system to adjust the training program to the subject's ability in safe environment by simulating different types of situations with different types of perturbation parameters (magnitude, velocity, acceleration and timing of the perturbation). For safety reasons the subject will be harnessed to safety straps from the ceiling. CONCLUSIONS: Training on the PerStBiRo system, besides improve strength, power and cardiovascular components, will also improve specifically and effectively the reactive balance control to reduce the risk of future falls among older adults. **ACKNOWLEDGEMENTS:** This study was partially supported by the Helmsley Charitable Trust through the Agricultural, Biological and Cognitive Robotics Initiative of Ben-Gurion University of the Negev.





P3-K-86 Immediate effect of a rehabilitation dog on weight-bearing and balance during early prosthetic training in individuals with vascular lower-limb amputation

Cyril Duclos¹, Brendon Pham², Valérie Martin-Lemoyne³, Dany Gagnon²

¹Université de Montréal, ²Université de Montréal, School of rehabilitation, ³Centre for Interdisciplinary Research in Rehabilitation (CRIR-IRGLM)

BACKGROUND AND AIM Major lower limb amputation alters walking and balance capacities. Mobility prognostic is better when individuals with lower-limb amputation use more their prosthesis for weight bearing during gait training. However, passive walking aids tend to reduce the weight placed on the prosthesis. Rehabilitation dogs can be used as a walking aid, and improved weight bearing in post-stroke case studies. The objective of this cross-sectional study was to determine the immediate effect of a rehabilitation dog compared to passive walking aids on weight bearing and balance in standing position and during gait in individuals with lower-limb amputation at the beginning of prosthetic gait training. **METHODS** Fourteen individuals with below-knee amputation due to vascular problems participated in this study once they were able to walk with walking aids after initial prosthesis fitting. They were asked to stand with the eyes open or closed, and with their current walking aid or with the rehabilitation (30 seconds each, two repetitions of each condition, 8 trials), and to walk also with both types of walking aids. Ground reaction forces were recorded in each task. Gait speed, vertical ground reaction forces on each side, range and velocity of centre of pressure (COP) displacements were compared between conditions using ANOVAs. **RESULTS** Higher vertical ground reaction forces were measured, particularly under the prosthetic foot when standing (p<0.01, large effect sizes) and walking (p<0.001, large effect sizes) when using the dog compared to passive walking aids. Standing with the rehabilitation dog also increased COP displacements, but only with the eyes closed under the prosthesis (p<0.05, large effect size). COP velocity increased under the non-amputated side during standing, and in the anteroposterior direction under the prosthesis during walking (p<0.01, large effect size) with the rehabilitation dog, compared to crutches. Gait speed did not change between walking aids (p=0.48). CONCLUSION Using the rehabilitation dog increased weight bearing on the prosthesis and postural activity during standing and walking. The rehabilitation dog may thus be a good stimulus for gait and balance training, rather than a simple walking aid. Further studies are warranted to evaluate the effect on gait and functional performance of using a rehabilitation dog regularly during prosthesis training post-amputation. FUNDING Programme des chiens d'assistance du Ministère de la Santé et des Services Sociaux du Québec.

P3-K-87 Effect of multi-tasking on gait and cognitive demands in adults with Alzheimer's dementia experienced in using a 4-wheeled walker

Susan Hunter¹, Alison Divine², Humberto Omana¹, Walter Wittich³, Andrew Johnson¹, Keith Hill⁴

¹University of Western Ontario, ²University of Leeds, ³University of Montreal, ⁴Curtin University



BACKGROUND AND AIM: Introduction of a mobility aid to facilitate independence in people with Alzheimer's dementia (AD) is routinely made by health-care professionals when clients exhibit balance and walking impairments. Learning to walk with a 4-wheeled walker increases cognitive demands in people with AD, though experience should moderate this effect. Community ambulation involves maneuvering around obstacles under sometimes complex situations (e.g., walking and talking), multi-tasking. Current research has not yet established how gait in people with AD experienced in using a 4-wheeled walker is affected in complex situations. Study objectives were: 1) to evaluate the effect of multi-tasking on spatial-temporal gait parameters in experienced 4-wheeled walker users, and 2) to evaluate gait and cognitive task cost while multitasking. METHODS: Twenty-three adults with mild to moderate AD (age 87.4 ± 6.2 years) and at least 6 months of walker use participated. Three walking configurations: 1) straight path (SP), 2) Groningen Meander Walking Test (GMWT), and 3) Figure of 8 path (F8) were tested under two walking conditions: 1) baseline (BL: walking with aid) and 2) multi-task (MT: walking with aid and counting backwards by ones). No task prioritization instructions were provided. Velocity and stride time variability were collected with accelerometers. Cognitive performance was evaluated as a single-task in sitting and then responses were recorded during multi-task condition. Gait and cognitive task cost was the difference in velocity performance between baseline and multi-task conditions as a percentage of the baseline performance. Two-way repeated measures ANOVAs were used to analyze the study aims. **RESULTS:** A significant interaction between walking configuration and condition was found for both velocity (p=0.002) and stride time variability (p=0.044). Gait velocity decreased and stride time variability increased as complexity of the walking configuration increased and with multi-tasking. Gait and cognitive task cost showed increased demands resulting in a deterioration in performance in the multi-task condition in all walking configurations. The majority of participants self-prioritized the cognitive task over the walking task while multi-tasking in all path configurations. CONCLUSIONS: Experienced 4wheeled walker users with mild to moderate AD exhibit impaired gait when walking in complex situations. A slowing of velocity is a fall reduction strategy in older adults, though an associated increase in stride time variability could increase falls risk. Importantly, in the multi-tasking situations the people with AD self-prioritized the cognitive task, a posture-second strategy in all test conditions that is associated with increased risk of falls. Future research needs to explore the possibility of training programs aimed at improving mobility aid walking in those with AD regardless of experience level. FUNDING: Alzheimer's Association Grant (AARG-16-440671).

P3-K-88 Evaluation of corrective moment of measurement orthosis using CB brace for knee osteoarthritis

Yasuhiro Mine¹, Tamotsu Sakima²

¹Toyo University, ²SAKIMA Prosthetics & Orthotics Co.,Ltd.





Introduction: The CB brace (The double hinge knee brace with center bridge) is a knee brace often prescribed for knee osteoarthritis (K-OA), and its pain reducing effect is well known. We have previously performed gait analysis by placing 8 markers on the primary positions of the CB brace and using the optical 3D motion capture system. Results showed that the arm of the brace at medialis cruris, one of the four arms of the CB brace, was found to be the involved in correction of the internal torsion of the knee. However, the measurement experiment only monitors the effect by the deformation amount of the arm terminal of the brace; thus, a device that monitors the corrective force itself was desired. In this study, we successfully developed such the measurement orthosis to measure the corrective force. METHODS: We developed the measurement orthosis using the CB brace. Fig(1) The sensor fixture, which contains the load cell, can be attached to the arm joint of the CB brace at the medialis cruris. As mentioned earlier, the arm of the brace at the medialis cruris is involved in correcting the internal torsion of the knee, and the vertical force to the sagittal plane of the brace arms during walking can be measured by the load sensor. Three different arm lengths of the brace at the medialis cruris, "short", "normal", and "long", were used for the experiment. Synchronous measurement by this device was performed with the optical three-dimensional motion capture analysis system. The Visual Analog Scale (VAS) recorded the knee pain during the experiment. Results showed different corrective force according to the arm lengths of the brace, which was defined as corrective moment and was used as a comparison parameter. **RESULTS:** The measurements results are shown in the figure. The subjects were diagnosed with bilateral knee osteoarthritis with varus alignments. One of the characteristics of the knee OA with alignment abnormality is the momentum sideways movement of the knee, sometimes called lateral thrust, which occurs suddenly in between the early stance phase of walking and the load response. It is caused by the floor reaction force and the varus torque moment. The developed device was feasible measuring the lateral thrust, and this is the first device that facilitates the measurement of the lateral thrust during walking. Discussion and **CONCLUSION:** The future possible development includes the use of Bluetooth and other devices to make the system wire-less and be able to monitor the condition of the knee during the walk through a portable terminal. Also, we are aiming to make selections of suitable knee bracing device specifically for each person, as well as supporting the conscious improvement of one's gait by monitoring the generation of lateral thrust, which exacerbates the knee OA. In this way, the device should improve the efficacy of the rehabilitation using the knee brace in many patients with knee OA. Key Words: CB-Brace, Knee-Osteoarthritis, Measurement-orthosis, Lateral thrust, Rehabilitation.

P3-K-89 Development of an active mechanical harness system

M Ann Reinthal¹, Debbie Espy¹, Lorenzo Bianco¹, Poya Khalaf¹, John DeMarco¹

¹Cleveland State University





BACKGROUND AND AIM: Intensive balance training is one of the most effective interventions in reducing falls for at-risk individuals. High-intensity protocols often require a harness system for safety, but almost nothing is known about the impact of harness support on balance related motor learning. Harness support may encourage more challenging training or greater effort, diminish the negative impacts of fear, and allow participation by otherwise too frail individuals; or, it may interfere with motor learning, or diminish the generalizability of postural control skills to the (nonharnessed) real world. An active, programmable harness system would allow the study of these impacts and identification of the optimal support parameters on training for balance and fall resistance. It would also serve as a therapeutic modality to be used in training as optimal protocols become identified. The purpose of this project was to develop such an active harness system, allowing modulation of vertical descent and support while continuously recording harness loading and fall velocity throughout all movements. METHODS: A motorized, active control, harness support system was designed and built. Iterative testing for functionality, safety, support control, and data collection was performed with weighted objects, then with human subjects during simulated balance loss, and then during a reactive slip protocol. Issues identified were corrected through changes to the hardware, software, or the protocols for their use. RESULTS: Major safety issues addressed included backup catch and limit switches for motor or system failure and control of disruptive noise and vibration. The first limit switch determines the starting point by finding the zero position when calibrating the system. The second limit switch prevents the subject from being lifted off the ground. Major functionality decisions included support modulation by primarily stiffness (vs. damping) control through the range from support initiation (X1) to lowest allowed point (X2). The stiffness is set to support the person's weight fully at X2, with damping only as needed to eliminate vibrations. Damping alone produced disruptive noise in the system. Support (stiffness) is modulated as a percentage of the user's weight. A graphical user interface was developed for ease of clinician use in setting parameters for testing. CONCLUSIONS: Collaboration was required to accommodate the desired requirements of the system and engineering capabilities. A major principle of motor learning is a withdrawal of feedback and support for optimal skill acquisition. Falls in the real world are rarely supported, so the training needs to translate. The active mechanical harness system could prove to be safer for older adults, especially the frail elderly, because of the ability to control the velocity of the lowering when falling. The mechanical harness system can also be used for proactive balance training where the tasks are self-initiated. Acknowledgments and FUNDING: This project was supported by Cleveland State University's Center for Human Machine Systems and the Undergraduate Summer Research Award program.

P3-K-90 Plantar foot mechanoreceptor topography and lower limb muscle activity

Kelly Robb¹, Stephen Perry¹

¹Wilfrid Laurier University





BACKGROUND AND AIM: The neuromotor control paradigm is one potential mechanism to understanding the physiological changes and effectiveness of foot orthoses [1]. By facilitating feedback from the plantar foot sole, foot orthoses can decrease fatigue and increase muscular efficiency during locomotion [2]. Secondly, by modifying the plantar foot sole interface, texture can increase cutaneous receptors ability to modify motor output [3]. The purpose of this study was to examine lower limb motor output when facilitating cutaneous mechanoreceptors on distinct plantar foot sole regions, as a method to further understand the relationship between site specificity of plantar foot sole mechanoreceptor facilitation and lower limb muscular output. METHODS: 55 healthy young adults (19 males, 36 females; 24.3±4.2years) were fit to customizable foot orthotics (Thinsport, Sole) and Rockport walking shoes (World Tour, Rockport). The plantar surface of the foot was divided into 5 topographical areas: medial & lateral forefoot, medial & lateral midfoot, and calcaneus, corresponding to 5 distinct areas of cutaneous receptor facilitation. Electromyography (EMG) data was collected during a series of level and incline walking trials (inclined platform during one single stance). Indwelling (iEMG) and surface (sEMG) EMG was recorded (sampling frequency = 1000Hz) from eight lower limb muscles (sEMG: tibialis anterior, peroneus longus, medial gastrocnemius, extensor digitorum longus; iEMG: extensor hallucis longus, flexor digitorum longus, flexor hallucis longus, tibialis posterior). The gait cycle was subdivided into 10% bins of normalized integrated EMG (full wave rectified, linear enveloped with 40Hz dual-pass Butterworth filter, and normalized to a percentage of peak activity), bins 1-6 correspond to stance phase, and bins 7-10 to the swing phase of gait. **RESULTS:** Preliminary results of tibialis posterior activity of 12 participants have been analyzed in stance phase (bins 1-6). There was a significant main effect of the sensory facilitated location on normalized tibialis posterior activity, F(5,11)=2.35,p=.04. In terminal stance (bin 6), the addition of texture to the medial midfoot significantly decreased tibialis posterior activity during level walking and significantly increased activity during incline walking (Figure 1a & b). CONCLUSIONS: Adding texture to the medial midfoot appears to modulate tibialis posterior activity, specifically decreasing its amplitude during flat walking, and increasing its amplitude when walking on incline surfaces. Further data processing is anticipated to strengthen these results and evaluate the remaining musculature. ACKNOWLEDGEMENTS AND FUNDING: Sole, Pedorthic Research Foundation of Canada, Natural Science and Engineering Research Council (NSERC), and Canadian Foundation for Innovation (CFI). REFERENCES:[1]Mills et al. (2010). Foot orthoses and gait: a systematic review and meta-analysis of literature pertaining to potential mechanisms. Br J Sports Med, 44(14), 1035-1046. [2]Nigg et al. (1999). Shoe inserts and orthotics for sport and physical activities. Med Sci Sports Exerc, 31(7), S421-S428. [3]Nurse et al. (2005). Changing the texture of footwear can alter gait patterns. J Electromyogr Kinesiol, 15(5), 496-5.

P3-K-91 Spinal cord stimulation improves gait and modulates cortical activity in parkinsonian patients unresponsive to dopaminergic medication

Olivia Samotus¹, Maria Alamos², Andrew Parrent¹, Mandar Jog¹





¹London Health Sciences Centre, ²Pontificia Universidad Catolica de Chile

BACKGROUND AND AIM: Axial symptoms such as postural instability, loss of balance, shuffling, freezing of gait (FOG), gait failure, and foot dragging are predominant in postural instability and gait dysfunction (PIGD) parkinsonian disorders including multiple system atrophy (MSA) and progressive supranuclear palsy (PSP). The response to dopaminergic (e.g. levodopa) medication is classically poor and patients require supportive therapies such as physiotherapy, occupational therapy, and rehabilitation to optimize function and alleviate suffering. Epidural thoracic spinal cord stimulation (SCS) is promising in treating gait dysfunction in Parkinson's disease patients with levodopa-resistant gait symptoms. The objective of this study was to investigate the neurophysiological and therapeutic effects of SCS in gait-dominant parkinsonian patients unresponsive to dopaminergic therapy. METHODS: One MSA and 4 probable PSP/PIGD participants with significant gait impairments underwent SCS implantation (T8-T10). Self-paced walking tasks were conducted across a 20-foot Protokinetics Zeno Walkway before SCS surgery and 3- and 6-months following SCS use. Six SCS settings were tested in a repeated, randomized and blinded fashion for each participant. SCS programming was individualized to each participant's spatiotemporal gait metrics within the first month post-SCS implantation. Participants utilized their best setting at-home. Eyes closed, resting state (EEG) recordings were conducted at baseline, with SCS turned off/on for 1-hour, and at 3- and 6-months of SCS use. RESULTS: Preliminary results demonstrated all participants improved on different SCS settings (300-400microseconds/30-130Hz). A mean 52% improvement in step length, stride velocity, swing and single support % gait phases were observed with SCS-ON for 1-hour in the laboratory. The number of FOG episodes reduced from a mean 20 episodes at baseline to 8 episodes with SCS-ON. The mean duration per FOG episode was reduced from 10 seconds at baseline to 4 seconds with SCS-ON. Similar improvements were observed over the 6-month period. Changes in low frequency oscillatory activity was observed over the treatment period. CONCLUSIONS: Personalization of SCS programming for each participant's gait symptoms was well tolerated and led to significant improvements in gait. The therapeutic effects of SCS may result from activity changes in sensory and motor cortical regions to a state preceding locomotion.

P3-K-92 How to encourage others: A perception-empathy biofeedback system for preventing falls in older adults

Kazuhiro Yasuda¹, Yuki Hayashi¹, Hiroyasu Iwata¹

¹Waseda University

•**BACKGROUND AND AIM:** Falls and fall-induced injuries are major global public health problems, and sensory input impairment in the elderly results in significant limitations of feedback-type postural control. The haptic-based biofeedback (BF) system can be provided to augment the somatosensory input in the elderly, and the application of the BF system can increase the





objectivity of the feedback and encourage comparison with that provided by a trainer. Nevertheless, an optimal BF system that focuses on interpersonal feedback has not been proposed. Thus, the purpose of this study was to propose a haptic-based perception-empathy BF system that provides information regarding the elderly's center-of-foot pressure pattern to both the elderly and trainer to refine the motor learning effect and to validate the feasibility of this balance training regimen in the healthy elderly. Furthermore, this study aimed to determine whether BF training required high cognitive load to clarify its practicability in real-life settings. •METHODS: Twenty older adults were assigned to two groups: BF and control groups. Participants in both groups tried balance training in the single-leg stance with the cognitive task (i.e., serial subtraction task). Retention was tested 24 h later. Testing comprised balance performance measures (i.e., 95% confidence ellipse area and mean velocity of sway) and dualtask performance (number of responses and correct answers). Finally, participants completed a questionnaire to measure their perceived impression associated with the proposed BF training. •**RESULTS:** Measurements of postural control using a force plate revealed that the stability of the single-leg stance was significantly lower in the BF group than in the control group during the balance task. The BF group retained the improvement of the 95% confidence ellipse area 24 h after the retention test. Dual-task performance during the balance task was not different between the two groups. Although those in the BF group reported at least some difficulty in performing the balance task, most participants could train with high motivation and accomplishment. •CONCLUSIONS: The proposed system demonstrated that the BF group more efficiently adapt to the balancing tasks than the control group that did not use BF, and elderly participants retained the improvement of postural spatial variability over 24 h, a sign of postural motor learning. With regard to the cognitive costs during the learning tasks, no significant difference was observed between the BF and control groups, thus suggesting the low cost (and high feasibility) of our system. Furthermore, the participants reported high levels of motivation and sense of accomplishment in their subjective evaluations, hence raising expectations that the system is conducive to augmenting learning efficacy and efficiency. ACKNOWLEDGEMENTS AND FUNDING: The authors thank Shinjyuku Silver Human Resources Center for assisting in participant recruitment and screening. This study was supported by the Japan Society for the Promotion of Science (JSPS), Grant-in-Aid for Scientific Research (C) No. 17K01875 and Grantin-Aid for Junior Researchers, Research Institute for Science and Engineering, Waseda University.

L - Effect of medication on posture and gait

P3-L-93 Gait speed does not mediate the association between antidepressants and falls

Orna Donoghue¹, Robert Briggs¹, Frank Moriarty², Rose Kenny¹

¹Trinity College Dublin, ²Royal College of Surgeons in Ireland





BACKGROUND AND AIM: Antidepressants are independently associated with gait impairments (Donoghue et al, 2015) and an increased risk of falls (Kvelde et al, 2015; Carriere et al, 2016; Marcum et al, 2016). This study examined if antidepressants are associated with recurrent and injurious falls over 4 years follow-up and if any observed association was mediated by gait speed. METHODS: Data was obtained from the first three waves of The Irish Longitudinal Study on Ageing (TILDA), a nationally representative sample of community-dwelling adults in Ireland. 4663 adults aged ≥50 years participated in an interview and had valid gait speed data from the health assessment at Wave 1 and interview at either Wave 2, 3 or both. Antidepressants were identified as medications with ATC code "N06A". Recurrent falls (two or more falls since the last interview or in the past year) and injurious falls (falls requiring medical attention) were reported at either Wave 2 or Wave 3. Usual gait speed was measured as the mean of two walks on a 4.88 m GAITRite walkway. Poisson regression analysis was used to examine the association between antidepressants and falls adjusting for socio-demographics, physical, cognitive and mental health and finally, gait speed. RESULTS: Compared to non-antidepressant users, those on antidepressants were more likely to report recurrent falls (35% versus 15%) and injurious falls (30% versus 16%) at follow-up. In bivariate regression analysis, antidepressants were associated with recurrent falls (IRR=2.12, 95% CI: 1.73, 2.61, p<0.001); this association was attenuated but still significant after adjusting for a wide range of covariates including gait speed (IRR=1.37, 95% CI: 1.08, 1.73, p=0.009). Antidepressants were associated with injurious falls in univariate analysis (IRR=1.71, 95% CI: 1.36, 2.16, p<0.001) and multivariate analysis (IRR=1.30, 95% CI: 1.02, 1.66, p=0.035). CONCLUSION: Antidepressants are associated with an increased risk of recurrent and injurious falls over four years independent of socio-demographics, self-reported and objective measures of physical, mental and cognitive health. Gait speed did not significantly mediate this relationship suggesting that this association may be driven by antidepressants themselves. ACKNOWLEDGEMENTS AND FUNDING: Financial support was provided by Irish Life plc, the Irish Government and the Atlantic Philanthropies. These funders had no involvement in analysis and preparation of this paper.

M - Exercise and physical activity

P3-M-95 Perturbation treadmill training: Sustainable effects on clinical gait and postural stability symptoms as well as gait variability in Parkinson's disease

Heiko Gaßner¹, Simon Steib², Sarah Klamroth², Cristian Pasluosta³, Werner Adler², Bjoern Eskofier², Klaus Pfeifer², Jürgen Winkler², Jochen Klucken²

¹University Hospital Erlangen, ²Friedrich-Alexander University (FAU) Erlangen-Nürnberg, ³University of Freiburg

BACKGROUND AND AIM: Impaired gait and postural stability are cardinal motor symptoms in Parkinson's disease (PD), substantially increase risk of falling, and reduce quality of life. Treadmill




training improves gait speed and stride length in PD. The aim of this randomized controlled trial was to evaluate the effect of a novel perturbation treadmill training (PTT) over 8 weeks on clinical motor symptoms, particularly gait and postural stability as well as objective gait parameters in PD. **METHODS:** PD patients recruited at the University Hospital Erlangen, Germany were included and randomly allocated to either the experimental group (PTT, n=21) or a control group (conventional treadmill training, CTT, n=22). Perturbation during treadmill walking was induced by a prototypical treadmill device consisting of a standard medical treadmill (mercury, h/p/cosmos medical GmbH) fixed on a platform with tilt option (zebris Medical GmbH). The platform allows three-dimensional tilting movements induced by three pneumatic actuators with a lifting capacity up to 30 mm. Structured treadmill training was realized in 16 sessions (two times per week over 8 weeks) for 40 minutes each. Outcome measures were collected at baseline, after 8 weeks of intervention, and at a 3 months follow-up visit. Clinical motor assessment consisted of the Unified Parkinson Disease Rating Scale part III (UPDRS-III), Postural Instability and Gait Difficulty score (PIGD), and subitems "gait" and "postural stability". Additionally, spatio-temporal gait parameters were assessed overground using inertial sensors. Intervention effects were compared to progression rates of a matched PD cohort (n=20) receiving best medical treatment (BMT). **RESULTS:** After 8 weeks, treadmill training significantly improved UPDRS-III motor symptoms in both groups with larger effect sizes for PTT (-38%, p=0.001, Effect size Cohen's d=-1.22) compared to CTT (-20%, p=0.046, d=-0.67). Importantly, only the PTT group significantly improved PIGD (-34%, p=0.005, d=-0.72), subitems 'gait' (-50%, p=0.023, d=-0.79) and 'postural stability' respectively (-40%, p=0.008, d=-0.95) in contrast to CTT (PIGD: -24%, p=0.103, d=-0.57; gait: -22%, p=0.257, d=-0.37; postural stability: -33%, p=0.132, d=-0.51). However, a significant between-group effect was not observed. Positive effects persisted in PTT after 3 months and appeared to be beneficial compared to BMT. The objective gait parameters swing and stance time improved in the PTT group only (p=0.020, d=-0.32), and swing time variability showed a significant between-group effect (p=0.019; d=-0.72) potentially linked to improved gait regularity. **CONCLUSIONS:** Eight weeks of PTT showed superior improvements of gait and postural stability. Sustainable effects indicate that PTT may be an appropriate add-on therapy for the treatment of gait and balance deficits in PD. Swing time variability may be a sensitive parameter for the objective evaluation of dynamic postural control.

P3-M-96 Clinical outcome measures and the patient experience: What we can learn from conducting a process evaluation of a balance training intervention

Breiffni Leavy¹, Conran Joseph¹, Hanna Johansson¹, Erika Franzén¹

¹Karolinska Institutet

BACKGROUND AND AIM: To achieve collaborative patient-centered rehabilitation in Parkinson's disease (PD) it is necessary to target and assess training which is responsive to patient preferences. Conducting a process evaluation of the interventions we deliver is recommended in





order to provide information that enables us to interpret findings from intervention trials (1). We performed a clinical effectiveness-implementation trial of highly challenging balance training (HiBalance program) among people with PD where we i) assessed program effects on balance control and gait outcomes and ii) conducted a process evaluation of how the intervention was delivered and perceived (2). The HiBalance program targets four main subsystems of balance control - stability limits, anticipatory postural adjustments (APA's), sensory integration and motor agility. Our aim is to demonstrate how process evaluation data can aid to further interpret the findings from a balance training clinical effectiveness trial. METHODS: Participants (n=117) with mild-moderate PD were consecutively included into either the 10-week HiBalance training (n=61) or control (n=56) group. Our primary outcome measure was balance performance (Mini-BESTest), we also collected patient-reported balance confidence (ABC scale). Patient experience questionnaires were included as one measure of barriers and facilitators to program implementation. The selection of process outcomes was guided by the UK medical research council's recommendations for planning and conducting process evaluations of complex interventions. RESULTS: In total, 98 people completed the trial. Compared to controls, the training group showed improvement in overall balance performance (P <.001), specifically in the domains APA's (P=.005) and Dynamic gait (P=.024) but no improvement in Postural responses or Sensory orientation. Of all domains, patients reported exercises targeting Sensory integration as most challenging, the domain which was subject to a ceiling effect (48% of patients achieving the maximal score at post-testing). Whereas we found no improvement in patient-reported balance confidence (ABC scale), 73 % of people in the training group reported their balance as being improved on a single-item question. CONCLUSIONS: Improvements in sensory orientation and perceived balance appeared to be inadequately captured by our chosen outcomes among this patient group. Further analysis of trainer focus-group interviews, planning protocols and training reports will provide findings that are highly relevant for those wishing to translate evidence-based exercise programs for PD into routine clinical practice. Acknowledgements/ FUNDING: The Swedish Research council for Health, Working life and Welfare (FORTE), The Swedish Research Council, 'Vårdalstifelsen' and the Swedish Parkinson Foundation, The Swedish NEURO foundation. 1. Moore et al. Process evaluation of complex interventions: Medical Research Council guidance. BMJ. 2015 2. Leavy et al. Evaluation and implementation of highly challenging balance training in clinical practice for people with Parkinson's disease: protocol for the HiBalance effectiveness-implementation trial.

P3-M-97 Effect of community-based brisk walking on enhancing motor and non-motor symptoms in people with Parkinson's disease

Margaret Mak¹, Irene Wong¹

¹The Hong Kong Polytechnic University





BACKGROUND AND AIM Parkinson's disease (PD) is a progressive neurodegenerative disease characterized with both motor and non-motor clinical features. In addition to dopamine replacement therapy, there is growing evidence to support the positive effects of exercise and physical therapy on PD. However, most of these studies reported the training effects on physical improvements such as walking performance and functional mobility. The effects on non-motor symptoms and quality of life have been overlooked. We have developed a community-based brisk walking program and the present study aimed to evaluate the effectiveness of this program on enhancing motor and non-motor symptoms as well as quality of life in people with PD. Methods This was a randomized controlled trial, with assessors blinded to the training intervention. Participants with PD (n=42) were randomly assigned to brisk walking (BW, n=22) or control group (CON, n=20). These participants had PD for a mean of 6.8 years. Their mean Hoehn and Yahr stage was 2.4 and Movement Disorders Society motor examination (MDS-UPDRS III) score was 30.0, indicating that they had mild to moderate PD. The BW group completed a 6-week supervised brisk walking training (one session per week) at moderate level of intensity (at 50-60% heart rate reserve). The exercise intensity of each participant was monitored with a physical activity tracker. The CON group received 6-week exercises for upper extremities with same number of sessions. Both subject groups were instructed to perform self-practice (either brisk walking or upper limb exercise) twice a week. The outcome measures included MDS-UPDRS III to evaluate PD motor symptoms, 6-minute walk test (6MWT) to assess the walking capacity, MDS-UPDRS I to measure PD non-motor symptoms, and PDQ-39, a questionnaire to measure the quality of life. Results All participants completed the training with no drop-out. There was no falls during both supervisedand self-practice sessions. After 6 weeks of training, only the BW group had significant improvements for 6MWT distance, MDS-UPDRS I and III scores (all p<0.001), and PDQ-39 (p=0.016). Between-group comparisons for the changes from baselines further indicated that the BW group had greater improvements than CON group for 6MWT (by 48.4±40.1m, p<0.001), MDS-UPDRS III score (by -6.8±3.7, p<0.001), MDS-UPDRS I score (by -3.1±2.7, p=0.003), and marginal improvement in PDQ-39 score (by -6.6±9.3, p=0.050). Conclusions This 6-week communitybased brisk walking program improved motor and non-motor symptoms as well as quality of life of people with PD. ACKNOWLEDGEMENTS AND FUNDING: The study was supported by Shun Hing Education and Charity Fund (847P).

P3-M-98 Effects of strength training the hip abductor-adductor muscles on protective stepping: a pilot study

Marie-Laure Mille¹, Maria Papaiordanidou², Guillaume Florent³, Karim El Koulali³, Jean-Louis Vercher³, Richard Fitzpatrick⁴

¹Aix Marseille Université, ²URF STAPS, Univ. de Bourgogne, ³CNRS & Aix-Marseille Univ, ⁴University of New South Wales





BACKGROUND AND AIM: Protective stepping is a common strategy to avoid falling. Control of lateral stability during stepping is challenging, particularly for elderly subjects. It requires an interlimb coupling of the hip abductor-adductor (AB-AD) muscles that are known to undergo agerelated strength losses. Thus, strengthening of these hip muscles is called for since it could improve balance recovery in older people. The aim of this preliminary study was to examine the effects of hip AB-AD muscle strengthening on protective stepping. We hypothesized that strengthening of these hip muscles would improve balance recovery. METHODS: Twelve elderly participants in good health (\geq 60 years old) were randomly assigned to a training group (TG) or to a control group (CG). Training sessions of the AB-AD muscles were performed twice a week for 8 weeks. Each session consisted of 30 then 40 voluntary contractions of 6s followed by 20s of rest, at 30 then 40% of maximal voluntary contraction (MVC). Before (PRE) and after (POST) the 8-week period, participants underwent a battery of tests comprising AB-AD force measurements as well as protective stepping abilities. Hip AB-AD strength was measured while sitting and pushing or pulling as hard as possible with both legs on a force transducer placed between the legs (Fig A). The AB/AD MVC was calculated as the average force between both sides for AB and AD muscles. To induce protective stepping, three perpendicular synchronized rotary motors under computer control applied forces at the waist in the forward or lateral (left or right) directions (Fig B). Participants performed 7 trials for each of the 3 perturbation directions in a random order. For each perturbation, the number of steps, the side of the first step and the first step characteristics (onset, duration, length, width and clearance) were determined. RESULTS: Training improved maximal contraction force of AB by 12% (Wilcoxon p<0.05) and AD by 19% (Wilcoxon p<0.05) in the TG between PRE and POST testing whereas these maximal forces were unchanged in the CG (Wilcoxon p>0.5) (Fig C). The percentage of trials in which only one step was made to recover balance increased from 39% to 54% in the TG (Wilcoxon p<0.05) but remained the same in the CG (PRE: 33%; POST: 39%; Wilcoxon p>0.5). Finally, first step duration decreased in the TG (PRE: 416ms; POST: 371ms; Wilcoxon p<0.05) but did not change in the CG (PRE: 427ms; POST: 397ms; Wilcoxon p>0.05) (Fig D). CONCLUSIONS: These results indicated that improving the strength of the hip abductor-adductor muscles also improves balance recovery to postural perturbation in the elderly by reducing the tendency to take multiple steps and step duration (i.e. single-leg stance time). Thus, targeting these muscles by simple strength training could be beneficial for balance and help prevent falls. ACKNOWLEDGEMENTS AND FUNDING: This work was supported by the Institut of Movement Sciences (CNRS & Aix-Marseille Univ).

P3-M-99 Effect of muscle fatigue on postural stability and muscular activation of the supporting leg in soccer players' kicking

Julia Oliveira¹, Caroline Souza¹, Daniel Coelho¹, Luis Teixeira¹

¹University of São Paulo





BACKGROUND AND AIM: Muscle fatigue accumulated in the legs during a soccer game can be a critical element in the challenging task of keeping unipedal stable balance while kicking a ball. The aim of this study is to evaluate the effect of fatigue of the support leg on postural regulation and activation of ankle stabilizing muscles during power kick, and maintenance of quiet upright posture in unipodal support. METHODS: Six university right-footed soccer players participated in this study. They were evaluated before and immediately after induction of muscular fatigue of the supporting leg by means of repeated fast oscillations of the kicking leg in the anteroposterior direction. Movement amplitude (about 1 m) was monitored visually, while a metronome was used to guide the leg oscillation rhythm. The evaluation task consisted of powerfully kicking a soccer ball attached to rubber bands in direction of a frontal target. The kick was performed with support on a force plate, monitoring different muscles through wireless electrodes of the supporting lower leg responsible for ankle stabilization. **RESULTS:** Results indicated that in quiet unipedal stance, fatigue led to increased oscillation amplitude of center of pressure in the mediolateral direction, as well as lower activation of the long fibular and medial gastrocnemius muscles. For the main kick task, fatigue did not affect postural stability of the support leg, given by maximal amplitude of center of pressure displacement, or maximal speed of the kicking leg. Electromyographic analysis revealed that fatigue led to decreased activation of the medial gastrocnemius muscle and increased activation of the soleus muscle in the period following foot-ball contact. In the period immediately preceding foot-ball contact no effect of fatigue was found. CONCLUSIONS: These results suggest task-specific adaptation of muscular responses in soccer players to optimize balance stability when kicking a ball.

N - Falls and fall prevention

P3-N-100 Increased resilience of judoists to unpredictable large-magnitude perturbations to body balance

Marina Betelli¹, Julia Oliveira¹, Patricia Takazono¹, Caroline Souza¹, Daniel Coelho¹, Luis Teixeira¹

¹University of São Paulo

BACKGROUND AND AIM: Sports' training has been shown to induce positive effects on the control of static and dynamic postures. However, the extent to which combat sports training affects reactive postural responses remains unclear. The aim of the current study was to evaluate postural reactions to unpredictable large-magnitude perturbations in judoists, as compared to athletes with reduced balance demand (runners and swimmers). **METHODS:** Judoists (n=9), and swimmers and runners (n=11, controls), with similar anthropometric and training duration, were tested through sudden support base displacements in the mediolateral direction, generated by a movable electronic platform, in the following modes: (a) rotation, (b) translation, and (c) combined rotation-translation. Perturbations were applied to either side, in three platform peak velocities: 20 (low), 30 (intermediaate) or 40° (cm)/s (high), generating 18 distinct stance perturbations.





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Evaluation of postural responses was performed through a scale for analysis of stability of compensatory arm and leg movements (CALM scale) and through kinematics of limb movements. **RESULTS:** The global arm-leg movement scores from the CALM scale indicated significantly higher scores for the judoists than the controls, reflecting more stable postural responses to the perturbations. Segmented analyzes showed that movements of the upper limbs were narrower in the combined mode perturbations in the judoists as compared with the controls. Additionally, for high-speed translation and combined perturbations, the judoists presented more stable responses with the lower limbs than the controls. Results from kinematics indicated that the judoists had narrower arm movements for the combined perturbations. For compensatory leg movements, the judoists showed narrower movements in high velocity perturbations. **CONCLUSIONS:** Judo training seems to improve reactive postural responses to unpredictable large-magnitude perturbations, increasing their resilience to balance perturbations distinct from those faced during their training.

P3-N-101 The effect of hearing loss on balance control - do hearing aids help?

Nicoleta Bugnariu¹, Victoria Kowalewski¹, Rita Patterson¹, Linda Thibodeau²

¹University of North Texas Health Science Center, ²University of Texas at Dallas

BACKGROUND AND AIM: Age-related hearing loss affects a large percentage of older adults. Individuals with hearing loss may be at greater risk of falls. We investigated the contribution of auditory inputs to balance control in older adults with normal hearing by simulating hearing loss, and in older adult with hearing loss by testing with and without hearing aids. **METHODS:** Twenty older adults with normal hearing and twenty older adults with and without hearing aids completed single- and dual- tasks consisting of an audiology test and maintaining standing balance in response to surface translations. Participants repeated back sentences from a standardized audiological test, the Bamford-Kowal-Bench Speech-In-Noise (BKB-SIN), played through wireless noise-cancelling headphones under randomized normal hearing and simulated hearing loss conditions, or through surrounding speakers under hearing aid or no hearing aid conditions. Backward surface translation perturbations inducing a forward loss of balance were synchronized with the auditory task and presented randomly at three levels (0m/s2, 2m/s2, and 5 m/s2). Dependent variables: reaction time for initiating the first compensatory step, maximum Center of Pressure - Center of Mass (COP-COM) distance during the first compensatory step, total number of compensatory steps after loss of balance, and performance on the BKB-SIN were analyzed with repeated measures ANOVA. RESULTS: Reaction time for initiating compensatory steps decreased, maximum COP-COM distance increased, and number of steps increased significantly as perturbation level increased. BKB-SIN scores and reaction time were significantly worse under the simulated hearing loss condition. In older adults with normal hearing, simulated hearing loss negatively affected the ability to regain balance as reflected by an increased number of steps needed after a perturbation. However, the balance performance while wearing hearings aids did



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not improved. While, hearing aids are beneficial for speech recognition, their impact in reversing the negative effect and improve balance control is not as easily measured or understood. **CONCLUSIONS:** Older adults with hearing loss appear to require an increased number of steps to regain balance and may be at a greater risk for falling compared to older adults with normal hearing. Hearing aids improved speech recognition in noise, but did not significantly changed the ability of older adults with hearing loss to initiate and execute the first compensatory step in response to balance perturbations. Further research is needed to determine whether a cause and effect relationship exists between hearing loss and balance deficits and, if so, whether hearing aids improve reactive balance control by decreasing listening effort and/or cognitive processing. **ACKNOWLEDGEMENTS AND FUNDING:** NIH T32 AG 020494 to Victoria Kowalewski.

P3-N-102 Synergistic ground reaction forces during double support while negotiating a curb

Chuyi Cui¹, HyeYoung Cho¹, Ashwini Kulkarni¹, Shirley Rietdyk¹, Fabio Barbieri², Satyajit Ambike¹

¹Purdue University, ²São Paulo State University (UNESP)

BACKGROUND AND AIM: Negotiating stairs or steps is a common cause of falls and injuries among older adults [1]. Furthermore, stepping down is associated with higher number of falls compared with stepping up [2]. The kinetic energy in the vertical direction must be dissipated at landing to avoid a fall during stepping down a curb [3]. However, little is known about the coordination between two limbs during double support phase. The aim of the study is to investigate coordination in the ground reaction forces (GRF) under both feet while ascending and descending a curb using the uncontrolled manifold (UCM) method. We hypothesize that across trials, the GRFs under the feet covary to stabilize the acceleration of the center of mass (CoM). We examine two variance components: one along the UCM (Vucm) and one orthogonal to the UCM (Vort). Vucm reflects compensation between two limbs that stabilizes the sum force and therefore CoM acceleration (via Newton's second law). Conversely, Vort implies lack of compensation between two limbs. Vucm > Vort indicates that a kinetic synergy stabilizes the CoM acceleration. As CoM needs to be controlled in three dimensions, we expect that kinetic synergies exist in all directions. METHODS: Eight older adults (73±5.3 yrs, 2 males) walked and ascended and descended a 15-cm curb in an 8 m walkway. GRF for the foot placement before and after the curb were collected at 500 Hz (Fig. 1A). Foot contact and toe off were identified with a threshold of 15 N vertical GRF to isolate the double support phase during curb negotiation. Across-trial variance in the GRF along the vertical, AP and ML directions was partitioned into Vucm and Vort. The corresponding synergy index (DVz) were computed at each percentage of double support phase. Signed peak values were isolated from the DVz time series. RESULTS: Peak DVz was significantly different from zero for the all three directions (p<0.01). Peak DVz was not significantly different between step up and step down in AP or ML direction, whereas in vertical direction peak DVz was significant larger for step up than step down (t(8)=6.25, p<0.01, Fig. 1E).

CONCLUSIONS: There exists kinetic synergy that stabilizes the CoM acceleration in all three directions during the double support phase of stepping up. Therefore, two limbs coordinate to maintain CoM acceleration while ascending a curb. While descending, CoM acceleration is stabilized in AP and ML directions, but not in the vertical direction. This anti-synergy (Fig. 1B) indicates that vertical CoM acceleration is variable across trials, and that angular acceleration about the ML axis might be stabilized while stepping down. These observations could be related to more falls observed with stepping down [2], but the mechanisms remain to be identified. **ACKNOWLEDGEMENTS AND FUNDING:** Fulbright scholar program. **REFERENCES:**[1] Startzell et al., J Am Geriatr Soc, 2000 [2] Tinetti et al., N Engl J Med, 1988 [3] van Dieën et al., J Biomech, 2008.

P3-N-103 The effect of handrail cross-sectional design on centre of mass control during compensatory reach-to-grasp reactions to recover balance

Philippa Gosine¹, Vicki Komisar², Alison Novak¹

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RESEARCH

ispgr

¹Toronto Rehabilitation Institute, ²Simon Fraser University

BACKGROUND AND AIM: A handrail is an effective tool used to arrest the centre of mass (COM) movement and counter the rotation of the body following balance loss on stairs, and help users to avoid falls. Although the highest voluntary forces that users apply to handrails depend on crosssectional shape and size (Maki, 1985), little is known about the effect of cross-sectional design on COM control during compensatory reach-to-grasp reactions during balance recovery. METHODS: Sixteen older and 16 young adults stood beside a handrail. Forward and backward balance loss was induced via support-surface translations, and participants were instructed to reach and grasp the handrail to maintain balance without stepping. We randomized perturbation direction and timing. To test full reliance on the handrail, the perturbation magnitude incrementally increased until the participant could not recover balance without stepping. The magnitude one level lower than failure was considered the maximum withstood perturbation (MWP). We tested seven handrails: a 1.5" round handrail, and 2.5" and 3" wide round, decorative and tapered handrails. COM displacement and change in trunk inclination angle with respect to global vertical were compared for all handrails at a common perturbation level for each participant, representing the lowest MWP across all handrails within each participant. A repeated measures ANOVA (significant p<0.05) was conducted for each variable. **RESULTS:** Results of six older adults and six young adults are reported; analysis of the full sample is ongoing. Older adults withstood significantly lower destabilization levels (p=0.007) than young adults in both directions, resulting in between-group differences in peak kinematic variables. In forward balance loss, we observed a trend toward effect of handrail cross-section (p=0.07) and handrail shape (p=0.07) in peak forward trunk angular displacement. The 1.5" round handrail resulted in the smaller angles than the 3" decorative (p=0.006), 3" round (p=0.03) and 2.5" tapered (p=0.008) handrails. When grouped by size, the 1.5" handrail had smaller angular displacement than the 3" handrails



(p=0.02). There were no significant differences in COM displacement or velocity between the different handrails following forward balance loss. This may stem from how most participants countered their trunk rotation with hip and knee flexion. No effect of handrail cross-sectional design was found during backward balance loss. **CONCLUSIONS:** Large trunk angles have been associated with reduced ability to recover balance from a trip (Owings et al., 2001). Our findings suggest that large-diameter handrails may impede recovery from balance loss on stairs, given the greater trunk angular displacement observed in this study. Analysis of full sample is needed to confirm results. Understanding how handrail design affects balance control is an important step toward informing safer built environments. **FUNDING:** NSERC, CIHR, AGE-WELL.

P3-N-104 Falls and hip fractures: A biomechanically based model of sex and age specific risk assessment

Andrew Hudson¹, Brian Street²

INTERNATIONAL SOCIETY OF

POSTURE <mark>&</mark> GAIT

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ispgr

¹University of California, Bakersfield, ²California State University, Bakersfield

Falls and hip fractures: A biomechanically based model of sex and age specific risk assessment Andrew Hudson1, Brian D. Street1,2, Ph.D 1.California State University, Bakersfield. 2. Gait and Posture Neuromechanics Laboratory BACKGROUND: As of 2016 those >65 years of age comprised 8.5% of the world population, this number is projected to increase to 17% by 2050. Falls are a common occurrence for this rapidly growing group, as one-third fall at least once a year. Hip fractures are a frequent and disastrous result of these falls. While methods for fall risk assessment like FRAX exist, it is not rooted in the mechanics of a fall or the hip, something which this projects seeks to do. Aim: The aim of this project was three-fold 1) to model falling forces and compare these against experimental data, 2) to generate a model for femoral fracture load, and 3) to use the results to generate a means of fall risk assessment. **METHODS**: The modeling of a fall trajectory in this study is based on a lateral fall, as falls in this direction are associated with a 30-fold hip fracture risk increase when compared to falls in any of the other directions. The faller is modeled as a box using a two-dimensional movement through a guarter arc of a circle with an assumption of no fall response. The position, velocity, and acceleration were derived. Force at impact was found. Fracture load as a function of bone mineral density (BMD) from Courtney et al. (1994) and Beck et al. (1990) are used. A corrective factor is generated for these with data from Pinilla et al. (1996). Arbitrary constants were then generated to establish agreement between the three. BMD as a function of age was taken from Riggs et al., (1982). Data from Warming et al., (2002) was then used to generate a corrective factor. **RESULTS:** Modeled impact forces held closely to data from Robinovitch et al., (1991). Modeled functions for BMD with respect to age were 97% and 84% that for females and males respectively in Augat et al., (1996), but were 139% that of Bessho et al., (2009). CONCLUSIONS: Agreement of modeled and experimental force data was observed. The difference found between Augat et al., (1996) and Bessho et al., (2009) suggests an increasing tendency towards osteoporosis, though additional data are needed to

further pursue this idea. The behavior of male and female risk functions are quite different, with male risk increasing linearly while female risk increases exponentially as a function of age. The model in its current state could be applied as an initial screening for fall risk triage. References:Augat et al.. (1996). J Bone and Mineral Res, 11(9), 1356-1363. Beck et al. (1990). Invest Radiology, 25, 6-18. Bessho et al. (2007). J Biomech, 40(8), 1745-1753. Courtney et al. (1994). Calcified Tis Intl 55, 53-58. Robinovitch et al. (1991). J Biomech Engineering, 113, 366-374.

P3-N-105 Effects of thin plantar stimulation on postural coordination patterns

Marc Janin¹, Emmanuelle Pivron Braquet², Frédéric Noé³

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POSTURE <mark>&</mark> GAIT

RESEARCH

1spgr

¹Université de Pau et des pays L'adour, ²PODOLOGUE, ³Laboratoire Mouvement, Equilibre, Performance, Santé (EA 4445)

BACKGROUND: Falls are a common and often devastating problem among older people (1). Ageing alters sensorimotor function which impairs balance control and increases the involvement of the hip joint (1-5). Among the age-related sensorimotor disturbances, reduced plantar cutaneous sensitivity impairs the ability to detect small postural changes during upright stance and increases the risk of falls (2-4). Increasing somatosensory cues from the foot when using posterior podiatric bars (PBs) in older adults can increase postural stability (6) and is likely to reduce the involvement of the hip in postural control (7, 8). Nevertheless, the effects of PBs on hip/ankle mechanisms have not been previously investigated, although they can potentially be assessed with the passive forward-push test (FPT), a simple clinical test that can be used to determine the preferential involvement of the hip or ankle joints in postural control (9). Aim: evaluation of PBs improving foot sensitivity on hip/ankle postural control mechanisms with the FPT test. **METHODS:** 19 elderly women (77.52 ± 6.77 years) were included. Thin resin PBs (2 mm) were applied at the rear-mid foot junction under each foot (anterior limit: line behind the styloid of the vertical projection of the talo-navicular joint in medial and the styloid of 5th metatarsal in lateral; posterior limit: line passing forward of the line bounded by the two malleoli) (6,7,8,9). The FPT test was conducted randomly with and without PBs. Result: no significant differences were observed on the FPT when using PBs or not. CONCLUSION: This study aimed to evaluate the effect of thin plantar stimulation provided by PBs on hip/ ankle postural control mechanisms. PBs increase the somatosensory information from the foot which can produce acute beneficial effects on gait and postural control in older adults (6, 7, 8). Our results showed that PBs did not significantly impact the FPT test. Two explanations can be given. First, the absence of influence of the PBs on postural coordination patterns could be attributed to the thinness of our 2mm PBs. With a static postural task, Viseux et al. (7) reported significant effects of 5mm without any effect of 3mm PBs on postural control. Nevertheless, 2mm PBs have been demonstrated to provide appropriate foot stimulation to improve gait. Then, one can also hypothesize that the FPT test was not adequate to observe an effect due to PBs appliance. The FPT test is performed by applying



an external forward perturbation and can only determine whether a subject is using hip mechanisms or not in a binary fashion. The ability of this simple clinical test to assess the subtle mechanisms involved in the study of postural coordination patterns can be questioned. Hence, the question about the influence of Pbs on hip/ankle postural control mechanisms remains open. Future studies should be performed by assessing the multi-joint control of posture with a kinematic analysis.

P3-N-106 Sex differences in predictors of subsequent falls in senior fallers: A prospective study of the Vancouver Falls Prevention Cohort

Deborah Jehu¹, Jennifer Davis¹, Kristin Vesley¹, Winnie Cheung¹, Anna Egbert¹, Liu-Ambrose Teresa¹

¹University of British Columbia

BACKGROUND AND AIM: Community-dwelling seniors who experience falls that results in medical attention are at a high risk for subsequent falls, fractures, and functional decline [1]. A better understanding of risk factors for subsequent falls in this high-risk group would facilitate the development of efficacious secondary falls prevention strategies. Evidence suggests that there are sex differences in the frequency of falling among older adults, but it is inconclusive as to whether older men or women fall more frequently [2,3]. Few studies to date have examined whether there are sex differences in falls-risk factors. Therefore, the purpose of this study was to 1) compare fall rates in older men and women post-falls clinic intervention, and 2) identify sexspecific risk-factors for subsequent falls in senior fallers. METHODS: 457 community-dwelling adults aged 70 years and older (Males: n=168, 82.49±6.19 years; Females: n=289, 80.89±6.70 years) who were referred by emergency or a physician to the Vancouver General Hospital Falls Prevention Clinic as a result of a fall in the last 12 months participated in this study. Participants completed the Physiological Profile Assessment, which examines visual function, lower limb proprioception, lower limb strength, simple reaction time, and postural sway [4]. Participants also reported demographic information and completed a battery of cognitive (the Mini-Mental State Examination, the Montreal Cognitive Assessment, the Trail Making Test (Form A and B), the Colour-Word Stroop, Verbal Digit Span (Forward and Backward Test), Digit Symbol Substitution Test, and the Phonetic Verbal Fluency Test), mood (the Geriatric Depression Scale (GDS)), psychological (the Falls Efficacy Scale, and the Visual Analogue Scale of Overall Health), comorbidities and functional independence (the Functional Comorbidity Index (FCI), Instrumental Activities of Daily Living questionnaire, the Barthel Index of Activities of Daily Living), and physical performance tests (the Dual-Timed-Up-&-Go test, and the Short Physical Performance Battery). Participants completed monthly falls calendars and were phoned to verify falls information. Separate stepwise multiple linear regressions were performed by sex. **RESULTS:** The total number of falls was significantly greater in older men than women (Males: 2.79±6.88 falls/year; Females:1.26±2.64 falls/year; p=0.006). The significant predictors of subsequent fall(s) for older





men were cognitive function (β =0.36), comorbidities (β =0.29), and depression (β =0.21; R2adj=0.26, p=0.002), while no predictors emerged among older women. **CONCLUSIONS:** This study suggests that risk factors for secondary falls may vary between older men and women with a history of falls; more research is needed to explore possible sex differences in falls-risk factors. 1. Russell M, et al. 2006. J Gerontol. 2. Gale CR, et al. 2016. Age Ageing. 3. Pereira CL, et al. 2013. Am J Phys Med Rehabil. 4. Lord SR, et al. 2003. Phys Ther.

P3-N-107 The frequency and circumstances of falls reported by unilateral lower limb prosthesis users

Janis Kim¹, Matthew Major², Brian Hafner³, Andrew Sawers⁴

¹University of Illinois at Chicago, ²Northwestern University, ³University of Washington, ⁴The University of Illinois at Chicago

BACKGROUND: The majority of lower limb prosthesis (LLP) users report falling at least once a year. Efforts to reduce falls among LLP users have traditionally focused on developing clinical tests to assess fall risk, designing prosthetic components to improve safety, and identifying risk factors to recognize fallers. Little information is however available regarding the circumstances of falls among LLP users. This gap may be attributed to the absence of a LLP user specific fall classification framework and taxonomy to easily, consistently, and comprehensively characterize fall circumstances. Identifying the most common fall circumstances among LLP users may guide and prioritize clinical and research needs. The objective of this study was to develop a novel fall classification framework and characterize the frequency and circumstances of falls reported by unilateral LLP users. METHOD: Self-reported falls data, and their narrative descriptions, were collected from 66 unilateral transtibial and transfemoral LLP users. A novel 3-level hierarchical classification framework was developed to categorize fall types based on the location of the destabilizing force (e.g., base-of-support (BoS), center-of-mass (CoM), other), the source of the destabilization (e.g., intrinsic or extrinsic), and the ensuing fall pattern (e.g., slip, trip, push). Activities at the time of a fall (e.g., walking, reaching) were classified separately. Frequencies, estimated proportions, and estimated counts were compared across fall types, as well as activities at the time of the fall using 95% confidence intervals. RESULTS: Thirty-eight LLP users (57.6% of the study sample) reported a total of 90 falls during the previous year. 36.3% of participants reported multiple falls. All reported falls were successfully categorized using the developed framework. Falls arising from base-of-support disruptions (54%) were more common than those attributed to center-of-mass disruptions (13%). Clinical balance tests that probe base-of-support disruptions might be needed to improve fall risk assessment in LLP users. Intrinsic factors (e.g., insufficient foot clearance), rather than extrinsic factors (e.g., cracked sidewalk), were the most common source of destabilization (58% vs. 33%), indicating that challenges unique to prosthetic gait rather than environmental factors may cause most falls. A diverse set of fall patterns, including slips (26%), trips (22%), and prosthetic issues (22%), were reported. Walking on level terrain

(45.6%) was the most common activity at the time of a fall. **CONCLUSION:** Falls remain frequent among ambulatory LLP users. Clinicians and researchers may wish to prioritize falls due to base-of-support disruptions that occur while walking. Additional research with a larger sample and a structured fall classification survey is needed to confirm these results, and characterize additional fall-related circumstances (e.g, situation, physical environment), as well as their physical, social, and psychological consequences.

P3-N-108 Effect of holding and grasping objects on risk for head impact during falls in older adults

Vicki Komisar¹, Nataliya Shishov¹, Stephen Robinovitch¹

¹Simon Fraser University

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BACKGROUND AND AIM: Falls cause up to 80% of traumatic brain injuries in older adults, and one-third of falls in residents of long-term care (LTC) result in head impact (Harvey & Close, 2012; Yang et al., 2017). Upper limb fall arrest is a common strategy for avoiding head impact (Hsiao & Robinovitch, 1998). In this study, we examined whether holding objects affects risk of head impact during real-life falls in LTC residents. METHODS: We analyzed videos of 1238 real-life falls from standing height in LTC residents (82.8+/-9.3 years; 58% women), using a validated questionnaire (Yang et al., 2013) to quantify fall direction, occurrence of head impact, and held objects of the time of imbalance, descent and impact. We used Chi-Square to test for differences in the probability of head impact for held objects classified as either "weight-bearing" (via contact to the fixed environment e.g., chairs, walkers, handrails) or "non-weight-bearing" (e.g., purses, cups). **RESULTS:** Risk for head impact was lower for falls where weight-bearing objects were held at the onset of imbalance (odds ratio = 0.64; 95% confidence interval = 0.51-0.81). The effect was strongest for forward falls (0.56; 0.34-0.91). For all fall directions, holding the object throughout the fall provided the greatest benefit (0.50; 0.38-0.66). Risk for head impact was also lower for falls where residents successfully reached to grasp weight-bearing objects (0.56; 0.35-0.89), especially in backward falls (0.34; 0.13-0.93). The objects most commonly-held in falls without head impact were chairs (n=184), walkers (n=151), other people (n=80), tables/counters (n=57), and handrails (n=24). By contrast, risk for head impact was higher for falls where non-weightbearing objects were held (1.42; 1.04-1.96). The effect was greatest in backward falls where residents failed to drop the object before landing (2.57; 1.30-5.09). Non-weight-bearing objects most commonly-held in falls with head impact were clothing, linens and tissues (n=24); toys, purses and reading material (n=18); and dishes and food (n=13). **CONCLUSIONS**: We found that risk for head impact during falls in LTC is decreased by holding weight-bearing objects, such as chairs, walkers and handrails, and increased by holding non-weight-bearing objects, such as clothing. These results may guide older adults in placing objects in backpacks or pockets, and encouraging the use of walkers for both mobility and reduced risk for serious injury during a fall. ACKNOWLEDGMENTS AND FUNDING: Supported by operating grants from the Canadian



Institutes of Health Research (TEI-138295) and AGE-WELL NCE (AW CRP 2015-WP5.2). VK is supported by a MITACS Accelerate Award and an AGE-WELL NCE Postdoctoral Award.

P3-N-109 Different types of tripping over an unexpected obstacle while walking on level ground - age and contributing factors

Ilan Kurz¹, Shlomit Eyal², Inbal Maiden², Anat Mirelman³, Nir Giladi³, Jeff Hausdorff³

¹Ben-Gurion University, ²Center for the Study of Movement, Cognition and Mobility, Neurological Institute, Tel Aviv Sourasky, ³Tel-Aviv Sourasky Medical Center

BACKGROUND AND AIM: Tripping over an obstacle is one of the most common causes of falls among older adults, however, little is known about the types of failures that occur when negotiating an unexpected obstacle. Here, we aimed to evaluate the failure rates in healthy young and older adults and the different types of failures. We examined the contribution of different subject characteristics (e.g., age, gait, balance, cognitive function) on types of obstacle negotiation failures. **METHODS:** Twenty older adults (ages: 77.7±3.4 years; 50% women) and twenty young adults (age: 29.3±3.8 years; 50% women) participated in this study. Obstacles were presented at heights of 25mm and 75mm and varied response times from 225msec-625msec resulting in expected and unexpected obstacles. Kinect cameras captured obstacle negotiation performance. Failures were classified as: hitting the obstacle with the leading foot, stepping on the obstacle with the leading foot, and hitting the obstacle with the trailing foot. Gait (e.g., speed), balance (e.g., Mini Best, Timed Up and Go-TUG and Four Square Step Test-FSST) and cognitive function (e.g., TMT A and B) were assessed as moderators of success and failure. RESULTS: As expected, older adults had significantly slower gait speed (p=0.001) worse balance performance (e.g., Mini Best, FSST scores p=0.001) and cognitive function (TMT A and B p<0.001) than young adults. Success rates for all subjects where higher when the obstacle was expected (99.0±2.8%; compared to unexpected 66.0±20.2%; p<0.001). This trend was also seen within each age group. 178 failures were recorded while crossing the unexpected obstacles, 66 among the young adults and 112 in the older adults (p=0.009). Among all subjects, 81.5% of failures were due to stepping on the obstacle, 16.9% to hitting the obstacle with the leading leg, and only 1.7% to hitting the obstacle with the trailing leg. Age-group differences were seen for hitting the obstacle with the leading leg (Y: 2.3±4 %; O: 7.3±7 %; p=0.023) and stepping on the obstacle (Y: 19.3±11 %; O: 28.9±17 %; p=0.046), with a trend for hitting the obstacle with the trailing leg (Y: 0 ± 0 ; O: 0.99 ± 0.2 ; p=0.083). The % of failures that occurred when hitting the obstacle with the leading leg was correlated with: BMI (ρ=0.461 p=0.003), FSST (ρ=0.316 p=0.047), TMT-B test (ρ=0.448 p=0.004), TMT B-A $(\rho=0.315 p=0.048)$ and the Mini BEST $(\rho=-0.371 p=0.018)$. The percent of failures with hitting the obstacle with the trailing leg was correlated with TUG times (p=0.325 p=0.041). Stepping on the obstacle failure % was not correlated with gait, balance or cognitive measures. CONCLUSIONS: These findings suggest that for unexpected obstacles, stepping on an obstacle is the most common type of obstacle negotiation failure in young and older adults. Further, three types of



failures are deferentially associated with distinct motor and cognitive abilities. The type of failure should be considered when tailoring interventions to an individual to improve obstacle negotiation abilities.

P3-N-110 Balance control in young healthy adults: Is relative performance across tasks indicative of a balance control characteristic?

Gary Mangan¹, William Mcllroy¹

¹University of Waterloo

BACKGROUND AND AIM: The etiology of falling and its elevated fall risk in older adults continues to be an important focus of research. In studies that explore age-related decline in cognitive function, it has been proposed that cognitive capacity when one is younger predicts the onset and progression cognitive dysfunction and dementia when older (e.g. cognitive reserve). While task conditions most certainly influence the measures of balance, the question of interest in the present study is whether young health adults are distinguished by their relative ability to control balance across a range of balance tasks of varying difficulty. In other words, if one were to perform well on a particular balance control task, would they perform well on another task of varying difficulty as compared to other adults? **METHODS:** Seventy-two university-aged (21.83 ± 3.55 years [18-34 years]) individuals (35 male; 37 female) performed five trials of four static balance tasks on an AMTI 6-DOF force plate. Manipulation of the individual's base of support (BOS) and their vision (VIS) challenged their balance control systems. The four static balance tasks are as follows: Standard-width stance with eyes open (SEO) and with eyes closed (SEC), and a narrow-width stance with eyes open (NEO) and eyes closed (NEC). A common measure that serves as a proxy for assessing one's balance control system is the Root-Mean-Square value center of pressure (COP) in the medial-lateral plane (RMS ML Sway). A repeated measures Analysis of Variance was performed on the RMS ML Sway values to validate the effects of BOS and VIS. Intraclass correlation was performed to assess rank performance. Averages of each participant's trials were standardized with respect to the task condition using a Z-score transformation. ICC estimates and their 95% confident intervals were calculated using SPSS (Ver. 25) based on a single-rating, absolute-agreement, 2-way mixed-effects model. RESULTS: Significant main effects for both BOS and VIS were observed. RMS ML Sway increased (F(1,70) = 825.81, p < 0.001) in Narrow stance $(4.12 \pm 0.12 \text{ mm})$ from Standard stance $(1.59 \pm 0.09 \text{ mm})$. RMS ML Sway increased (F(1,70) =48.08, p < 0.001) in the Eyes Closed condition (3.07 ± 0.10 mm) from the Eyes Open condition $(2.71 \pm 0.10 \text{ mm})$. There was moderate reliability (ICCSingle= 0.656) of a single task being able to predict the rank of the individual in other tasks. Values are reported as mean ± SE. CONCLUSIONS: This initial study revealed modest subject-specific differences in the control of balance across various task challenges. This may provide some support for the idea that, even among young healthy adults, there are potentially important between-subject differences in the





control static stability. Current work focuses on assessing other measures of stability control while future research will focus on other tasks (e.g. dynamic stability control).

P3-N-111 Anticipatory and reactionary postural movements during handrail grasping while forward walking in young and older adults

Emily McIntosh¹, Lori Ann Vallis¹

¹University of Guelph

BACKGROUND AND AIMS: Incorrect weight shifting and forward walking are a frequent cause and activity during falls in retirement homes(1). To explore the mechanisms underlying this increased fall risk, the current study will evaluate balance responses during forward walking when a rapid, functional and ecologically valid weight shift is required: grabbing a handrail. This paradigm enables the comparison of anticipated (ANT) and reactive (RX) movements and permits the examination of age-related changes to stability when a priori knowledge is/is not available about movement direction. We hypothesize that participants will respond quicker to ANT cues than to RX and that this will be amplified with age. As falls have been linked to sarcopenia(2) we also expect body composition, strength, and power will be correlated to response time and postural stability. METHODS: To date, six young adults have completed the study (4F/2M, 22.2±0.8 years, 171.5±16.5 cm, 73.3±16.5 kg). Handgrip strength (HG) was measured with a Vernier dynamometer and 10-repeated Sit to Stands were completed on an AMTI force plate (Accugait; 50 Hz). Anatomical landmarks were digitized (Optotrak, NDI; 100 Hz) with respect to rigid body markers fixed to the head, trunk, pelvis and feet in addition to bilateral wrist markers. Muscle activity was also recorded (bilateral deltoid and medial gastrocnemii; Bortec; 2000 Hz). Participants completed 36 x 5m randomized walking trials. Instructions were to walk directly forward and if an audiovisual cue ("Left" or "Right") occurred they were to grab the indicated handrail as quickly as possible (12 non-perturbed walking trials; 6 trials each for ANT/RX and Left/Right). For ANT trials, advanced notice of which side to grab was given. Mixed factors ANOVA (significance p<0.05) were performed (independent variables: ANT/RX and dominant/nondominant; dependent variables: peak lateral centre of mass velocity (MaxCOMv); time from cue to peak deltoid activation (RxDel); time from cue to MaxCOMv (RxCOM). Correlation analyses were performed between HG and RxDel and HG and power index(3). RESULTS: There were no interaction effects. A main effect of side for MaxCOMv was observed. MaxCOMv was significantly quicker towards the dominant (1.22±0.28 m/s) compared to the non-dominant side (1.08±0.21 m/s). There was also a main effect of ANT on RxCOM; participants achieved peak velocity earlier during ANT (1.87±0.59 s) compared to RX (2.04±0.41 s). No main effect of ANT was observed for RxDel. A statistical trend for the correlation between HG and power index was observed (r=0.867, p=0.133). CONCLUSIONS: There was no increased RxDel with ANT, however whole-body movement was more rapid; participants moved quickly toward their dominant side. If similar results are observed in older adults it may suggest that handrails on the dominant side should be



used when executing complex, weight transfer tasks. **REFERENCES**:1)Robinovitch, 2013; 2)Roubenoff, 2000; 3)Takai, 2009.

P3-N-112 Compensatory rapid leg movements during unexpected loss of balance while walking- differences between fallers and non fallers

Hadas Nachmani¹, Shani Batcir², Itzhak Melzer¹

¹Faculty of Health Sciences at Ben-Gurion University of the Negev, ²Ben-Gurion University

BACKGROUND AND AIM- Falls among older adults are a known problem contributing to the rise in morbidity and mortality rates all over the world and result in a significant economics expands. Balance recovery abilities resulted from unexpected loss of balance decline with age and as a result, there is an increased risk of falling. Many falls occur during walking thus it is extremely important and ecologically valid to measure balance recovery abilities during walking and the recover effectively following unexpected balance perturbation. The flaw of many studies is that they measure balance recovery reactions during standing. Thus, we aimed to compare compensatory balance responses while walking among fallers and non-fallers older adults. Methods- A sample of 35 older adults, 14 reported falls and 21 non-fallers, (age 77.2±5.8 and 79.2±4.6 respectively) instructed to walk on a perturbation treadmill (BaMPer System) that provide unexpected lateral perturbations to trigger a compensatory stepping response. During the experiment the perturbations were systematically increased from low to high magnitude. Balance recovery responses and kinematics of compensatory step (i.e., reaction time, step length, step velocity, swing time, step duration and center of mass (COM) displacement) was measured. Results- Compared with fallers the compensatory step reaction time was shorter in the non-fallers (342±124 vs 306±122, , p=0.001), step length was shorter (21±10 vs 17±9, p>0.001), step velocity was faster (0.066±0.02 vs 0.061±0.02, p=0.028) and whole step duration (670±195 vs 602±191, p>0.001) was shorter. Differences were also found in COM parameters, minimal COM displacement was smaller (6±1.7 vs 5.4±2.3, p=0.003) in the fallers group. In addition, the ability of fallers to complete the study protocol was significantly lower than non-fallers older adults (10±2.9 vs 12.4±2.6, p=0.016). There were no differences in first step threshold and demographic characteristics between groups. Conclusions- Fallers had less effective recovery step abilities (i.e., higher step time). This shows that the quality and efficiency of executing a step is lower and their ability to control their COM over their base of support is impaired. Fallers were unable to complete the test protocol, requesting to stop the test earlier.

P3-N-113 Fear of falling following a 12-week attentionally focused balance training intervention: Preliminary data





Louisa Raisbeck¹, Lauren Higgins¹, Ruth Stout¹, Danielle Felsberg¹, Sean Cochran¹, John Palazzolo¹, Jeff Labban¹, Christopher K¹

¹University of North Carolina, Greensboro

BACKGROUND AND AIM: Fear of falling due to a lack of postural stability is common in older adults. This fear can be disabling and reduce independence and the ability to perform activities of daily living. Because of this, effective interventions to improve balance and reduce fear of falling are important for this population. Adding cognitive factors such as attentional focus to balance training interventions may be beneficial above and beyond the current standard of care. The purpose of this study was to assess changes in fear of falling, evaluated by The Short Activities-Specific Balance Confidence Scale (ABC-6), following 12 weeks of attentionally focused dynamic balance training. It was hypothesized that participants who received external focus instructions would report increased confidence on the ABC6 compared to those who received internal focus instructions. **METHODS**: Older adults (N=14, 6 males; 79.0 ± 6.0 yrs) who reported a fall in the past year, participated in 12 weeks of dynamic balance training utilizing CanDo® Balance Boards. Training occurred twice per week for 20 minutes (20 continuous rounds; 30 sec balance, 30 sec rest). Participants were randomly assigned to either an external focus group (EF, N=8) or internal focus group (IF, N=6). Prior to each trial, the EF group was instructed to, "Focus on keeping the board level with the floor", while the IF group was instructed to, "Focus on keeping your feet level with the floor". At baseline and 12 weeks, the ABC-6 was used to assess fear of falling. For six separate tasks participants rated on a scale from 0% (no confidence) to 100% (completely confident) their confidence that they would not lose their balance or become unsteady. Their average rating for the six tasks was then calculated. Hedges' g effect size calculations were used to quantify the effect of group assignment. **RESULTS:** In the EF group, there was a moderate positive effect of training on fear of falling, with the ABC-6 score improving by 10.2% (d= 0.41). In contrast, a moderate negative effect of training on fear of falling was observed in the IF group. ABC-6 score decreased by 7.2% (d= -0.47). CONCLUSION: The decrease in fear of falling for EF relative to IF suggests that an external focus of attention may be a valuable training strategy to improve balance confidence in older adults. Fear of falling can reduce independence by restricting physical and social activities, supporting the need for effective interventions to lessen this anxiety. Adopting an external focus of attention may be a beneficial technique to augment balance interventions to reduce fear of falling in older adults.

P3-N-114 Assessing recovery time from unexpected loss of balance during walking in young and older adults

Uri Rosenblum Belzer¹, Itzik Melzer², Shani Kimel-Naor¹, Lotem Kribus-Shmiel¹, Yotam Bahat¹, Gabi Zeilig³, Meir Plotnik¹

¹Sheba Medical Center, ²Ben-Gurion University, ³Sheba Medical Center, Tel Hashomer





BACKGROUND AND AIM: No systematic methodology has been introduced to assess the temporal domain of balance recovery during walking. Aims: 1. To evaluate the feasibility of applying an automated algorithm for assessing recovery time (RcT) from destabilizing perturbations in young (YA) and older adults (OA); 2. To test the hypothesis that RcT from perturbations while performing dual task (DT) is longer than during single task - (ST; i.e. without a concurrent cognitive task) in OA but not in YA. METHODS: Twelve YA (5 females, 26.9±3.4 y) and 12 OA (7 females, 69.5±5.2 y) performed gait trials while fully immersed in a virtual reality system (Motek Medical, The Netherlands). 18 types of unexpected perturbations (i.e., varying in in direction, e.g., anterio- posterior, AP, right and left, medio lateral, ML, and in time of application within the gait cycle) were introduced randomly under DT and ST conditions. Self-paced treadmill synchronized with a motion capture system (Vicon, Oxford, UK) was used. RcT indicates the time point from perturbation onset in which gait parameters (step width - SW & length - SL) restored their baseline values (based on statistical moments). RcT was calculated using a customized algorithm. We ran Wilcoxon sign rank test or Mann-Whitney (accordingly) to compare RcT between groups (YA vs. OA), gait parameters (SL vs. SW) and ST vs. DT independently on ML and AP perturbations. Values are expressed as medians. RESULTS: We analyzed 1039 perturbations: 346 for SL and 351 for SW for YA, and 229 and 226, respectively, for OA (data from 6 OA were analyzed). We excluded perturbations with less than 10 gait cycles prior to perturbations' onset, and with responses in which either SL or SW did not deviate from baseline values (<15% of cases). ML perturbations led to faster RcT for OA in comparison to YA, for SL (2.71 sec. vs. 4.44 sec., p=0.007; respectively) and SW (2.66 sec. vs. 4.21 sec., p=0.007; respectively). However, no differences in RcT were observed between SW and SL (p>0.84; Fig. 1 bottom panel). For AP perturbations, there was no significant difference between YA and OA $(p \ge 0.08)$. Additionally, RcT was faster for SL (2.26 sec.) in comparison to SW (3.89 sec.; p=0.001; Fig. 1 top panel). No significant difference was found in any of the comparisons between ST and DT ($p \ge 0.16$). **CONCLUSIONS:** These preliminary results suggest that: (1) A statistical moments based RcT detection algorithm is feasible for successful application for both YA and OA; (2) OA had faster recovery than YA for SL and SW in response to ML perturbations. (3) The perturbation direction (i.e. AP/ML) differentially influences the RcT based on SL and SW; (4) RcT for DT condition is not different from ST regardless of the participants' age, therefore refuting our hypothesis. Further research is needed to understand the mechanisms driving the differences in RcT between YA and OA and between perturbation directions.

P3-N-115 Re-enactment - a method to reproduce real-world fall events

Kim Sczuka¹, Lars Schwickert¹, Clemens Becker¹, Jochen Klenk¹

¹Robert-Bosch-Krankenhaus

BACKGROUND AND AIM: Falls are a common health problem even leading to death. In order to develop reliable fall detection algorithms as well as suitable prevention interventions, it is



important to understand circumstances and characteristics of real-world fall events. Although falls are common, they are seldom observed and reports are prone to bias. Wearable inertial sensors provide an objective approach to capture real-world fall signals. They provide precise inertial measurements, but it is not possible to directly derive visualisation and interpretation of movements during a fall event and video data is in the majority of cases not available. To bridge the knowledge gap the re-enactment method uses the available information from inertial sensors to simulate the event, replicate the data, validate the simulation and thereby enable a more precise description of the fall event. The aim of this poster is to describe the method and demonstrate the validity of the re-enactment approach. METHODS: Real-world fall data, measured by inertial sensors, were selected from the FARSEEING-database. We focused on well described, common fall events, which can be simulated under safe conditions in a laboratory setting (e.g. loss of balance during walking backwards or stumbling). The sensor signals were used to establish a detailed simulation protocol based on identified postures and well known movement patterns. The following re-enactment experiments were recorded with comparable IMU configurations as well as with video cameras to analyze the sensor signal in detail. The re-enacted sensor signals were compared with the original real-world signals to adapt the protocol and repeat the re-enactment method if necessary. The similarity between the simulated and the real-world fall data was analyzed with dynamic time warping algorithms, which enables the comparison of two temporal sequences varying in speed and timing. The two time series were aligned by stretching the two vectors so that the sum of the Euclidean distances between corresponding points is smallest. **RESULTS:** With the re-enactment method it is possible to reproduce a quite similar sensor signal based on establishment of a detailed simulation protocol (Figure 1). Although fall events are heterogeneous concerning curve progression and chronological sequence and show high variability due to three-dimensional account, it is possible to reproduce the motion of a person's center of mass (sensor attached to lower back) in a good approximation. CONCLUSION: Reenactment is a promising method to understand and visualize the biomechanics of real-world falls when performed in a suitable setup. Furthermore, simulated fall-related sensor signals can be a useful resource for comparison and verification of movement patterns as well as for identification of hazardous activities especially in cases where video data is not available. This work was supported by the German Research Foundation (KL 2922/2-1).

P3-N-116 Designing optimal visual cues to increase stair climbing safety in young and older adults

Timmion Skervin¹, Mark Hollands¹, Constantinos Maganaris¹, Andrew Schofield², Neil Thomas¹, Richard Foster¹

¹Liverpool John Moores University, ²Aston University

BACKGROUND AND AIM: Older adult stair falls present a significant public health challenge and account for over 60% of older adult deaths [1]. The visual appearance of stairs is important for





stair safety and can affect the perception of step heights [2]. Age-related decline in visual functions (such as visual acuity and contrast sensitivity) may impair this perception and could predispose older adults (OA) to a higher risk of falls on stairs [3]. Previous findings on stairs support a perception-action link; showing that visual cues on a step cause an overestimation of perceived step height and a corresponding increase in foot clearance during stair ascent [2]. The visual cues, which represent versions of the horizontal-vertical illusion, appear as multiple black and white vertical stripes superimposed on the stair riser with an abutting horizontal edge highlighter on the tread above. However, the perceptual change in response to the visual cues has only been previously demonstrated in young adults (YA) (mean±1SD; 37±14y). This study aims to determine if OA show the same perceptual response as YA, and whether the visual cues can be simplified in appearance (reduced vertical stripes) and remain effective. This information will be used to develop visual cues suitable for placement on home or public stairs to help improve stair safety for OA. METHODS: A computer-based perception test (forced choice method design) was used to assess perceptual responses to four visual cues (Fig 1A). Fourteen people (six YA; age 23±4y, eight OA; age 68±6y) compared the bottom step height of a three-step stairway superimposed with a visual cue (test stimulus) to plain steps varying in height (reference stimulus) (Fig 1B). Observers selected the image they perceived to have the taller bottom step over a maximum of 560 trials. Images were scaled to represent step heights found on physical stairs. A logistic function was used to determine the reference stimulus step height that matched the perceived height of the test stimulus (the point at which the test step was judged to be taller on 50% of trials). A one-sample t-test compared perceptual differences between the test and reference stimulus, a two-way repeated measures ANOVA compared between age groups and test stimuli. RESULTS: Both groups overestimated the veridical step height for each test stimulus by 7-14% (YA; p=0.023, OA; p=0.003, Fig 1C). No differences were found in the overestimation magnitudes between age groups (p=0.130) and test stimuli (P=0.095). CONCLUSIONS: Simplified versions of the visual cue (reduced vertical stripes) were effective in altering perceived height of the step in both YA and OA. Our computer-based perception testing in OA and YA is ongoing and we plan to place these visual cues on physical stairs to see whether there is a corresponding increase in foot clearance in the same OA. This would demonstrate an explicit perception-action link, thereby risk of a trip or fall on stairs. References [1] ROSPA. reducing the 2016. https://www.rospa.com/home-safety/advice/older-people/#where. [2] Foster et al., 2015. Invest Ophthalmol Vis Sci [3] Lord, S.R. 2006. Age Ageing,

P3-N-117 Postural sway of the fallers based on retrospective and prospective studies with CTSIB

Taeho Kim¹, Jinsoo Lee¹, Junggil Kim¹, Jeongwoo Seo¹, Jinseong Choi¹, Gyerae Tack¹

¹Konkuk University





The characteristics of postural sway due to reduced balance ability of the fallers have been reported. Most previous studies have derived the characteristics of the posture sway of the faller only using previous fall records. However, there are some limitations in showing fundamental characteristics of postural sway by dividing them into faller and non-faller groups based on retrospective records alone. The purpose of this study is to confirm trends of measured variables over time for fall-experienced (F) and no-fall-experienced (N) subjects by conducting prospective follow-up study as well as retrospective study. METHODS: Total 76 elderly people aged over 65 years who live in the community were divided into four groups by FF (recurring fall group), FN (restoring group), NF (new fall group), and NN (non-fall group) with an interval of one year. For performance tasks, data were measured using the IMU sensor system (APDM Inc.) based on the Clinical Test of Sensory Interaction of Balance(CTSIB) [1]. Based on the measured data, total 13 variables were calculated. The trends of the measurement variables over time are analyzed. **RESULTS:** Results of NN showed that the effect of aging was not found during two years. Results of FF and FN showed that there were no significant differences in all variables between two-year intervals. Results of NF showed that there were significant differences in most variables with the eyes-open firm surface between two years, which explains that postural sway increases with time and balance ability decreases. CONCLUSION: This study presents an approach to characterize the differences in postural sway between faller and non-faller groups by subdividing them into detailed-subgroups.

P3-N-118 A biomechanics-based investigation of walking aid use in gait laboratory and home settings

Sibylle Thies¹, Alex Bates¹, Eleonora Costamagna¹, Laurence Kenney¹, Malcolm Granat¹, Jo Webb¹, Helen Dawes²

¹University of Salford, ²Oxford Brookes University

BACKGROUND AND AIM: Walking aids are designed to provide stability, but their general use ("yes"/"no") has been reported as a major risk factor for falls [Deandrea et al. 2010]. However, binary classification of an individual's use cannot capture the complex patterns of everyday use, and hence the exact underlying reasons for falls of walking aid users are to date unknown. We argue that the effectiveness of walking aids in preventing falls is determined by how appropriately they are used, yet little guidance is offered to users. There are no available means to monitor frame use, and how they are used in real-life situations is entirely unknown. It was the aim of this study to establish a set of benchmark data on walking frame use and associated user stability, using our previously developed approach [Costamagna et al. 2017]. **METHODS:** Two front-wheeled Smart Walker systems were used: a) The "basic" system for home assessments: this system consisted of load cells which record forces through each of the walker's feet, and which were synchronized with force-sensing insoles in the user's shoes. The system transmits data, in real time, to a laptop. This set up on its own informs on 1) the movements of the walking frame in





relation to foot placements, 2) whether or not the user adhered to clinical guidance, i.e. the front wheels should not be lifted off the ground, 3) the amount of body-weight that the frame supports ('device loading'). b) The "extended" system for assessments in the gait laboratory and Activities of Daily Living (ADL) flat: this system, in addition to load cells and insoles, also included 3D optoelectronic cameras. Those provide data of the relative position of the feet of user and frame, thereby allowing for calculation of the combined stability margin 'SM' of the user-frame system, defined as the distance between the system's CoP and the nearest edge of its BoS. From that, we calculate the minimum value of the stability margin 'SMmin' for a given single or dual support phase; SMmin represents the distance at which the system was closest to "tipping over". Sixteen front-wheeled walking frame users were assessed at home, and 7 in the gait laboratory and ADL flat. Video was recorded to explore walker use in relation to environmental features. RESULTS: All sixteen participants assessed at home lifted the front-wheels off the ground at times, for example to get over door thresholds and when needing to turn. Lifting happened (on average) during 16% of single support and 30% of dual support periods. Lab- and ADL flat-assessed walking stability (SMmin) was reduced during both single and dual support when one or both front-wheel(s) were not grounded, as was the associated device loading (both p < 0.01). CONCLUSIONS: Walker lifting was found to be common and is associated with decreased stability and reduced device loading. Environmental features together with the fixed, non-swivel wheels at the front of the frame appear to be the cause. ACKNOWLEDGEMENTS AND FUNDING: This work was supported by The Dunhill Medical Trust [grant number R473/0216].

O - Habilitation & rehabilitation

P3-O-119 Effects of dance on motor and non-motor symptoms of Parkinson's disease: A feasibility study

Anna Carapellotti¹, Michail Doumas¹

¹Queen's University Belfast

BACKGROUND AND AIM: Dance has been shown to improve motor function and cognition in people with mild-moderate Parkinson's disease (PD), and the Dance for PD model has had worldwide success at being implemented in the community. Despite this model's popularity, few studies have examined its effects on motor and non-motor symptoms in people with PD. The aim of this study was to determine the feasibility and acceptability of delivering a twelve-week dance intervention based on the Dance for PD model in Northern Ireland and to identify suitable measures for evaluating motor and non-motor outcomes for a future randomized controlled trial. **METHODS:** Eight people with PD (Mean Age = 67; H&Y: I-III) took part in 20 one-hour dance classes over 12 weeks. Assessments were completed at baseline and within one week of the 20th class. Balance and functional mobility were assessed using the Sensory Organization Test (SOT) and Timed Up and Go (TUG), respectively. Cognitive assessments included Trail Making Tests A





& B (TMT-A&B), Digit Symbol Substitution Test (DSST), Digit Span Forward and Backward (DF & DB), and Montreal Cognitive Assessment (MoCa). Participants also completed the following questionnaires: Patient Health Questionnaire-9 (PHQ-9), Falls Efficacy Scale International (FES-I), Freezing of Gait Questionnaire (FOG-Q), and Parkinson's Disease Questionnaire (PDQ-39). An exit questionnaire was administered at post-test to evaluate participant perceptions of the program. **RESULTS:** The dance classes were seen as feasible and acceptable among this group of people with PD, with no dropouts and all participants "Strongly Agreeing" with the statement, "I enjoyed participating in the dance classes." This was further evidenced by the fact that 50% of the participants took part in extra classes after finishing the prescribed program. Preliminary analysis indicated significant improvements (p < 0.05) in functional mobility (TUG), symptoms of depression (PHQ-9), health-related quality of life (PDQ-39), and attention, visual search and motor function (TMT-A). No significant effects were found for other outcomes. CONCLUSIONS: This study supports the idea that dance is a feasible and enjoyable form of physical activity for people with PD that may promote adherence. Significant improvements in functional mobility, cognition, depression, and quality of life were shown; however, a high-quality randomized controlled trial is needed to confirm our preliminary evidence suggesting that dance classes modeled after the Dance for PD method can positively impact PD motor and non-motor impairments. Research isolating and examining specific elements of dance classes is also needed so that curricula can be optimized and the mechanisms by which dance may lead to improvements in motor and cognitive domains can be better understood. ACKNOWLEDGEMENTS AND FUNDING: The authors would like to thank the Thouron Award, Sport NI, and Queen's University Belfast Impact Case Study Fund for funding this project. They would also like to thank the participants, people with PD who were involved in the design stage, Parkinson's UK for supporting recruitment and research involvement activities, and the QUB students and dance artists who assisted in the classes each week.

P3-O-120 Enhanced postural control in experienced karate practitioners: Further evidence that practice does make perfect

Amit Hadad¹, Natalie Ganz², Eran Gazit², Nathan Intrator¹, Jeff Hausdorff²

¹Tel Aviv University, ²Tel-Aviv Sourasky Medical Center

BACKGROUND AND AIM: Previous work suggests that "practice makes perfect" and that people who repeatedly perform tasks that challenge their balance are likely to have enhanced postural control. Karate is a martial art that putatively demands postural control, and, over time, should lead to better balance. The aim of the present work was to explore whether karate training is associated with high levels of postural control. More specifically, to rule out the general effects of fitness, we compared experienced karate practitioners to an age-matched group of healthy swimmers. **METHODS:** 20 male karate practitioners (mean yrs of practice at least twice per week: 15.86±10.73) and 20 male experienced swimmers (mean yrs of practice at least twice per week:





15.20±04.92) 20-50 years of age participated. The subjects performed four standing tasks with increasing difficulty: 1) eves open, 2 legged, quiet standing, 2) one-legged standing with eyes open; 3) one-legged standing with eyes closed, and 4) one-legged standing with eyes closed and serial subtractions. In the three one-legged tasks, the number of times the raised foot touched the floor were counted. In all tasks, the movement of the center of gravity was quantified using a 3D accelerometer to further quantify postural control. MANOVA was used to compare the two groups. **RESULTS:** The two groups were similar with respect to age, height, weight, health status, and the amount of time spent exercising weekly (p>0.072). Most postural control measures were related to the level of task difficulty in both groups. In contrast, group differences were seen in only two measures: floor touches (p<0.001) and Shannon entropy of the acceleration signals (p=0.002). For example, in the one-legged eyes closed task, the median number of touches was 0.0 in the karate group and 6.5 in the swimmers. In the dual task condition, the median number of touches was 0.0 in the karate group and 5.0 in the swimmers. In the karate group, Shannon entropy was 4.15±0.51 and 4.31±0.47 during one-legged eyes open and eyes closed, respectively. In the swimmers, these values were 4.63±0.66 and 4.69±0.58, respectively. CONCLUSIONS: Three main conclusions emerge: (1) Since there were significant differences between tasks of different levels of difficulty, these findings support the utility and sensitivity of the outcome measures applied in healthy young adults; (2) The lower Shannon entropy values in the karate group suggests that it a highly sensitive measure. Perhaps this reflects the idea the more predictable and less complex a series is, the lower the entropy value. (3) Under some challenging conditions, karate practitioners exhibit a higher level of postural control as reflected in the large difference in the number of floor touches between the two groups and in the Shannon entropy measure. More generally, these findings suggest that karate and perhaps other types of balance training may be useful as a form of prehabilitation, possibly preventing age-associated declines in balance control.

P3-O-121 Characteristics of people with stroke who withdraw from mobility and balance rehabilitation research studies.

Kara Patterson¹, Jennifer Wong², Avril Mansfield²

¹University of Toronto, ²Toronto Rehabilitation Institute

BACKGROUND & AIM: Balance and mobility are frequently impaired after stroke. Considerable research has focused on characterizing deficits and developing rehabilitation interventions. The generalizability of these studies is limited when participants withdraw. Understanding the characteristics of research participants with stroke who withdraw can help inform better recruitment and retention strategies, thus improving generalizability of clinical research. This study aimed to characterize participants with stroke who withdrew from rehabilitation studies that included measures of balance and mobility. **METHODS:** A secondary analysis of 6 stroke rehabilitation studies conducted by two investigators at an urban research hospital between 2010 and 2016 was performed. Study databases were searched to extract data related to study





characteristics (objectives, sample size, outcome measures), and participant characteristics (age, sex, time since stroke onset, National Institutes of Stroke Scale (NIHSS), Chedoke McMaster Stroke Assessment (CMSA) leg and foot scales, Montreal Cognitive Assessment (MOCA), and Berg Balance Scale (BBS)). A participant was categorized as 'withdrawn' if they 1) provided informed consent; 2) initiated participation such that some measures were collected; and 3) withdrew before the measures required to achieve the main study objective were collected. Withdrawal rate was calculated as (# participants withdrawn/n)*100% for each study. Individual participant data from all 6 studies were pooled, descriptive statistics were calculated, and Wilcoxon rank tests were used to compare participants who withdrew and completed the studies. **RESULTS:** The total pooled sample size for all 6 studies was 283. Of these, 21 discontinued participating in the study in which they were enrolled. The withdrawal rate for all 6 studies combined was 7.4% and ranged from 0-17.9% for individual studies. For all studies combined, participants who withdrew had a significantly higher (worse) NIHSS scores (5.1+/-3.7) and lower BBS scores (34.9 +/-17.3) compared to those participants who completed the study (NIHSS=2.7 +/-2.2, p=0.005; BBS=44.5 +/-12.0, p=0.03). CONCLUSIONS: The main finding is that participants who withdraw from balance and mobility rehabilitation studies had greater stroke severity and poorer standing balance. Interestingly, motor recovery of the leg and foot did not differ between participants who withdrew and those who did not. This suggests that factors other than motor control (e.g. dynamic balance, sensation, language abilities) may have a greater influence on participant retention even in studies where motor performance is a focus. The characteristics of participants who withdraw should be considered when interpreting the results and the generalizability of post-stroke mobility and balance rehabilitation studies. These results may also be used to inform initiatives to facilitate research participation by people more severely affected by stroke.

P - Modeling

P3-P-122 Collision avoidance between a walker and a person on an electric powered wheelchair

Anne-Hélène Olivier¹, Nicolas Le Borgne², Marie Babel², Armel Crétual¹, Julien Pettré²

¹University of Rennes / Inria, ²Inria Rennes

BACKGROUND AND AIM: We are interested in the development of smart electric powered wheelchairs (EPW), which provide driver assistance. Developing smart assistance requires to better understand interactions between walkers and such vehicles. We focus on collision avoidance task between an EPW (fully operated by a human) and a walker, where the difference in the nature of the agents (weight, maximal speed, acceleration profiles) results into asymmetrical physical risk in case of a collision, for example due to the protection EPW provides to its driver, or the higher energy transferred to the walker during head-on collision. In this study, our goal is to





demonstrate that this physical risk asymmetry results into differences in the walker's behavior during collision avoidance in comparison to human-human situations. METHODS: 20 participants (15 walkers and 5 EPW drivers) volunteered to this study. The experiment was performed in a 30mx20m gymnasium. We designed a collision avoidance task, where an EPW and a human walker moved towards a goal with orthogonal crossing trajectories. We recorded their trajectory among 246 trials (each trial being 1 collision avoidance). We compared the predicted passage order when they can first see each other with the one observed at the crossing point to identify if inversions occur during the interaction. Note that during walker-walker interactions it was shown that the initial passage order is almost systematically preserved all along the interaction up to the crossing point. We also computed the shape-to-shape clearance distance. RESULTS: We observed 25.6% of passage order inversion, specifically in 22.7% of trials where walkers were supposed to cross first, they crossed second. This means that walkers were more likely to pass behind the EPW than in front. On average, human walkers crossed first when having sufficient advance on the wheelchair to reach the crossing point. We estimated this advance up to 0.91m. The shape-to-shape clearance distance was influenced by the passage order at the crossing point (p<0.001), with larger distance when the walker cross first (M=0.78m) than second (M=0.34m). **CONCLUSIONS:** Results show that walkers set more conservative strategies when interacting with an EPW. By passing more frequently behind the EPW, they avoid risks of collisions that would lead to high energy transfer. Also, when they pass in front, they significantly increase the clearance distance, compared to cases where they pass behind. These results can then be linked to the difference in the physical characteristics of the walkers and EPW where asymmetry in the physical risks raised by collisions influence the strategies performed by the walkers in comparison with a similar walker-walker situation. This gives interesting insights in the task of modeling such interactions, indicating that geometrical terms are not sufficient to explain behaviours, physical terms linked to collision momentum should also be considered. FUNDING: Inria associated team ISI4NAVE and INTERREG VA FMA ADAPT project.

P3-P-123 Accounting for sensory noise is important to simulate stable and human-like control of perturbed standing balance

Tom Van Wouwe¹, Friedl De Groote¹, Lena Ting²

¹KU Leuven, ²Emory University and Georgia Tech

BACKGROUND AND AIM Computer simulations of movement typically lack the stability of human movement. Traditional simulation techniques do not account for the fact that sensory signals are noisy and external perturbations are unpredictable, causing simulations of standing to be easily destabilized. As such, it is difficult to use simulation to understand how decreased sensory acuity affects balance. Here we developed a robust optimal control framework to test how balance strategies would change when sensory noise increases. We applied the robust optimal control framework developed by Houska [1] to perturbed standing balance and evaluated how robustness





against sensory noise and unpredictable perturbations affected control of standing balance. METHODS The musculoskeletal system was modeled by a torque driven double inverted pendulum. Neural control was modeled as linear time-invariant feedback mapping kinematics to excitations. First-order activation dynamics described the relation between excitations and joint torques. The state co-variance matrix describes the uncertainty on the states (ankle and hip angles and velocities) and was propagated through the dynamics using the Lyapunov differential equations [1]. The model was perturbed by a support surface translation. Optimal feedback gains were computed by minimizing the weighted sum of center of mass movement, joint torques and the sensitivity of the kinematics at the end of the movement to the uncertainty. This last term was computed based on the state co-variance matrix and the importance of this term was altered by changing the corresponding weight in the cost function. Two sources of uncertainty were considered. First, sensory noise was modeled by additive Gaussian noise on the kinematics that is input to the feedback law. Second, the acceleration profile of the perturbation was parametrized using three parameters with a Gaussian distribution. More details in Figure 1A. We efficiently solved the resulting optimal control problem using direct collocation. **RESULTS** The predicted postural strategy changed significantly when robustness was taken into account (Figure 1B). When neglecting robustness to uncertainty the optimal feedback law was unstable and hip extension in response to the perturbation was unrealistic (Figure 1C). Minimizing movement endpoint variance increased the realism of the postural response. A moderate weight on movement variance resulted in a stable hip strategy (hip flexion $\approx 5^{\circ}$). When end-point variance was highly penalized, motion in the hip joint was very limited. Minimizing state variance came at the cost of increased joint torques. CONCLUSION We showed that taking into account uncertainty is important to generate stable and realistic simulations of perturbed standing balance. The presented robust optimal control framework can easily be extended to study a wide range of movements controlled by both feedforward and feedback. We will use this method to study the effect of decreased sensorimotor acuity on coordination. REFERENCES [1] Houska B., Control Applications, 2010.

Q - Neurological diseases

P3-Q-124 The effect of dopaminergic medication on planned gait termination in Parkinson's disease

Ali Aljaroudi¹, Nicolaas Bohnen¹, Martijn Müller¹

¹University of Michigan

BACKGROUND AND AIM: Gait dysfunction is common in Parkinson disease (PD) patients. It manifests as hypokinesia, motor blocks, difficulty in gait initiation and termination, and freezing of gait. The initiation of gait has been examined in some detail; however, gait termination has received little investigation. Spatiotemporal data have been shown to be useful for describing and





understanding gait characteristics, and are able to provide reliable indicators to define gait events such as initiation and termination cycles. Previous studies have shown an important role of dopaminergic medications on horizontal mobility (propulsion) but effects on vertical mobility, including braking function, are less well studied. The aim of this study was to investigate the effect of dopaminergic medication on spatiotemporal gait termination metrics in PD patients during a planned stopping event. METHODS: A total of 58 PD subjects (44 Males/14 Females; Age: 66.6±6.1 years old; MDS-UPDRS-III score of 35.22±14.03; median Hoehn & Yahr 2.5; motor disease duration: 6.1±4.2 years) were included in this study. An electronic walkway system (Zeno? Walkway, ProtoKinetics LLC.) was used to evaluate planned gait termination metrics by walking straight and come to a full stop as closely possible in front of a cone, once at normal pace (NP) and once at fast pace (FP) and both trials assessed in the dopaminergic "off" and "on" states. Spatiotemporal gait termination data included: a) Normalized braking distance defined as total length of brake pathway over time needed to stop, and b) peak velocity during the stopping approach. Repeated-measures ANOVA was used to examine the effect of pace (NP vs. FP) and medication (off vs on) on these spatiotemporal parameters. RESULTS: There were pace and medication main effects on both breaking distance (F=38.8, p<0.001 and F=6.2, p=0.015, respectively) and peak velocity (F=68.4, p<0.001 and F=11.6, p=0.001, respectively). There was also a pace x medication interaction effect for both breaking distance (F=10.2, p=0.002) and peak velocity (F=9.3, p=0.003). Post-hoc analysis showed that peak velocity increased as a result from medication intake during NP (t=-5.4, p<0.001) but not during FP (t=-0.204, p=0.839). A similar effect was observed for braking distance (NP: t=-4.4, p<0.001; FP: t=0.259, p=0.796). **CONCLUSIONS:** The study results show a modulatory effect of dopaminergic medication on spatiotemporal parameters of planned gait termination during normal pace; however, this effect could not be found during fast pace. Modulation of planned gait termination during fast pace may, in part, be driven by non-dopaminergic systems, such as recruitment of accessory brain networks subserving mobility. These findings expand on previous observations of a dopaminergic medication involvement in propulsion and now may also play at least a partial role in braking functions in PD. FUNDING: NIH P50 NS091856.

P3-Q-125 Protective postural control with divided attention: Effects of Parkinson's disease

Daniel Peterson¹, Jordan Barajas¹, Anandita Nadkarni², Linda Denney³, Shyamal Mehta⁴

¹Arizona State University, ²Carnegie Mellon University, ³Northern Arizona University, ⁴Mayo Clinic

BACKGROUND & AIM: The ability to take quick and effective "protective steps" after a loss of balance is critical to prevent a fall [Maki & McIlroy, 1997], and protective steps are often small and delayed in people with Parkinson's disease (PD) compared to neurotypical adults [Peterson et al. 2016]. However, most previous literature has investigated protective stepping in isolation. Balance perturbations that occur while attention is divided can increase fall incidence [Jacobs et al. 2014].





Therefore, it is important to characterize protective stepping during the more ecologically valid, dual tasking scenario. The aim of this project is therefore to determine the impact of dual tasking on cognitive and postural performance in people with PD and neurotypical adults. METHODS: Data from seven neurotypical adults (age: 67.1±7.4; MoCA: 27.9±3.2) and nine people with PD (age: 70.2±4.9; MoCA: 24.4±4.8; MDS-UPDRS III: 43.3±8.7) were included a preliminary analysis of an ongoing data collection. Participants underwent postural perturbations: quick translations of the support surface (3m/s2) from stance, and a cognitive task: auditory Stroop task, in isolation and in combination (dual tasking). For the dual tasking scenario, participants underwent 8 auditory Stroop stimuli, with one postural perturbation released simultaneously with auditory stimuli 5, 6, 7 or 8. Protective step outcomes included margin of stability (MOS) at first foot contact, and first step length and latency. The cognitive outcome was average verbal reaction time to auditory Stroop stimuli prior to the perturbation release. **RESULTS:** As shown in the Figure, cognitive performance, measured as the verbal response reaction time was not statistically significantly impacted by addition of a secondary task in either group (PD: p=0.79; Control: p=0.87). Protective stepping performance (MOS), was significantly worse (smaller) in neurotypical adults during dual tasking compared to single tasking (p=0.043). This was due to a significant reduction in step length during dual tasking (Figure; p=0.004). Addition of a cognitive task did not significantly impact MOS or step length in people with PD (p=0.64 and p=0.89, respectively). CONCLUSIONS: We analyzed cognitive and protective stepping performance during single and dual task conditions in neurotypical and Parkinsonian participants. In this preliminary analysis, and partially consistent with previous reports [Brauer et al. 2002] we observed dual task interference in protective stepping performance in neurotypical adults. Interestingly, dual tasking did not impact stepping performance in people with PD. This is partially consistent with previous work, which also did not show dual tasking to impact step kinematics [Jacobs et al. 2014], and may reflect an increased prioritization on postural stability in people with PD compared to neurotypical adults. ACKNOWLEDGEMENTS AND FUNDING: This grant was funded in part by the Arizona State University / Mayo Clinic Collaborative Seed Grant.

P3-Q-126 Initial center of pressure position prior anticipatory postural adjustments during gait initiation in people with Parkinson's disease with freezing of gait

Madli Bayot¹, Delval Arnaud¹, Hansen Clint², Walter Maetzler³, Christian Schlenstedt²

¹University of Lille - Inserm U1171-Degenerative and Vascular Cognitive Disorders, ²Christian-Allbrechts-University of Kiel, ³Christian-Albrechts-University of Kiel

BACKGROUND AND AIM: Freezing of gait (FOG) in Parkinson's disease (PD) is linked to a shift of the center of pressure (COP) towards the heels during stance and this COP displacement correlates with the severity of FOG [1]. It is unclear whether this COP shift during stance impacts the preparation and execution of the first step during gait initiation or whether the altered COP position serves as a compensatory mechanism to avoid forward falls. We aimed to investigate the



impact of the initial COP position prior anticipatory postural adjustments (APAs) on the preparation and execution of the first step in people with PD with and without FOG and healthy controls. METHODS: Twenty-seven PD patients with FOG (PD FOG), 30 without FOG (PD-FOG) and 27 healthy controls (HC) were included. Patients were tested ON Medication. Participants performed three trials of self-initiated gait. Anticipatory postural adjustments were assessed with force plates. Initial foot position and step kinematics were captured with reflective markers. Initial mean anterioposterior (AP) and medio-lateral (ML) COP positions as percentages of foot length were assessed 0.5, 1 and 2 seconds prior APA onset. **RESULTS:** PD FOG and PD-FOG did not differ in disease severity (UPDRS III) (p>0.05), and the three groups were well balanced for gender and age. No differences in terms of mean AP COP position prior APA onset were observed between groups. Furthermore, no significant correlation was found between initial mean AP COP position and ML or AP size of APA or step kinematics (first step length and velocity). With regard to the ML direction, PD FOG showed a trend of the COP position shifted towards the stance leg. **CONCLUSIONS:** It seems that the mean AP COP position prior to APA onset is not affected by FOG. Moreover, average AP COP position does not seem to impact preparation and execution of the first step and may therefore play a minor role in the gait initiation process. Overall, the previously observed posterior shift of the mean COP position during quiet stance in freezers does not seem to impact gait initiation and our results indirectly support the idea that this COP shift toward the heels during quiet stance might be a compensatory strategy in order to avoid forward falls. The ML shift of the COP towards the stance leg might explain impaired ML size of APAs in PD FOG which has been reported previously [2] and that needs further investigation. FUNDING: "The project leading to this application has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie grant agreement No 721577". [1] C. Schlenstedt, M. Muthuraman, K. Witt, B. Weisser, A. Fasano, et G. Deuschl, « Postural control and freezing of gait in Parkinson's disease », Parkinsonism Relat. Disord., vol. 24, p. 107-112, mars 2016. [2] C. Schlenstedt et al., « Are Hypometric Anticipatory Postural Adjustments Contributing to Freezing of Gait in Parkinson's Disease? », Front. Aging Neurosci., vol. 10, 2018.

P3-Q-127 The effect of a high intensity treadmill training and self-management program on physical activity in stroke patients undergoing rehabilitation: A RCT.

Sandra Brauer¹, Suzanne Kuys², Jenny Paratz³, Louise Ada⁴

¹University of Queensland, ²Australian Catholic University, ³Griffith University, ⁴University of Sydney

BACKGROUND AND AIM: After stroke, physical activity levels are low. Community-dwelling stroke survivors take fewer steps than age-matched controls [1]. Physical activity requires both the capacity and motivation to be active. Walking capacity can be increased with high-intensity treadmill training [2]. Self-management may contribute to improved physical activity after brain





injury, but results are inconclusive [3]. Addressing both walking capacity and self-management may have greater effect. The aim of this study was to determine the effect of a combined highintensity treadmill and self-management program on step count compared with usual gait training in stroke survivors undergoing inpatient rehabilitation. METHODS: A parallel-arm, two-group randomized controlled trial with concealed allocation and assessor blinding was conducted across six hospital sites in two states in Australia. Stroke survivors undergoing inpatient rehabilitation who could walk 10m were randomized into two groups. The experimental group participated in a highintensity treadmill and self-management program for up to 30 minutes, three times a week for up to 8 weeks. The control group received the same volume of usual gait training. Both received usual rehabilitation. The primary outcome measure was physical activity (daily steps measured via ActivPAL over 4 days) measured post intervention (Week 8) and at follow up (Week 26) analysed using linear mixed models. RESULTS: 119 stroke survivors were randomised, with 9% lost to follow up at week 8 and 15% at week 26. Attendance at sessions was 80% and no serious adverse events related to the trial were reported. Over the 8 weeks, the length of intervention sessions increased from 20 to 30 minutes, mean treadmill speed increased from 0.75m/s to 1.22m/s, and walking distance increased from 905m to 1968m. The proportion of participant-led self management discussions increased over the intervention period (self monitoring 6% to 30%, coping strategies 3% to 27%). At baseline, there was no difference between groups for demographic or outcome measures. The primary analysis revealed a group effect (p=0.010), but no time effect (p=0.993) and no group x time interaction (p=0.524). At week 8, the intervention group increased their step count in comparison to the control group (mean difference 1436 steps, 95% CI 229 to 2643), but at week 26 there was no difference between groups (mean difference 871 steps, 95% CI -386 to 2129). CONCLUSIONS: A high-intensity treadmill training program embedded within a self management approach during inpatient rehabilitation showed good compliance and resulted in an increase in step count post training, but was not sustained at 6months. Analysis of secondary outcome measures will be undertaken to assist to understand underpinning mechanisms. ACKNOWLEDGEMENTS: This study has been supported by a NHMRC project grant ID: GNT1047426. We would like to thank the participants and staff who contributed to this trial. [1] English C et al. Phys Ther 2016. 94: 184-196. [2] Kuys S et al. Clin Rehabil 2011. 25(4):316-26 [3] Jones TM et al. Syst Rev. 2015;4:51.

P3-Q-128 Unpredictable gait perturbation training improves reactive responses, and gait stability functions contrary to gait training without perturbations in stroke individuals

Vahid EsmaeiliMahani¹, Laurent Bouyer², Cyril Duclos¹

¹Université de Montréal, ²Université Laval

Unpredictable gait perturbation training has been shown to improve post-stroke balance deficits effectively. Dynamic balance control is a complex system, relying on several functions necessary for anticipatory and reactive responses, sensory orientation, and stability during gait. To support





the clinical decision of using perturbation training in stroke rehabilitation and to better understand the specific effects of such training, the aim of this study was to compare the effects of training with and without unpredictable gait perturbations on the different functions involved in dynamic balance control, in post-stroke individuals. METHODS: Nineteen stroke individuals were assigned to two groups through covariate adaptive randomization: perturbation training (PT) and noperturbation training (nPT) and attended 9 training sessions over 3 weeks using a split-belt treadmill. For PT, perturbations were produced by changing the speed of one of the belts during stance phase every 8 to 16 steps. The intensity of the perturbations increased progressively between sessions according to participants' tolerance. The duration of the training sessions in nPT, i.e. without perturbation, was matched with a PT subject walking at similar speed. The effects of the training programs on the different functions of balance control, evaluated using the Mini-BESTest, were compared using nonparametric statistics. RESULTS: Total Mini-BESTest score was different between groups after training (p=.040) but not before training (p=.438). Unpredictable perturbation training improved the functions involved in anticipatory (p=.053) and reactive responses (p=.027), and stability during gait (p=0.01). No significant improvements were found over training in nPT group in any balance function (p>.33 for the other functions) except for anticipatory responses (p≥.066). Between-group comparison showed better anticipatory function (p=.017) pre-training and better sensory orientation function (p=.022) post-training in the PT group than in the nPT group. CONCLUSION: Unpredictable gait perturbation resulted in the specific improvement in functions involved in reactive responses and stability during gait. Results are in accordance with the task specificity principle and support the choice of unpredictable gait perturbation training over walking on the treadmill in post-stroke individuals who have reactive and gait stability deficits.

P3-Q-129 Feature selection of objective metrics of balance dysfunction in Parkinson's disease

Naoya Hasegawa¹, Vrutangkumar Shah¹, Anjanibhargavi Ragothaman¹, Samuel Stuart¹, Patricia Carlson-Kuhta¹, John Nutt¹, Fay Horak¹, Tadayoshi Asaka², Martina Mancini¹

¹Oregon Health & Science University, ²Hokkaido University

BACKGROUND AND AIM: Balance dysfunction in Parkinson's disease (PD) has been characterized by four main postural control domains: 1) balance during quiet stance, 2) reactive postural adjustments to external perturbations, 3) anticipatory postural adjustments in preparation for voluntary movements, and 4) dynamic balance during walking. Recently, instrumentation of these motor tasks has been developed with wearable inertial sensors, leading to a proliferation of objective metrics. However, the best metrics to use as outcomes for clinical trials and rehabilitation interventions are unclear. This study aimed to determine the most sensitive objective metrics of balance dysfunction that differ between people with PD and healthy control (HC) subjects to be used for future investigation of rehabilitation intervention. **METHODS:** We recruited 142 subjects





with idiopathic PD (age: 68±8 yrs., MDS-UPDRS III: 41±13) and 76 HC (age: 68±8 yrs.). All participants wore 8 inertial sensors (Opals, APDM) attached to both feet, shanks, wrists, sternum, and the lumbar region, while performing sway, push and release, step initiation, limits of stability, and gait tasks (PD in their practical off state). In addition, gait and step initiation tests were performed with and without a concurrent cognitive task; and sway test was executed both on firm and foam surfaces with eyes open. All metrics of mobility were computed from inertial sensors, and dual-task cost was calculated from gait task. We first calculated the Standardized Mean Difference (SMD), and took metrics that had SMD value beyond 0.5 (large effect). Next, we computed a correlation matrix, and removed highly dependent metrics (R>0.70) to avoid the problem of multi-collinearity. In addition, we used a random forest algorithm to find a subset of highly sensitive metrics and compared the results. **RESULTS:** We started from a comprehensive set of 57 objective metrics from various mobility tasks. After applying a threshold on SMD, we were left with 31 metrics. After reducing highly correlated metrics, we were left with 17 metrics, highly sensitive to PD. The 4 most sensitive metrics in SMD and ranked highly in random forest were: turning velocity, foot angle at heel strike, arm range of motion (ROM) during walking and gait velocity during fast walking. Lastly, running the random forest with 10-fold cross validation on the reduced metrics (n=17) showed mean accuracy of 82.6% compared to the mean accuracy of 83.1% on all metrics (n=57). CONCLUSIONS: We propose a procedure to reduce the number of objective metrics of balance needed to differentiate PD from HC subjects. The most sensitive objective metrics were turning velocity, foot angle at heel strike, arm ROM during walking, and gait velocity during a fast walk. The proposed method reduced the objective metrics from a comprehensive set of 57 to 17 metrics that still obtained similar classification accuracy as that of running random forest on all metrics.

P3-Q-130 Influence of reactive balance training on responses to an unexpected slip in individuals with chronic stroke: A randomized controlled trial

Andrew Huntley¹, Alison Schinkel-Ivy², Anthony Aqui¹, Avril Mansfield¹

¹Toronto Rehabilitation Institute, ²Nipissing University

BACKGROUND AND AIM: People with chronic stroke have an increased risk of falls compared to community-dwelling older adults without stroke [1,2]. Reactive balance training (RBT) can decrease fall rates in people with sub-acute stroke [3], and improve balance reactions following perturbations to stance in people with chronic stroke [4,5]. This study aimed to determine the effects of RBT on responses to an unexpected slip during overground walking in people with chronic stroke. **METHODS:** This study is a sub-study of a larger randomized controlled trial [5]. Twelve people with chronic stroke (>6 months post stroke, 6 RBT/6 control), completed 3 trials of unperturbed walking, followed by 1 overground walking trial with a slip perturbation. RBT involved training movement responses to instability, while the control group underwent traditional balance training involving movement execution during functional tasks. Walking trials were completed on





a 6x3m moveable platform. Participants were told that the platform would not move in all trials; however, the platform moved on the final walking trial to induce a slip-like response [6]. Whole body kinematic (Vicon, UK) and kinetic (AMTI, USA) data were captured, and used to determine gait step characteristics and gait events, respectively. Number of falls (body weight supported by safety harness), failure to continue overground walking (initial reactive step velocity or overall gait velocity ≤ 0 m/s), and arm reactions were documented. **RESULTS:** No participants fell after the slip perturbation. 1/6 RBT participants and 3/6 control participants failed to continue overground walking after the slip. 5/6 RBT and 5/6 control participants executed reactive arm movements in response to the slip. No interaction effect of training group by walking condition was observed for initial reactive step distance (p=0.70), step timing (p=0.50), or step velocity (p=0.94). A main effect of training group was observed for step distance (greater in PBT participants, p<0.001), step timing (quicker in RBT participants, p<0.001), and step velocity (faster in PBT participants, p<0.001). CONCLUSIONS: Preliminary results indicate RBT may improve overall stepping characteristics in individuals with chronic stroke. However, significant changes between groups across the gait to slip conditions (group by condition interaction) did not occur. Analyses to be presented at the conference will include dynamic postural stability throughout the slip response, to better characterize changes in reactive balance control in response to a slip perturbation in individuals with chronic stroke. TRIAL REGISTRATION: ISRCTN05434601 REFERENCES:[1] Weerdesteyn et al (2008) J Rehab Res Dev 45(8):1195 [2] Rubenstein (2006) Age Ageing 35:37-41 [3] Mansfield et al (2017) J Stroke Cerebrovasc Dis 26(10:2174-2180 [4] Schinkel-Ivy et al (2018) J Stroke Cerebrovasc Dis, in review [5] Mansfield et al (2018) BMJ Open 8(8):e021510 [6] Huntley et al (2018) Gait Posture, in review.

P3-Q-131 Motor training improves motor performance at the preclinical stage of degenerative cerebellar ataxia

Winfried Ilg¹, Matthis Synofzik¹

¹Hertie Institute for Clinical Brain Research

BACKGROUND AND AIM: It is well known for many neurodegenerative diseases that subtle movement changes often occur years before clinical manifestation, corresponding to a neurodegenerative disease process starting many years before clinical onset. In earlier work1, we have shown that increasing complexity of balance and gait tasks allow to unravel dysfunctions in preclinical stages of degenerative spinocerebellar ataxia (SCAs). This calls for early intervention strategies aiming to slow down disease progression already at the preclinical stage of the disease as a promising window of opportunity for intervention. Here, we examined the effects of a 6-weeks exergaming-based coordination training in preclinical mutation carriers of SCA. **METHODS:** The motor exercise program consisted of five whole-body controlled video games based on Microsoft Xbox Kinect? (e.g. Juggling, Hacky Sack, Light Race). Subjects received a two-day introductory training, followed by six weeks of home training, We recruited three intervention groups 1.)





EARLY: 5 patients with early stage SCA [SARA2 score: 3-8]; 2.) PRE: 14 preclinical mutation carriers for SCA types 1,2,3 or 6; [SARA<3]; 3.) CON: 8 age-matched healthy controls. The effects were examined within an intra-individual control study design by quantitative movement analysis. We assessed (i) stance (Romberg test) in different complexities including closed eyes and on an elastic mat as well as (ii) walking and tandem walking on hard and soft ground. RESULTS: Before intervention a difference in body sway was observed in all Romberg conditions between the groups EARLY and CON (p<0.001) as well as between EARLY and PRE (p<0.02). Differences between PRE and CON were identified in Romberg on the mat with closed eyes (p<0.002). For tandem walking and tandem walking on a mattress PRE showed significant increased variability in step length and in step cycle time compared to CON (p<0.006). After intervention, subjects of groups CON and PRE improved in stance and tandem tasks with high complexity (Romberg on the mat with closed eyes: reduced body sway, p<0.02; tandem on the mat: reduced temporal step cycle variability, p<0.03). Improvements in tandem gait correlated with improvements in the game score in a goal-directed stepping task game (p<0.02). CONCLUSIONS: We identified features in complex stance and gait tasks, which differentiate pre-clinical SCA mutation carriers from controls. These features improved after a 6-weeks exergaming-based motor intervention revealing specific motor improvements in preclinical SCA mutations carriers. Further analyses will examine the neural correlates of motor improvements in preclinical mutation carriers and healthy controls by brain imaging techniques (VbM, DTI). 1 llg et al Mov Disord. 2016;31(12):1891-1900. 2 Schmitz-Hübsch et al, Neurology. 2006;66(11):1717-20.

P3-Q-132 Influence of environmental context on locomotor skill learning in virtual reality in people with Parkinson's disease

Aram Kim¹, James Finley¹

¹University of Southern California

BACKGROUND AND AIM: People with Parkinson's disease (PD) often have difficulty expressing motor skills learned in one environment in a different environmental context, even when the context is not directly relevant to the task. This problem is referred to as context-dependent learning (CDL). Although CDL has been explored experimentally during finger sequence learning in people with PD, it has yet to be determined whether people with PD also exhibit CDL during locomotor learning. Here, we used a virtual reality-based obstacle negotiation task to study locomotor skill learning in people with PD and a group of age-matched controls. Our primary aim was to understand how the manipulation of environmental context impacts the expression of learned locomotor skills. **METHODS:** On Day 1, participants with PD and a group of age-matched older adults (HO) practiced stepping over a total of 180 virtual obstacles viewed via a head-mounted display while walking on a treadmill. The goal of the task was to step over obstacles while achieving a target foot clearance during crossing. Each obstacle was one of three heights and each height was associated with a level of foot clearance that defined successful performance.




We provided auditory performance feedback that scaled with the size and direction of clearance errors. After 24 hours (Day 2), participants completed retention tests in the same (SAME) and a different (SWITCH) virtual environment without auditory feedback in a counterbalanced order. The SWITCH environment was created through a simple manipulation of the color of the environment. Effect size (d) was calculated to quantify the magnitude of success. RESULTS: Both HO and PD groups improved their obstacle negotiation skill in VR on Day 1. The success rate from Block 1 to Block 5 in VR increased in HO by $21\pm12\%$ (d=1.5) and in PD by $9\pm4\%$ (d=0.6, Fig 1). The increase in success rate was accompanied by a decrease in error magnitude from Block 1 to Block 5 (HO: 2±1 cm, PD: 2±2 cm) and a reduction in foot clearance variability from Block 1 to Block 5 (HO: 1±1 cm, PD: 1±2 cm). On Day 2 in the SAME condition, the PD group maintained a consistent success rate by only 3±7% change (d=0.04) and had no changes in error magnitude or variability compared to Block 5 on Day 1. In the SWITCH condition, the PD group reduced their success rate by 6±9% (d=0.5) while the HO group was more successful by 8±14% (d=0.8) relative to the SAME condition (Fig 1). Neither group had a difference in average error magnitude or variability between the SWITCH and SAME conditions. CONCLUSIONS: Our results reveal that locomotor skill acquisition and retention are preserved in people with PD compared to HO. However, people with PD exhibit difficulty executing a newly acquired locomotor skill in a different environmental context. This suggests that people with PD may have CDL during locomotion. This finding should be confirmed with a larger sample size and future studies should identify potential mechanisms of CDL in people with PD. ACKNOWLEDGEMENTS AND FUNDING: This work was supported by the Link Foundation and the National Institutes of Health under award R21 HD088342-01.

P3-Q-133 Executive functioning, muscle power and reactive balance are major contributors of gait adaptability in people with Parkinson's disease

Maria Joana Duarte Caetano¹, Stephen Lord², Natalie Allen³, Jooeun Song³, Serene Paul³, Colleen Canning³, Jasmine Menant²

¹Prefeitura Municipal de São Carlos, ²Neuroscience Research Australia, University of New South Wales, ³University of Sydney

BACKGROUND AND AIM: The ability to adapt gait when negotiating unexpected hazards is crucial to maintain stability and avoid falling. This study investigated whether impaired gait adaptability in a task requiring obstacle and stepping target negotiation is associated with cognitive and sensorimotor capacities in people with Parkinson's disease. **METHODS:** Fifty four people with Parkinson's disease (PD) were instructed to either (a) avoid an obstacle at usual step distance or (b) step onto a target at either a short or long step distance projected on a walkway two heel strikes ahead and then continue walking. Participants also completed clinical (Hoehn and Yahr rating scale; Movement Disorders Society version of the Unified Parkinson's Disease Rating Scale), cognitive (Trail Making and Stroop stepping [difference between incongruent and





congruent choice stepping reaction time] tests) and sensorimotor (simple reaction time, hip abductor muscle power and reactive balance [pull test from the MDS-UPDRS-III]) function assessments. RESULTS: Discriminant function analysis revealed Stroop stepping test performance was the best predictor of stepping errors across the gait adaptability test conditions. Poorer executive function (Trail Making test) and reactive balance predicted poorer stepping accuracy in the short target condition; poorer reactive balance predicted increased number of steps taken to approach the obstacle and the long target; and poorer executive function predicted obstacle avoidance. Weaker hip abductor muscle power (for all conditions), poorer reactive balance (short/long target conditions) and poorer performance in the Stroop stepping test (obstacle avoidance condition) were significant predictors of shorter step length while negotiating the obstacle/targets. CONCLUSIONS: Superior executive function, effective reactive balance and good muscle power were associated with successful gait adaptability. Executive function and reactive balance appear particularly important for precise foot placements; and cognitive capacity for step length adjustments particularly while avoiding obstacles. Our findings suggest that impaired inhibitory control contributes to stepping errors and consequently may increase fall risk among people with PD. This information may elucidate mechanism as to why people with Parkinson's disease fall and may facilitate fall risk assessments and fall prevention strategies for this group. ACKNOWLEDGEMENTS AND FUNDING: This work was supported by the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPg-200748/2012-2) to M.J.D.C.; National Health and Medical Research Council to S.R.L.; Parkinson's New South Wales and The University of Canberra grant to N.E.A..

P3-Q-134 Diurnal systematic variance of gait during normal daily monitoring

James McNames¹, Vrutangkumar Shah², Patty Carlson-Kuhta², Mahmoud El-Gohary³, John Nutt², Rebecca Spain², Fay Horak², Carolin Curtze⁴

¹Portland State University, ²Oregon Health & Science University, ³APDM, ⁴University of Nebraska Omaha

BACKGROUND AND AIM: Gait assessment during daily life is affected by behavior and daily schedules as well as by disease, injury, and interventions. The purpose of this study was to determine how much of the variation various measures of gait Parkinson's Disease (PD), Multiple Sclerosis (MS) and Healthy Control (HC) subjects exhibit over a week of continuous monitoring in daily life. **METHODS:** We recruited 8 people with PD, 7 people with MS and 8 age-matched healthy control subjects to date. Subjects wore three inertial sensors (Opals, APDM) attached to both feet and the lumbar region for a week of continuous monitoring with an average of 8 hours per day. From the data, we derived about 40 gait metrics. We used a nonparametric with a bandwidth of 30 minutes to estimate the systematic component each measure of gait at the time of day the gait was observed (minutes since midnight). We calculated the ratio of the variance of the model estimates with respect to the total variance, and interpreted the ratio as a percentage





of variance explained by the model. We repeated this process with random data with the same variance as the observed data to ensure the model was not overfitting. **RESULTS:** For most measures of gait, MS and PD subjects had a similar percent of variance explained by the diurnal pattern, and both were much larger than the healthy control subjects. For example the average gait speed variance explained was 13.2% (5.5-21.7%) for MS, 13.3% (3.5-39.8%) for PD, and 6.9% (3.3-12.7%) for controls. The random noise had less than 0.4% of variance explained. **CONCLUSIONS:** Measures of gait vary systematically throughout the day, and to a much greater degree than would be expected due to chance. The systematic variation differs between groups with different neurological diseases, as well as between individuals. As wearable sensors used during normal daily activities are adopted for clinical research and trials, this systematic variation should be accounted for in the study design and analysis so that more of the observed variation. **ACKNOWLEDGEMENTS AND FUNDING:** NIA grant # 5R44AG055388, and NMSS Mentor Fellowship: MB 0027.

P3-Q-135 Objective quantifiable assessment of nocturnal movements in patients with Parkinson's disease using a wearable sensor

Anat Mirelman¹, Inbar Hillel¹, Lynn Rochester², Bastiaan Bloem³, Laura Avanzino⁴, Alice Nieuwboer⁵, Inbal Maidan¹, Shirley Shiratzki¹, Talia Herman¹, Jesse Cederbaum⁶, Nir Giladi¹, Jeff Hausdorff¹

¹Tel-Aviv Sourasky Medical Center, ²Institute of Neuroscience, Newcastle University, ³Radboud University Medical Center, ⁴University of Genoa, ⁵KU Leuven, ⁶Biogen Biotechnologies, Cambridge Massachusets

BACKGROUND AND AIM: Nocturnal hypokinesia (NH) or impaired bed mobility is a common motor problem in Parkinson's disease (PD). Recent studies using wearable technologies reported that patients with PD have fewer nocturnal movements than controls. NH has been associated with relative undertreatment during the night (nocturnal off periods). In the current study, we aimed to explore the relationship between impaired bed mobility, disease severity, and other factors putatively related to NH. **METHODS:** Subjects wore a tri-axial accelerometer continuously (24/7) on the lower back for >3 days. Nocturnal activity was extracted from 100Hz raw acceleration data, with lying defined based on the vertical. Orientation was used to define positions in space such that turning reflected a change from one static position to another that was sustained for at least 5 min. Waking time was defined as upright position during the night. Disease severity was classified using the Hoehn and Yahr (H&Y) staging scale, cognitive function was assessed using the MoCA test and autonomic function was evaluated using the Non-Motor Symptom Questionnaire (NMS). All analyses were adjusted for age. **RESULTS:** Data from 272 patients with PD in various disease stages were included in the analysis (H&Y1: n=36, H&Y2: n=150, H&Y3: n=86). Age and disease duration differed between the groups (p<0.005). Sleep duration was





similar across the H&Y stages (H&Y1: 7.8±1.3hrs; H&Y2: 8.1±1.3hrs; H&Y3: 8.1±1.4hrs; p=0.348). However, H&Y3 patients were more awake during the night than the two other groups (H&Y1: 0.38±0.40%; H&Y2: 0.48±0.40%; H&Y3: 0.65±0.42%; p=0.004). In addition, the number and velocity of turning in bed was significantly reduced in H&Y3 patients (H&Y1: 6[4-8] turns, 16.45±7.52 deg/sec; H&Y2: 4[4-6] turns, 10.48±7.35 deg/sec; H&Y3: 3[1-5] turns, 8.19±6.18 deg/sec; p<=0.004). The percent wake-time at night was associated with poorer cognitive performance (r=-0.141, p=0.014) and more non-motor symptoms (r=0.369, p<0.0001). Similarly, the number of turning during the night were associated with higher cognitive performance (r=0.122, p=0.035) and less non-motor symptoms (r=-0.450, p<0.0001). The velocity of turning was significantly associated with less non-motor symptoms (r=-0.254, p=0.004), but not with cognitive performance (p=0.844). CONCLUSIONS: These findings demonstrate that although sleep duration is similar in different disease stages, worse nocturnal movement at night is associated increasing PD severity and worse dysautonomia. From a clinical perspective, the use of a wearable sensor for continuous monitoring at night could provide valuable information to enhance clinical care including optimal nighttime dopaminergic treatment and education about turning strategies in bed. ACKNOWLEDGMENT AND FUNDING: we wish to thank the participants and staff of the FOG, VTIME and BeaT studies. This research was funded by grant monies from the EU FP7 V-TIME project and Biogen Biotechnologies.

P3-Q-136 Evaluation of gait parameter thresholds to distinguish idiopathic Parkinson's disease from atypical parkinsonism using instrumented gait analysis

Ken Möhwald¹, Julian Decker², Max Wuehr², Roman Schniepp²

¹University Hospital, LMU Munich, ²Ludwig-Maximillians Universität München

BACKGROUND AND AIM: The parkinsonian gait is a hypokinetic gait disorder characterized by a decreased gait velocity, reduced stride length and increased double support phases. Falls and freezing of gait are common observations. Idiopathic Parkinson's disease (PD) patients frequently show asymmetric arm and leg movements. In addition, there are patients with atypical parkinsonism (AP) with a different underlying pathophysiology (e.g. multiple system atrophy, progressive supranuclear palsy, corticobasal degeneration, dementia with Lewy bodies) and additional symptoms with a worse prognosis and response to medication compared to PD patients. Distinguishing PD from AP patients based on their gait is a clinical challenge. However, there has been no systematic investigation evaluating gait parameters between the two syndromes on a larger study sample. The aim of this study is to evaluate gait parameter thresholds by comparing PD and AD patients using instrumented gait analysis. **METHODS:** Inpatients as well as outpatients with clinically proven PD and AP underwent gait analysis using a 6.7 m pressure-sensitive GAITRite® carpet. Patients performed eight different gait conditions according to our institute's Munich Sensorimotor-Cognition Paradigm (preferred/slow/fast walking speed, head reclination, eyes closed, serial sevens/semantic/motoric dual task conditions) while





spatiotemporal gait parameters being collected. Statistical analysis was performed using R and MATLAB®. Binary logistic regression (BLR) and receiver operating characteristic (ROC) analysis were performed to assess the area under the curve (AUC) weighting sensitivity and specificity in an inverse BLR determining the threshold value. **RESULTS:** In the preliminary analysis comparing 68 PD (mean age 70.6) with 208 AP patients (mean age 69.6 years) we found following results assessing the AUC: The most significant difference was a broadened base of support in AP patients in all gait conditions (e.g. preferred 12.5 cm, 0.56, 0.78 | eyes closed 13.8 cm, 0.63, 0.64 | semantic 13.9 cm, 0.59, 0.71). Furthermore, during semantic dual task, in AP double support and stance phases were elongated (30.2%, 0.61, 0.52 | 65.3%, 0.59, 0.51) and swing phases were decreased (35.2%, 0.64, 0.46). Further gait parameters and conditions showed no consistent differences. CONCLUSIONS: This systematic analysis evaluated gait parameter cut-off levels, which may help to distinguish AP from PD patients. AP patients walk with a broader base of support compared to PD patients in all gait condition. In addition, there are significant differences regarding gait cycle phases during the semantic dual task condition. Even though AP includes a variety of neurological conditions with additional impairments of other brain areas, the oculomotor system and the autonomic nervous system, only a few distinctive gait parameters could be identified. In the future, this approach may help to establish further cut-off values for subgroups of AP. ACKNOWLEDGEMENTS AND FUNDING: Supported by the Federal Ministry of Education and Research (BMBF), Germany.

P3-Q-137 Persons with MS exhibit declines in upper body control during walking

Steven Morrison¹, Cortney Armitano¹, Corey Rynders², Jake Sosnoff³

¹Old Dominion University, ²University of Colorado, ³University of Illinois at Chicago

BACKGROUND AND AIM: The progressive nature of Multiple Sclerosis (MS) means that individuals suffering from this disease exhibit a range of neuromotor problems including a general slowing of walking. Most studies of walking in MS have focused on changes in lower limb function and/or spatio-temporal features. However, control of upper body function is important to ensure a stable platform for visual and vestibular input at the head. In particular, if the ability to attenuate gait related oscillations is impaired, this can lead to higher accelerations at the head thereby potentially affecting visual and vestibular feedback required for balance control. This study was designed to examine changes in spatio-temporal features of gait for a cohort of adults diagnosed with MS during the performance of the 6 min walk test (6MWT). It was also of interest to examine whether the pattern of acceleration for the trunk, neck and head segments changed during the performance of the 6MWT, individuals walked back and forth between cones placed 175 feet apart. Spatio-temporal features related to gait were collected using a 20ft GAITRite mat which was positioned within the walking track. In addition, upper body acceleration were collected using three triaxial accelerometers affixed to the head, neck, and lower trunk. The GAITRite and





acceleration data were collected during each minute of the 6MWT. For the acceleration data, changes in amplitude (i.e., RMS), signal regularity (i.e., SampEn), of the gait-related acceleration data were determined. An estimation of the overall gain or attenuation between the trunk-neck and neck-head combinations were determined by applying a transfer function to the amplitude (RMS) of the respective acceleration signals. **RESULTS:** Over the course of the 6MWT, adults with MS walked progressively slower (i.e. decreased velocity). This slowing of walking speed was similarly reflected by significant decreases in cadence and step length. Despite this progressive slowing of gait over the 6MWT, medio-lateral and vertical accelerations for the trunk, neck and head segments significantly increased in amplitude and became more irregular (i.e. higher SampEn) towards the latter period of the test. Further, there was also a decrease in attenuation of the vertical accelerations from the trunk to the head as over the time period of the 6MWT. CONCLUSIONS: Overall, persons with MS had a reduced ability to dampen gait-related accelerations during the 6MWT. This result was observed even though these individuals significantly reduced their walking speed over the course of this test. This finding indicates that the ability of persons with MS to effectively accommodate and dampen oscillations was diminished with prolonged walking. This decline may directly affect head control, impacting on the individuals overall balance ability and leaving them more susceptible to falling.

P3-Q-138 Effect of different exercise regimens on walking performance in people with multiple sclerosis

Klara Novotna¹, Lucie Sucha¹, Petr Reznicek¹, Lukas Sobisek², Eva Kubala Havrdova¹

¹Charles University, ²Czech Economical University, Faculty of Probability

BACKGROUND AND AIM Gait impairment is one of the most common symptoms of multiple sclerosis (MS) that can be present even in people with minimal neurological disability. The impairment of gait increases with advancement of the disease and may result in wheelchair dependency. Most people with MS mark ability to walk as the most valuable physical function. Various rehabilitation interventions are recommended to people with MS and abnormality of gait. There is an evidence, that exercise programs are associated with some gait improvement, but results vary among studies. In our clinical practice we have a positive experience with exercise in a format of a circuit training for adapted for patients with MS. The aim of this study was to evaluate the effect of two different types of circuit training on gait parameters in people with MS. Methods MS patients were randomized either to a repeated aerobic-resistance circuit training or a resistance circuit training. Interventions were administered twice a week over 12 weeks (3 months) and consisted of a 5-minute warm-up, 50 minutes of an exercise and a 5-minute cooldown. Spatial and temporal parameters of gait were evaluated with a GAITRite instrument. We measured gait velocity and symmetry during a Normal walk test (comfortable walking speed) and a Fast walk test (walking as fast as possible). Gait performance was assessed at baseline and after 12 weeks of intervention to determine the immediate effect of the training. Results Total number



of 59 participants were enrolled to the study, but only data from 50 participants were used for final analysis (7 drop outs for non-compliance, 2 participants had an injury not related to the training regimen). Fifty people with MS were analysed (6 men) with median age 42 years and median disease duration 9 years. Neurological disability ranged from EDSS 1.0 to 6.0 with median EDSS 3.0. Group with aerobic-resistance training reached significant improvement only in velocity during the Normal walk test. Improvement of velocity and step symmetry during the Fast walk test in this group did not reach statistical significance. Group of patients with resistance circuit training reached statistically significant improvement in velocity and step symmetry during the Normal walk and an improvement in velocity during the Fast walk test. **Conclusion** Both types of exercise regimens lead to some improvement of gait parameteres. Resistance training was associated with an improvement in gait velocity, but also in gait symmetry. We intend to validate our experience in a larger study.

P3-Q-139 Fast paced gait may be more discriminating than dual tasking for detecting severity of gait and turn deficits in Fragile X-Associated Tremor/Ataxia Syndrome (FXTAS)

Joan O'Keefe¹, Danielle Carns¹, Joseph Guan¹, Erin Robertson¹, Timothy Tung¹, Nicollette Purcell¹, Elizabeth Berry-Kravis¹, Deborah Hall¹

¹Rush University Medical Center

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BACKGROUND AND AIMS: Individuals with a 55-200 CGG repeat expansion in the fragile X mental retardation 1 gene are at risk for developing FXTAS, a neurodegenerative disorder characterized by cerebellar ataxia, balance deficits, tremor and cognitive dysfunction. We explored gait deficits in subjects with FXTAS to examine the effects of 1) a DT cognitive motor testing paradigm and 2) fast paced gait, which are more likely to reflect real life/challenging situations which we hypothesized would exacerbate gait deficits and increase fall risk. We also examined the association between cognitive function, gait outcomes and falls in FXTAS. METHODS: Thirty four individuals with FXTAS (mean age 68.2 ± 8/9 yrs.) and 27 controls (mean age 63.5 + 7.7 yrs.) participated in the study. Gait analysis was conducted using an inertial sensor based 25-meter two-minute walk test (APDMTM) under a 1) normal self-selected pace, 2) fast as possible (FAP) pace and 3) DT cognitive interference condition asking subjects to perform a concurrent verbal memory task (animal naming) while walking at their normal speed. The dual task cost (DTC) for gait and turn parameters was calculated as ST-DT/ST value x 100. A neuropsychological test battery measuring different cognitive domains was also administered. Subjects self-reported of the number of falls they had sustained within the past year. **RESULTS:** FXTAS subjects had marked reductions in stride length and velocity, increased stride length and velocity variability and slower peak turn velocity and more steps to turn compared to controls (0.0001 > p < 0.043). These deficits were observed with all three testing conditions (SS, FAP, and DT), except that gait variability was not increased under the FAP condition (p = 0.06). FXTAS participants additionally had significantly lower cadence (p = 0.002) and spent greater time in

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double support and reduced time in swing phase (p = 0.043) under FAP conditions, reflecting less gait stability. There were no significantly greater DTC of the concurrent verbal fluency task on gait and turn outcomes for FXTAS compared to control participants. Lower information processing speed and working memory were associated with a greater number of falls self-reported in the past year (p = 0.012 and 0.008, respectively) in FXTAS participants. **CONCLUSIONS:** FXTAS participants in this study appeared to have prioritized gait over cognition such that there were no significantly elevated DTC for gait and turning. The use of fast paced gait to stress the locomotor system may have more discriminatory ability than a DT cognitive motor paradigm to exacerbate gait and turn deficits in FXTAS. Lower executive function and information processing speed correlated significantly with falls in FXTAS participants. Gait stress testing paradigms and associated gait and cognitive markers may be useful in future studies to: 1) help detect fall risk in FXTAS, 2) determine efficacy of treatment interventions and 3) provide clinically relevant outcome measures for clinical research trials.

P3-Q-140 Leukoaraiosis, an invisible factor contributes to balance and gait disorders after stroke

Dominic Pérennou¹, Shenhao Dai², Céline Piscicelli¹, Emmanuelle Clarac², Patrice Davoine², Anne Chrispin², Andréa Kistner², Marie Jaeger², Olivier Detante², Monica Baciu², Marc Hommel²

¹University Hospital Grenoble-Alpes, ²Grenoble Alpes University Hospital

BACKGROUND AND AIM: Leukoaraiosis is associated with balance and gait disorders in elderly persons, but its effect on these disorders after stroke remains to be clarified. The purpose of this study is to investigate whether leukoaraiosis affects balance and gait capacities after stroke. **METHODS:** Cohort study of consecutive participants admitted to neurorehabilitation ward after first hemisphere stroke from 2012 to 2018. Leukoaraiosis was diagnosed on MRI (Flair sequence) performed within the 3 first months after stroke, using the 4-grade Fazekas scale. Individuals were then classified in 2 groups (G1: absent or mild vs G2: moderate or severe leukoaraiosis). Clinical data systematically collected at day 30±3 (D30) post-stroke and at discharge were retrospectively analyzed. Balance disorders were assessed with the Postural Assessment Scale for Stroke (PASS), gait disorders with the modified Fugl-Meyer Gait Assessment, lateropulsion with the Scale for Contraversive Pushing (SCP) and independence with the Functional Independence Measure (FIM). Kaplan-Meyer survival curves were applied to analyze the recovery between two groups. **RESULTS:** 184 persons met inclusion criteria: age 63.5(12.5) years, 63 females, 157 with infarction. A total of 143 (78%) persons presented leukoaraiosis with following median score (1[Q1=1-Q3=2]) and distribution:Grade 0: 41[22%]; 1:75[41%]; 2:55[30%]; and Grade 3:13[7%]. Moderate to severe leukoaraiosis (G2) was present in 68 (37%). Among the initial assessments (D30), G2 had greater balance disorders (31[18-34] vs 33[26.5-36],p=0.003), gait disorders (3[0-6] vs 5[3-6],p=0.009), but didn't present greater lateropulsion; their independence in daily life was lower (80[48.5-107] vs 100[65-116.5],p=0.004). Length of stay was much longer in G2 (91[53-158]

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vs 69[48-117],p=0.026). And also they showed worse recovery both in balance (p=0.002) and gait (p=0.005) disorders, 42% and 39% respectively in G2 couldn't regain monopodal stance and independent ambulation at discharge. **CONCLUSIONS:** Leukoaraiosis is a cause of balance and gait disorders after stroke, and also a source of dependence. Stroke consequences might be limited by early detecting and treating risk factors of leukoaraiosis.

P3-Q-141 Balance control impairments in Fabry disease

Philippe Perrin¹, Laetitia Peultier-Celli², François Feillet², Roland Jaussaud²

¹University of Lorraine and University Hospital Nancy, ²Université de Lorraine et CHRU de Nancy

BACKGROUND AND AIM: Fabry disease is an X-linked recessive inborn error glycosphingolipid metabolism due to the deficient activity of the lysosomal enzyme alpha-galactosidase A. The deficiency of this enzyme leads to an accumulation of glycosphingolipids throughout the body. Impairments include renal, cardiac and neurological damages. Fabry disease may also have neurootological and visual impairments, which can generate postural control alterations, inner ear and vision being involved in this function. This study aimed to evaluate the impact of Fabry disease on postural control. METHODS: Fourteen adult patients (mean age = 37.62 +/- 11.43 years) and two children (13.5-y-old girl, 8.5-y-old boy) with Fabry disease and 19 healthy adults (mean age = 36.51 +/- 16.99 years) and two children (2 boys, 9,7 and 11,3 y-old) took part in this study. Postural control was evaluated by a sensory organisation test combining three visual situations (eyes open, eyes closed, sway referenced visual surround motion) with two platform situations (stable platform, sway referenced platform motion), aiming to calculate a composite equilibrium score (CES). Somatosensory contribution to postural control (R-SOM), visual contribution (R-VIS) and vestibular contribution (R-VEST) were calculated. RESULTS: The CES was lower in patients with Fabry disease compared to healthy subjects (p < 0.001). R-VIS (p = 0.001) and R-VEST (p = 0.003) were lower in Fabry disease patients compared to the control group, whereas no difference in R-SOM was observed. CONCLUSIONS: Inner ear and visual pathologies associated to central nervous system impairments are factors of a postural control impairments. Physical activities, which can also be rehabilitative, by maintaining or increasing the weight of proprioception, may help diminish dependency to altered sensorial inputs.

P3-Q-142 Development of an automated, instrumented composite index to quantify the performance of a 'freezing provoking test' in patients with Parkinson's disease

Tal Reches¹, Eran Gazit¹, Moria Dagan², Talia Herman¹, Pablo Cornejo Thumm¹, Nir Giladi¹, Manor Brad³, Jeff Hausdorff¹



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¹Tel-Aviv Sourasky Medical Center, ²Tel Aviv University, ³Hebrew SeniorLife / Harvard Medical School

BACKROUND AND AIMS: Freezing of gait (FOG) severity is typically rated based on self-report and the observed frequency of the episodes. These methods are subjective and sub-optimal. To address this issue, we developed a new index based on several measures of subtasks of the FOG provoking test proposed by K Ziegler et al. (Mov Dis, 2010). In this initial validation study, we evaluated whether this new composite index is different in the three FOG provoking conditions, whether it differs in Parkinson's disease (PD) freezers (FOG+) and PD non-freezers (FOG-), and whether it is different in ON and OFF medication states. In addition, we compared the new index to the existing clinician-based rating method and their ability to distinguish different states. METHODS: The FOG provoking test is performed under 3 conditions: 1) single, 2) motor, dual tasking (walking while carrying a tray), and 3) motor + cognitive loading, (walking while holding a tray and subtracting 7s). The subtasks that were used for this index include turning 360° clockwise and counter-clockwise and turning 180° before sitting down on a chair. Typically, each subtask is scored from 0 to 3 according to the clinician observation. Separate analyses were performed on two different cohorts; we compared FOG+ (n=27 age=66.7±8.3 yrs, UPDRS motor score=26.2±15.0, disease duration=4.2±3.6 yrs) to FOG- (n=11 age=68.9±6.9 yrs, UPDRS motor score=35.6±11.1 disease duration=7.6±4.4 yrs) and PD patients with FOG who performed the FOG provoking test ON and OFF medication cycle (n=27, age=67.4±7.6 yrs, UPDRS motor OFF=39.8±13.7, UPDRS motor ON=33.6±11.9, disease duration=8.2±5.5 yrs). Subjects conducted the FOG provoking test while wearing 3 inertial sensors (attached to the lower back and above each ankle). The new composite index was computed based on 7 metrics: test duration, normalized angular velocity of the turn before sitting down, and for the two directions of the 360° turns, the duration, dynamic time warping similarity, freezing index, normalized angular velocity and smoothness of movement. RESULTS: The new index was higher (p<0.05) in FOG+ (0.25±0.66) than in FOG- (-0.26±0.22), higher (p<0.001) in OFF than in ON in all three test conditions and was higher in condition 2 vs 1 (p<0.05) and 3 vs 2 (p<0.01). Scores on the clinical rating method were not different in OFF and ON for the first test condition. The effect sizes of the index in conditions 2 and 3 of the OFF vs ON comparisons were higher for the composite score (0.544 vs. 0.401 and 0.439 vs. 0.369, respectively). CONCLUSIONS: The present findings demonstrate that automatic segmentation and quantification of a FOG provoking test is possible and its initial validity. Further, these results suggest that a composite index based on the objective, instrumented evaluation of different aspects of the performance is apparently more sensitive than the clinical rating scale and it may enhance the objective assessment of FOG. ACKNOWLEDGEMENTS AND FUNDING: This work was supported in part by the Michael J FOX Foundation.

P3-Q-143 The impact of split-belt treadmill walking on freezing related gait features in Parkinson's disease





Christian Schlenstedt¹, Jana Seuthe¹, Pieter Ginis², Markus Hobert¹, Nicholas D'Cruz², Alice Nieuwboer²

¹Christian-Allbrechts-University of Kiel, ²KU Leuven

BACKROUND AND AIM: Freezing of Gait (FOG) in Parkinson's disease (PD) is associated with gait asymmetry and impaired set shifting. Split-Belt Treadmill (SBT) is an attractive tool to modulate both, gait asymmetry and adaptation to changing gait patterns. The improvement of these gait features might be beneficial to avoid FOG episodes [1]. The aim of this study was to investigate the short term effects of SBT walking versus traditional treadmill gait on FOG related gait features. METHODS: Individuals with PD with FOG and healthy controls (HC) were recruited in two centers (CAU Kiel, Germany and KU Leuven, Belgium) and randomized to four 30-minutes (6x5min) intervention groups: A) SBT belts' speed ratio 1:2; B) SBT belts' speed ratio 3:4; C) SBT changing belts' speed ratios; D) Tied-Belt. For the SBT condition the belt's velocity of the body side with the longer step length was reduced. Gait analysis was performed overground, on a treadmill and during a FOG provoking turning in place task at Pre and Post intervention and 24h Retention. The SBT groups (A-C) were pooled for this preliminary analysis. Linear mixed models were calculated to investigate the effect of group (PD vs. HC), time (Pre, Post, Retention), intervention-group (SBT vs. Tied-Belt) and the respective interaction effects. RESULTS: Thirtynine subjects with PD and 27 healthy controls, matched for age, were tested and analyzed so far. SBT and Tied-Belt walking led to a significant improvement in overground gait speed (F=4.73, p=0.011) and double support time (F=12.94, p<0.001). A significant time*intervention-group interaction was found for step length asymmetry (F=3.87, p=0.023), indicating that SBT walking provided larger improvements in step length asymmetry than Tied-Belt walking. CONCLUSIONS: Walking on a SBT was feasible for HC and individuals with PD with FOG. This preliminary analysis indicates better improvements in gait asymmetry due to SBT walking compared to normal treadmill walking. SBT seems to be a promising tool to alleviate FOG- related gait deficits and may as such be beneficial to avoid FOG episodes. However, long-term effects of SBT training interventions on FOG-related outcomes need to be investigated in the future. [1] M. Plotnik, N. Giladi, J.M. Hausdorff, Is freezing of gait in Parkinson's disease a result of multiple gait impairments? Implications for treatment, Parkinson's disease 2012 (2012) 459321. Acknowledgements. This study was funded by the Jacques & Gloria Gossweiler Foundation.

P3-Q-144 Global lower limb coactivation during gait in patients with cerebellar ataxia

Mariano Serrao¹, Lorenzo Flori², Tiwana Varrecchia³, Carmela Conte⁴, Antonella Tatarelli², Carlo Casali¹, Francesco Pierelli¹, Francesco Draicchio², Alberto Ranavolo²

¹Sapienza University of Rome, ²INAIL, ³University Roma Tre, ⁴Fondazione Don Gnocchi, Milan

BACKGROUND AND AIM In both healthy subjects (HS) and patients affected by gait disorders, lower limb muscles coactivation has been usually investigated only at single joint level [1].



However, a global characterization of the muscles coactivation may be helpful to understand the general strategy adopted by CNS to control the lower limb [2,3]. In this study, we investigated the global lower limb muscles coactivation during gait in patients with cerebellar ataxia (CA). Our hypothesis herein was that patients with cerebellar ataxia try to stiffen the limbs to contrast incoordination, unbalance and hypotonia, by simultaneously activating many lower limb muscles. At this aim we investigated a time-varying multi-muscle coactivation function (TMCf) [2,3] in both HS and CA. Methods A total of 23 patients with CA (SCA and SAOA) and 23 HS, matched for age, sex and gait speed, were included in the study. SARA scale was used to evaluate the disease severity. Participants were asked to walk barefoot at both comfortable and low gait speeds along a walkway. We recorded the gait parameters and surface EMG signals from 12 lower limb muscles (SMART-DX 500, FreeEMG300, BTS, Milan, Italy). We measured the coactivation index (CI), maximum of the TMCf curve, center of gravity (CoA) [2,3], spatio-temporal parameters and energetic variables (R-step and TEC). The CI, the maximum of the TMCf and the kinematic variables were compared between groups by using parametric (t-test) or non-parametric (Mann-Whitney) tests according to the data distribution, while CoA values were compared using Watson-Williams test for circular data. Pearson or Spearman tests were used to compare muscles coactivation variables with the kinematic, energetic and clinical variables. Results Significant higher values of the CI (17.2 \pm 3.4 % vs 11.1 \pm 1.9 %, p<0.001) and maximum of the TMCf curve (33.3±5.2 % vs 22.3 ± 3.6, p<0.001)were found in CA than in HS. Figure 1a shows an higher muscles coactivation, mainly present in the early phases of the gait cycle (i.e. loading responses and mid-stance phases) and reveals that CA lose the typical "M" shape of the HS. Significant differences in CoA values were found between CA and HS (1.0±0.2 vs 1.2±0.3, p=0.03) (Figure 1b). Significant higher values of the step width (60.6±16.4 % vs 66.6±8.1, p=0.046) and lower values of the R-step (32.5±5.7 % vs 24.8±3.2 %, p<0.001) were found in CA than HS, Significant correlations were found between CoA and R-step (r: -0.44, p=0.03) and between CoA and SARA scores (r: 0.52, p=0.009). **Conclusions** Our results suggest that patients with CA adopt a global compensatory strategy aimed at stiffening the lower limbs in response to the muscle incoordination, hypotonia and unbalance, by increasing the global muscles coactivation mainly in the early phases of the gait cycle at the expense of a reduced ability in recovering energy. Bibliography [1] Le P et al., J Electromyogr Kinesiol. 2017;32:51-60. [2] Ranavolo Aet al. Ergonomics 2015;58(6):966-79. [3] Varrecchia T, et al. J Electromyogr Kinesiol 2018; 43:148-157.

P3-Q-145 Clinical correlates of fatigue in patients with multiple sclerosis: Is mental fatigue more important than gait speed?

Shirley Shema Shiratzky¹, Ruopeng Sun², Keren Regev¹, Arnon Karni¹, Jacob Sosnoff², Jeff Hausdorff¹, Anat Mirelman¹

¹Tel-Aviv Sourasky Medical Center, ²University of Illinois at Urbana-Champaign



BACKGROUND AND AIM: Fatigue is a disabling symptom, reported by up to 90% of patients with multiple sclerosis (MS). People experience fatigue as exhaustion, lack of energy or weakness that is aggravated during activity. Fatigue is multi-faceted; it is triggered by mental and physical effort and in turn may affect motor, cognitive and social function. A better understanding of the clinical correlates associated with fatigue may improve the design of interventions that target its effect on daily life. The aim of the current study was to explore potential motor and cognitive factors associated with fatigue in a group of patients with MS. METHODS: Subjects were recruited as part of a multi-center intervention study aimed to address motor-cognitive interactions in MS using virtual reality. Individuals between 18 and 65 years old, with relapsing-remitting MS and mild to moderate disability (EDSS between 2 and 6) were included. We excluded patients who were unable to walk unassisted, or had other health conditions that may affect gait, cognitive and mental function. Fatigue was rated using the Modified Fatigue Impact Scale (MFIS). The Brief Cognitive Assessment for MS was used to assess information processing speed (via SDMT scores), verbal & visual memory. Gait speed, cadence and stride variability were measured with an electronic walkway (ProtoKinetics Zeno) at a comfortable speed for 1-minute under single & dual-task conditions. Univariate models determined the associations between gait parameters and cognitive performance with fatigue. Then, measures significantly related to fatigue were entered into a backward multiple linear regression model that was adjusted for age, gender, disease duration & EDSS. RESULTS: Fifty-one subjects with MS (mean age 49.8±4.1 yrs, 75% female, mean disease duration 14.5±10.2 yrs, mean EDSS score 3.7±1.5) were studied. Participants reported mean MFIS scores of 40.1±17.6, with physical, cognitive and psychosocial fatigue accounting for 49%, 42% and 9% of the total score, respectively. Subjects walked at a mean gait speed of 1.07±0.32 m/sec and scored an average of 48.6±13.1 on the SDMT. Univariate analyses revealed that SDMT, usual and dual-task gait speed were significantly associated with MFIS. The multiple regression model significantly predicted fatigue (R²=0.51, p=0.03). However, in the final model, only slower processing speed (i.e., lower SDMT score) was significantly associated with greater fatigue (β =-0.364, p=0.009), explaining 13.3% of the variance in the MFIS total score. **CONCLUSION:** In the current study, information processing speed was significantly linked to the fatigue reported by the participants. While gait speed was associated with fatigue, it was not an independent predictor of MFIS score. These findings highlight the role of attention and executive function in the experience of fatigue in MS and further emphasize the importance of cognitive function to daily living routine in this group of patients.

P3-Q-146 Does transcranial direct current stimulation improve reaction times of people after stroke during balance perturbations, gait initiation, or voluntary movement?

Wouter Staring¹, Milou Coppens¹, Alexander Geurts², Vivian Weerdesteyn²

¹Radboud University Medical Center, ²Donders Institute, Radboud University Medical Centre





BACKGROUND AND AIM Non-invasive brain stimulation techniques may enhance rehabilitation in people after stroke, however, current evidence for balance and gait recovery is inconsistent. Transcranial direct current stimulation (tDCS) has been reported to improve hand reaction times (RT) in people with stroke [1]. Therefore, we aimed to investigate whether tDCS would also have a beneficial effect on delayed leg motor responses after stroke. We studied the effect of tDCS on tibialis anterior (TA) RT in three tasks: gait initiation, backward balance perturbations, and voluntary ankle-dorsiflexion movements. We hypothesized that ipsilesional anodal tDCS (a-tDCS) would enhance cortical excitability of the affected hemisphere, whereas contralesional cathodal tDCS (c-tDCS) would decrease interhemispheric inhibition of the affected hemisphere, both improving reaction times. Methods Thirteen participants with chronic supratentorial stroke completed three sessions of 15 min ipsilesional anodal, contralesional cathodal, or sham stimulation (2mA) over the primary motor cortex on separate days. The order of conditions was balanced across participants. In response to a visual cue, participants performed 12 trials of gait initiation with the preferred leg and 12 trials of paretic ankle-dorsiflexion movements as fast as possible while sitting. In addition, participants were subjected to 12 trials of translational supportsurface perturbations inducing a backward fall, which they had to overcome with a feet-in-place response. We recorded EMG from the paretic TA and 3D movements of markers on the feet and vertebra C7. Results On group level, TA RTs did not differ between tDCS conditions in any of the three tasks (Gait: p=0.690, Balance: p=0.239, Ankle: p=0.287), nor were step onsets during gait initiation influenced by tDCS (p=0.071). However, C7 displacements following balance perturbations were slightly larger (4mm) after a-tDCS (tDCS: p=0.027; a-tDCS vs. sham: p=0.020). For gait initiation and balance perturbations, differences between sham and stimulation (a-tDCS or c-tDCS) did not correlate with leg motor impairment. Yet, during ankle dorsiflexion RT differences between c-tDCS and sham were strongly associated with Fugl-Meyer Lower Extremity scores, with more severely impaired patients exhibiting delayed paretic RT following c-tDCS (p=.779, p<0.01). Conclusion Contrary to our expectations, we found no evidence of tDCSinduced benefits. Interestingly, we found that c-tDCS may even have an unfavourable effect on voluntary leg motor control of the paretic leg in more severely impaired chronic stroke patients. This finding points at potential vicarious control from the unaffected hemisphere to the paretic leg. In addition, the absence of a tDCS-induced effect on gait and balance suggests that such motor behaviour is controlled differently, and inadequately stimulated by our current methods. [1] O'Shea et al. NeuroImage, 2014 (85):924-933.

P3-Q-147 Protective stepping in multiple sclerosis: a pilot study

Charles Van Liew¹, Leland Dibble¹, Grace Hunt², K. Foreman², Daniel Peterson¹

¹Arizona State University, ²University of Utah

Aim: To determine whether a brief training bout improves protective steps in individuals with multiple sclerosis (MS). **BACKGROUND:** MS is a leading cause of disability among adults in the





United States and Europe often causing problems with gait and balance. In particular, protective stepping after a loss of balance is impaired in people with MS and may be predictive of falls. Whether such steps can be improved via training in those with MS is unknown. METHOD: Participants with MS (n = 14) and neurotypical, age-matched controls (n = 11) completed 2-days of training using support surface perturbations [Day 1 (25 trials) and Day 2 (10 trials)] via an instrumented treadmill. Kinematic marker trajectory data were used to calculate Margin of Stability (MOS), Step Length, Step Latency, Leg Angle (line from the mid-pelvis to the toe-marker compared to vertical), and Trunk Angle (line from the mid-shoulder to the mid-pelvis compared to vertical). T and x2 tests were performed to evaluate differences in baseline characteristics. Repeated measures data (i = 25; t = 35) were analyzed using linear growth models (LGMs) to evaluate improvement and mixed effects models (MEMs) to evaluate an a-priori retention hypothesis. Retention analyses compared the average performance over the first five trials of Days 1 and 2. The effects of group (MS or Control), trial, and the interaction were modeled as fixed effects. Random effects for participant, day, and trial were included for the learning analyses. A random effect for participant was included in the retention analyses. RESULTS: Participants with MS had significantly worse scores on balance and cognitive tests and a greater frequency of selfreported falls than control participants at baseline, ps < .05. The LGMs revealed significant effects of group for all outcomes, ps < .05, except Trunk Angle. The interaction was significant for MOS, Step Length, and Leg Angle, ps < .05, with MS participants showing greater improvement than controls across perturbation exposure. Simple slopes showed significant improvements in Step Length, B = .0027, p < .001, and Leg Angle, B = .1312, p < .001, and a trend for improvement in MOS, B = .0007, p = .075, among those with MS. Step Latency and Trunk Angle did not show significant changes, ps \geq .095. Significant retention of improvements in Step Length, $\chi^2(1) = 4.56$, p = .033, and Leg Angle, $\chi 2(1) = 5.98$, p = .015, were found among MS participants. No other retention effects were significant, ps > .05. CONCLUSION: The present study indicates that people with MS can improve protective steps through repeated perturbation exposure and retain that improvement over a short period without practice. Although researchers should determine the generalization of such effects to real-world contexts and evaluate dosage necessary for lasting performance change, perturbation training may be a means of decreasing fall risk among those affected by MS. FUNDING: National Multiple Sclerosis Society pilot award (PP-1512-07101).

P3-Q-148 Walking speed improves with arm swing manipulation in people with Parkinson's disease

Vinicius Zampier¹, Rodrigo Vitório¹, Victor Beretta¹, Diego Jaimes¹, Diego Orcioli-Silva¹, Lilian Gobbi¹

¹São Paulo State University (UNESP)

BACKGROUND AND AIM: Walking speed is a robust measurement of an individual functional capacity and general health status. The aging process causes locomotor deficits in step length





and speed that compromise the individual' functional capabilities. Such deficits are more pronounced in the presence of neurodegenerative diseases such as in Parkinson's disease (PD). In addition to presenting deficits on the lower limb movements, people with PD also present a reduction and asymmetry on the arms swing during walking, and these deficits are associated with an increase in the risk of falls and a decrease in the walking speed. Strategies that increase walking speed are relevant to improve the general health status and the quality of life of people with PD and neurotypical olders. So, the aim of this study was to verify the effects of an increased arm swing frequency or amplitude on the walking speed in people with PD and neurotypical olders. METHODS: Seventeen people with PD and 19 neurotypical olders (GC) were invited to walk over a 10m pathway under three experimental conditions: (i) usual walking under their preferred speed (UW); (ii) increased arm swing amplitude (IAA); and (iii) increased arm swing frequency (IAF). Walking speed was registered on a carpet with sensors of pressure placed in the middle of the pathway. Data were analyzed by means of repeated measure ANOVAs two-way for group (PDG x CG) and condition (UW x IAA x IAF). RESULTS: ANOVA revealed interaction between group and condition for stride velocity (F2,68=3.554; p=0.034; np2=0.095). People with PD improved stride velocity from UW to IAA and to IAF in a linear fashion while the CG had a more significant improvement from IAA to IAF. The bradykinesia (reduction in movement velocity) is a crucial sign/symptom of PD that increase with the disease progression. The results revealed that increments both in frequency and amplitude of arm swing provoked changes in walking speed of people with PD. These results allow us to confirm that people with PD present flexibility in the motor control system. Motor deficits caused by the disease are not enough to impede the patient's adjustments maybe due to attention driven to arm swing. Walking behavior changed according to arm swing conditions also maybe by the increment of cortical activity in the frontal areas or by the suppression of the inhibitory mechanisms in the brainstem. CONCLUSIONS: We concluded that manipulation of arm swing frequency is more efficient to improve walking speed and perhaps interventions focused on arm swing frequency can help to ameliorate functional capacity and general health status of people with PD. ACKNOWLEDGEMENTS AND FUNDING: FAPESP (2015/22141-0) CAPES (0000-0002-1964-5656).

P3-Q-149 The effects of Parkinson's disease and essential tremor on the multiscale dynamics of hand tremor motion

Junhong Zhou¹, Dongning Su², Shuo Yang², Ying Wang², Zhu Liu², Hua Pan², Tao Feng²

¹Harvard Medical School, ²Beijing Tiantan Hosptital, Capital Medical University

BACKGROUND: Tremor is a common movement disorder, severely diminishing individual's capacity to stand or walk safely. It can commonly be observed in two distinct pathological conditions: Parkinson's disease (i.e., parkinsonian tremor, PT) and essential tremor (ET). It is thus of great significance to identify these two types of tremor, helping the treatment in clinics. The spontaneous motion of our body and extremities, including the tremor, is dependent upon





numerous physiologic systems interacting and interconnecting over multiple scales of time or space. As such, the dynamics of the tremor motion is "complex", containing meaningful information over multiple temporal scales. This physiologic complexity has been linked to aging and age-related diseases. However, it is still unknown if the complexity of the tremor motion is related to the pathological conditions (i.e., PT and ET). Here we hypothesize that the complexity of the hand tremor motion would be sensitive to and identifiable between those the PT and ET. **METHODS:** Eighteen adults with PT (age: 62.4±2.3 years) and 18 age-matched participants with ET (age: 63.7±2.2 years) completed this study. The PT and ET were clinically diagnosed. Each participant was asked to sit in the chair and maintain their arms outstretched horizontally for 30 seconds. The wearable accelerometers were attached on both left and right hands to measure the acceleration of the tremor motion during the outstretch task. The multiscale entropy was then used to quantify the complexity of the recorded acceleration time-series for left and right hand separately. The area under the MSE curve was used as the complexity metric and greater MSE means greater complexity. Additionally, the frequency of tremor motion of each hand was also calculated. **RESULTS:** Twelve participants in ET group and 10 in PT group presented obvious postural tremor of hand. Age and "if obvious tremor was presented" were used as covariates in the models. We observed that those with ET had significantly lower complexity of tremor motion in both left and right hands as compared to those with PT (F>5.3, p<0.02, Figure 1A). Moreover, the complexity of the left hand was associated with the history of ET and PT (Figure 1B) ($r^{2}>0.41$, p<0.01, Figure 1B). Those with lower complexity had longer time of suffering from these conditions. No significance was observed in the frequency between the two groups. **CONCLUSION:** We here demonstrate for the first time that the PT and ET have different effects on multiscale dynamics of hand tremor motion, as captured by the complexity metric, even when the obvious tremor is not presented. Moreover, the complexity metric is associated with the duration of these pathological conditions, and may thus serve as a novel marker to help the identification of the pathological conditions in clinical practice.

R - Orthopedic diseases and injuries

P3-R-150 Effects of repetitive head impacts on tandem gait performance over an ice hockey season

Melissa DiFabio¹, Jessie Oldham², Thomas Buckley¹

¹University of Delaware, ²Boston Children's Hospital

Current evidence has suggested sustaining repetitive hits to the head during sport may be damaging to neurological health, even if they do not result in clinical concussion. However, most of these studies have focused on functional neuroimaging and cognitive performance; few have assessed the role of these repetitive impacts on motor performance. Tandem gait (TG) is a dynamic task that has successfully identified alterations in postural control following concussion,





but it is unknown what effects sustaining non-concussive head are on TG performance. Therefore, the purpose of this study was to examine changes in TG performance over the course of an ice hockey season. METHODS: Ten collegiate club ice hockey players (20.2 ±1.6 y/o, 1.83 ±.24m, 82.8±7.0kg) performed the tandem gait task at three time points throughout the 2017-2018 season: preseason, midseason, and postseason. The tandem gait task is a clinically feasible test of dynamic postural control, in which participants walk heel to toe down a three meter line down and back. Four trials of single task (tandem gait alone, ST) and dual task (tandem gait with simultaneous cognitive task, DT) were collected and the fastest of the four trials was used for analysis. ANOVA was used to examine differences in over time, and dual task motor cost was calculated as DTbest-STbest/STbest. Alpha value was set to 0.05. RESULTS: There were no significant effects in performance for ST (p=0.805) or DT (p=0.672) tandem gait over the three time points. Mean ST best times were 10.3s at baseline, 10.3s at midseason, and 10.5s at postseason. Mean DT best times were 14.2s at baseline, 16.6s at midseason, and 18.2s at postseason. Dual-task cost decreased over time (30.4% at baseline to 17.1% at postseason), but this change was not statistically significant (p=0.398). DISCUSSION: There were no significant changes in either ST or DT tandem gait performance over the course of an ice hockey season, suggesting repetitive head impacts sustained while playing hockey may not effect motor control in a way that is detectable by this task. Although not statistically significant, players improved their dual-task motor cost over the season, which may be explained by practice effects. It is possible that more sensitive analysis (e.g. motion capture) may show changes in motor control that are not able to be picked up by these more clinically feasible assessments of postural control.

P3-R-151 How persons with transtibial amputation regulate lateral stepping in destabilizing environments

Jonathan Dingwell¹, Jonathan Rylander², Joseph Cusumano¹, Jason Wilken³

¹Pennsylvania State University, ²Baylor University, ³University of Iowa

BACKGRUND & AIM: Over 50% of persons with lower limb amputation fall annually. Walking humans are less stable side-to-side. Healthy humans regulate lateral stepping movements to maintain mainly step width, but also absolute lateral body position on their path (see companion abstract). Here, we characterized lateral stepping control of individuals with unilateral transtibial amputation (TTA) walking unperturbed and in laterally destabilizing virtual environments. **METHODS:** Eight physically active traumatic TTA and 13 and able-bodied (AB) controls (age 22-40) walked in a CAREN virtual environment. Each participant completed 5 3-minute trials each for each of 3 conditions: walking with either no perturbations (NOP), or pseudorandom mediolateral visual field (VIS) or treadmill platform (PLAT) perturbations (Beltran et al., J Biomech., 2014). For each trial, we computed step-to-step time series of absolute lateral position (zB) and step width (w). Standard deviations of zB and w quantified movement variability. Detrended Fluctuation Analysis (DFA) quantified statistical persistence, reflecting step-to-step "control" (Dingwell et al.,





PLoS Comput. Biol., 2010). Lastly, we quantified how deviations from the mean values were directly corrected on the subsequent step (Dingwell & Cusumano, PLoS ONE, 2015). RESULTS: Standard deviations for zB and w increased (p < 0.0005) with both VIS and PLAT perturbations, significantly destabilizing both groups. Persons with TTA exhibited greater increased variability of zB (p = 0.025) and w (p = 0.054) during PLAT perturbations. Across conditions and groups, DFA exponents were much smaller (closer to 0.5) for w than zB, reflecting tighter w control. DFA exponents of zB and w decreased (p < 0.0005) with both VIS and PLAT perturbations. However, there were no group differences for either zB (p = 0.27) or w (p = 0.55). All participants corrected deviations in w more strongly than deviations in zB in all conditions. All participants also corrected deviations in both zB and w more (p < 0.0005) with both VIS and PLAT perturbations. Again, there were no differences between groups (all p > 0.40) for these analyses. **DISCUSSION:** All participants tightly corrected deviations in w, but also weakly corrected deviations in zB and that control of both w and zB increased when perturbed. These high-functioning TTA adopted approximately the same control strategies as AB across all conditions. ACKNOWLEDGEMENTS & FUNDING: Work conducted at Center for the Intrepid, Brooke Army Medical Center, JBSA Ft. Sam Houston, TX, USA. Funded by DoD/CDMRP/BADER Consortium W81XWH-11-2-0222 & NIH R01-HD059844. DISCLAIMER: The view(s) expressed herein are those of the author(s) and do not reflect the official policy or position of the Brooke Army Medical Center, the U.S. Army Medical Department, the U.S. Army Office of the Surgeon General, the Department of the Army, the Department of the Air Force and Department of Defense or the U.S. Government.

P3-R-152 Knee joint function and walking biomechanics in patients in acute phase anterior cruciate ligament (ACL) tear

Sergey Kaurkin¹, Dmitriy Skvortsov¹, Alexander Akhpashev¹

¹Federal Research and Clinical Centre of Russia's Federal Medical-Biological Agency (FNKC FMBA)

ACL injury is the most common trauma of the ligamentous apparatus. Functional impairments secondary to ACL tear are not studied enough. The purpose of the study was to investigate the biomechanics of walking and of the knee joint in the acute phase of ACL injury. We examined 18 patients with ACL tear were examined 3 to 38 days post-trauma, with the mean post-trauma time being 15.9 days. and 20 healthy adults as controls. The ACL tear was caused by indirect trauma in 15 patients and by direct trauma in 3 patients. Some of them were examined 3 to 10 days post-trauma, the others were examined 10 to 25 or even more days post-trauma. Their knee joint function varied accordingly. The biomechanics of the knee joint and of walking was assessed. Based on the results of examination, the patients were divided into two groups: with severe function impairment (6 patients) and with moderate function impairment (12 patients). It was found that in the first days post-trauma not only the knee function was reduced, but the function of the entire lower limb as well. This led to a functional asymmetry. The kinematics of movements in the





joints changed in accordance with slower walking. The walking became not only slower, but it was also associated with a decreased impact load in the weight acceptance phase. At later dates the functional impairments were less pronounced. The total range of flexion motion did not exceed 20 degrees in the first group and 55 degrees in the second one. The injured joint developed functional immobilization within the first days post-injury. This was a guarding response by additional muscle stifness to prevent unusual and limit physiological movements in the knee joint. The movements in the knee joint while walking were of small amplitude, rocking and occurred only under load. The amplitude of the main flexion in the swing phase was reduced. The study demonstrated that the recovery of knee joint motion after an ACL tear largely depends not only on concomitant traumas but also on patient management in acute period. The obtained results suggest that the stages of post-trauma condition of the joint (acute, subacute, chronic) can be defined not only in terms of time (because individual response may vary significantly), but also based on the functional condition. The conducted study showed that acute ACL injury is associated with an overall reduction of function of the entire lower limb. The stage of an ACL injury should be assessed not only based on the time post-trauma, but also taking account of the functional parameter - the knee range of flexion while walking. For isolated ACL tears, the KJ function did not depend on the mechanism of trauma. According to our findings, the only factor that had influenced the functional condition of the KJ was the duration of joint immobilization after trauma.

P3-R-153 Function of the knee joint during walking before and after the meniscus resection

Sergey Kaurkin¹, Dmitriy Skvortsov¹, Alexander Akhpashev¹

¹Federal Research and Clinical Centre of Russia's Federal Medical-Biological Agency (FNKC FMBA)

Injuries of meniscus are one of the most frequent traumas of the knee joint (KJ). A number of meniscal injuries remains stable up to the ages of 50-60. The study enrolled 24 patients operated for meniscus tear, both of traumatic and degenerative nature. The inclusion criteria were as follows: isolated meniscal injury, knee joint osteoarthritis (OA) of no more than grade 2 according to Kellgren-Lawrence, adequate ligamentous apparatus of the knee. The patient group included 19 female and 5 male subjects. The mean age of the patients was 46.9 years, ranging from 18 to 72. Seven patients in the group were aged 60 or older. The mean period from the date of surgery to the biomechanics study was 3.04 months. The control group included 20 adult healthy subjects, 14 males and 6 females. Their mean age was 29.7 years. Gait analysis was done before surgery and 3 month after it by using 5 inertial sensors were fixed to the lower back, the thigh and the shank for the both legs. The temporal characteristics of the gait cycle remained normal both before and after surgical treatment. Only one parameter - the impact load on the affected limb - shows a significant increase, up to normal values, after surgical treatment. For the hip joint, there





was a significant decrease in flexion amplitude at the beginning of stance phase (SP) compared to the control group (p<0.05), symmetrically for both limbs. After the treatment, there was no difference in this parameter from the control group. A significant increase in the hip extension amplitude on the affected side was observed after the treatment. The amplitude of the first flexion in the KJ on the affected side was significantly (p<0.05) decreased compared to the control group. The amplitude increased significantly after surgery but was still smaller than in the control group. On the intact side, there was a significant (p<0.05) increase in this amplitude after surgery, up to the control group values. Also, on the affected side, knee extension in the single support phase (A2) was completed significantly earlier than in the control group. There was no difference in this parameter after surgery. On the intact side, the post-surgery extension amplitude in the single support phase (A2) was significantly larger than in the control group (p<0.05). The main, swing amplitude (A3) was significantly reduced on the affected side before treatment and increased significantly after treatment (p<0.05). On the intact side, we observed its significant increase after the treatment. A meniscal injury does not cause significant changes in the biomechanics of walking. This of course applies to typical cases only. The most apparent changes in the KJ function were those on the affected side. They include a decrease in the amplitude of the first and second flexion. At about 3 months after surgery the functional parameters of operated KJ recovered to normal values. However, this only applies to walking on flat surface under conditions of this study.

S - Proprioceptive function and disorders

P3-S-154 Reduced balance stability in obese individuals is associated with low tactile sensibility of the feet soles

Luis Teixeira¹, Jair Bueno¹, Caroline Souza¹, Daniel Coelho¹

¹University of São Paulo

BACKGROUND AND AIM: A possible factor leading to decreased balance stability in quiet posture of obese individuals is reduced tactile sensitivity of the feet soles. In the current investigation we aimed at assessing the relationship between tactile sensitivity and balance stability in quiet upright posture and dynamic balance. **METHODS:** Participants were morbid obese (n=13), body mass index 48.39 (SD=4.01), or non-obese (n=13), body mass index 22.17 (SD=1.79) women. Tactile sensitivity of both feet soles were evaluated through pressure of nylon filaments with different diameters at nine plantar points, ranging from the hallux to the heel. To evaluate balance stability in quiet posture, participants stood either on the rigid surface of a force platform or on a malleable foam surface toping the platform during 30 s. For evaluation of dynamic balance while standing, the task consisted of rhythmic hip flexion-extension at .5 Hz during 15 s. Tasks were performed under full or no vision. Results showed reduced sensibility in different points of both feet soles in the obese in comparison with the non-obese women. **RESULTS:** Analysis of balance stability in quiet posture, both on the rigid and malleable surfaces, showed



greater amplitude of anteroposterior center of pressure (CoP) sway in the obese than in nonobese women. In the mediolateral direction, lack of vision on the malleable surface led to greater amplitude of balance sway in the obese than in non-obese women. Correlation analysis showed significant associations between feet soles sensibility and balance sway amplitude and velocity both in the anteroposterior (highest correlation: CoP velocity, rigid/no-vision, r = .66, p < .01) and mediolateral (highest correlation: CoP RMS, malleable/no-vision, r = .76, p < .01) directions. For the dynamic balance task, analysis showed lack of significant differences between groups and low correlation between plantar sensitivity and balance stability. **CONCLUSIONS:** These results lead to the following **CONCLUSIONS:** (a) morbid obesity leads to reduced quiet balance stability, (b) reduced quiet balance stability in morbid obese individuals is associated with low plantar sensibility, and (c) dynamic balance control seems to be unaffected by obesity.

P3-S-155 Investigation of the relationship between talking time on the mobile phone and neck proprioception, pain, and disability in the university students

Gamze Yalcinkaya¹, Nurullah Buker¹, Yesim Sengul

¹Health Sciences Institute

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BACKGROUND AND AIM: The time that spent on mobile phone during the day is increasing with the development of technology and rapid life style in young adult population. Current studies indicated that long-term use of smartphones could lead various health problems, especially on behavioral, pyschological and musculoskeletal fields. However, the number of studies were limited about the effect of long-time using mobile phone on the cervical region. Therefore, the purpose of our study is to investigate the relationship between the university students' daily talking time on the mobile phone and the neck proprioception, pain and disability. METHODS: Sixty-four university students (F: 38, M:26) whose mean ages 22.88±1.92 years and mean body mass index (BMI) 22.27± 2.51 kg/m2 were included in the study. The daily talking time on the mobile phone was recorded daily for one week and the average values were determined in minutes for all participants by using their battery usage data on the mobile phone. The neck proprioceptions "repositioning error sense" were assessed by laser pointer method (Dugailly, 2015). The repositioning errors were recorded in centimeters on the target and were converted in degrees by the following formula "angle α (degrees) = tan -1(error component (cm)/ distance (180 cm)". The constant error (CE, the mean of raw repositioning errors) was calculated by computing the root mean square error (RMS) considering horizontal, vertical and x-y components. Pain levels were evaluated by visual analog scale (VAS) at resting and activity in the neck region and neck disability levels by neck disability index (NDI). RESULTS: The average daily talking times (ADTT) on the mobile phone of students' were 22.93±17.67 minutes. ADTT had no significant correlation with the cervical proprioception in flexion, right lateral flexion, right and left rotation directions. However, the positive low correlations were determined between the ADTT and the cervical repositioning error sense of the extensor (rho: 0.317, p:0.01) and left lateral flexion sides (rho:

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0.332, p: 0.008). Additionally, there were low and significant positive correlations between ADTT and pain severity (rho:0.256, p:0.043) and neck disability levels (rho:0.373, p:0.003) (Table 1). **CONCLUSIONS:** The long talk time on the phone could affect cervical proprioception, pain severity and disability in healthy university students. Future research could also be done in clinical populations such as neck pain.

U - Robotics

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P3-U-156 Does the selection of specific control strategy options during walking with a wearable robotic exoskeleton affect muscle synergies in healthy individuals?

Manuel Escalona¹, Daniel Bourbonnais¹, Damien Le Flem¹, Michel Goyette¹, Cyril Duclos², Dany Gagnon³

¹University of Montreal, ²Université de Montréal, ³Université de Montréal, School of rehabilitation

BACKGROUND AND AIM: Wearable robotic lower extremity exoskeletons (WRE L/E) represent a promising rehabilitation intervention for locomotor training that aligns with activity-based neuroplasticity principles in terms of specificity (e.g., optimal sensory input, proper kinematics) and intensity (e.g., possibility to take > 2000 steps/session). Diverse L/E control strategy options (e.g., assistance, adaptive, resistance) are now emerging to increase perceived utility and acceptability of the WRE L/E in the neurorehabilitation community. However, little is known about whether or not these control strategy options affect the neural control of L/E muscle during walking that is typically structured into four key functional units known as muscle synergies (MSs). Each MS is responsible for a well-organized co-activation pattern of multiple L/E muscles associated with specific biomechanical function during gait. The present study aims to compare MSs in terms of number, composition and activation profiles when walking without and with the WREL/E set in 7 different control strategy options in healthy individuals. METHODS: Twenty healthy adults walked a 20-m distance without the WRE L/E at a natural self-selected speed (NAT) and thereafter with the WRE L/E. When walking with the WRE L/E, seven distinct controlled strategy options predominantly affecting the L/E during the swing phase were tested. Surface EMG of eight key muscles at the right L/E was recorded. A custom-made software was used to process the EMG data and generated the MSs using a non-negative matrix factorization algorithm. The number of MSs, alongside the weighted muscle composition and temporal profile of each MSs, were extracted. Correlation coefficients characterized similarities between temporal MS profiles. **RESULTS:** The four typical L/E MSs were identified when walking without and with the WRE L/E, independently of the motor control options used, and highlight specific and consistent combination of EMG patterns. Only subtle weighted muscle composition and temporal profile changes were observed and particularly affected MSs linked to the swing phase (i.e., MS# 3 - foot clearance and MS#4 - limb deceleration). For these two MSs, an early phase shift and low correlation (r <0.49) were observed when walking with the WRE compared to walking without





WRE. In 40% of participants, a 5th MS, composed mostly of hip abductors and occurring throughout the stance phase, was observed when maximal assistance was provided by the WRE and may relate to the exaggerated anterolateral weight shift needed for this option. **CONCLUSION:** Despite the new constraints generated by the various L/E control strategy options when walking with the WRE L/E, the typical MSs remain relatively stable in terms of number, composition and activation profiles. Hence, WRE L/E may represent a promising activity-based neurorehabilitation intervention for locomotor training.

P3-U-157 Do high and low spinal cord injured subjects learn exoskeleton skills differently?

Rosanne van Dijsseldonk¹, I.J.W. van Nes², H. Rijken², H. van de Meent³, N.L.W. Keijsers²

¹Radboudumc & Sint Maartenskliniek, ²Sint Maartenskliniek, ³Radboud University Medical Center

BACKGROUND AND AIM For safe application of exoskeletons in the community, it is required to have completed an exoskeleton training in which users learn to perform basic and advanced skills. In our previous study we developed a framework of exoskeleton skills-tests to measure the progress in performing basic and advanced exoskeleton skills[1]. The aim of this study is to assess the effect of injury level (above or below thoracic (Th) 6) on the ability to perform exoskeleton skills. Because people with a high thoracic SCI have less trunk control, we hypothesized that participants with a high SCI achieve exoskeleton skills at a slower rate than participants with a low SCI. METHODS Twenty participants with a complete SCI (8 high SCI (Th1-6) and 12 low SCI (Th7-12)) were given 24 training sessions in 8 weeks with the Rewalk exoskeleton. During the 2nd, 4th and 6th training week the Intermediate-skills-test was performed consisting of 27 skills, measured in an hierarchical order of difficulty, until two skills were not achieved. When participants could walk independently, the Final-skills-test, consisting of 20 skills, was performed in the last session. A two-way mixed ANOVA with measurement (Intermediate-skills-test one, two or three) as a within subjects factor and injury level (high or low SCI) as a between subjects factor was performed. In case of a significant main effect (a=0.05), paired samples t-tests (a=0.017) were performed as post-hoc. A Fisher's exact test (a=0.05) was performed to assess differences between participants with a high and low SCI who could perform the Final-skills-test. RESULTS Seventeen participants (8 high SCI and 9 low SCI) completed the training program. The ANOVA revealed a significant main effect of measurement (F(2,30)=14.6, p<.001) and no significant interaction effect (F(2,30)=.074, p=.93) nor a main effect of injury level (F(1,15)=2.78, p=.12) (Figure 1). Post-hoc analysis revealed a significant increase in the achieved intermediate skills from 5±6 at the first to 8±6 at the second and 13±9 at the third Intermediate-skills-test. Thirteen participants met the criteria to perform the Final-skills-test. Fisher's test revealed no significant difference in the number of participants with a high (5 out of 8) and low SCI (8 out of 9) who could performed the Final-skills-test (p=.29). Figure 1. Progression in achieved intermediate skills. Blue lines are participants with a high SCI (Th1-6) and red lines participants with a low SCI (Th7-12).

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Dotted lines are the mean values for high and low SCI participants. **CONCLUSION** There were no differences between participants with a high and low SCI in the number of achieved intermediate-skills and number of participants who met the criteria to perform the Final-skills-test. Hence, injury level does not influence the learning rate of exoskeleton use. REFERENCES [1] van Dijsseldonk, et al. Front. Neurosci. 11 (2017) 1-12 **ACKNOWLEDGEMENTS AND FUNDING** This work is part of the research programme Wearable robotics with project number P16-05, which is financed by the NWO.

V - Sensorimotor control

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P3-V-158 A balance control model for vestibular loss subjects balancing on a tilting support

Lorenz Assländer¹, Georg Hettich², Markus Gruber¹, Thomas Mergner³

¹University of Konstanz, ²Aesculab, ³Neurological University Clinics, Freiburg

Introduction Subjects without vestibular function are able to cope with everyday situations without major balance problems. Only in rare situations, such as walking on soft ground in the dark, does the sensory deficit become evident. In this study, sensory deficits were used as an experimental tool to investigate basic principles of sensor fusion in standing balance with a systems identification approach. Methods Sway responses to support surface tilts were measured in 5 subjects without vestibular function (VL; 2 female; 18.8 /- 0.8 yrs) and in 7 vestibular able subjects (VA; 4 female, 27.1 /- 3.6 yrs). A pseudo-randomized stimulus sequence was applied at 4 angular amplitudes in eyes closed and eyes open conditions. Hip and shoulder sway was measured and whole body centre of mass movement was calculated thereof. 6 consecutive repetitions of the stimulus cycle were measured twice in each condition and averaged across cycles to provide an estimate of the sway response to the stimulus. Model simulations including parameter estimation were conducted to extract a model of human balance control without vestibular function in eyes open and eyes closed conditions. **Results** With eyes open, VL showed sway responses that indicated sensory reweighting and were comparable to eyes closed sway responses of VA. With eyes closed, VL sway responses did not show a typical reweighting behaviour and subjects lost balance at higher stimulus amplitudes. Notably, a small reweighting effect was observed in VL during eyes closed conditions. Model simulations suggest an integration of centre of pressure, i.e. ankle torque cues. The torque cues appear to be filtered similarly to the filter characteristics of the body mechanics, reminiscent to an internal model. Discussion Sway responses of VL subjects showed a small reweighting effect during eyes closed conditions that has not been reported before. Since only the proprioceptive reference to the floor is available in eyes closed conditions, the integration of force cues was explored as a potential explanation and confirmed in model simulations. Internal processing of the force cues appears to involve an internal model of the body. Since earlier studies did not report any reweighting in VL, the internal





model could point to an adaptation in the young and active group of VL that participated in the current study.

P3-V-159 Synergies between postural control, eye movements and cognitive involvement in precise visual tasks performed upright

Cedrick Bonnet¹, Tanguy Davin¹, Jean-Yves Hoang¹, Stéphane Baudry²

¹University of Lille, ²Université Libre de Bruxelles

BACKGROUND AND AIM: In upright stance, individuals sway continuously in unpredictable ways. The question then holds how they can succeed in moving their eyes precisely on specific targets in such a situation? In 2016, Dr. Baudry and I suggested that the brain may use synergistic relations between eye and center of pressure (COP) and/or body movements (i.e. eye-COP/body movements) to succeed in goal-directed (precise) visual tasks (H1). We also hypothesized that the brain may use greater cognitive involvement in precise than unprecise visual tasks to get synergistic eye-COP/body relations (H2). The present study's first objective was to test the validity of these two hypotheses in healthy, young adults. The second objective was to test whether an additional cognitive task could strengthen synergistic relations between eye movement, COP/body movements and cognitive involvement (H3). ? METHODS: Sixteen healthy young adults (19.8 ± 1.6 years) performed a search (goal-directed) and a free-viewing (control) tasks either alone or in addition to a counting task (counting silently backward by seven) in upright stance. In searching, the participants had to visually locate as many animals (targets) as they could in the images projected onto a large visual display (120°). In free-viewing, they had to watch similar images randomly. COP, head, neck, lower back and eye movements were recorded during each trial. The cognitive involvement was recorded after each task with a multidimensional subjective questionnaire. In searching, significant negative Pearson eye-COP/body correlations were expected to be found. These correlations were expected to be functional in showing a reduction of postural sway when larger goal-directed eye movements need to be performed. In free-viewing, we expected to find no significant negative eye-COP/body correlations because no precise eye movement needs to be performed in this task. ? RESULTS: As expected, the young adults exhibited significant negative eye-body (head and neck) correlations only in the two search tasks, thus validating H1. The significant negative eye-body (head and neck) correlations were stronger in the double task of searching and counting than in searching, thus validating H3. The cognitive involvement was significantly higher in both search tasks than in both free-viewing tasks and similar in both search tasks. When the cognitive involvement was controlled, 50% and 100% of the correlations in searching and search counting were not significant anymore, thus validating H2 and again H3. ? CONCLUSION: Our results showed that younger adults may need to engage more cognitive involvement in goal-directed tasks to use functional relations between eye and body movements to succeed in these tasks. They also showed that the more difficult the goal-





directed task was, the higher the functional eye-body correlations needed to be. Taken as a whole, this study validated the synergistic model of postural control in a strong way.

P3-V-160 How does visual input affect the learning process of a balance skill?

Orit Elion¹, Yotam Bahat², Itamar Sela³, Itzchak Siev-Ner⁴, Patrice (Tamar) Weiss³, Avi Karni³

¹Ariel University, ²Sheba Medical Center, ³University of Haifa, ⁴C. Sheba Medical Center, Tel Hashomer, Israel

BACKGROUND AND AIM: Sensory input from the visual, vestibular and somatosensory (mainly proprioceptive) systems is a key requisite for balance maintenance. Visual input has a major role in triggering anticipatory postural adjustments that predict disturbances, and in turn, produce preprogrammed, task dependent responses (i.e., non-stereotypic) that maintain stability. The objective of this study was to explore the effect of elimination of visual input on the time-course of learning a balance task in healthy adults within a virtual environment (VE). METHODS: Seventeen healthy participants were divided into two groups: No-Vision group: training blindfolded, with no visual input (N=7, male: female 4:3, mean age (±SD) = 28.57 (±2.5) years), and With-Vision group: training with visual input (N=8, male: female 4:4, mean age (±SD) = 26.4 (±1.7) years). Participants were required to maintain their balance while standing on a moving platform and "travelling" along a "road" that was displayed onto a large screen. The completion of each run (i.e., route along the road) took 2:48 min. The platform's movements were correlated with the visual stimuli. The participants in the No-Vision group were blindfolded throughout all iterations of the training session. Center of pressure (CoP) displacements were analyzed for each task iteration within the training session, and in retests at 24 hours, 4 weeks and 12 weeks post-training to test for between-sessions ("offline", delayed) gains and retention. To measure the transfer of training related gains, a structured battery of stability tests was performed immediately before the training session. The stability tests were repeated at the same time-points above, before performing the training task. **RESULTS:** In contrast to participants, who trained with eyes open (p=0.001), blindfolded participants had no reduction in the task-related CoP displacements during the training session (p=0.63); however, already from the first task iteration, their CoP displacements were comparable to those finally attained in the eyes-open session (p=0.425). Nevertheless, significant delayed reductions in the task-related CoP displacements evolved latently, becoming apparent by 4 and 12 weeks, (p=0.026; p=0.033, respectively) post-training. The practice-related gains were not generalized to the performance of stability tests that differed from the trained task condition (p=0.474). CONCLUSIONS: These results suggest that while long-term experiencespecific skill is gained in both the blindfolded and eye-open VE conditions, the initial phases of balance learning in a VE may reflect a minimizing of redundant anticipatory postural adjustments. Training to maintain balance with no visual input relies on pre-established, visual-input independent balancing skills which appear to provide a scaffold for generating task-specific balancing routines. slow process mainly reflected in post-training gains. а





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P3-V-161 Obesity and gait: where/when body representation and its symbolic counterpart meet in the brain?

Marie Fabre¹, Pascale Chavet¹, Théo Fornerone¹, Benjamin Juan², Olivier Abossolo³, Fabrice Pardo³, Lionel Dany¹, Laurence Mouchnino¹

¹Aix-Marseille University CNRS, ²Aix Marseille Université, ³Equilibre hôpital de jour, Clinique Saint-Christophe

BACKGROUND AND AIM. Obesity is a significant worldwide public health concern. One obesity characteristic is the alteration of balance control, involving difficulty to move, higher risk of falling and the resultant injuries. Concerning obese individuals, balance control is perturbed partly due to a reduced sensitivity of the plantar mechanoreceptors because of the permanent pressure of supporting a heavy weight. Indeed, simulated obesity lead to a depressed sensory afferents transmission and disturbed somatosensory process involving area known to host representation of the body in space. When initiating gait, the relevance of tactile information to determine the actual standing position prompts the brain to increase plantar cutaneous inputs transmission to the cortex and posterior parietal cortex (PPC) activity where representation of the body in space is known to be hosted. Given that how we experience and perceive our body, involves sensorimotor brain mechanisms, any change in the somatosensory response to the stimulation may reflect an altered body image, known to be distorted for obese patients. In the present study, we hypothesized that a program improving body representation for 15 days, without targeting any weight loss, may enhance the activation of specific brain areas. Such increased activity will restore the sensory facilitation processes, critical for setting the body weight transfer prior to gait initiation. In this way the program, could have some psychological and cognitive counterparts by modifying body image evaluation of obese patients. Methods. Sensory afferents transmission and process was assessed with the P50N90 somatosensory evoked potential (SEP) and brain cortical activities. They were compared between step preparation and natural quiet standing in 18 obese patients during the first (D1) and last (D15) days of the program. We used a body satisfaction and body perception questionnaires to assess body image at D1 and D15. Task performance during step and balance during step preparation and natural quiet standing was evaluated at D1 and D15. Results. The amplitude of the P50N90 SEP in D1 was not different between standing and preparing a step whereas a facilitation of the P50N90 SEP was identified in D15. Source localization indicated the PPC as the likely origin of the response modulation in D15. This is associated with an improvement of body satisfaction and task performance. There were no difference in balance. Conclusion. Our findings provide the first evidence of cortical plasticity closely related to body wellness and not to weight loss or balance modification in obese patients.

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The facilitation of the P50N90 SEP together with PPC activation can be considered as biomarkers reflecting body image which is known to be disrupted in obese persons. We propose that any clinical intervention should consider the implementation of task-relevant sensory processes in obesity intervention programs.

P3-V-162 Postural control during induced stabilization of the center of mass and light touch

Dasa Gorjan¹, Angélina Bellicha², Jernej Camernik¹, Wael Bachta², Jan Babic¹

¹Institute Jozef Stefan, ²Sorbonne Université - ISIR

BACKGROUND AND AIM: Lately we witnessed the emergence of robotic canes to aid mobility and prevent falling. Light grip of the handle of the cane is known to reduce sway. The removal of a sensory channel has been shown to increase the effect of a light touch. We developed a system to stabilize the center of mass (CoM), which decreases sensory information and was used to investigate the effect of light touch on posture. Previous studies showed that stabilization of the CoM increases the center of pressure (CoP) oscillations, possibly to replace the missing CoM sensory information. The aim of this study was to investigate the effects of two methods for stabilization of CoM during quiet standing and addition of the light touch. METHODS: We developed two devices for CoM stabilization in real time without mechanical obstruction of the participant's movement. One device is robotic platform, that is programmed to move horizontally, accordingly to the movement of the participant's CoM in the anterior-posterior (AP) direction. More specifically, the platform follows the movement of CoM with minimal delay with the goal to stabilize the COM. The second device is a waist-pull system that applies corrective forces to the participant's waist in order to held the CoM stable. Apart from the stabilization device, we used force plate to monitor the CoP, a force sensor to monitor the force applied by the finger, a motion tracking system for the position of CoM and the kinematics and EMG on the muscles tibialis anterior and soleus. We divided our experiment in five conditions. In all conditions healthy young participants were standing quietly with their arms crossed over their chest. In the middle of each condition we included the stabilization period for 75s. We used each stabilization device for conditions: eyes opened and eyes closed with the light touch. With the waist-pull system we had another condition with eyes closed only. **RESULTS:** Preliminary results suggest that stabilization of CoM with two distinct methods decrease CoP oscillations. We did not find any difference in the forces applied by the finger during the light touch conditions when the CoM is stabilized in comparison to quiet stance. CONCLUSIONS: CoM stabilization with or without vision and with or without light touch does not increase the CoP oscillations, which is in contrast to previous studies. This difference may be due to the nature of stabilization. Indeed, the devices do not obstruct the participant's movement. The absence of difference in forces applied by the finger during the stabilization is coherent with the absence of increase of the CoP. The stabilization of the CoM does not seem to induce an increasing use of another sensory channel.





P3-V-163 Comparison of EMG parameters during uphill walking on a self-paced treadmill and outdoors

Eunice Ibala¹, Karen Chase¹, Nicholas Smith¹, Andrew Kerr¹

¹University of Strathclyde

BACKGROUND AND AIM: Walking in the community includes changes in gradients, which can be a challenge for people with impaired gait, such as stroke survivors. Training on treadmills capable of changing gradients may help individuals recover community walking ability if they create similar muscle activation patterns. The aim of this observational study was to compare the muscle activation patterns between uphill walking on a treadmill and outside, in able-bodied and a chronic stroke participant. METHODS:10 able-bodied participants (3 males, age 25.9±5.4, height 1.66±0.10m, weight 69.1±8.2kg), constituted the reference data for the comparison to one chronic stroke survivor (female aged 68, height 1.59m, weight 64.3kg, left-sided hemiplegia, 5 years since stroke). Electromyography (EMG) surface electrodes integrated with inertial sensors (Delsys Inc., Boston, USA) were attached over tibialis anterior (TA) and gastrocnemius (GA) of both legs to collect muscle activity and identify gait cycles events. 12.9±3.7 cycles per person were extracted for analysis. EMG parameters analysed were pattern repeatability (Variance Ratio, (VR) a ratio closer to 0 indicates high repeatability) and number of contractions per cycle. Participants walked on a self-paced treadmill at two positive gradients of 3 and 6° and uphill an outdoors slope that varied between 3 and 6°. RESULTS: Pattern repeatability was poorer on the hemiplegic (hemi) side compared to the opposite (op) side for both muscles during treadmill walking, VR (op-GA)=0.32±0.18, VR (hemi-GA)=0.61±0.07, VR (op-TA)=0.36±0.07, VR (hemi-TA)=0.71±0.09), than during outdoor walking (VR (op-GA)=0.31 ±0, VR (hemi-GA)=0.17 ±0, VR (hemi-TA)=0.29 ±0). Able-bodied participants had similar range of values (VR (left-GA)=0.23±0.03, VR (right-GA)=0.25±0.04, VR (left-TA)=0.3±0.02, VR (right-TA)= 0.26±0) and outdoors (VR (left GA)=0.42, VR (right GA)=0.31, VR (left TA)=0.4). The number of contractions per gait cycles was higher during treadmill walking (mean (op-GA)=2.5±0.7, (hemi-GA)= 5.5±0.7, (op-TA)=3.5±0.7, (hemi-TA)=1.5±2.1) compared to outdoor uphill walking ((GA)=1.5±0, (TA)=1±0). It was of similar values in all walk environments for the able-bodied participants (sides and environment combined: mean (GA)=1.7±0.4, mean (TA)=1.95±0.3). A technical fault meant the outdoor op-TA data were missing. CONCLUSIONS: Able-bodied participants were less symmetrical during their uphill treadmill walking compared to outside walking. However, the stroke participant demonstrated a higher variability of muscle pattern on the hemiparetic side and a higher number of contractions per cycles during treadmill walking. Treadmill walking was proven to reduce the gait asymmetry in hemiplegia, but the muscle activity observed with this chronic stroke survivor suggests this may not apply to uphill walking. Further stroke participants analysis is necessary to confirm these observations and possible differences in motor control strategy.





P3-V-164 Anticipatory postural adjustments while initiating a step on a flat surface or over an obstacle

Hirofumi Ida1

¹Jobu University

BACKGROUND AND AIM: The central nervous system controls standing posture to maintain dynamic balance while initiating a step. The forward translation of body mass should be in accordance with expected step length, and in case that the foot avoids an obstacle on the floor, this is additionally accompanied by a leg lift. In general, anticipatory postural adjustments (APAs) are observed in postural muscles prior to such postural perturbations. The purpose of this study was to demonstrate how step length and obstacle clearance affect the APAs of the stance side. **METHODS:** Twenty-six healthy participants stood barefoot and initiated a step (a) on a flat surface and (b) over a 10-cm high obstacle, where the step length was set at 30, 40, 50, 60, and 70 cm. The ground reaction force (GRF), plantar center of pressure (COP), surface electromyography (EMG), and coordinates of body landmarks were recorded. The time origin (T0: T = 0) was determined as the instance that the ankle of the swing leg began to move upward. The integrals of EMG activity (IEMG) were calculated for two APAs phase (APA1: T = -350 ms to -150 ms, APA2: T = -150 ms to +50 ms). **RESULTS:** During the APAs phase, a decrease of the vertical GRF and medial shift of the stance foot COP was observed respectively. ANOVAs and post-hoc pairwise comparisons showed that the minimum peak of this vertical GRF appeared significantly later and the amplitude of the peak was significantly greater in the obstacle condition than in the flat condition. Likewise, significantly later peak time and greater peak amplitude in the obstacle condition were revealed for the medial shift of the stance foot COP. Among these variables on GRF and COP, a significant main effect of step length was shown only in the peak time of the vertical GRF. Subsequently, it was indicated that the vertical GRF peak of the 70 cm step length condition occurred significantly later than that of the 30 cm condition. Meanwhile, ANOVAs and post-hoc pairwise comparisons for the erector spinae IEMG suggested that a decrease from the baseline IEMG in the APA1 phase was significantly greater in the flat condition than in the obstacle condition. On the other hand, the tibialis anterior IEMG of the flat condition was significantly greater than that of the obstacle condition both in the APA1 and APA2 phases, and furthermore, significantly increased as the step length. CONCLUSIONS: The results suggested that the muscle activities in the APAs phase were modulated by the presence of obstacle and as the expected step length. Meanwhile, the GRF change and COP shift were critically affected by whether or not obstacle clearance is required.

P3-V-165 Central sensorimotor integration delays: Does response latency to pseudorandom balance perturbations relate to reaction time?

Douglas Martini¹, Lucy Parrington¹, Peter Fino², Robert Peterka¹, Laurie King¹





ispgr INTERNATIONAL SOCIETY OF POSTURE & GAIT RESEARCH

¹Oregon Health & Science University, ²University of Utah

BACKGROUND AND AIM: The Central Sensorimotor Integration (CSMI) test identifies parameters that characterize mechanisms contributing to balance control. The identified parameters include a system time delay (TD) that represents the combined delays associated with sensory transduction, neural transmission, central processing, and muscle activation. We sought to determine if TD from the CSMI test correlated with two computerized measures; a simple reaction time (sRT) and a recognition reaction time (rRT) determined from a Go/No-Go task. We hypothesize that a chronic mild traumatic brain injury (mTBI) group will be slower than control subjects across both RTs and CSMI TDs, and that slower RT will be related to slower CSMI TDs. METHODS: Subjects included 52 controls (mean age 36.7 years) and 22 people with chronic (>3 month) balance complaints following a clinically diagnosed mTBI (mean age 39.1 years, mean time from injury 70.0 months). Participants completed the CSMI test and the Automated Neuropsychological Assessment Metrics (ANAM) The CSMI is performed using a modified Neurocom CRS (Natus Medical Inc.), adapted to deliver pseudorandom surface and/or visual tilt stimuli and collect sway data. The CSMI presents 2° and 4° (peak-peak) stimuli, respectively, in four sensory conditions: surface tilts with eyes closed (C1 and C2), surface tilts with eyes open (C3 and C4); visual tilts (C5 and C6), and combined surface-visual tilts (C7 and C8). The outcome variable for each CSMI condition is TD. The ANAM is a computerized clinical assessment of acute mTBI which provides sRT and rRT. Independent samples t-tests assessed group differences. Pearson's correlations assessed relationships between the RTs and CSMI TDs. RESULTS: There were no group differences for the RTs or CSMI TDs. Significant correlations were found between sRT and CSMI TD for C1(r=0.27;p=0.02), C2(r=0.28; p=0.02),C3(r=0.33;p<0.01), C4(r=0.43;p<0.01), C7(r=0.25;p=0.03), and C8(r=0.35;p<0.01). At the group level, only the control participants had a significant relationship between sRT and CSMI TD, but only for C2(r=0.44;p<0.01), C3(r=0.42;p<0.01), C4(r=0.55;p<0.01), and C8(r=0.43;p<0.01). Weaker, yet still significant, relationships were found between the rRT and CSMI TD for C3(r=0.26;p=0.02), C4(r=0.36;p<0.01), and C7(r=0.24;p=0.04). At the group level, only the control participants maintained a significant relationship between rRT and CSMI TD for C2(r=0.37;p=0.01), C3(r=0.38;p=0.01), C4(r=0.51;p<0.01), C7(r=0.31;p=0.03), C8(r=0.41;p<0.01). and **CONCLUSIONS:** The chronic mTBI group did not perform differently than the control group in any RT or TD outcome measure. When assessing the relationship between RTs and CSMI TDs, the sRT yielded the strongest and most consistent relationships with the TDs. Only the control group exhibited significant relationships between RTs and TDs. Our future work will determine what factors alter the relationship between sRT and CSMI TD in people with chronic mTBI.

P3-V-166 Augmenting balance with tactile robotic feedback

Raymond Reynolds¹, Lorenz Asslander², Craig Smith¹

¹University of Birmingham, ²University of Konstanz

BACK TO THE TOP



BACKGROUND: Manual contact with an earth-fixed object can be as effective as vision in reducing postural sway, even when interaction forces are too low to offer significant mechanical support [1]. Conversely, contact with a moving object can evoke sway in a systematic fashion [2,3]. Here we determine if a moving haptic interface can be used to augment stability when its movement is time-locked to body sway, effectively altering the gain of haptic feedback. **METHODS:** Ten volunteers stood barefoot with their eyes closed and feet together, while grasping the end of a robotic manipulandum (MOOG haptic master) with their index finger and thumb, maintaining force below 1N. Body sway was sampled at 100Hz using a Polhemus Fastrak sensor attached to the back at the same height as the manipulandum. The manipulandum was driven in real-time using the body sway signal from the Fastrak sensor, thus allowing haptic feedback gain to be systematically manipulated. For example, when gain was set to +2, the haptic master moved in the same direction as body sway, but with double the amplitude. During negative gains it moved in the opposite direction. Postural sway was recorded for 1 minute periods of standing during the following haptic feedback gains: -2, -1, -0.5, -0.25, 0 (static), +0.25, +0.5, +1, +2. A no-contact condition was also included for comparison. **RESULTS:** There was a significant effect of haptic feedback gain upon body sway (F(1,8) = 47.4, p<0.001; Fig. 1). The +1 gain did not alter sway compared to no touch. For each person, we calculated the most stable gain condition; the median value was -0.25, being significantly different from zero (t(13) = 2.99 p = 0.011). CONCLUSIONS: We altered haptic feedback gain during light touch in standing. The setup is validated by the observation that +1 gain resulted in identical sway to no touch, effectively mimicking a freelyfloating object, thus providing no feedback. Negative gains were most stabilizing, presumably because they are consistent with natural haptic feedback. Conversely, the +2 gain condition was actively destabilizing. This condition theoretically offers useful feedback despite being a reversal of natural gain, and future work will determine whether people can adapt to positive haptic gain. The most stable condition was -0.25, although it was only marginally better than a static object. This opens up the possibility of using enhanced haptic feedback to augment balance, particularly for people with balance difficulties. REFERENCES:1. Jeka, J. J. & Lackner, J. R 1994. Fingertip contact influences human postural control. Exp. Brain Res. 100, 495-502. 2. Jeka, J., Oie, K., Schoner, G., Dijkstra, T. & Henson, E 1998. Position and velocity coupling of postural sway to somatosensory drive. J. Neurophysiol. 79, 1661-1674. 3. Reynolds, R. F. & Osler, C. J 2014. Mechanisms of interpersonal sway synchrony and stability. J. R. Soc. Interface 11, 20140751. LEGENDS: Figure 1. Effect of altered haptic feedback upon body sway. Mean trunk speed (+/-SEM) is shown for each condition of haptic feedback gain, with a quadratic fit. Individual subject values are shown by dots. The red/unconnected value indicates the no touch condition.

P3-V-167 Foot sole cutaneous stimulation mitigates plantar flexor fatigue

Simone Smith¹, Geoffrey Power¹, Leah Bent¹

¹University of Guelph





BACKGROUND AND AIM: Neuromuscular fatigue has been shown to induce changes in motor coordination, movement stability, and proprioception, which may further affect performance. Coupling exists between cutaneous mechanoreceptors in the foot sole and motor neurons of the lower limb. Specifically, cutaneous stimulation on the foot sole has been shown to alter plantar flexor activity. While it is evident that skin stimulation can modulate neuromuscular excitability, the contribution of skin sensory input on muscle fatigue is not well understood. The purpose of this study was to investigate whether activation of foot sole cutaneous mechanoreceptors modifies fatigability of the plantar flexor muscles during a sustained plantar flexion isometric task. METHODS: 16 participants (mean ± SD age 24.1 ± 2.6 years, height 180.7 ± 5.9 cm, mass 83.5 ± 11.1 kg) took part in this study. Each subject underwent three collections which included a fatigue and recovery protocol. During the fatigue task, subjects held an isometric plantar flexion contraction at 30% MVC with an MVC conducted every 30 seconds until failure. During the recovery protocol, plantar flexor MVCs were conducted intermittently following the fatigue task for 30 minutes. Electrical stimulation was applied to the skin of the right foot at the heel (HEEL), metatarsals (MET), or no stimulation (CONTROL). The stimulation was administered for three seconds every 10 seconds throughout the protocol. EMG was collected from the tibialis anterior, soleus, and medial and lateral gastrocnemius. RESULTS: 4/16 participants had a shorter time to task failure (TTF) during the HEEL and MET conditions compared to the CONTROL. These individuals also had significantly greater pain scores in response to the stimulation compared to the other participants (p = 0.003). 12/16 subjects demonstrated a significantly longer TTF in both the HEEL and MET conditions compared to the CONTROL. On average, the 12 subjects were able to maintain the sustained contraction for 27% and 22% longer during the HEEL and MET conditions respectively (Fig. 1). When normalized to TTF, no significant change was found for the MVCs conducted throughout the fatigue protocol, or EMG RMS of the muscles between conditions (p > 0.05). **CONCLUSIONS:** There were no significant differences between maximal torque outputs, however, 12/16 participants were able to maintain a submaximal contraction longer with stimulation. No significant differences were found in MVC torgue and EMG data between the conditions when normalized to time (% TTF). Individuals were therefore able to maintain the same MVC torque and muscle activity for a longer duration, as they held the contraction for a longer period of time. We hypothesize this may occur due to changes in the weighting of inhibition and excitation to the motorneuron pool of the plantar flexor muscles when the stimulation is present. These results may have implications for fatigue mitigation in various populations.

P3-V-168 Lightbulb characteristics affect stepping biomechanics during stair descent in young and older adults

Neil Thomas¹, Costis Maganaris¹, Thomas O'Brien¹, Richard Foster¹, Vasilios Baltzopoulos¹, Carolyn Lees¹, Timmion Skervin¹, Mark Hollands¹





INTERNATIONAL SOCIETY OF POSTURE & GAIT RESEARCH

¹Liverpool John Moores University

BACKGROUND AND AIM: Adequate illumination is important for stair safety [1]. Lighting has become particularly pertinent since incandescent bulbs were banned in many countries, resulting in households using energy saving compact fluorescent lamp bulbs (CFLs). These can take minutes to reach full brightness, which may leave stairwells poorly lit initially. However, they are a cheap option sold in the UK. Light emitting diode bulbs (LEDs) are also energy efficient, but reach full brightness immediately. Yet, how CFLs and LEDs affect stair safety has not previously been examined. This was the aim of the present study. METHODS: Stair tread illumination (lux) was measured in a home (2.23m ceiling) from a low (50W, 630 lm) and a high (103W, 1450 lm) power CFL, thus yielding a warm-up curve for each. Lux was also recorded from a low (40W, 470 lm) and a high (100W, 1521 lm) power LED at first turn-on. Power ratings for the CFLs and LEDs were matched as closely as possible. Custom lighting then replicated these profiles, in addition to a bright control (350 lux), on an instrumented staircase descended (3×trials per light condition) by 12 young (25.3±4.4 years; 5 males) and 18 older (70.1±3.9 years; 8 males) healthy adults. Wholebody 3D kinematics (Vicon) quantified descent speed (DS), root mean square (RMS) trunk vertical acceleration (TA), and foot-step edge clearance variability (FCvar) - an important factor in older adults during stair descent [1]. These were calculated across 4 successive steps in each trial. 3×Kistler force platforms also measured peak vertical ground reaction force (GRFpeak), with the mean of 3 successive steps analysed. A mixed ANOVA examined lighting (within) and age (between). RESULTS: Low and high power CFLs generated 10 and 20 lux in the average time taken to descend the stairs in each respective condition (4.11s and 4.12s). This compared to 35 and 112 instantaneous lux from the low and high power LEDs. The young and older adults descended at the same speed in all lighting conditions. However, CFLs caused a significant reduction in GRFpeak (within: F4,76=3.102, p=0.02) compared to the LEDs and bright control. There was also a reduction in TA (within: F4,76=2.58, p=0.04) in the young adults, but not in the older adults (interaction: F4,76 = 2.65, p=0.04; Fig. 1). This suggests the young adults adapted their centre of mass control in lower light, whereas the older adults showed no such adaptation from normal, walking cautiously throughout. Finally, the older adults had greater FCvar (F1,19= 4.40, p=0.049), but this was not affected by the lighting. CONCLUSIONS: Warm-up characteristics of CFL bulbs result in inadequate illumination as evidenced by more cautious stair descent in young adults. Greater FCvar in combination with less adaptation to lower light compared to young adults may place older adults at greater fall risk. LEDs are thus preferable for use over stairwells. 1. Hamel et al. (2005) DOI: 10.1016/j.gaitpost.2004.01.006.

P3-V-169 Performance of dual-tasking between arm movement and postural adjustments in subjects with stroke

Yosuke Tomita¹, Nicolas Turpin², Daniele Piscitelli³, Mindy Levin³

¹Takasaki University of Health and Welfare, ²University of Ia Réunion, ³McGill University



BACKGROUND AND AIM: Reaching from standing involves the coordination of two task components: the endpoint (EP) trajectory and postural stability, in a process known as dualtasking. Stroke often affects dual-tasking ability leading to difficulties in maintaining each of the task components during reaching from standing. The objective of this study was to compare the stability of the EP trajectory and postural adjustments during reaching from standing between subjects with and without stroke. METHODS: Uncontrolled Manifold (UCM) analysis was applied to data derived from 30 trials where 19 subjects with stroke and 11 age-matched healthy controls reached from standing toward a target located beyond the arm length. To estimate the stability of different variables during the reaching movement, we conducted separate UCM analyses for the EP position or the center of mass (COM) position as the performance variable, while the same kinematic models were used for the elemental variables. We computed the motor equivalent index (ME index), which was the proportion of the difference between goal-equivalent and non-goalequivalent variability related to the total variance. We compared the ME index for EP and COM separately between subjects with and without stroke. **RESULTS:** The kinematic models had only small errors compared to the actual EP (6.2±4.5 mm) and COM positions (2.3±1.0 mm). In both groups, MEEP index had an initial value of ~1, decreased in parallel with EP velocity and returned close to its baseline at the end of the movement. MEEP index and EP velocity were correlated to each other in both stroke (-0.81, QR: 0.15) and healthy (-0.80, QR: 0.04) subjects. The range of MEEP index was significantly greater in the stroke subjects, compared to healthy subjects (95%CI: [-0.52 -0.09], p<0.01). MEEP index decreased more in stroke than in healthy subjects (about 0.6 and 0.3 in healthy and stroke respectively, 95%CI: [0.06 0.50], p<0.05) despite similar movement velocity. MECOM index had a value of 1 at the beginning of the movement, slightly decreased after EP reached its peak velocity and remained decreased until the end of the movement in both groups (~0.8), while it did not differ between the two groups (p>0.05). **CONCLUSIONS:** Our kinematic model had only small amount of error, showing the validity of our kinematic model for the tested movement. The high MECOM index suggests that subjects with stroke maintain a high level of control of the COM trajectory as in healthy subjects. The finding of a significant reduction of the MEEP index but not of the MECOM index during reaching in subjects with stroke compared to healthy controls, suggests that subjects with stroke prioritized the stability of posture while compromising the stability of the endpoint movement.

P3-V-170 Unidirectional beta connectivity from motor cortex to muscle is involved in voluntary modification of locomotor muscle activity in humans

Hikaru Yokoyama¹, Naotsugu Kaneko², Yohei Masugi³, Tetsuya Ogawa², Katsumi Watanabe⁴, Kimitaka Nakazawa²

¹Tokyo University of Agriculture and Technology, ²University of Tokyo, ³Tokyo International University, ⁴Waseda University




BACKGROUND AND AIM: Modification of ongoing walking movement to fit changes in walking condition requires fine voluntary control. In cat studies, it has been established that the motor cortex plays crucial roles for modification of muscle activity during walking. In humans, however, how the motor cortex contributes to voluntary adjustments of locomotor muscle activity is still unknown. We examined cortical activity and directed cortico-muscular connectivity while participants performing voluntary gait task with simultaneous а recordina of electroencephalogram (EEG) and electromyogram (EMG). METHODS: Thirteen healthy male participants performed two walking tasks: normal walking and the precision stepping tasks. The precision stepping task required participants to step on pre-specified positions projected on a treadmill, which varied randomly based on each participant's gait pattern. We measured EMGs from the tibialis anterior (TA) and the soleus (SOL) muscles and EEGs with 63-channels. After separating EEG data into brain, eye activity and other artifact components by using independent component analysis, a spatial location of a current dipole and event related spectral perturbations (ERSP; intra-stride changes in the spectrograms) were calculated for each brain component. The brain components were clustered across participants based on their spatial position, frequency spectra and ERSPs to identify sensorimotor areas involved in locomotor control. The fullfrequency Directed Transfer Function (ffDTF), which is a frequency-domain estimator of directed connectivity, was computed between identified sensorimotor areas and two leg muscles. **RESULTS:** Three clusters were identified in the sensorimotor areas (left, right and central sensorimotor areas). In the all three sensorimotor areas, larger ERSPs were found in the beta band (15-30 Hz) during the precision stepping than normal walking. In both walking tasks, significant directed connectivity was observed from the brain to the muscles but not from the muscles to the brain. We found that the directed connectivity from the central sensorimotor cortex to the TA muscle was stronger in the high beta band (23–30 Hz) during the precision stepping than the normal walking. No difference was observed between the two tasks in the connectivity from the brain to the SOL muscle. **CONCLUSIONS:** This study aimed at examining how the motor cortex contributes to voluntary adjustments of locomotor muscle activity in humans. The ERSP analysis indicated that gait related activity becomes larger in the sensorimotor cortices during the precision stepping task, which requires voluntary modulation of gaits. The connectivity analysis demonstrated that the voluntary modification of locomotor muscle activity is driven by cortical descending commands in the high beta band. The findings have implications in neural control of human locomotion and development of volitional control system of neuroprothetics for walking rehabilitation.

W - Tools and methods for posture and gait analysis

P3-W-171 Straight vs curved walking: quantification of dynamic balance through an instrumented version of the Figure-of-8-Walk-Test





Valeria Belluscio¹, Elena Bergamini¹, Yuri Russo¹, Amaranta Orejel Bustos¹, Marco Tramontano², Giuseppe Vannozzi¹

¹Interuniversity Centre of Bioengineering Bohnes, University of Rome Foro Italico, ²Santa Lucia Foundation

BACKGROUND AND AIM: Most clinical measures of walking ability are based on straight paths, despite the evidence that everyday walking is likely to involve curved paths. It is well known that, in curved paths, spatiotemporal gait characteristics differ from those of straight paths, mainly due to the more challenging nature of curved walking. However, little is known about a deep characterization of dynamic balance and symmetry during curved paths. To our knowledge, no comparative analysis is available about the different motor strategies adopted during these two walking modalities. In the clinical environment, curved walking is often implemented through the Figure-of-8-Walk-Test (F8W) which is generally based only on clinical observations, e.g. time and number of steps needed to complete the test. Therefore, the purpose of this study was to objectively characterize the F8W using an instrumented approach based on inertial sensors, to quantify differences in dynamic balance and symmetry of gait between straight and curved paths. METHODS: Forty-two healthy controls (32.4±10.8 years; 30 males) performed a 10-meterwalking-test (10mWT) and a F8W, while wearing a set of 5 inertial sensors: 2 positioned on both distal tibiae and used for step segmentation, and 3 located at the pelvis (P), sternum (S), and head (H) levels. The following parameters related to dynamic balance and symmetry of gait were obtained: i) root mean square (RMS) values of the measured acceleration in the antero-posterior, medio-lateral, and cranio-caudal directions at each upper body level; ii) the variation of RMS accelerations among each upper body level pair, i.e. attenuation coefficients; iii) the improved Harmonic Ratio (iHR) index. To evaluate differences between the 10mWT and the F8W, a Wilcoxon Test was used for all the parameters (α =0.05). **RESULTS:** All the above-mentioned parameters differ between the 10mWT and the F8W. In details, when performing the F8W, participants show: higher RMS accelerations at P, S, and H levels in the antero-posterior and medio-lateral directions; lower attenuation coefficients in the medio-lateral direction between both P-S and P-H; lower iHR in the three directions. CONCLUSIONS: The comparison of strategies adopted during straight and curved walking allowed to objectively evidence the difficulty in managing upper body accelerations, showing a reduced dynamic stability in the curved path. As expected, a lower symmetry was displayed during curved walking due to the intrinsic asymmetrical nature of the task. However, the results obtained with the instrumented version of the F8W highlighted the more challenging nature of curved paths, arising the interest in protocols based on this walking modality. The proposed approach could be a useful tool for early screening of those at risk for decline in mobility, allowing clinicians to base the rehabilitation treatment on quantitative information which relies on a more ecological and demanding motor task.

P3-W-172 Extending the centre of pressure to include handhold forces





Emily King¹, James Borrelli², Vicki Komisar³, Brian Maki⁴, Alison Novak⁴

¹University of Waterloo, ²University of Maryland, ³Simon Fraser University, ⁴Toronto Rehabilitation Institute

BACKGROUND AND AIM: Various measures describing movement of the Centre of Pressure (COP) are often used to characterize postural control. Traditionally, COP derivations assume that individuals are in contact with the force plates on a single plane - typically the floor but occasionally the seat, with the COP being the centre of the distribution of the total force applied to the support surface. However, postural stability may be affected by forces exerted on multiple planes, especially when assistive devices such as walkers, handrails and grab bars are used. In these cases, it is common to either avoid using COP to characterize postural control or to calculate the COP based on ground reaction forces of the feet while ignoring external loads However, both approaches limit the assessment of postural control in the presence of handheld supports. This work aims to: (1) Derive equations for COP that include forces exerted at both the hands and the feet. (2) Evaluate the influence of including hand forces in a common balance recovery scenario. METHOD: Balance recovery reactions were evoked in 12 young adults using small, medium and large forward and backward translations of a moving platform. A handrail was mounted to the participant's right. Participants were instructed not to step, but otherwise to 'react naturally'. Kinetic data were collected through force plates under each foot and load cells mounted at each end of the handrail. COP was calculated using the force plates only (COP feet), and using data from both the force plates and handrail load cells (COP_extended). Two-way repeated measures ANOVAs were used to test the effects of COP definition and perturbation magnitude on common COP metrics (path length; RMS and maximum excursion; and average and maximum velocity). Responses to forward and backward perturbations were assessed separately. Significant interactions (p<.05) were evaluated for simple effects using Tukey's HSD. **RESULTS:** Significant interactions between perturbation magnitude and COP definition revealed that COP_extended often led to longer path lengths, greater excursions (Figure 1), and higher velocities than COP_feet, and that these effects were most pronounced for higher perturbation levels (with greater handrail forces). During responses to backward falling, most COP excursions and velocities in the ML axis changed signs, with COP_feet moving toward the handrail while COP_extended moved away from the handrail. CONCLUSIONS: Our findings suggest that including hand forces in COP calculations can present a different view of balance control than relying on COP feet. These effects are minimal when hand forces are small, but substantial when hand forces are larger, such as during recovery from large perturbations. COP_extended may be useful in assessing balance control tasks that involve handrails or hand-held mobility devices. Future work will explore the effects of using COP_extended for other activities, such as assisted gait or transfers, and the relationship between the COP_extended and COM. FUNDING: The Canadian Institutes of Health Research (MAT-91865 & 396160), Mitacs Accelerate (EK, VK), University of West Florida CREO (JB), University of Maryland ANRRT (JB), and an AGE-WELL NCE Postdoctoral Award (VK).



P3-W-173 Normative data for Balance Tracking System (BTrackS) modified Clinical Test of Sensory Integration and Balance (mCTSIB)

Daniel Goble¹, Harshan Brar¹, Elise Brown¹, Charles Marks¹, Harsimran Baweja²

¹Oakland University, ²San Diego State University

BACKGROUND AND AIM: Force plate based postural sway assessments of balance are valuable in a variety of clinical and research settings. Unfortunately, force plate technology has largely been underutilized due to the high cost and lack of portability. A new, accurate and reliable force plate called BTrackS is rapidly emerging as a low cost and portable alternative to overcome such barriers. The latest version of the system allows implementation of the mCTSIB a popular balance protocol for evaluating the contribution of various sources of sensory informant for postural sway control. The aim of the present study was to provide the first set of normative data for the BTrackS mCTSIB in healthy adults. METHODS: Center of pressure path lengths from 539 healthy adults (261 men, 278 women) between the ages of 18 and 29 years were collected according to the BTrackS mCTSIB protocol. This protocol consists of four, 20 second trials that manipulate the relative contribution of vision, proprioception and vestibular sensory systems for balance performance. The first trial is a "standard" trial whereby bipedal, static standing is performed on the firm surface of the plate, with eyes open to assess balance with all sensory sources available. In the second trial, the participant does the same as the first, but closes his/her eyes to force greater use of, primarily, proprioception. The third and fourth trials mimic the first and second trials but with the participant standing on a compliant foam surface to disrupt proprioception. These trials aim to assess the relative contributions of visual and vestibular feedback respectively. **RESULTS:** Analysis of variance showed an interaction between sex and task condition on the mCTSIB (p<0.001). This interaction was such that women out performed men (i.e had less postural sway) in all conditions but, that this difference was especially pronounced in the fourth trial with eyes closed on a compliant surface. In this way, percentile rankings "look up" tables were accordingly calculated based on both sex and mCTSIB trial condition. CONCLUSIONS: Normative data from this study suggest sex and task differences in performance on the mCTSIB. Percentile rankings stratified by these factors are vital for establishing balance dysfunctions that may exist clinically and in the laboratory setting, as well as the locus of sensory impairments. In addition, this data can aid in the tracking of changes over a rehabilitation period and/or the effectiveness of various balance interventions.

P3-W-174 Gaps between gait measured in the lab during usual and dual-task walking compared to free-living walking: evidence from 24/7 monitoring of older adults





Inbar Hillel¹, Laura Avanzino², Lynn Rochester³, Ugo Della Croce⁴, Marcel Olde Rikkert⁵, Silvia Del Din⁶, Pieter Ginis⁷, Nir Giladi¹, Anat Mirelman¹, Jeff Hausdorff¹

¹Tel Aviv Sourasky Medical Center, ²University of Genoa, ³Institute of Neuroscience, Newcastle University, ⁴University of Sassari & Interuniversity Centre of Bioengineering of the Huma, ⁵Donders Institute for Brain, Cognition and Behaviour; Radboudumc, department of Neurology, Nijmegen, ⁶Newcastle University, ⁷KU Leuven

INTRODUCTION AND AIM: The traditional one-time evaluation of gait in the laboratory and clinic during short, structured, supervised testing has provided important insights and documented clinical utility. Recent work using wearables has enabled monitoring of gait in real-world environments over an extended period of time, allowing for multiple measures over days and even weeks. Initial findings show that in-lab and real-world measures may differ, however, the relationship between measures obtained in these two settings is not well understood. As a step towards better understanding these gaps, we directly compared in-lab usual-walking (UW) and dual-task (DT) walking to daily-living measures of gait. METHODS: In-lab gait metrics (i.e., step time, step length, gait speed, step regularity, and stride regularity), derived from usual and DT walks were compared to daily-living gait metrics in elderly fallers. In both settings, metrics were extracted from a lower-back accelerometer. In the real-world setting, the device was worn for >3 days and pre-processing identified 10 sec daily-living walking bouts that were most likely to be straight-line, steady-state walking. A histogram of all walking bouts was determined for each walking feature for each subject and then each subject's 50% (typical, median), 10% percentile (worst) and 90% (best) values for each gait feature over the week were determined (e.g., see Figure 1a). RESULTS: 144 older adults (age: 76.5±6.3 years, 27.1% men) were studied. About 60% of the daily-living gait bouts did not meet the criteria of stationary, straight-line walking and were removed, reducing the gaps across the two settings. In-lab step length during usual-walking (55±9 cm) and DT walking (54±9 cm) and in-lab gait speed (UW: 102±19 cm/sec; DT: 96±20 cm/sec) were significantly different (p<0.001) from daily-living walking measures (step length 10%: 39±4 cm, 50%: 52±8 cm, 90%: 63±9 cm; gait speed 10%: 60±6 cm/sec, 50%: 90±16 cm/sec, 90%: 115±20 cm/sec). For step regularity and stride regularity, usual walking values in the lab were similar (p>0.25) to the best (90%) daily-living walking values, while DT walking in-lab measures differed from the best, worse, and typical daily-living values (p<0.001)(e.g., see Figure 1b). For step time, in-lab values of DT walking (0.58±0.07 sec) were similar (p=0.349) to the typical (50%) daily-living values (0.58±0.05 sec). CONCLUSIONS: These findings suggest that for several gait metrics assessed in the lab overestimate typical daily living walking function, both for usual-walking and even for DT walking. In other words, an older adult's typical daily-living gait cannot be obtained by simply measuring walking in a structured, laboratory setting. Future work is needed to examine the influence of pre-processing and different cohorts on these gaps as well as the potential of real-world measures to augment in-lab gait assessments of risk and responsiveness to interventions. ACKNOWLEDGEMENTS: We thank the study participants and all of those who help and contributed to the V-TIME project. This work was funded in part by a grant from the European Commission.

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P3-W-175 Development of a body balance assessment system with integrated virtual reality technology; construct validity testing in healthy older adults

Yu Imaoka¹, Nadja Saba¹, Anne Vanhoestenberghe², Eling de Bruin³

¹ETH Zurich, ²University College London, ³Karolinska Institutet

BACKGROUND AND AIM: Older adults (OA) prone to mild cognitive impairment can express balance dysfunction via presence of anteroposterior (AP) displacement compared with OA without cognitive impairment. Balance evaluation with added visual challenges can be useful in detecting small postural instabilities to identify weaknesses in balance (Leandri, M., et al. 2009). A valid and reliable assessment for early prediction of dementia has so far not been developed. To achieve such a system, we integrated virtual reality (VR) technology with a stabilometer to trigger measurable behavioural reactions. We aimed to assess the validity of our construct in healthy OA. We hypothesised that differences in body balance sway are observable between conditions with and without a VR environment mainly on AP direction. METHODS: 14 healthy elderly (mean age 73.3 ± 4.3 years, 6 men and 8 women) were recruited. All were screened using the Montreal Cognitive Assessment (MoCA). Preferred walking gait speed was measured on Walkway (MW-1000 by ANIMA). Individual preferred speed was used for the speed of visual flow experienced in the test-integrated VR environment while standing in different positions on a stabilometer (GP-5000 by ANIMA). Changes of Centre of Pressure were recorded in 22 test conditions (3 conditions without VR and 19 conditions with VR) to evaluate three main parameters: 1) three different VR sceneries (reference, closed, open), 2) two different foot positions (tight, wide), and 3) three types of "visual flow" walking speed (preferred, increased, decreased) in a VR environment. Participants were wearing a VR headset (Oculus Rift by Oculus VR) while standing on the stabilometer. The measurement took 60 seconds/condition and averaged body sway speed was calculated. The order of test conditions was partly randomised. **RESULTS:** The participants achieved ≥ 25 MoCA points (27.79 ± 1.89). Preferred walking speed was 1.27 ± 0.15 m/s and stride length 1.30 ± 0.14 m. We compared body sway speed between the baseline condition (tight foot position, no VR) and each of the other 21 conditions. For AP sway, significant differences were found in all comparisons except one (P<.020; effect size>.77). The difference was not found in this one comparison because of too much similarity with baseline. Significant differences were observed in only five comparisons for medio-lateral (ML) sway. When we compared sway speed between AP and ML directions in each test condition, significant differences were observed for all but the baseline condition (P<.017; effect size>.53). **CONCLUSION:** The results imply that the test-integrated VR environment affected the body sway in AP direction as expected. Our evaluations showed responses in balance in the intended AP direction in an OA convenience sample. Presence of AP displacement can be an early sign of postural control impairment in people threatened to develop dementia, and the evaluation with added VR can be useful in





detecting small postural instabilities. The results of this study warrant further research and should continue the validation process by comparing OA diagnosed with and without cognitive deficits.

P3-W-176 A novel functional ambulation toolkit to assess children with locomotor deficits

Alexandra Leclerc-Valade¹, Jolin Jiang¹, Liav Lugassy¹, Zachary Weber¹, Elizabeth Dannenbaum², Claire Perez¹, Filomena Pietrangelo², Lora Salvo², Joyce Fung¹

¹McGill University, ²Jewish Rehabilitation Hospital (CISSS-Laval)

BACKGROUND AND AIM: There are currently no evidence-informed guidelines on whether or not to prescribe or discharge from wearing an ankle-foot orthosis (AFO) in children with locomotor disabilities. Clinically, there is often a lack of objectivity and consistency when assessing a child's need for an AFO. The objectives of this study were (1) to evaluate the performance of children with locomotor deficits on different functional ambulation tasks when wearing their AFO and not, and (2) to determine what set of gait components could identify a difference in these children's performances between these two conditions. METHODS: An initial survey of the literature identified 126 functional ambulation tasks which were feasible and clinically relevant to our research objectives. Following consensus with research and clinical experts in the field, this list was reduced to a set of 16 tasks, which challenge ambulation across eight dimensions (distance, temporal, ambient, terrain, physical load, postural transition, attentional demands and density and collisions). Eight children with locomotor deficits were evaluated with and without their AFO during a 90-minute session across this set of 16 tasks. The order of "with AFO" and "without AFO" conditions was randomized prior to participation. In this multiple single-subject study, changes in performance scores were calculated for each child and were considered to be clinically relevant if they met or exceeded a task-respective response threshold (10% of the mean of all subjects' raw scores with and without AFO). The effect size of each task was then ranked using Standardized Response Means (SRMs). RESULTS: The thresholds varied from 0.12-0.22m/s for speed outcome tasks, 0.40-3.04s for timed outcome tasks, and 12.41m for the 2-minute walk test (2MWT). The SRMs ranged from 0.33 to 1.93. A final comprehensive set of 7 tasks was recommended as a clinically relevant toolkit to detect differences when walking with and without an AFO. These locomotor tasks include: 2MWT, Carpet walk, Figure-of-8 walk, Standardized Walking Obstacle Course (SWOC2) with a lunch tray, Walking with Head Turns, Walking Backwards (BWD), and Walking with Eyes Closed (EC). Thus, for each child, a circular plot can be generated consisting of scores in each of the 7 spokes representing those different task dimensions. The figure shows the performance of a cerebral-palsied hemiparetic child walking with (blue) or without (red) an AFO. There are variable responses to wearing an AFO depending on the requirement of each task, with a trade-off between stability, agility, adaptability and safety. **CONCLUSIONS:** A final comprehensive set of 7 tasks is recommended as a clinically relevant toolkit to detect differences in children with locomotor deficits when walking with and without their AFO. This locomotor set targets the multiple dimensions of functional ambulation. This is the first

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toolkit to offer a comprehensive, objective, and standardized profile of functional ambulation for a pediatric population.

P3-W-177 A do-it-yourself low-cost foot switch device to measure stride intervals

Masahiro Okano¹, Tadao Isaka¹

¹Ritsumeikan University

BACKGROUND AND AIM: Variabilities in stride intervals while walking and running offer information about the walker and runner. Stride intervals are measured using motion capture systems and foot pressure sensors. However, these systems are mostly used to measure whole body movement and foot pressure distribution. Thus, the time resolution of these equipment is relatively low to analyze the dynamic structures of stride interval variabilities. Systems measuring biological signals such as electromyography are equipped with optional foot switches. While such systems offer a sufficient time resolution, the cost of introducing such systems is very high. Especially, while measuring stride intervals during running, a system that can flexibly change the number of channels and size of foot switches is necessary to handle different foot strike patterns. This study proposes a do-it-yourself foot switch device specialized for foot contact timing measurement. The device can be produced with commercially available electronic components at around 10 US dollars. METHODS: We constructed a bridge circuit by using pressure-sensitive conductive sheets (PSCSs). These are vinyl sheets whose electric resistance changes according to the applied pressure. A PSCS was cut into a rectangle of having a width of 5 cm and breadth of 7 cm. Lead wires were stuck on both sides of the PSCS. The ends of the lead wires were soldered so that the PSCS constituted one of the resistances in the circuit. The PSCS with the wires was attached to an insole. To confirm the accuracy of the device, eight participants walked and ran on a treadmill with a force plate attached to the insoles in their shoes. The bridge voltage and Fz increased when the foot contacted the force plate, the rising edge of which was detected. The difference in foot contact timing (the timing for the force plate was subtracted from that for the proposed device) and its variation and the correlation coefficient of the stride intervals were calculated. RESULTS: The means of the timing difference between the proposed device and force plate were -17.21 ± 7.67 ms and -14.92 ± 11.46 ms for walking and running, respectively. The means of SD for the timing difference were 2.80 ± 1.48 ms and 3.11 ± 1.72 ms for walking and running, respectively. The means of the correlation coefficients between stride interval series measured by the proposed system and force plate were 0.98 ± 0.05 and 0.95 ± 0.08 for walking and running, respectively. CONCLUSIONS: We succeeded in developing an inexpensive do-ityourself device that can acquire foot contact timing during walking and running. The stride interval series acquired using the proposed device and force plate showed a strong correlation. Such a device would make it easier to evaluate the properties of walking and running by measuring stride interval variabilities. ACKNOWLEDGEMENTS AND FUNDING: This study is partially supported by the JSPS Grants-in-Aid for Scientific Research 18K17907 awarded to MO.



P3-W-178 Performance of surface and fine-wire electrodes over time when recording from the tibialis anterior in walking

Joanna Reeves¹, Chelsea Starbuck¹, Wasseem Rafiq¹, Chris Nester¹

¹University of Salford

Performance of surface and fine-wire electrodes over time when recording from the tibialis anterior in walking Joanna Reeves, Chelsea Starbuck, Wasseem Rafig, Christopher Nester University of Salford, UK **BACKGROUND**: The consistency of indwelling electromyography (EMG) over time using fine-wire electrodes has not been documented. Activation patterns of shank muscles recorded using indwelling EMG is like that recorded with surface EMG [1]. Yet, indwelling EMG may be less consistent over time vs. surface EMG, perhaps due to changes in electrode capacity with exposure to the internal environment. Our group's experience using indwelling EMG suggests that there is a reduction in amplitude in indwelling EMG after 20-40 mins of walking using certain fine-wire electrodes. AIM: To characterise the EMG signal over time when recording from the tibialis anterior (TA) during walking using fine-wire and surface electrodes. METHODS: Healthy males (n=5, age=35±11 yrs, height=1.74±0.09 m, mass=79±13 kg, mean±SD) walked shod along a 6-10 m walkway in the laboratory for 50 mins. Ten walking trials of 5 mins each were completed, interspersed with 1 min breaks. Self-selected walking speed was controlled. Fine-wire electrodes (Chalgren Enterprises Inc., USA, 50 mm long, 25 gauge) were inserted into the right TA with the protruding wires of the electrode connected to a spring contact sensor (Delsys, Inc.). A Delsys Trigno? Mini sensor was attached near the fine-wire insertion site and a standard Delsys surface sensor (EMG + IMU) was attached to the distal aspect of the right shin to determine foot contact from acceleration. EMG signals were collected at 2000 Hz and bandpass filtered between 10-500 Hz. A 75 ms and 250 ms window was used to calculate the route mean squared envelope per gait cycle for surface and fine-wire EMG respectively and averaged per trial for each signal. Amplitude was normalized to the mean of the peak from each gait cycle in trial 1 and time normalized to the gait cycle. **RESULTS:** Figure 1. shows how the EMG profile of the TA across the gait cycle decreased in amplitude with progressive walking trials when recorded with indwelling EMG. By trial 5 (up to 30 mins) amplitude reduced by ~40% and by trial 10 (up to 50 mins), amplitude reduced by ~50%. In contrast, the EMG of TA recorded with surface EMG remained relatively consistent. CONCLUSIONS: Reduced signal amplitude over time with indwelling EMG and not surface EMG suggests that the recording capacity of these fine-wire electrodes diminishes with continuous use, rather than altered activation of the muscle itself. Any change in signal properties over time is a vital consideration for any repeated measures study design using indwelling EMG, as a change in the recording capacity of the electrode would confound the effect of the independent variable being tested. REFERENCE: [1] Chimera, N. et al. (2009). J ELECTROMYOGR KINES 19(6), e494-e499.





P3-W-179 Integrating technology into clinical practice for the assessment of balance and mobility: perspectives of exercise professionals practicing in retirement and long-term care

Kathryn Sibley¹, Karen Van Ooteghem², Elizabeth Inness³, Avril Mansfield³, Jaimie Killingbeck⁴

¹University of Manitoba, ²University of Waterloo, ³Toronto Rehabilitation Institute, ⁴Schlegel Villages

BACKGROUND AND AIM: Current balance and mobility assessment practices in clinical settings rely heavily on standardized assessment protocols that have limited sensitivity to detect change and are often unable to determine underlying causes of impairment. Recent advances in measurement technologies could address these limitations but there is little evidence of uptake in clinical settings. Understanding clinicians' views on technology are essential for determining the feasibility, acceptance, and utility of technology integration. This study explored exercise professionals' perspectives on technology integration for balance and mobility assessment practices in retirement and long-term care settings, including barriers and solutions to technology integration. METHODS: Qualitative semi-structured focus group discussions were conducted with 18 exercise professionals working at a privately-owned and operated assisted living facility in Ontario, Canada. Open-ended questions explored perceptions of technology integration along with factors influencing its adoption. A qualitative descriptive approach was used to identify key themes from focus group transcripts, and analysis included multiple rounds of coding, an audit trail, investigator triangulation, and member-checking to establish data credibility and trustworthiness. Findings: In general, exercise professionals' views on technology centered on benefits of technology-derived data for programming and communication about balance and mobility status. A number of challenges for technology integration also emerged, but these related primarily to the need for an adaptable system that meets specific needs rather than the technology itself. The primary barrier identified was the feasibility of assessment, both with respect to resident willingness or ability, as well as resources required for assessment irrespective of the technology. Solutions to these barriers emphasized the need for system flexibility, including the use of appropriate norms for interpretation of technology-derived data. CONCLUSIONS: Exercise professionals working in retirement and long-term care settings see value in using technology as an adjunct to current clinical practice. To increase the likelihood for clinical uptake, technology must be flexible enough to accommodate a wide range of resident abilities. This study raises several important issues that need to be addressed to improve technology integration, emphasizing the need for continuous dialogue between technology producers and end users.

P3-W-180 Accepting the null hypothesis: how and why?

John Stins¹

¹Vrije Universiteit Amsterdam





BACKGROUND AND AIM Many studies in behavioral sciences and life sciences make use of null hypothesis significance tests, such as the t-test and analysis of variance. If the p-value is below a critical value (usually .05) the null hypothesis (H0) is rejected, and the alternative hypothesis (HA) is accepted. This statistical procedure is well established and permeates the scientific literature. However, the logic cannot be reversed; if an observation yields a p-value > .05, it is logically invalid to accept H0. At best, we can state that the data are ambiguous, and do not allow us to accept or reject a hypothesis. But sometimes it is desirable to test a prediction that is formulated as a null effect. For example, researchers may want to test that there is NO difference between two populations on some measure, or that two measurement procedures yield identical outcomes. In the past years there has been a surge of papers that offer a solution to this problem, especially in the field of psychology. I argue that the field of gait and posture research can benefit from these insights. Method I will discuss two methods that allow researchers to accept the null. The first is equivalence testing, making use of the so called two one-sided tests (TOST) procedure. This procedure is based on prior specification of the smallest effect size of interest. The TOST procedure can tell us that the effect size is so small, that it is equivalent (but not necessarily identical) to zero. The other procedure uses Bayesian hypothesis testing. This procedure quantifies the probability that either of the hypotheses (H0 or HA) is true, based on the observed data, thus yielding quantified relative evidence in favor of one of hypotheses. The evidence is expressed in a so called Bayes Factor (BF), which can range from 0 to infinity. A BF of 1 states that both hypotheses are equally likely, so that the data are not informative. Results I briefly present the logic behind the two statistical approaches, and illustrate both procedures with published data. The TOST procedure will be illustrated with an example of equivalence between two sensor systems to calculate various gait parameters, yielding near-identical outcomes. The Bayesian procedure will be illustrated with an example testing that various cognitive activities (mental imagery of different scenarios) have no discernable effect on postural sway dynamics. Conclusions Both the TOST and Bayes procedure can be used to ask whether there is empirical support for the hypothesis that no noticeable difference between two conditions or two populations can be found. But it is important to keep in mind that both procedures adopt a fundamentally different philosophy to probability. As such, they are incompatible, and they answer fundamentally different questions regarding the relationship between empirical evidence, and the truth value of scientific hypotheses.

P3-W-181 Muscle coordination changes with assistance from lumbar support exoskeleton

Chun Kwang Tan¹, Hideki Kadone¹, Kousei Miura², Tetsuya Abe², Masao Koda², Yasushi Hada¹, Masashi Yamazaki¹, Yoshiyuki Sankai¹, Kenji Suzuki¹

¹University of Tsukuba, ²Faculty of Medicine, University of Tsukuba Hospital





BACKGROUND AND AIM: Lower back pain is a common problem in the world, leading to the development of various lumbar support exoskeletons to tackle this problem. Previous studies of such devices quantified assistance with reduction in back muscle activity and perceived fatigue. However, the impact of such devices on muscle coordination has not been well studied. Exoskeletons constrain the range of movement and changes the dynamics of movement, hence a change in muscle coordination would be expected. Such analysis would be useful for the design of future generations of exoskeletons. METHODS: 20 healthy subjects(age:20-35y) repeatedly lifted a box(6-12kg) until they were fatigued, when using HAL for Lumbar Support. The exoskeleton assists hip extension torque in accordance with back muscle activity. Muscle activity measured bilaterally from the biceps brachii (BB), latissimus dorsi (LD), erector spinae (ES) and gluteus maximus (Gmax), were evaluated with root-mean-square (RMS) and Non-Negative-Matrix-Factorization (NNMF). Kinematics and dynamics of the lifting action were also analyzed to provide context for the muscle activity. **RESULTS:** Muscle synergies were significantly different when comparing between the HAL and no HAL conditions (r = 0.36 (Non-Fatigue) vs 0.13 (Fatigue), p < 0.05). A significant decrease in muscle activations of the back muscles was also noted (20% reduced, p < 0.05). Number of lifts performed was greater when using HAL (87 and 67 p < 0.05). Perceived fatigue was lower when using HAL (6.15 and 7.12, p < 0.05). Significant reduction in the RMS of muscle activity in the Right LD, left LD and Right ES were also noted. **CONCLUSIONS:** The change in muscle synergies suggests that subjects coordinate their muscles in response to the assistance provided by HAL. The change in coordination can also be observed in muscles that were not directly supported by HAL, suggesting muscle coordination change affects the entire body. Design and control of future generations of lumbar support exoskeletons should also take into consideration the change in muscle coordination throughout the body. ACKNOWLEDGEMENTS AND FUNDINGS: This study was supported by the Industrial Disease Clinical Research Grant of the Ministry of Health, Labour and Welfare, Japan (160401-01) and Empowerment Informatics Program of University of Tsukuba. Authors thank Ms. Mayuko Sakamaki and Ms. Yumiko Ito of Center for Innovative Medicine and Engineering (CIME) of University of Tsukuba Hospital, for their excellent assistance during HAL treatments.

P3-W-182 Application and evaluation of the extrapolated centre of mass as a clinical gait stability measure

Albert Vette¹, Jeremy Hall¹, Juan Forero¹, Jacqueline Hebert¹

¹University of Alberta

BACKGROUND AND AIM: Since gait includes the need to regularly position the body in a state of imbalance, it is accompanied by an increased risk of falling. Furthermore, the precarious nature of gait makes it difficult to establish an exact definition of stability, leading to the development of different quantitative stability measures. They, however, have varying characteristics and experimental requirements, often limiting their clinical implementation. One proposed measure





that does appear clinically feasible is the extrapolated centre of mass (XCoM), a quantity that accounts for both the position and velocity of the centre of mass. The degree of stability at a given instant in time is then given by the margin of stability (MoS): the minimum distance between the XCoM and the base of support. Evidence on the clinical utility of this measure is, however, limited. Therefore, the objective of this study was to: (1) demonstrate the practical feasibility of obtaining the MoS and assess its robustness for a non-disabled sample; (2) evaluate the between-session reliability of the MoS, as a key requirement for clinical implementation; and (3) demonstrate the clinical utility of the MoS using three clinical case studies. METHODS: Fifteen non-disabled participants were asked to walk in the Computer-Assisted Rehabilitation Environment at selfselected speed on a level, treadmill-driven surface. All participants returned for a repeat session several weeks following initial testing. Three case study participants with hemophilic arthropathy, unilateral transtibial amputation, and mild traumatic brain injury were also included, each completing one session. To quantify stability in the mediolateral and anteroposterior directions, mean MoS values were taken at heel strike (MoS-HS) and mid-stance (MoS-MS). The protocol was designed to minimize the burden on the patient, the setup time, and overall trial length. **RESULTS:** Our results suggest that MoS-HS is best suited for quantifying stability in both the mediolateral and anteroposterior directions. Not only does MoS-HS demonstrate reasonable within- and across-participant variability, it also showed good repeatability between sessions. Despite this, MoS-HS failed to achieve the sensitivity necessary to detect differences in gait stability for the impaired participants (Figure 1). However, as shown in Figure 1, MoS-HS provided promising results towards highlighting differences between right and left body sides in the case participants, particularly in the anteroposterior direction. CONCLUSIONS: This work represents a significant step towards demonstrating that the MoS is a robust measure that can be reliably used in fundamental research to quantify human gait stability. Further work is necessary to achieve the repeatability necessary for clinical purposes and investigate the ability of the MoS measures to detect stability differences in a larger sample of impaired participants.

P3-W-183 Influence of taking a rest between measurement of stabilometry with eyes open and closed

Tomoe Yoshida¹, Masahiko Yamamoto¹, Kazuo Ishikawa², Eigo Ohmi³

¹Toho University, ²Japanese Red Cross Akita Hospital, ³Akita University

[BACKGROUND AND AIM] Stabilometry is a convenient method of examining body sway with subjects' eyes open and closed. In "Q & A of performing stabilometry" issued by the Japan Society for Equilibrium Research in 1995, many detailed points of view regarding to perform this examination are stated. Among them it has been recommended to take some rest between the "eyes open" and "eyes closed" tests. However, in clinical settings, most clinicians might perform the measurements without taking resting period between the two tests. We examined whether taking a rest or not between the two tests could affect the over all results. [SUBJECTS AND





METHODS This study consisted of 30 volunteers who were healthy and did not have any history of vertigo or balance disorders. Among them, 20 participants were male and 10 were female. The age of the participants ranged from 25 to 46 years, with an average age of 30.8 years. The equipment used was Anima-G620 (Anima Co., Tokyo, Japan). Consecutive recordings were made in a group that underwent the "eyes open" and "eyes closed" tests with no rest between the two tests ("no rest" examination). The recordings were repeated, with the difference that after the "eyes open" test, the subjects were asked to sit in a chair and rest for 60 seconds, after which the "eyes closed" test was conducted ("with rest" examination). During the tests, the subjects stood with their feet closed parallel and maintained an upright posture. Examinations were performed for 60 seconds on each subject. Results were measured during the analysis using the total distance (cm), area (cm2), and spectral analysis with the maximum entropy method (MEM) in stabilometry. For the statistical analyses, a paired t test was used. In accordance with the tenets of the Declaration of Helsinki, the experimental procedures were explained to the volunteers, and each of the subjects provided written informed consent before participation in the study. The authors have no conflicts of interest to declare. [RESULTS] There were no significant differences in the total distance (cm) and area (cm2) between the "no rest" and "with rest" examinations. In the frequency analysis, a significant difference was observed in a part of the high frequency region. At higher frequencies, the "with rest" examination was even lower in power. [CONCLUSIONS] In the "with rest" examination, there may be a relationship with a decrease in muscle tone, and it appeared to detect the difference of the control system with no rest. In screening tests in the general clinical setting, it is suggested that there is no problem in conducting examinations without allowing patients to rest between the "eyes open" and "eyes closed" tests.

X - Vestibular function and disorders

P3-X-184 Abnormal subjective vertical perception in patients with vestibular migraine

Mitsuhiro Aoki¹, Hisamitsu Hayashi¹, Bunya Kuze¹

¹Gifu University Hospital

BACKGROUND: The prevalence of vestibular migraine (VM) is about 1% in all population. However, no definitive diagnostic test has been evaluated. The onset of VM attack may be associated with abnormal overactivity vestibular-thalamic pathway, developing subjective vertical perception. Hypothetically, the VM patients may have an abnormality of the vertical perception by central regions involved in central vestibular pathways, central sensory pathways and other regions related to visuospatial analysis. Objective: We, therefore, investigated whether the VM patients the larger variance of the SVV and the SVV variance is helpful for differentiating the VM with cochlear signs from early MD. In addition, we investigated the subjective visual vertical (SVV) perception of the VM patients and a clinical significance of the SVV test for differentiating the VM from Meniere's disease. **METHODS:** This study consisted of patients with vestibular migraine





(n=20, VM), Meniere's disease (n=20, MD), psychogenic vertigo (n=20, PD) and other peripheral vertigo (n=94, OP). A 15-cm long rod (5 mm wide) charged fluorescent tape was placed at eye level in front of the subjects at a distance of one meter in complete darkness (i.e., without a frame or optokinetic stimulation in the background). Each subject was seated with their head held in place by a chin-rest and asked to adjust the rod to gravitational vertical by rotating the handle of a potentiometer. The average deviation and the variance of the actual values of the eight trials in SVV test were measured. **RESULTS:** The average of the SVV in the VM group was significantly greater than that in the MD group (p < 0.05). The variance of the SVV of the VM group and PD group was significantly larger than that of MD and OP groups (p < 0.01). The SVV variance of the VM with cochlear symptoms group was significantly larger than that of early MD group (p < 0.01). The variance of the SVV reexamined in VM patients showing the larger variance of the SVV in a few months interval were 8.1±8.5 degree (first time) and 6.7±7.2 degree (a few months later) and no significant difference was found between both times (p > 0.05). **CONCLUSIONS:** our results may indicate an abnormal subjective vertical perception in VM patients. We found that the VM patients with the larger variance of the SVV showed the reproducible results in the SVV variance in different time. It may indicate that the degree of the SVV variation may not depend on the degree of subjective dizziness. Furthermore, we suggested that the greater variation of the SVV may apply to not only VM patients but also some patients with migraine, who do not meet the criteria of VM. Furthermore, the variance of the SVV may provide useful information for differentiating VM from MD.

P3-X-185 Recovery of head trunk kinematics during functional movement tasks following unilateral vestibular hypofunction

Lee Dibble¹, Brian Loyd¹, Grace Hunt¹, Mark Lester², Serene Paul³

¹University of Utah, ²Army-Baylor University, ³University of Sydney

BACKGROUND AND AIM: Acute unilateral vestibular hypofunction (UVH), causes loss of gaze stabilization from the vestibulo-ocular reflex and of postural stability from the vestibulo-spinal reflex. While the characteristic en bloc movement associated with acute UVH is well recognized during observational gait analysis, the biomechanical characteristics and coordination of head and trunk behaviors are less well studied. The aim of this study was to longitudinally examine head and trunk kinematics after surgically-induced UVH from the acute period (2-4 days post-surgery) to the subacute period (approximately 6 weeks post-surgery) and compare these behaviors to individuals without UVH. **METHODS:** Twelve Individuals who underwent a unilateral resection of a vestibular schwannoma (VS) and 20 healthy controls were included. VS participants were assessed acutely while in the hospital and again sub-acutely, at their first surgical follow-up visit. Controls were assessed once. Head and trunk kinematics in the pitch and yaw planes were quantified using measurements obtained from wearable sensors (Opals, APDM Inc) positioned on the head, sternum and waist during standardized functional mobility tasks (the Timed up and Go





[TUG] and 6 m straight walking test). TUG time and gait speed were also recorded as secondary outcomes. Longitudinal changes in the VS group were compared using Wilcoxen Signed Ranks tests. Mann-Whitney U tests were used to compare differences between the VS group and healthy controls at the sub-acute time point. RESULTS: Six weeks after resection of VS, individuals improved the amplitude and velocity of their pitch plane head and trunk movements during sit to stand and their yaw plane head and trunk rotational velocity during the Timed up and Go turn relative to their acute post-operative examination, but had not normalized kinematics compared to healthy individuals. No differences in yaw plane kinematics were noted during the 6 meter walk. TUG time and gait speed were significantly different between acute and subacute time periods. (Table 1) CONCLUSIONS: The utilization of standardized functional mobility tasks and wearable sensors allowed the longitudinal examination of the effects of VS surgery on head and trunk kinematics. While it is clear that improvement of head and trunk kinematics occurs from the acute to the subacute period, the recovery of pitch and yaw plane movements at this time appears incomplete relative to healthy controls. Longer follow-up to determine the time course and extent to which individuals post VS surgery normalize head and trunk behavior could aid in more targeted delivery of vestibular rehabilitation.

P3-X-186 Vestibular precision and postural sway variability

Adam Goodworth¹, Yulia Valko², Robert Peterka³, Daniel Merfeld⁴, Faisal Karmali⁵

¹University of Hartford, ²University Hospital Zurich, ³Oregon Health & Science University, ⁴Ohio State University, ⁵Massachusetts Eye and Ear Infirmary

BACKGROUND AND AIM: Sensory feedback plays a considerable role in posture sway and the detection of body motion and orientation. The vestibular organs are unique amongst the sensory systems as they provide cues related to motion and head orientation relative to gravity. Little is known about the role of tilt vs. translational vs. rotational vestibular cues; indeed, the role of otolith organ and semicircular canal cues has been debated. In this study, we examined if inter-subject differences in postural control are correlated with inter-subject differences in detection of vestibular cues. METHODS: To assess vestibular function, we used an established protocol to quantify vestibular direction-recognition perceptual thresholds. Seated subjects were passively moved in the dark via a motorized platform. Directions included lateral translation, vertical translation, yaw rotation, and head-centered roll tilts. The smallest motion reliably discriminated by a subject was determined. Following vestibular threshold tests, postural sway was quantified via center of pressure root-mean-square measures in both sagittal and frontal planes during the Sensory Organization Tests (SOT). Fourteen healthy adult subjects were tested. RESULTS: We had three main results. First, the variability across subjects was high in both threshold measures and posture sway. Coefficient of variation was about 50-60% for posture sway (highest in sagittal plane for SOT tests requiring high reliance on vestibular cues) and between 33-68% for vestibular threshold testing. Second, we found a strong positive relationship between frontal plane postural





sway and lateral translation thresholds, which provide sensory feedback relevant to motion in the frontal plane. There was not a correlation with other threshold measures. There was a correlation between sagittal plane postural sway and lateral translation thresholds, which may be attributed to intersubject correlations between thresholds and sway between the two planes. Generally, since thresholds assay sensory noise in the vestibular system, these results support the hypothesis that sensory noise contributes to postural sway. More specifically, higher precision of vestibular cues in the lateral direction is related to one's ability to limit postural sway in the frontal plane. Third, we found that lateral thresholds had the highest correlation with postural sway in SOT conditions that cause elevated vestibular weights. This result is consistent with postural sway being more influenced by vestibular noise when vestibular weights are higher. CONCLUSIONS: High inter-subject variability in posture sway and vestibular thresholds was leveraged in our study design to examine correlations. Lateral translation vestibular thresholds were correlated with posture sway amongst the 14 healthy adults investigated; and this correlation was strongest in SOT conditions requiring the highest vestibular reliance. Our results generally show that precision of vestibular cues contributes to sway variability in healthy subjects and suggests that the sensation of lateral translation is an important contributor. ACKNOWLEDGEMENTS AND FUNDING: NIH NIDCD R03-DC013635 (FK). NIH/NIDCD R01-DC04158 (DMM).

P3-X-187 Risk of falling in bilateral vestibulopathy: How should we predict this?

Nolan Herssens¹, Evi Verbecque², Wim Saeys¹, Luc Vereeck¹, Bieke Dobbels³, Julie Moyaert³, Vincent Van Rompaey¹, Ann Hallemans¹

¹University of Antwerp, ²University of Hasselt, ³Antwerp University Hospital

BACKGROUND AND AIM: Patients suffering from bilateral vestibulopathy (BVP) experience severe balance deficits due to the underlying partial or complete vestibular loss, which is linked to a greater risk of falling (RoF)1,2. Fall-related injuries and fear of falling can result in a decline of social interaction and quality of life. Therefore predicting the patient's individual RoF seems useful to improve symptomatic therapeutic planning for BVP. **METHODS:** Twenty-four BVP-patients were included based on the diagnostic criteria suggested by the Bárány Society². Fall risk was investigated through static, functional and dynamic balance tests. Static balance tests included standing on a firm surface, foam, tandem stance and one-legged stance, both with eyes open and closed for 30 seconds. Functional and dynamic balance was tested through the Timed Up-and-Go (TUG), Five times Sit-to-Stand (5-STS) test, Tinetti POMA and Functional Gait Assessment (FGA). **RESULTS:** Ages ranged from 33-74 years (15 men;9 women). None of the patients were able to complete the standing on foam with eyes closed condition while healthy elderly (60-89 years) should be able to keep standing for 10 seconds³. Based on the performances on the TUG (8.51±4.62s) and 5-STS (12.85±7.33s), only 2 and 8 patients respectively showed an increased risk of falling. Results of the Tinetti test (23.33±2.91) indicated low (n=14) to moderate (n=9) and high (n=1) risk of falling, while FGA-performances (18.04±5.29) indicated an increased risk of

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falling in 18 patients4 (Fig. 1). **CONCLUSIONS:** Testing without perturbation of sensory modalities (TUG/5-STS) does not reflect the true risk of falling in bilateral vestibulopathy patients. Whenever one or more sensory perturbations are present, for example during the FGA, the majority of the patients are not able to perform up to standard. This may indicate an increased reliance on visual or somatosensory information to counter the loss of vestibular input. In unperturbed circumstances, this substitution of vestibular information with visual or somatosensory information appears to be sufficient. However, whenever multiple sensory perturbations are present, the compensation mechanisms seem to fail and bilateral vestibulopathy patients show an increased risk of falling. 1. Schniepp et al. (2017) J Neurol 264(2), 277-83 2. Strupp et al. (2017) J Vestib Res 27(4), 177-89 3. Vereeck et al. (2008) Int J Audiol 47, 67-75 4. Saman et al. (2014) J Neurol Surg B 75, 332-8 **ACKNOWLEDGEMENTS AND FUNDING:** This work was supported by the University of Antwerp Research Council [grant number ID33586], the University of Antwerp and the Antwerp University Hospital.

Y - Visual function and disorders

P3-Y-188 Virtual perturbations: Individual differences in static posture

Robert McIlroy¹, Michael Barnett-Cowan¹

¹University of Waterloo

Introduction The effect of vision on the maintenance of standing posture has been assessed using various research methods and paradigms. Removing visual information increases postural sway during quiet stance, while dynamically moving visual scenes can result in illusory perceived self-motion, which in turn can initiate compensatory postural sway. Such findings reinforce the theory that visual information is critical in providing environmental cues to the central nervous system (CNS) for planning movements and detecting our relative motion in the external environment to maintain balance. The availability and accessibility of virtual reality (VR) has presented a unique opportunity when investigating the role of visual information and the control of standing posture. VR allows users to be exposed to unique immersive environments that would under most circumstances not be able to be presented in a lab setting. Hence, the primary goal of this research is to explore how postural responses change when the presented visual scene is perturbed during situations of varying postural threat. This research can in turn provide insight into how the CNS utilizes visual cues from the environment to alter postural responses to perceived instability. Methods Participants wore a VR head mounted display and were presented with a virtual scene depicting a home in Tuscany. Participants were placed at two positions that varied in their threat to postural stability. The first position was at ground level and the second was at the top of a set of stairs. Visual perturbations either mimicked falling forward or backward by rotating the VR point of view camera, based on a modelled perturbation of an inverted pendulum in a 1-G environment, or a forward or backward linear translation whose velocity profile was





equivalent to falling camera motion. Two force plates quantified centre or pressure (COP) sway characteristics during the various conditions. In addition, bilateral surface electromyography (EMG) was measured from the medial gastrocnemius and tibialis anterior to detect lower limb muscle onset and amplitude. Two accelerometers were utilized; one placed on the head to detect head movement and the second placed on the sternum to measure and upper torso movement. **Results** Initial results show highly variable COP sway responses between participants. These individual differences vary from: i) no noticeable pattern of COP sway response, ii) consistent direction-dependent postural sway patterns, or iii) increased COP sway only in the presence of increased visual threat at heights. These results will be discussed with respect to individual differences in EMG and accelerometer data in effort to determine whether participants exhibited whole body postural responses to the visual stimuli or whether their reactive responses are limited to head deviations. **Conclusion** Postural responses evoked through the use of VR could play an important role in further developing our understanding of how the CNS interprets and perceives visual cues. Gaining a greater understanding of how visual information drives postural responses, and how this varies within the population can potentially assist in our approach of rehabilitative strategies of postural control.

P3-Y-189 Visual exploration during walking and turning in mild traumatic brain injury and controls

Samuel Stuart¹, Lucy Parrington¹, Doug Martini¹, Peter Fino², James Chesnutt¹, Laurie King¹

¹Oregon Health & Science University, ²University of Utah

BACKGROUND AND AIM: Visual exploration of the environment is vital for safe and effective mobility. Visual exploration encompasses saccadic eye movements and fixations that are influenced by cognitive processes. Cognitive deficits are common in mild traumatic brain injury (mTBI) and likely affect visual exploration, which may contribute to walking problems. These preliminary analyses 1) investigated visual exploration during walking in mTBI in response to different environmental and attentional demand compared with healthy controls; and 2) examined the relationship between visual exploration, symptom severity and cognition in those with mTBI. METHODS: Ten healthy control (age 21.0±5.2 years) and 9 mTBI (age 19.2±13.6 years, 50.1±13.8 days since injury) subjects walked under different environmental conditions (straight ahead and while completing a turning course) and attentional loads (single- and dual-task). Real-time visual exploration was measured during walking using a mobile eye-tracker (100Hz, Tobii pro-Glasses2). Outcomes included saccade frequency (sacc/sec), amplitude (°), peak velocity (°/sec) and fixation duration (sec). Symptom severity was measured with the sports concussion assessment tool (SCAT3) and cognition was measured with the automated neuropsychological assessment metrics (ANAM) computer battery. **RESULTS:** Fixation duration when walking was significantly increased in mTBI compared to controls when turning under dual-task conditions (p=0.03). This suggests that people with mTBI require more time for visual processing of regions of interest than





controls when attention is distracted. Interestingly, dual-task fixation duration did not relate to cognitive performance or symptom severity within mTBI, which suggests that it may be a purely motor deficit. There were no significant differences between groups in other visual exploration metrics, however the mTBI group had non-significantly reduced saccade frequency, peak velocity and increased saccade amplitude when walking compared to controls. Within the mTBI group, these changes in visual exploration related to worse symptoms. Specifically, longer fixation duration and smaller saccade amplitude during single-task walking with turns related to worse cognitive ability (ANAM composite score) (r=-0.78, p=0.01), and greater symptoms severity (SCAT3 symptom evaluation) (r=-0.74, p=0.02), respectively. Across groups there were few significant differences in visual exploration in response to environmental complexity and attentional demands. However, saccade amplitude increased with greater attentional demand (dual-task) (F=9.78, p=0.01) in both groups. CONCLUSIONS: These preliminary results indicate that visual exploration metrics, particularly fixation duration, may be deficient during walking tasks in people with mTBI compared with healthy controls, and relate to symptom severity and cognitive ability. However, these subtle deficits in visual exploration may only be prominent during complex tasks (walking while turning under dual-task conditions), with implications for future functional assessments (i.e. tasks involving multiple systems) in mTBI. Future work will establish findings within a larger cohort. ACKNOWLEDGEMENTS AND FUNDING Funding No. W81XWH-17-1-0424 (PI: King).

P3-Y-190 Measuring dynamic balance control in children with cerebral palsy

Ruud Van der Weel¹, Audrey van der Meer¹

¹Norwegian University of Science & Technology

BACKGROUND AND AIM:Prospective dynamic balance control was examined in children with CP and compared to typically developing children using the tauG. Centre of pressure (CoP) movement data of the weight shift onto the supporting foot during gait initiation were collected from a force platform and ground reaction forces were used to calculate the CoP movement in the anteroposterior (CoPy) and mediolateral (CoPx) direction, which in turn was tauG analysed. **METHODS:** Nine children aged 7-17 years diagnosed with CP and 11 typically developing controls 6-14 years of age were included in this study. Tau of the CoP motion gap (τ CoP) was τ -coupled onto an intrinsic tauG-guide (τ G) for the movement, by maintaining the relation CoP = K τ G, for a constant K. **RESULTS:** Since the r2 values were above 0.95 and the tauG guidance percentage was 100% in all trials, the analysis implied that τ CoPx and τ CoPy were proportional to the intrinsically generated τ G-guide for the movement, and that the retrieved K values can be considered good indicators of the extent of balance control. A significant difference of the K values between the groups was found in both CoPy and CoPx direction. The K values of the CP group were significantly higher than 0.5 in both CoPy and directions indicating that the CoP movement of children with CP collided with the boundaries of the base of support in both CoP directions





during the weight shift of gait initiation (K > 0.5). The control group retrieved K values significantly higher than 0.5 only in the CoPx direction indicating touch contact with the boundaries of the base of support. **CONCLUSION:** The findings may, together with previous studies, provide us with a measure for further testing prospective balance control of people with motor disorders.

ORAL ABSTRACTS

O.1. Parkinson's disease

O.1.i Episodic motor impairments of falls and freezing of gait differ in regional cerebral central cholinergic system changes in Parkinson's disease

Nicolaas Bohnen¹, Prabesh Kanel¹, Zhi Zhou¹, William Dauer¹, Roger Albin², Martijn Muller¹

¹University of Michigan, ²University of Michigan & VAMC

BACKGROUND AND AIM: Postural instability and gait difficulties (PIGD) features represent debilitating disturbances in Parkinson's disease (PD). Prior acetylcholinesterase positron emission tomography (PET) imaging studies implicate cholinergic pathways degeneration as significant contributors to PIGD features. These studies were limited in quantification of striatal and cerebellar cholinergic synapse integrity. Vesicular acetylcholine transporter (VAChT) PET ligands are better suited for evaluation of high binding areas. This study examined associations between regional VAChT expression and freezing of gait (FoG) and falls PIGD features. **METHODS:** Ninety-four PD subjects (sex: 72 males/22 females; age: 67.9 ± 7.6 yrs; Hoehn & Yahr stage: 2.5 ± 0.6 ; duration of disease: 6.0 ± 4.5 yrs) underwent clinical assessment and VAChT ([F-18]FEOBV) PET imaging. **RESULTS:** Thirty-five subjects (37.2%) reported a history of falls and 15 (16%) had observed FoG. Univariate volume-of-interest (VOI) analyses demonstrated significantly reduced thalamic (P =





0.0016) VAChT expression in fallers compared to non-fallers. VAChT expression was significantly reduced in the striatum (P = 0.0012) and limbic archicortex (P = 0.004) in freezers compared to non-freezers. Exploratory and complementary whole brain voxel-based analyses of FEOBV PET demonstrated several key regions associated with falling history including the right visual thalamus (especially the right lateral geniculate nucleus, LGN), right caudate nucleus, and bilateral prefrontal regions. Freezers had prominent VChAT expression reductions in the bilateral striatum, notably the right more than left caudate and accumbens nuclei, temporal and mesiofrontal limbic regions. **CONCLUSIONS:** Our findings confirm previous PET findings of thalamic cholinergic deficits associated with falling history and now emphasize right visual thalamus complex changes, including the right LGN. FoG status is associated with reduced VAChT expression in striatal cholinergic interneurons, in particular the right caudate nucleus, and the limbic archicortex. These observations suggest different network changes underlying falls and FoG in PD. **ACKNOWLEDGEMENTS AND FUNDING:** National Institutes of Health, Department of Veterans Affairs grant, and the Michael J. Fox Foundation.

O.1.ii Immediate and long term effects of intensive multimodal balance and gait training on gait and gait variability in Parkinson's disease

Linda Rennie¹, Niklas Löfgren², Erika Franzén²

¹Sunnaas Rehabilitation Hospital, ²Karolinska Institutet

BACKGRUOND AND AIM: Disturbances of continuous gait is prevalent in individuals with Parkinson's disease (PD), affecting multiple aspects of walking. Exercise is an important adjunct to pharmacological treatment in the management of PD. Intensity, specificity, and complexity of practice are important parameters in facilitating motor learning, also in gait re-education, driving potential lasting effects on both brain and behaviour. The aim was therefore to evaluate the immediate and long term effects of intensive multimodal balance and gait training on gait and gait variability variables for individuals with PD, measured at both self-selected normal and fast gait speed. METHOD: 100 (56 males) subjects with idiopathic PD, Hoehn & Yahr 2 (n=44) and 3, and i Y 60 years were included. Participants randomized to the intervention group partook in 10 weeks of balance and gait training. The control group continued with activities as usual. Spatiotemporal gait variables at self-selected normal and fast gait speeds were collected using a pressuresensitive mat, at baseline, post-intervention and at 6 and 12 months post-intervention. A linear mixed model was used to investigate group differences immediately after the training period, and for the follow-up time points. RESULTS: The training group showed increased gait speed for normal (8.3 cm/s, p=0.03) and fast speed (10.7 cm/s, p=0.04). This was due to both increased step length (normal: 3 cm, p=0.05; fast: 2.3 cm, p=0.05), and cadence (normal: 2.7 steps/min, p=0.03; fast: 5.1 steps/min p=0.03) as compared to the control group immediately after the





training. Reduced stance time (normal: -24 ms, p=0.01; fast: -30 ms, p=0.02) was also seen, mainly due to less time spent in double support (normal: (-29 ms, p>0.01; fast -22 ms, p=0.04). Additionally, for the fast gait speed condition only the training group had significantly reduced swing time (-9 ms, p=0.04), and reduced variability in stance time (-4 ms, p=0.02), swing time (-3 ms, p=0.02) and step time (-3 ms, p=0.02) compared to controls. None of the significant group differences were maintained at the 6 and 12 month follow-up. CONCLUSIOIN: The reduced time spent in double support suggests improved control and effectiveness during stepping which in turn impacts the ability to take longer steps at higher step frequencies. Additionally, the improvement seen in gait variability variables during fast walking suggests improved postural and motor control. However, lasting positive effects were not retained after 6 months, and at least biannual bouts of intensive multimodal balance and gait training is recommended to uphold gait function in the mild to moderate stages of PD.

O.1.iii Comprehensive measures of balance and gait in GBA mutation carriers and non-carriers in Parkinson's disease

Rosie Morris¹, Douglas Martini¹, Katrijn Smulders², Valerie Kelly³, Amie Hiller¹, Kathy Chung¹, Shu-Ching Hu³, Cyrus Zabetian³, Kathleen Poston⁴, Ignacio Mata³, Karen Edwards⁵, Thomas Montine⁴, Joseph Quinn¹, Fay Horak¹

¹Oregon Health & Science University, ²Sint Maartenskliniek, ³University of Washington, ⁴Stanford University School of Medicine, ⁵University of California

BACKGROUND AND AIM Gait and balance difficulties are cardinal features of Parkinson's disease (PD) with impairment varying across patients. Genetic variation might account, in part, for this heterogeneity. Variants in the glucocerebrosidase (GBA) gene are the strongest known genetic risk factor for PD and are associated with younger onset, faster disease progression, greater motor severity, and higher rate of cognitive impairment. Previously, patients with GBArelated PD have demonstrated a faster decline in the postural instability and gait difficulty (PIGD) phenotype, representing greater balance and gait impairment. However, comprehensive measures of balance and gait have not been assessed in this genetic cohort of PD. Therefore, we aimed to assess differences in comprehensive measures of balance and gait in PD patients with and without GBA variants. methods One-hundred and seventy-seven people with PD were recruited to the Pacific Udall Center (PUC), comprised of three sites: VA Puget Sound/University of Washington, Seattle; Oregon Health & Science University/Portland VA Medical Center, Portland; and Stanford University. Genomic DNA extracted from blood or saliva was used to determine GBA status. Seventeen characteristics of gait representing four domains (pace & turning, rhythm, variability, and trunk movement) were measured during a two-minute continuous walk whilst wearing six inertial body worn sensors (APDM, Portland, OR). Thirteen comprehensive





measures of balance representing four domains (sway area & jerk, sway velocity, sway frequency medio-lateral, and sway frequency anteroposterior) were assessed during a sixty-second quiet stand. A one-way ANCOVA compared groups controlling for age, gender, disease duration, and site. An $\alpha \leq 0.05$ was deemed significant. Results Thirty-two of the 177 participants carried a GBA mutation or the E326K polymorphism. GBA carriers were significantly younger (p=.027), a higher daily levodopa dose (p=.05), and worse cognition (p<.01). MDS-UPDRS III was significantly worse in GBA carriers when controlling for levodopa dose (p=.01). GBA carriers demonstrated slower pace & turning (reduced speed [p<.01], shorter stride length [p<.01], reduced foot strike angle [p=.03] and slower turns [p=.05]), poorer rhythm (swing time [p<.01] and stance time [p<.01]) and increased variability across all measures (all p<.05). In addition, mutation carriers demonstrated greater sway & jerk (sway area [p<.01], Jerk AP [p<.01], Jerk ML [p<.01] and RMS ML [p<.01]), medio-lateral sway velocity (p=.04) and sway frequency in the anteroposterior direction (p<.01). Conclusions In our cohort, GBA carriers exhibited more severe disease than non-carriers, representative of other GBA cohorts. Furthermore, GBA carriers demonstrated greater impairment in discrete measures of balance and gait. This suggests that therapeutics targeting GBA might be useful for improving gait and balance and in turn reduce falls in this population of PD.

O.1.iv Effects of a 6-week cognitively challenging agility exercise program in people with Parkinson's disease

Martina Mancini¹, Fay Horak¹, Naoya Hasegawa¹, Se Hee Jung¹, Vrutangkumar Shah¹, Anjanibhargavi Ragothaman¹, Daniel Peterson², Katrijn Smulders³, Patricia Carlson-Kuhta¹, John Nutt¹, Laurie King¹, Jodi Lapidus¹, Martina Mancini¹

¹Oregon Health & Science University, ²Arizona State University, ³Sint Maartenskliniek

BACKGROUND AND AIM: Falls in people with Parkinson's disease (PD) have a multifactorial causation, and gait and balance impairments are a major contributor to this important problem. In PD, gait and balance impairments have been associated with cognitive deficits. Hence it may be helpful to integrate cognitive challenges into mobility rehabilitation. We previously designed a cognitively challenging Agility Boot camp (ABC-C) rehabilitation program for patients with PD. In the current analysis, we report the effect of this short, 6-week program on clinical, perceived, and objective measures of balance and gait in people with PD. **METHODS:** In this cross-over design, 94 people with PD (age 68±7, MDS-UPDRS III: 42±12; mean±SD), of which 40 with Freezing of Gait, completed 6-weeks of ABC-C exercise program and 6-weeks of Education classes (placebo), with the order of interventions randomized. Outcome measures (Off medication) included clinical (mini-BESTest and MDS-UPDRS III, and the MDS-UPDRS sub-score of Postural Instability and Gait Disorder [PIGD]), perceived condition (PDQ-39 ADL, MDS-UPDRS II), objective measures of





balance and gait (inertial-sensors), and cognitive function (SCOPA-COG). To evaluate the change in outcome measures, we calculated each of the differences before and after intervention and used a linear mixed-model that included fixed effects, education versus exercise, order (exercise or education first), and period; and random effects, such as subjects. RESULTS: Among clinical measures, the PIGD score improved after the ABC-C program but not after education (p=0.002), while the MDS-UPDRS III and total mini-BESTest did not change (p=0.25, p=0.08, resp). Perceived functional independence showed a significant improvement (PDQ39, p=0.001, and MDS-UPDRS II, p=0.01). Among the objective measures of gait and balance, the following spatio-temporal gait parameters: gait speed, stride length, foot strike angle, and arm swing range of motion, significantly improved after the ABC-C program but not after education (p<0.00001). Postural sway while standing eyes open on foam improved after the ABC-C program but not after education (p=0.03), while postural responses to a Push and Release test did not change. Executive function measured with the SCOPA-COG were similar after the ABC-C program and education (p=0.06), but showed a significant improvement after the ABC-C only in those participants with longer disease duration (p=0.009). Lastly, the dual-task cost on gait speed significantly improved after ABC-C program but not after education (p=0.001). CONCLUSIONS: A 6-week cognitively challenging exercise program significantly improved specific characteristics of gait and balance in a large group of patients with PD. The outcomes that improved the most with exercise were the objective measures of balance and gait. When correcting for multiple comparisons, spatiotemporal parameters of gait, dual-task cost of gait, perceived functional independence, and PIGD were the most sensitive to change after exercise compared to after education. ACKNOWLEDGMENTS: R01 AG006457, I01 RX001075-01.

O.1.v Textured insoles improve gait in people with Parkinsons disease who have impaired peripheral sensation

Graham Kerr¹, Feng Qiu¹, Keith Davids², Ewld Hennig¹, Michael Cole³, Sandy Brauer⁴, Anna Hatton⁴

¹Queensland University of Technology, ²Sheffield Hallam University, ³Australian Catholic University, ⁴University of Queensland

BACKGROUND AND AIM: People with Parkinson's disease (PD) have reduced peripheral sensation, which is associated with increased postural instability during standing and walking. Increased postural instability is associated with increased risk of falls. The objective of this study was: 1. to quantify the peripheral sensory deficits in people with PD; and 2. to determine whether enhanced somatosensory information provided by textured insoles would improve gait. **METHODS:** Participants were 20 people with early stage PD (Hoehn & Yahr 1.4+/-0.9; UPDRS 40.9+/-17.9) and 20 age- and gender-matched controls, all of whom were free of signs of dementia







(Addenbrookes >83). PD participants were optimally medicated. Peripheral sensation was assessed with monofilaments at the lateral malleolus and nine other positions on the soles of the feet. Thresholds for temperature, vibratory perception and nociception (pain) of the feet were also assessed. Electrophysiological assessment of 1) the peroneal nerve; 2) the tibial nerve; and 3), the sural nerve of the dominant leg provided measurements of nerve conduction velocity, latency and amplitude, F wave latency and amplitude. Dominant lower extremity somatosensory evoked potentials in terms of latency between two input marks (N20-Lumbar ~20ms and P37-Cranial ~37ms) were recorded after stimulation of the posterior tibial nerve at the ankle. Gait was assessed during walking while barefoot, and while wearing smooth and textured insoles inserted into standardised footwear (soft canvas upper, shankless rubber sole). Walking was assessed on firm and uneven surfaces using 3D motion analysis (Vicon). Vicon data were used to derive temporospatial variables of stride length, cadence, double-support time, stride time variability. **RESULTS:** Touch discrimination thresholds were increased across the whole plantar surface of the foot in PD patients relative to controls. Thresholds for temperature, pain and vibration were also increased for PD patients. Electrodiagnosis of peripheral nerves revealed that both motor (peroneal & tibial) and sensory (sural) nerves had slower nerve conduction velocities for PD patients. Somatosensory evoked potentials from posterior tibial nerve stimulation were also of longer latency. During walking on the firm surface with textured insoles there was a significant reduction in the double-support phase of gait for PD patients to a level similar to controls. Both groups benefited from the textured insole on the uneven surface. Use of the textured insoles also resulted in increased stride length for both groups on the firm surface, and minor improvement for the PD patients on the uneven surface. CONCLUSIONS: Impairment in peripheral nerve function and sensation was associated with Gait impairment in PD. In both PD and healthy control participants, textured insoles produced an immediate improvement in walking.

O.1.vi Test-retest reliability and minimal detectable change of the new freezing of gait questionnaire

Pieter Ginis¹, Carolien Strouwen², Bauke Dijkstra¹, Bastiaan Bloem³, Alice Nieuwboer¹

¹KU Leuven, ²Hasselt University, ³Radboud University Medical Center

BACKGROUND AND AIM: Freezing of gait (FOG) is one of the most disabling symptoms that patients with Parkinson's disease (PD) can experience. Clinical trials to alleviate FOG are hampered by a lack of reliable and responsive outcome measures. The New Freezing of gait questionnaire (NFOG-Q) is currently a widely used and validated tool to quantify FOG severity over the past month. It is fast and easy to administer and does not require additional equipment. However, to properly interpret NFOG-Q scores, the reliability and minimal detectable change estimates (MDC) are crucial, but still unknown. Therefore, this study determined the test-retest





reliability and responsiveness of the NFOG-Q. METHODS: As part of the Duality clinical trial, 117 PD patients completed the NFOG-Q at two baseline assessments (T1 and T2), separated by an interval of six weeks without intermediate intervention. Freezers were identified at T1 based on a NFOG-Q score ≥1. A T-test was used to detect systematic differences in NFOG-Q scores between T1 and T2 in freezers only. Reliability of NFOG-Q scores was calculated using an ICC two-way mixed effects model with absolute agreement for single measures. MDC was calculated using the formula MDC=SEM*1.96* $\sqrt{2}$ whereby SEM=SDpooled* $\sqrt{(1-ICC)}$. **RESULTS:** Among the 117 PD patients, 57 were identified as freezers and 60 as non-freezers at T1. After six weeks, the NFOG-Q classified seven initial non-freezers (11.7%) as freezers and seven freezers (12.2%) as nonfreezers. Among the 57 initially identified freezers, the mean (SD) NFOG-Q score was 12.88 (5.53) at T1 and 12.00 (7.07) at T2 (p=0.20), reflecting no systematic differences between both assessments. The ICC (95% CI) between both tests was 0.81 (0.68 - 0.89), indicating a moderate to good test-retest reliability of the NFOG-Q. MDC was determined as 9.35 points, meaning that an improvement of 10 points or more is required before an intervention can be considered effective according to the NFOG-Q. Considering the 50 patients who scored >1 on the NFOG-Q at both moments, ICC (95%) was 0.77 (0.59 - 0.87) and MDC was 10.35, which indicates that including only freezers whom repeatedly scored >1 on the NFOG-Q, does not improve the reliability and MDC of the NFOG-Q. CONCLUSIONS: The analysis shows that over a period of 6 weeks without intermediate training, the NFOG-Q noted a change in freezing status in about 12 percent of study participants, possibly implicating a classification limitation of the NFOG-Q. Furthermore, the NFOG-Q is a useful screening tool to differentiate between freezers and nonfreezers with good test-retest reliability. However, based on the large MDC, the NFOG-Q appears not sufficiently responsive to detect small effect sizes. Based on these results, we recommend not to use the NFOG-Q as a primary outcome for intervention studies. Future work on testing the psychometrics of wearable sensor-based measures as an objective digital biomarker for detecting FOG is therefore urgently needed.

O.1.vii Gait deficits in early stage Parkinson's disease are related to the expression of REM sleep without atonia

Sommer Amundsen Huffmaster¹, Matthew Petrucci¹, Devin O'Connell¹, Maria Linn-Evans¹, Jae Woo Chung¹, Aleksandar Videnovic², Paul Tuite¹, Colum MacKinnon¹

¹University of Minnesota, ²Massachusetts General Hospital

BACKGROUND AND AIM: Advancing Parkinson's disease (PD) is associated with the emergence of postural instability and gait disturbances. These symptoms tend to occur earlier and be more severe in people that have PD and rapid eye movement (REM) sleep behavior disorder (RBD). RBD is a parasomnia characterized by dream enactment and elevated muscle activity during REM



sleep (termed REM sleep without atonia, RSWA). We tested the hypotheses that: (1) people with early stage PD who express abnormal RSWA (PD-RSWA+) would show significant changes measures of steady-state gait compared to those with PD without RSWA (PD-RSWA-) and matched controls; and (2) that the level of gait impairment would correlate with measures of RSWA (tonic and phasic EMG activity). METHODS: Thirty individuals with PD were tested (17 PD-RSWA+, age 65.0 ± 7.3; 13 PD-RSWA-, age 62.5 ± 7.8) and 12 matched control subjects (age 62.5 ± 8.0). Categorization of RSWA group was based on overnight polysomnographic recordings and blinded scoring of EMG activity in the chin, arm and leg muscles. Steady-state gait was tested after overnight withdrawal from PD medications by collecting more than 35 steps on an oval course containing a GaitRite walkway (CIR Systems, Inc.). Standard spatial and temporal gait characteristics were computed. Asymmetry was tested by comparing the most-affected (MA) and least-affected (LA) sides. RESULTS: There were no significant differences between PD groups in clinical measures of motor disease severity. A one-way ANOVA showed significant differences (p < 0.05) between the PD-RSWA+ group and controls for measures of gait speed, normalized speed (leg length/s), step lengths (% leg length, %LL), stride lengths (%LL), and double support times for both sides. There was a significant correlation between deficits in gait speed and normalized step/stride lengths and the amount of phasic EMG in the leg muscles during REM sleep in the PD-RSWA+ group (r = -0.6, p = 0.01), but not in the PD-RSWA- or control group (p > 0.05). Correlations between RSWA and gait deficits in the PD-RSWA+ group were specific to the leg muscles and not chin or arm recordings. CONCLUSIONS: These results demonstrate that reductions in gait speed, particularly through changes in step length, in early stage PD are related to the abnormalities in the muscle tone regulation in the leg muscles during REM sleep. RBD is associated with development of alpha-synucleinopathy in brainstem structures that control both REM sleep muscle tone and locomotion (pedunculopontine nucleus and reticular formation). Our findings suggest that abnormally elevated RSWA may be a biomarker of early locomotor brainstem dysfunction. ACKNOWLEDGEMENTS AND FUNDING: We thank the volunteers for participation in this research. This work was supported grants NIH RO1 NS070264 & NS088679 (CDM), NSF NRT Fellowship DGE-4731815 (MLE), the Wallin Neuroscience Foundation (JWC), and the MnDRIVE Fellowship (SLAH).

O.1.viii Inter-individual balance adaptations in response to perturbation treadmill training in Parkinson's disease

Sarah Klamroth¹, Heiko Gassner¹, Jürgen Winkler¹, Björn Eskofier¹, Jochen Klucken¹, Klaus Pfeifer¹, Simon Steib¹

¹Friedrich-Alexander University (FAU) Erlangen-Nürnberg





BACKGROUND AND AIM: Perturbation training is a promising approach for fall prevention in Parkinson Disease (PD) [1]. So far, only little is known about the underlying mechanisms in balance adaptation, and previous findings indicate that persons with PD respond differently to this form of training [2]. Therefore, we aimed at gaining a better understanding of inter-individual differences in balance adaptations in response to regular perturbation treadmill training (PTT) in PD. METHODS: 43 PD patients (Hoehn & Yahr stage 1-3.5) were randomly assigned to either 8 weeks of perturbation treadmill training (PTT; n=21) or conventional treadmill training (CTT; n=22). For PTT, a tiltable platform below the treadmill created an uneven walking surface, thereby constantly applying perturbations to patients' balance control. At baseline and post intervention, data from four domains of balance function were collected: 1) balance during quiet stance, 2) reactive postural adjustments, 3) anticipatory postural adjustments, 4) dynamic postural control. For evaluation of inter-individual differences in balance adaptations, a responder analysis (using anchor- and distribution-based methods) with calculation of responder rates and relative risk ratios (RR) with 95%-Confidence Interval (CI) were performed. To identify differences in patientspecific characteristics between responders and non-responders, Mann-Whitney U test and independent samples t-test were used. RESULTS: PTT revealed larger responder rates (22% -44%) in comparison to CTT (CTT: 5% - 19%) in all measures, with a significant between-group effect in the Mini-BESTest subscore reactive postural control (PTT = 44 %; CTT = 10 %; RR = 4.22, CI 1.03-17.28). Most pronounced balance adaptations were observed for PTT in reactive and dynamic balance. Further, responders from the PTT group were characterized by lower balance and cognitive function at baseline, higher age and advanced disease stage, compared to non-responders. CONCLUSIONS: Our findings suggest that PTT may lead to meaningful improvements in reactive but not proactive balance-recovery strategies in PD. Thus, integration of different perturbation types, during dynamic as well as static motor tasks, may be beneficial to enhance various postural control strategies. Importantly, there were large differences in interindividual balance adaptations in response to PTT, with patients with fall risk factors possibly benefiting the most. These preliminary results on inter-individual balance adaptations and potential outcome predictors require further attention in well-designed trials, in order to evaluate the need of an individual-based approach for fall prevention in PD. ACKNOWLEDGEMENTS AND FUNDING: The study was financed by the Emerging Fields Initiative of the FAU (Germany) and the German Foundation Neurology (Deutsche Stiftung Neurologie). REFERENCES:[1] Gerards, M. H. G.; McCrum, C.; Mansfield, A.; Meijer, K. (2017). Geriatrics & gerontology international 17 (12), S. 2294-2303. [2] Barajas, J. S.; Peterson, D. S. (2018). Journal of neurology 265 (5), S. 1138-1144.

O.2 Aging and Falls



O.2.i Prevention of cautious strategy in obstacle-avoidance situations in older adults: The effect of spatial constraints on collision-avoidance behavior

Takahiro Higuchi¹, Risa Okada¹, Ryo Watanabe¹, Takuya Goto¹, Tomoki Hakamata¹, Ryota Hiyoshi¹, Ryuma Yonemoto¹, Akiko Imura¹

¹Tokyo Metropolitan University

BACKGROUND AND AIM In the course of their daily locomotor activities, many older adults display difficulty in avoiding collision with obstacles. In an experimental setting in which they are asked to avoid collision, however, they often show no collision. One reason for the discrepancy in collision occurrence between practical and experimental situations is that the participants tend to be more careful than usual to avoid collision in the experimental one. To clearly observe collisions even in an experimental setting and investigate how the collisions occur, we propose the effectiveness of introducing spatial constraints on the collision-avoidance behavior; that is, older adults are asked to avoid collision while they try to create a minimal spatial margin between the body and the obstacle. Methods Thirty-four older adults (72.6 ± 3.9 yrs old) and 12 younger adults $(26.2 \pm 7.6 \text{ yrs old})$ participated. They were asked to hold a parallel bar with a length 0.8, 1.5, or 2.2 times their shoulder width and walk through a narrow opening without collision under two conditions. In one condition (constrained condition), participants were instructed to do so while try to create the smallest possible spatial margin between the body and the obstacle. In the other condition (unconstrained), they were allowed to freely employ obstacle-avoidance behavior (e.g., body rotation at the time of crossing). **Results** The rate of collision with the door, which created the narrow opening, was significantly higher for the older participants. Notably, the collision rate was particularly higher under the constrained condition. With regard to the spatial margin created between the door and the parallel bar at the time of crossing, older participants showed a significantly smaller margin under the constrained condition than under the unconstrained condition. This was in contrast with the results of younger participants, who showed no difference between these two conditions. Conclusions We demonstrated that spatial constraints on the collision-avoidance behavior required of older participants ensured the occurrence of collisions even in an experimental setting. Analyses of spatial margins show that older adults are likely to have difficulty fine-tuning their collision-avoidance behavior. When asked to create a minimal spatial margin between an obstacle and the body, they tried to suppress making the collisionavoidance behavior more than usual, which results in frequent collision.

O.2.ii The association of clinic-based mobility tasks and measures of community performance and risk

Michele Callisaya¹, Joe Verghese²





¹University of Tasmania, ²Albert Einstein College of Medicine

BACKGROUND AND AIMS: Gait speed predicts a range of adverse outcomes in older people including mobility disability and falls. However, it is unknown whether other more complex mobility tasks are better predictors of such outcomes. The aim of this study was to examine a wide range of clinic-based mobility tests and determine which were most strongly associated with measures of community performance and risk (CP&R). METHODS: Participants aged 65 years and over (n= 424) were recruited into the Central Control Mobility and Aging Study, Westchester County, New York. Clinic-based mobility measures included gait speed under normal and dual-task conditions, the Floor Maze Immediate and Delay tasks, and stair ascending and descending. CP&R measures were obtained by standardized questionnaires and classified into measures of performance (distance walked, travel outside one's home [life space], activities of daily living, and participation in cognitive leisure activities) or risk (balance confidence, fear of falling, and past falls). Linear and logistic regression were used to examine associations between the clinic-based mobility measures and CP&R measures adjusting for covariates. **RESULTS:** The mean age of the sample was 77.8 (SD 6.4) years, and 55.2% (n= 234) were female. Quicker walking speed was most strongly associated with 5 of the 7 community measures (greater distance walked, greater life space, better activities of daily living, higher balance confidence, and less fear of falling; all P < .05). Poorer performance on more complex tasks (walking while talking and maze immediate) was associated with less participation in cognitive leisure activities (P < .05) and ascending stairs was the only measure associated with a history of falls (P < .05). CONCLUSION: Walking speed examined at usual pace is a simple and inexpensive clinic-based mobility test that is associated with a wide range of CP&R measures. The addition of measuring stair performance may assist in identifying those at risk of falls and measuring more complex mobility tasks (walking while talking and maze immediate) may identify those with higher level cognitive problems. ACKNOWEDGEMENTS AND FUNDING: National Institute on Aging grants (R01 AG039330, RO1AGO44007, AGO44829 and R01AG036921)

O.2.iii The inter-relationships between glycemic markers and gait patterns across age groups

Maayan Agmon¹, Ram Weiss², Hagit Hochner³, Iaroslav Youssim², Yechiel Friedlander², Tamar Shochat¹, Rachel Kizony¹

¹University of Haifa, ²Hebrew University, ³The Hebrew University of Jerusalem

BACKGROUND: High prevalence of Type 2 diabetes mellitus (T2DM) in the aging population is a major obstacle to successful aging. T2DM is not only a major contributor to cardiovascular morbidity and mortality worldwide but is also related to cognitive decline, increased risk of dementia and reduced mobility. High glucose variability over time was recently proposed as a





marker for accelerated aging. Ability to perform an additional task while walking, i.e., a dual task (DT), declines with age and is related to reduced mobility and cognition. Possible mechanisms of poor DT performance were suggested; however, the contribution of glycemic markers was not examined. The aim of this study was to explore the association between gait with DT and diabetic markers across different age groups. METHODS: One hundred thirty-one participants, age 56-75 years, were recruited as part of a longitudinal study. They were divided into two age groups: 56-65 (n=51) and 66-75 (n=80). Each participant walked for one minute without (single-task; ST) and with (DT) a subtraction-by-seven task. Gait parameters (speed and speed variability) were measured with wireless sensors (APDM Mobility Lab). Trail Making Tests (TMT) A and B were administered to assess executive function. Additionally, fasting glucose, insulin, Haemoglobin A1C (HgA1C) and 7 days glucose monitoring by FreeStyle Libre flash system were collected. Insulin resistance and intra-personal glucose variability within a 7-day period were calculated. Pearson's correlations between these variables were determined. Stepwise linear regressions were performed within each age group; with gait speed variability during DT as dependent variable and glycemic markers included first and TMT B in the second step, as independent variables. **RESULTS:** For the younger group, fasting glucose and HgA1C correlated positively with gait speed variability during ST (r=.47, r=.39; p<.01, respectively) and DT (r=.51, r=.44; p<.01, respectively) and negatively with gait speed during DT (r=-.29, r=-.39; p<.05, respectively). Glucose variability correlated with gait speed variability during DT (r=.44; p<.01). TMT-A correlated with gait speed during ST (r=.-34; p<.05). TMT-B correlated with gait speed variability during ST and DT (r=.62, r=.41; p<.01, respectively) and with fasting glucose (r=.35; p<.05). Regression analysis showed that glucose markers included at the first step explained 26.3% (p<.01) of the variance of speed variability, yet, glucose variability was the only significant independent variable (p=.02). Among the older group, only insulin was correlated with gait speed during DT (r=-.29; p<.05). TMT-A correlated with gait speed variability during DT (r=.26; p<.05) and with gait speed during ST and DT (r=-.32, r=-.30; p<.01, respectively). TMT-B correlated with gait speed during ST and DT (r=-.26, r=-.27; p<.05, respectively). Regression analysis showed no significant associations within this age group. CONCLUSIONS: Glycemic markers were related to gait during DT in all age groups; however, the inter-relationships between variables changed between age groups. The relationships especially in the younger group, may indicate that this group is at higher risk for gait deterioration.

O.2.v Obstacle-induced trip perturbation training: Proactive and reactive adaptation to reduce falls in community-dwelling older adults

Yiru Wang¹, Shuaijie Wang¹, Tanjeev Kaur¹, Tanvi Bhatt¹

¹University of Illinois at Chicago





Background. The study purpose was to investigate to what extent older adults could adapt from obstacle induced trip given in a "blocked-and-mixed" manner during over-ground (OG) gait and whether they could retain the training effects for a short term. **Methods**. 40 community-dwelling older adults (66.4±4.1 yrs) were exposed to a sudden release of an 8-cm tall obstacle during the mid-to-late left swing phase in OG gait. 24 trips were given in 3 blocks in the acquisition training session. Subjects received 2 blocks of 8 trips (T1-T8) and (T9-T16) separated by 3 unperturbed walking trials. The last block comprised a mix of 8 trips and unperturbed walking trials (T17-T24). A trip was given again 30 minutes post-training (RT). Trip recovery outcomes (fall vs. no fall), recovery strategies (lowering-hit: obstructed foot lowered to the ground and unobstructed foot took recovery step; elevating-hit: obstructed foot took recovery step; and elevating-cross: completely avoiding trip) were analyzed. Within-trial changes on proactive and reactive dynamic center of mass (COM) stability (STA), pre-trip toe clearance, trunk angle at recovery completion, recovery step length were analyzed. Results. 48% of subjects fell on their novel trips (T1). Subsequently, fall rate rapidly dropped to 28% on the second trip (T2), 16% on the third trip (T3) and 4% by the end of the first block of training (T8), with no fall on the last, 24th trip (T24). The decrease in the incidence of fall resulted from both improved feedforward and feedback adjustment in the control of COM STA and body kinematics. The proactive adaptations included a reduced forward COM velocity and position that lessened forward instability, and an elevated toe clearance which increased the likelihood of elevating-hit to completely avoid obstacle. The reactive adjustments included a reduced forward instability attributed by both the posterior COM shift and the reduction in its forward velocity, and the improved trunk control (reduced forward rotation) at completion of recovery step. Training effects were retained for at least 30 minutes in terms of fall incidence, that, subjects were significantly more stable and had fewer falls on RT than T1. Though they had decreased to clearance on RT than T24, which induced more obstacle-hits leading to increased forward instability; this deterioration did not impact fall-incidence, which remained the same as in T24. Conclusion. These findings suggested that older adults could demonstrate appropriate locomotor-balance adaptations and shorter-term retention to repeated obstacle-induced trips similar to young adults and thus reduce their likelihood of falls. Effects on fall reduction through a "blocked-and-mixed" designed trip training protocol could be retained for at least 30 minutes. Future studies need to establish efficacy of such perturbation training for longer-term retention and reducing community falls.

O.2.vi Motoric cognitive risk syndrome and risk for falls, their recurrence and post-fall fractures: Results from a prospective observational population-based cohort study

Harmehr Sekhon¹, Gilles Allali², Olivier Beauchet¹

¹McGill University, ²Geneva University Hospitals





BACKGROUND AND AIM: Motoric Cognitive Risk syndrome (MCR) is a predementia stage associated with increased risk for falls. There are conflicting results regarding its association with recurrent falls and no information about its association with post-fall fractures. The aim of the study was to examine the association of MCR and its components (i.e., slow walking speed and Subjective Cognitive Complaint (SCC)) with the occurrence of falls, their recurrence and post-fall fractures in older community-dwelling adults. Methods. Participant data (n=5,958) from the EPIDémiologie de l'OStéoporose (EPIDOS) study, an observational prospective and longitudinal cohort study, were used for the analysis. MCR was defined as both the presence of SCC and slow walking speed in women free of major neurocognitive disorders. Falls (>1), recurrent falls (>2) and post-fall fractures (any fractures and hip fractures) were prospectively recorded using mail and/or phone call questionnaires every 4 months over 4 years. At baseline, the prevalence of SCC was 43.1% (n=2,569), slow walking speed 5.7% (n=341) and MCR 9.9% (n=591). Overall, 25.7% (n=1,533) of participants reported any fall over the follow-up. The incidence of post-fall hip fractures was higher in participants with MCR compared to healthy participants and those with SCC (P≤0.001). Cox regression models revealed that only participants with MCR had a significantly high risk for falls (Hazard ratio (HR)=1.22, P=0.021), recurrent falls (HR=1.46 with P=0.030) and post-fall hip fractures (HR=2.54, P≤0.001). Conclusion. MCR, but not its individual components, is associated with the occurrence of falls, recurrent falls and post-fall hip fractures, suggesting a specific risk caused by the association of SCC with slow walking speed reflecting impairment of higher levels of gait control. MCR does not only constitute a pre-dementia syndrome, but also a syndrome associated with poor motor outcomes, such as falls, their recurrence and post-fall fractures.

O.2.vi Standing steadiness and variability of older adults on a step ladder

Erika Pliner¹, Daina Sturnieks², Kurt Beschorner¹, Mark Redfern¹, Stephen Lord²

¹University of Pittsburgh, ²Neuroscience Research Australia, University of New South Wales

BACKGROUND AND AIMS: Ladder fall injury rates are highest among older adults [1] and ladder falls commonly occur when the user is standing on the ladder as opposed to climbing [2]. Standing stability measures have been used to classify general fall risk of older adults [3], but the standing stability of older adults performing tasks on ladders has not been investigated. The objective of this study was to investigate the standing stability of older adults at high fall risk while performing the task of changing a light bulb on a household step ladder. **METHODS:** 104 older adults participated in the study. Participants completed the short-form Physiological Profile Assessment (PPA) to classify fall risk [3] and climbed to the second step of a household step ladder to change a light bulb. The light bulb height was set to slightly above the participant's head height. Force plates under the step ladder were used to calculate the center of pressure (COP) between the





ground and step ladder [4]. COP parameters during ladder standing (excluding climbing to standing transitions) were extracted to assess participant stability on the step ladder including path length (time normalized), RMS and elliptical area (the area that the COP remains within for 95% of the assessed time) [5]. In addition, the task time (including transitions) was recorded. The task time and COP parameters were compared between 10 participants with the highest fall risk (z-score \geq 1.49) and 10 participants with the lowest fall risk (z-score \leq -0.22) scores in the study. **RESULTS:** Task time was 8.4 seconds (63.9%) longer for the high fall risk group than the low fall risk group. Time normalized path lengths were similar between the low (39.9 mm/s) and high (38.5 mm/s) fall risk groups. The high fall risk group showed an increase in RMS by 18.1% and elliptical area by 44.6% compared to the low fall risk group (Figure 1). CONCLUSIONS: Moderate-to-large differences in tasks time, COP RMS and COP elliptical area were observed between low and high fall risk groups when completing a task on a ladder. Larger RMS values and elliptical area indicate more movement away from the average COP location. This suggests high fall risk older adults to be more variable than low fall risk older adults in their standing stability when completing a task on a step ladder. Therefore, standing stability measures of fall risk at the ground level may extended to fall risk during tasks on ladders. ACKNOWLEDGEMENTS AND FUNDING: Whitaker International Program. REFERENCES:1. Faergemann, C., and Larsen L.B. (2000). Accident Analysis Prevention. 2. Faergemann, C., and Larsen L.B. (2001). J Safety Research. 3. Lord, S.R, et al. (2003). Physical Therapy. 4. Winter, D., et al. (2003). J Electromyography Kinesiology. 5. Prieto, T.E., et al. (1996) IEEE Transaction Biomedical Engineering.

O.2.vii The effectiveness of the StandingTall home-based, unsupervised balance exercise program in preventing falls in community-dwelling older people

Kim Delbaere¹, Kim van Schooten², Stephen Lord¹, Lindy Clemson³, GA Rixt Zijlstra⁴, Jacqueline Close⁵

¹Neuroscience Research Australia, University of New South Wales, ²University of New South Wales, ³University of Sydney, ⁴University of Maastricht, ⁵Prince of Wales Hospital

BACKGROUND AND AIM: Falls in older people are a growing public health issue worldwide, with 1 in 3 people aged 65 and over falling each year. Because of the pervasiveness and costs associated with falls, there is an increasing need for effective and self-managed fall prevention programs tailored to participants. The aim of this study was to determine the effectiveness of StandingTall, a home-based exercise program using mobile technology, in preventing falls in community-dwelling older people. **METHODS:** We enrolled 510 individuals aged 70-94 years into this single-blind randomized controlled trial. Inclusion criteria were being independent in daily activities and the absence of medical conditions that precluded unsupervised exercise. This trial is registered in the Australian and New Zealand Clinical Trials Registry (ACTRN12615000138583).





Participants were randomly assigned to the intervention group (IG: StandingTall + health education) or control group (CG: health education). IG participants were asked to complete 2 hours of unsupervised balance exercises at home through a tablet computer for 1 year. The exercises were automatically tailored to the participant's balance abilities for the duration of the trial. Participant adherence (volume, frequency) was monitored following automatic data transfer to a server. The primary outcome measures include number of fallers and falls rate as assessed through weekly diaries; secondary outcomes include adherence and balance. Outcome assessors were masked to group allocation and analysis was by intention to treat. RESULTS: Between February 2014 and October 2017, 963 individuals were screened. 510 participants were included, and randomly assigned to IG (n=255) or CG (n=255). 232 IG participants (91.0%) and 226 CG participants (88.6%) completed their 12-month falls follow-up. Overall, 171 of participants (37.3%) fell at least once in the 12-month follow-up, with an average of 0.59 (SD 1.05) falls per year in IG and 0.73 (SD 1.22) in CG. IG participants experienced 17% fewer falls than CG participants, however, this result was not statistically significant (incidence rate ratio (IRR) 0.83, 95% confidence interval 0.63 to 1.12, P=0.23). Similar results were found for the proportion of fallers (IRR 0.86, 95% CI 0.68 to 1.08, P=0.195). Adverse events (falls while exercising) occurred in 3 (1.2%) IG participants. Adherence to Standing Tall was good, with a median of 88.5 minutes (IQR 49) in the first 6 months and 81.4 minutes (IQR 66) over 12 months, and the dropout rate was 19.2%. Significant improvements in IG compared to CG were found for balance (one leg balance, maximum leaning balance range). CONCLUSIONS: StandingTall uses technology to provide tailored and progressive balance exercises and collect real-time data of adherence. Findings from this large randomized controlled trial suggest that a home-based, unsupervised balance exercise program using mobile technology can maximize long-term adherence. in older people. Although reductions in fall rates were not statistically significant, high adherence rates and improvement of balance hold promise for the future.

O.2.viii Walking adaptability for targeted fall-risk assessments

Daphne Geerse¹, Melvyn Roerdink¹, Johan Marinus², Jacobus van Hilten²

¹Vrije Universiteit Amsterdam, ²Leiden University Medical Center

BACKGROUND AND AIM: The incidence of falls increases with age, but is particularly high in patients with neurological disorders, such as stroke and Parkinson's disease. Most falls occur during walking and are often associated with trips, slips or misplaced steps. This suggests a reduced walking adaptability, an aspect of walking that is difficult to assess with clinical tests. The Interactive Walkway (Figure 1) may be used to quantify various aspects of walking adaptability [1]. The aim of this study is to evaluate the potential merit of the Interactive Walkway for identifying prospective fallers and risk factors for future falls in a composite cohort with stroke patients,




Parkinson's disease patients and healthy controls (n=30 per subgroup). **METHODS:** This study comprised an evaluation of subject characteristics (e.g., age, fall history, group), clinical gait and balance tests, a quantitative gait assessment and a walking-adaptability assessment with the Interactive Walkway. Falls were registered prospectively with falls calendars during a 6-month follow-up period. Falls calendars were used to classify subjects as prospective fallers (i.e., those reporting at least one walking-related fall during the follow-up period) or non-fallers. Generic and walking-related fall-risk factors were compared between prospective fallers and non-fallers. Binary logistic regression and Chi-square Automatic Interaction Detector analyses were performed to identify fallers and predictor variables for future falls. RESULTS: In addition to fall history, obstacleavoidance success rate and normalized walking speed during goal-directed stepping correctly classified prospective fallers and were predictors of future falls. Compared to the use of generic fall-risk factors only, the inclusion of walking-related fall-risk factors improved the identification of prospective fallers (72.7% versus 87.9%, respectively). CONCLUSIONS: If cross-validated in future studies with larger samples, these fall-risk factors may serve as quick entry tests for falls prevention programs. In addition, the identification of these walking-related fall-risk factors may lead to more targeted, personalized and possibly more effective falls prevention programs. Figure 1. The Interactive Walkway for an assessment of walking adaptability, which may unveil potential fall-risk factors. [1] Geerse DJ, Coolen BH, Roerdink M. Walking-adaptability assessments with the Interactive Walkway: Between-systems agreement and sensitivity to task and subject variations. Gait Posture. 2017;54:194-201.

O.3 Somatosensory & vestibular function

O.3.i Noisy galvanic stimulation and vestibular perception: Otolith versus semicircular canal mediated mechanisms

Klaus Jahn¹, Aram Keywan¹, Max Wuehr¹

¹Ludwig-Maximillians Universität München

BACKGROUND AND AIM: There is strong evidence that the presence of noise can enhance information processing in the vestibular system via stochastic resonance. Galvanic vestibular stimulation delivered as imperceptible zero-mean white noise (nGVS) can improve static and dynamic balance in healthy subjects and patients with bilateral vestibular loss. Further, nGVS improves vestibuar perception in a direction recognition task. However, it is unclear whether both the semicircular canals (SCCs) and otolith organs contribute to this improvement or if it is confined to one of these structures. The objective of this study was to test whether the effect of nGVS on vestibular perception depends on head position and thereby on the amount of otolith input. **METHODS:** Twelve healthy subjects (26.8±2.3 years, 7 males) performed quiet stance tasks for 30 sec on foam with eyes closed (Kistler 9261A, Winterthur, Switzerland) during nGVS at different





amplitudes ranging from 0 mA (baseline) to 0.7 mA (DS5 Digitimer, Hertfordshire, UK; zero-mean Gaussian white noise, 0-2 Hz). The nGVS amplitude that caused the maximal reduction in velocity, path and area of the sway was taken as the optimal nGVS level. Stimulation with optimal effect on postural control was applied during perceptual direction-recognition tasks in inter-aural translation (otolith-mediated perception, 1 Hz) and in yaw rotation with the head pitched forward 71 degrees (SCC-mediated perception, 1 Hz), and compared to sham stimulation (150 trials each, 3-down 1up; 6-degree-of-freedom motion platform, Moog 6DOF2000E, East Aurora, New York, USA). **RESULTS:** All participants showed optimal nGVS amplitudes in the postural tasks during head straight (0.24±0.16 mA) and head pitched (0.34±0.2 mA) conditions. Nine out of 12 subjects showed significantly improved direction recognition thresholds in the inter-aural translation task during nGVS compared to sham stimulation (p=0.029; mean threshold reduction: 38.8%). Only 6 of 12 subjects showed mild improvements in the yaw rotation task during nGVS (p=0.642). In addition, elevated baseline thresholds during the inter-aural translation task significantly correlated with larger magnitude of improvement (R=0.72, p=0.01). CONCLUSIONS: Noisy GVS appears to impact otolith-mediated perception more than semicircular canal mediated perception. Thus, for improvement of vestibular function, this stimulation approach could be complementary to invasive vestibular stimulation (vestibular prostheses) that primarily targets semicircular canal function in patients with partial vestibular loss. Acknowledgments and FUNDING: This work was funded by the German Federal Ministry of Education and Research (BMBF grant 01 EO 1401).

O.3.ii Postural regulation strategies in Ehlers-Danlos Syndrome Hypermobility type

Emma Dupuy¹, Leslie Decker¹

¹UMR-S 1075 COMETE UNICAEN/INSERM

BACKGROUND AND AIM: Ehlers-Danlos syndrome (EDS) is the clinical manifestation of connective tissue disorders, comprising several clinical forms. The EDS hypermobility type (EDSh) is characterized by generalized joint hypermobility, variable skin hyperextensibility, and impaired proprioception. The aim of this study was to understand the impact of impaired proprioception on postural regulation in EDSh patients. More specifically, we seek to examine how the EDSh-related proprioceptive deficit modifies the regulation mechanisms of postural adaptation, and how these modifications affect the efficiency, stability, and regularity of the postural control system. **METHODS:** Postural control of 19 EDSh patients (28 ± 11.68 years old) and 19 age-matched controls (25.6 ± 5.4 years old) was assessed with eyes opens under single-and dual-task conditions, and with eyes closed, on the GRAIL treadmill's force platforms (Motekforce Link). Efficiency, stability, and regularity of postural control was respectively analyzed through mean velocity (Vm), root mean square (RMS), and sample entropy (SampEn) of COP time series in both anteroposterior (AP) and mediolateral (ML) directions. Short and long terms serial





correlations (a scaling exponents of detrented fractal analyses - DFA) were also calculated for CoP velocity time series, to examine the regulation mechanisms of postural control: the shortterm α exponent reflects the efficiency of automatic processes and the long-term α exponent reflects the tightness of cognitive control. **RESULTS:** In patients, regardless of the conditions, the automatic regulation of COP fluctuations in AP is less efficient compared to controls (increased short-term α exponent in AP). Also, the postural control of patients was less efficient in ML (increased Vm in ML), less stable (increased RMS in both AP and ML) and more regular (decreased SampEn in AP and ML) than that of controls. However, EDSh patients regulate their COP fluctuations tighter in AP (decreased long-term α exponent in AP) under visual deprivation or when performing a concurrent cognitive task. CONCLUSIONS: Collectively, these results suggest impaired automaticity of postural control (looser control of fluctuations over short-term intervals) in EDSh patients, which is accompanied by greater instability (increased RMS), decreased control efficiency (increase of Vm), and simplification of its dynamics (more regular sway pattern). When facing postural constraints (through restriction of either sensory or cognitive resources), EDSh patients compensate their reduced postural control automaticity by regulating more strongly the COP sway when approaching the boundaries of CoP velocity (tight control of fluctuations over long-term intervals). In conclusion, the EDSh-related proprioceptive deficit induces a loss of complexity of the postural control system, which expresses through impaired automatic adjustments compensatory active control and rigid strategies. ACKNOWLEDGEMENTS AND FUNDING: The Normandy Integrative Biology, Health, Environment Doctoral School, and the Regional Council of Basse-Normandie (European Regional Development Fund), funded this research. We sincerely thank the Association des Patients Normands Ehlers Danlos, and all the participants in our study

O.3.iii Haptic touch feedback that is sway-referenced and graded can improve center of mass stability in post-concussion syndrome

Andrew Meszaros¹, Alyssa Carey¹, Tyler Cuddeford¹

¹George Fox University

BACKGROUND AND AIM: Individuals with post-concussive syndrome often have postural control instability while standing. To reduce the fall risk associated with these deficiencies, a maladaptive dependency on visual or tactile sensory input can develop. For example, standing stability may become contingent on sensing a ground-fixed reference via proprioceptive input that is derived remotely (i.e. via an assistive device) or directly (i.e. via finger light-touch on objects). Unfortunately, such aides require use of the hands, which can be quite restrictive during activities of daily living. The aim of this study was to develop a wearable device that provided a hands-free ground reference, and subsequently reduced center of mass (COM) sway, for a post-concussive





patient who was dependent both visually and proprioceptively. METHODS: A 26 year old active female with a history of sports-related concussion suffered severe impairments of balance in community environments during the following conditions: low-light, inability to view feet/ground, and during states of mental fatigue. A novel wearable device was designed and constructed to augment ground reference by providing graded-touch feedback based upon trunk orientation. A sway detection algorithm drove six high speed digital servo motors via piezoelectric force feedback regulation. These tactors were position in an array on the upper thorax to simulate graded touch that was referenced to sway direction and magnitude. A two-degree sway allowance was permitted prior to input. COM behavior was assessed during trials of static standing. Motion was analyzed using a Qualysis 3D system (10 cameras, 100Hz rate, 6Hz Butterworth filter) with an AMTI force plate (1,000 Hz), C-Motion Visual3D (with Dempster Hanavan for COM) and DataGraph software (Visual Data Tools Inc.). COM excursion and range were compared for several "standing support" conditions (i.e. wearing the haptic device; use of light finger contact; use of a pole) under various "challenge" conditions (i.e. on foam; with visual conflict; and with cognitive loading). RESULTS: Under all challenges, the haptic device reduced sway excursion and range in the medial-lateral and anterior-posterior planes. It did so significantly better than any of the alternative support conditions that relied on hand input. COM reductions with the device ranged from -20% (anterior/posterior excursion on foam with a cognitive load) to -86% (medial/lateral range under cognitive load) compared to the condition's baseline. **CONCLUSIONS:** The non-generalizable results of this single patient, examined under multiple conditions, suggests that sway-referenced touch-graded haptic feedback can be effectively employed to provide a hands-free ground reference that reduces COM instability in standing. ACKNOWLEDGEMENTS AND FUNDING: Robin Dorociak; Nathan Slegers; Gary Spivey; GFU DPT/Engineering students; RM Pitts

O.3.iv Perception of gait movements using gait-like vibrations in individuals with and without sensorimotor deficits

Tapin Alexandre¹

¹Université de Montréal

1- Background / Aim Virtual reality (VR) immersion is mostly generated through realistic visual and auditive stimulations. But it can be improved by adding other types of stimulations such as proprioceptive information. However, little has been done to include proprioceptive perception of movements to VR. Slow, non-repetitive limb movement can be perceived, with the eyes closed, when multiple vibrations are applied with an appropriate temporal pattern on upper-limb muscles. No data are currently available on the perception of rhythmic and bilateral movements, like gait movements, generated by muscle vibration, and on the effect of vision or body weight support on





these perceptions. The first aim of the study was to determine if multiple vibrations can generate gait movement perception. The second aim was to determine if some factors (vision, number of joints stimulated, body weight support and sensory deficits) alter gait movement perception. 2methods Twenty healthy subjects received 1 minute gait-like stimulations using 12 vibrators placed on the flexor and extensor muscle groups at the hips, knees and ankles, with various combination (1, 2 or 3 joints bilaterally, eves open or closed, a 13th vibrator on the posterior neck muscles) depending on the trial (12 trials total). Ten subjects with incomplete spinal cord injury (ASIA Impairment Scale C or D, able to walk at least 10m a speed below 0.8 m/s) participated to 6 trials, using the control, 12-vibrator configuration, with eyes open at three different weight support (0%, 20%, 40%) each at two different gait speed cycle (1 and 2 steps per second). Subjects rated their perception after every stimulation using a visual analog scale (VAS, score 0-10). Both descriptive statistics and ANOVA were used to compare stimulation conditions and groups. 3- Results All participants but one healthy (n=29) had a good perception score (≥6/10) for at least one configuration. Perception of gait movement was not affected by vision (p>0.63), presence of sensorimotor deficits (p>0.88) or body weight support (p>0.68). The alterations of perception were maximal with configurations involving only one joint bilaterally, especially the hip (-2/10 points compared to other configurations) (p<0.02). 4- Conclusion It is possible to induce gait movement perception using gait-like vibration in individuals with or without sensorimotor deficits. The similar perception of movement with eyes open than closed supports a potential combination of visual and proprioceptive virtual reality. In addition, the presence of perception regardless of the body weight support offers new possibilities for applications in entertainment and gait rehabilitation. Using less vibrators for simpler setups seems also possible, though variable between participants.

O.3.v 3D head stability of people with vestibular dysfunction during gait in variable sensory conditions

Brian Loyd¹, Janie Saviers-Steiger¹, Peter Fino¹, Serene Paul², Mark Lester³, Lee Dibble¹

¹University of Utah, ²University of Sydney, ³Army-Baylor University

BACKGROUND AND AIM: Head stabilization during gait is essential for processing sensory information and for maintaining gaze and postural stability. People with vestibular schwannoma resection (PwVSR) experience vestibular deficits which confound sensory integration. With this impairment, individuals may not effectively stabilize their head, contributing to gait instability, complaints of motion sensitivity, and increased risk for falls. We sought to characterize head stabilization during two dynamic sensory conditions in PwVSR and healthy controls (HC). We hypothesized that PwVSR would demonstrate greater difficulty controlling head accelerations than HC and that these difficulties would increase without visual input. **METHODS:** Fourteen





PwVSR approximately 6 weeks post-surgery and 15 HC were included. Participants performed components of the Functional Gait Assessment (FGA), specifically FGA-1 (self-selected gait speed with eyes open) and FGA-8 (self-selected gait speed with eyes closed). Linear acceleration was recorded by an inertial sensor (Opal, APDM inc.) worn on the head, and quantified using root mean square (RMS) analysis. RMS values were calculated for walking periods of FGA-1 and FGA-8 using the anterior-posterior (AP), medial-lateral (ML), and cranial-caudal (CC) linear accelerations and were normalized to gait speed. Linear mixed models were fit for each RMS value and adjusted for group, condition, and a group by condition interaction. Post-hoc contrasts were run to determine specific group and condition differences for each RMS value, adjusting for multiple comparisons (p<0.013). **RESULTS:** A significant group effect was found, with PwVSR on average having significantly greater RMS values in all three planes. Additionally, the group by condition interaction showed that on average change in RMS from FGA-1 to FGA-8 was significantly higher in PwVSR than HC in all three planes. Contrasts showed that PwVSR had significant increases in RMS values during FGA-8 in all three planes, while HC only experienced a significant increase in CC RMS during FGA-8.(Table 1) CONCLUSIONS: After 6 weeks of recovery, it appears that PwVSR adapt to sensory loss in part by using visual information to effectively stabilize their head during gait. The removal of vision during gait resulted in significant increases in head accelerations in all planes in PwVSR suggesting impairment in sensory integration necessary for effective head stabilization. Differences in the CC directed accelerations support the hypothesis of an increased reliance on the visual system to maintain stability in PwVSR. Furthermore, increased RMS values in the ML direction could be explained by PwVSR walking with a widened base of support. While these results illustrate the cross-sectional differences of PwVSR at 6 weeks post-surgery to HC, future research is needed to determine the extent to which head stabilization continues to recover beyond 6 weeks and if it responds to vestibular rehabilitation.

O.3.vi Interaction between lower limb cutaneous and muscle afferent pathways during standing

Robyn Mildren¹, Gregg Eschelmuller¹, Ryan Peters², Jean-Sebastien Blouin¹, Mark Carpenter¹, J. Timothy Inglis¹

¹University of British Columbia, ²University of Calgary

BACKGROUND AND AIM: Somatosensory feedback from lower limb muscles and skin contributes to the control of posture and balance. Stretch reflex pathways are often probed by delivering transient stimuli (e.g., tendon tap, electrical nerve pulse) and recording evoked responses. Using linear systems analyses, we previously observed that continuous noisy vibration of the Achilles tendon was correlated with soleus (SOL) surface EMG, as well as the spike times





of single SOL motor units, across a broad bandwidth (~10-80 Hz) [1]. Cutaneous feedback from the feet provides balance relevant information, and has the potential to interact with spinal circuitry involved in the vibration response (the excitatory la pathway). The aim of this experiment was to examine how cutaneous feedback from the foot sole (heel vs. metatarsals) interacts with vibrationevoked lower limb muscle responses during standing. METHODS: In 12 healthy adults (7 male, 5 female), we applied noisy (10-115 Hz) vibration to the right Achilles tendon, along with electrical pulses (five 1 ms square-wave pulses at 200 Hz) under the heel or metatarsals intermittently (every 0.8-1 s), over a series of 2 min standing trials. We recorded SOL surface EMG, tendon probe force and acceleration, and ground reaction forces. We analyzed time-dependent (referenced to cutaneous stimuli) coherence and cross-correlations between probe acceleration and rectified EMG. Based on results of this experiment, we performed two subsequent experiments to examine potential mechanisms underlying the observed cutaneous interaction with the vibration responses. To investigate whether the observed effects of cutaneous input resembled characteristics of presynaptic inhibition via primary afferent depolarization (PAD), we stimulated the deep branch of the common fibular nerve (1 ms square-wave pulse) intermittently (every 0.8-1 s), while we applied tendon vibration (n = 6). (Group I afferents in the common fibular nerve provide strong input to PAD interneurons that mediate PSI [2].) To determine whether the observed effects of cutaneous input were contingent upon a post-synaptic response, we reduced the amplitude of the cutaneous stimuli to below motor threshold (n = 10). **RESULTS:** Vibration-EMG coherence across a bandwidth of ~10-80 Hz was suppressed by heel (peak suppression 110 ms) and enhanced by metatarsal (peak enhancement 88 ms) stimuli. Similarly, crosscorrelation strengths were significantly suppressed by heel (from 104-155 ms) and enhanced by metatarsal (from 75-128 ms) stimuli. The observed modulations were not consistent with characteristics of PAD, and minimal modulations were observed in the absence of a post-synaptic response induced by cutaneous stimuli. CONCLUSIONS: Cutaneous and muscle afferent feedback interact in a spatially organized manner during standing. This interaction is likely not mediated by PAD, and appears contingent upon a cutaneous volley sufficient to evoke a postsynaptic response. These findings enhance our understanding of the spinal integration of different somatosensory channels during standing. [1] Mildren et al. 2017, J Appl Physiol. 122(5):1134-1144. [2] Hultborn et al. 1987, J Physiol. 389:729-756. ACKNOWLEDGEMENTS AND FUNDING: Funded by NSERC

O.3.vii Subthreshold electrical noise enhances mechanically-evoked cutaneous reflexes

Tushar Sharma¹, Ryan Peters², Leah Bent¹

¹University of Guelph, ²University of Calgary





BACKGROUND AND AIM: During stance, cutaneous mechanoreceptors sense pressure distribution across the foot sole and reflexively modulate muscle activity to ensure successful maintenance of balance. Deterioration of these responses, as observed in older adults, has been proposed to contribute to increased prevalence of balance deficits in this population. Therefore, improving cutaneous reflex generation may be a mechanism of improving balance in such populations. A possible method of doing so is through stochastic resonance, which involves the increased detection of a weak signal following the addition of certain intensities of subthreshold noise. Noise-mediated enhancements have been observed in tactile stimulus detection but have yet to be explored in cutaneous reflexes. As such, the purpose of this study was to explore whether subthreshold noise could enhance cutaneous reflex generation. METHODS: Nine healthy young adults were recruited (mean age \pm SD: 21.6 \pm 0.7 years). As participants performed quiet stance (slight anterior lean), cutaneous reflexes were evoked by applying a vibrotactile stimulus to the plantar foot surface of the heel at an intensity of ten times perceptual threshold (PT). For the noise component, an electrotactile stimulus was concurrently applied to the same location. Electrotactile noise intensity varied between 0% (no noise) and 100% of PT. Both vibrotactile and electrotactile stimuli were Gaussian noise stimuli, low-pass filtered at 50 Hz. Electromyography was recorded from the soleus (SOL) and tibialis anterior (TA). To quantify reflex magnitude, data from all participants were pooled and cumulant density analyses were performed. The peak to peak amplitude (PTP) of the cumulant function compared across noise intensities for each muscle. Coherence was also calculated to assess relationships in the frequency domain. **RESULTS**: Compared to 0% PT noise, SOL PTP increased when 20% and 100% PT noise were applied (40% increase in reflex amplitude with 20% noise and 30% increase at 100%). In the TA, PTP was reduced at 20% PT and 60% PT noise (largest reduction at 20% PT) but increased at 80% PT noise. In both muscles, smaller differences were observed at other noise intensities. Peak coherence was observed at 30 Hz. CONCLUSIONS: These results suggest that the addition of tactile noise to the foot can modulate cutaneous reflex generation in lower limb muscles with the optimal intensity of noise being about 20% of PT. At this intensity, reflex magnitudes were optimally enhanced in the SOL (agonist) and reduced in the TA (antagonist). Coherence at 30 Hz may suggest primary contributions from FAI mechanoreceptors (Strzalkowski et al. 2017, J Neurophys, 118). This information may inform the incorporation of noise components in biomedical aides such as shoe insoles to improve balance in clinical populations. ACKNOWLEDGEMENTS AND FUNDING: Supported by NSERC Discovery Grant (L.R.B.) and CBS Graduate Tuition Scholarship (T.S.).

O.3.viii The plantar surface of the foot: The bigger picture

Leah Bent¹, Erika Howe¹, Simone Smith¹, Nicholas Strzalkowski², Ryan Peters³, Timothy Inglis⁴





¹University of Guelph, ²Mount Royal University, ³University of Calgary, ⁴University of British Columbia

BACKGROUND AND AIM: The plantar surface of the foot is known to contribute to balance orientation in standing and locomotor control in gait1,2. Loss of tactile sensitivity, and impaired cutaneous reflexes are prevalent as we age3,4,5, which has stimulated the development of sensory interventions to augment low threshold mechanoreceptors. Here we examine the evidence of receptor density, distribution and responses to loading and foot position across regions of the foot. The aim is to understand what and how to facilitate receptor activation with the goal of determining best practice for interventions regarding plantar skin and optimal feedback. METHODS: In separate experiments, microneurography was performed on the tibial nerve within the popliteal fossa. The electrode was manipulated until a single cutaneous afferent fibre was isolated. Afferents were classically identified 6; Slow Adapting (SA), Fast Adapting (FA), Type I or II. Receptor field size (RF), sensitivity and location were assessed across all experiments. Load was applied in a ramp fashion perpendicular to the surface of the RF. Load was calculated to 100% of body weight (BW) according to the foot sole location. Prolonged and dynamic loading were also explored. Heating was applied over RF area to a maximum of 43°C. Load was repeated at elevated temperature levels. Finally, perceptual thresholds were assessed across locations using monofilaments (FA), JVP domes (SAI) and skin stretch sensitivity (SAII) to relate to afferent data. **RESULTS:** In contrast to previous work, we found a receptor gradient toward the toes and the lateral border of the foot. Additionally, FAI were the most densely populated, composing 48% of the receptors across the foot. This was followed by 13% 18% and 21% for FAII, SAI and SAII respectively. There was a location and position effect for acuity and stretch sensitivity, with the heel demonstrating the highest JVP domes acuity and lowest stretch ratio. Ankle position influenced sensitivity in all locations except the heel. Finally, loading the foot to 100% BW demonstrated firing commensurate to load, with persistent firing with prolonged loads. Increased firing was also seen with loads exceeding 100%. Heating increased SA firing frequency to load but was variable for FA afferents. CONCLUSIONS: Afferent excitation affects both muscle modulation and tactile perception, each of which contribute to balance control. Distribution of receptors across the foot sole has implications in optimal placement of vibrotactile, electrical or heating devices to evoke afferent activation; an important consideration for receptor enhancement. Heating was shown to have a large effect on SA receptor firing, with minimal effect on FA receptors, leading to temperature considerations in targeted sensory interventions, for enhancement of afferent feedback. Importantly, stretch perception and acuity were found to be highest at the heel, suggesting that not only receptor number, but central factors also contribute to overall perception. Hence, activation of skin for perception or for increased afferent input for muscle modulation may necessitate different intervention profiles. ACKNOWLEDGEMENTS AND FUNDING: NSERC Discovery Grant (LRB, JTI), OGS Graduate Scholarship (NDJS, EH).



O.4 Balance control

O.4.i Effect of external base-of-support perturbation parameters on measures of forward reactive stepping

Taylor Winberg¹, Andrew Laing¹

¹University of Waterloo

BACKGROUND: Examination of responses to translating base-of-support perturbations are commonly used in an effort to explore balance control capabilities. However, the techniques and approaches employed are variable; the magnitudes of both support surface translation acceleration and velocity vary widely. While there is value in developing study-specific perturbation parameters (e.g. acceleration and velocity profiles) based on individual research questions, this variability can cause challenges in comparing and generalizing findings across studies. Therefore, the goal of this study was to explicitly explore the effects of surface translation acceleration and velocity on normalized step length and minimum anteroposterior margin of stability (MOSmin) following heel strike. In this study, both programmed and achieved perturbation kinematic profiles were considered. METHODS: Twenty-three younger adults (mean (SD) age = 24.0 (3.61) y, mass = 73.2(12.5) kg, height = 1.71(0.08) m) were perturbed during quiet stance using a translating surface. The surface translated 0.3 m with varying accelerations (1.0-3.5 m/s2 across 6 levels) and velocities (low vs high) in four directions (forward/backward/left/right) for a total of 119 trials. Translation order was randomized to minimize anticipation effects. Perturbations resulting in single forward steps (backward translations) were analyzed for step length, normalized to leg length, and MOSmin after heel strike. **RESULTS:** Normalized step length ranged from 45.5% - 60.3% of leg length. Increasing acceleration resulted in no changes in step length during low velocity trials (p = .150), but the high velocity trials resulted in increases (up to 30.7% increase) in step length (p < .001). Increasing velocity while maintaining acceleration resulted in increased step length (up to 26.8% increase) at all acceleration rates ($p \le .001$) except for 1.0 m/s2 (1.3% increase). Minimum AP margin of stability ranged from 0.087 m - 0.201 m. Increasing acceleration resulted in no changes in MOSmin (p = .164) but the high velocity trials resulted in increases (up to 90.4% increase) in MOSmin (p < .001). Increasing velocity while maintaining acceleration resulted in increased (up to 127.6% increase) MOSmin at all acceleration rates ($p \le 0.017$) except 1.0 m/s2 (0.1% increase) and 1.5 m/s2 (13.9% increase). A secondary analysis examined the contribution of quiet-stance characteristics on outcome measures. CONCLUSIONS: Based on the findings of this study, the magnitude of translation acceleration and velocity have a direct influence on young healthy adult responses to surface translations. Attention to the methodology of study designs should be noted and considered carefully when comparing past literature. Plateaus in the response measures were observed at higher accelerations when accompanied with high velocity leading to the recommendation that future research employing surface translations use accelerations of at least 3.0 m/s2 and high peak velocities.

O.4.ii Upward perturbation - novel methodology to study stumbling during walking

Desiderio Cano Porras¹, Jesse Jacobs², Rivka Inzelberg³, Gabriel Zeilig¹, Meir Plotnik¹

¹Sheba Medical Center, ²University of Vermont, ³Tel Aviv University

BACKGROUND AND AIM: Vertical perturbations (i.e., balance disturbances due to rapid, unexpected change in the surface height) are one major cause of falling. However, few studies have investigated the effect of vertical perturbations while walking. Incidentally, while conducting a comprehensive study comparing effects of vertical perturbations with the effects of horizontal perturbations, we discovered a systematic stumbling-like response induced by upward perturbations. The aim of this study is to describe and characterize this stumbling response. **METHODS:** Fourteen healthy participants (10 male; age: 27±4 yr) walked self-paced on a treadmill. The treadmill was embedded in a moveable platform and synchronized with a motion capture system to a virtual reality system, such that the participants walked on a virtual one-lane road projected over a 360° dome-shaped screen. While walking at a stable speed, 36 perturbations (12 types, 3 repetitions) were presented randomly. Here, we report only on the four types of upward perturbations: intense, 1g acceleration (platform moves 20 cm in 202 ms) and moderate (20 cm in 300 ms), with perturbations occurring at left (L) or right (R) foot contact. We calculated kinematic parameters, such as heel elevation and anteroposterior displacements of the knee and hip angles. Wilcoxon rank sum tests were used to compare kinematic parameters from before (baseline; i.e., 12s prior to perturbation) to after perturbations. RESULTS: In comparison to a baseline heel elevation of (mean ± standard error) 26.0±0.41 cm, upward perturbations (combining intense and moderate intensities) increased the elevation of the perturbed foot by 2.93±0.65 cm at 765±12.4 ms after perturbation (p<0.001; video: https://goo.gl/juByZj, Fig 1). On the side of the perturbed foot, the hip angle decreased -6.67±0.65° (P<0.001) and the knee angle augmented 0.89±0.57°. Decreases of the hip angle moderately correlated with increases in the knee angle (Spearman: r=-0.49, P<0.01). CONCLUSIONS: Our results suggest that upward perturbations can induce a stumbling effect characterized by an increase in the ensuing elevation of the perturbed foot. An integrated adjustment of hip and knee subserves postural reactions. Further research might explore the incorporation of upward perturbations to investigate postural reactions and risk of falling. Our findings might have translational benefits for balance and gait rehabilitation. FUNDING: Marie Sklodowska-Curie grant agreement No 642961.

O.4.iii A startle response is not evoked during falls following large postural perturbations in young adults



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Andrew Sawers¹, Stephen Robinovitch², Vivian Weerdesteyn³

¹The University of Illinois at Chicago, ²Simon Fraser University, ³Donders Institute, Radboud University Medical Centre

BACKGROUND: A startle response has been linked to first trial responses during unexpected balance perturbations. Startle-like muscle coordination patterns have also been observed during slip and trip-induced falls, leading to speculation that startle impedes balance recovery. While automatic postural responses and startle responses share common neural substrates, and a similar time-course of habituation, there is no evidence directly linking startle responses to falls. Understanding the relationship between startle response and falls may explain the success of perturbation training, and inform future fall-prevention interventions. The aim of this study was to determine if a startle response interferes with an otherwise successful balance response to lead to a fall. **METHODS:** Ten young adults (3 females, age 29.2±4.9 years, mass 69.5±14.2 kg, height 174.4±13.1 cm) were subjected to a series of 10 to 12 large posteriorly directed postural perturbations (displacement 1.2m, acceleration 15m/s2) that were sufficiently challenging to evoke falls in 42% of trials. Electromyographic signals were recorded from the sternocleomastoid (SCM) at 960Hz, and normalized to peak activity. SCM onset latency, peak activity (i.e. integrated area), and timing of peak activity were analyzed at each trial to identify potential startle responses. Z-tests were used to compare distributions, and t-tests were used to compare point estimates between fall and recovery trials. **RESULTS:** Overall, we found no evidence of an exaggerated startle response during falls. First, SCM onset latencies remained unchanged (i.e. did not habituate) as the proportion of falls decreased across trials (first trial: 103±17ms; last trial: 98±13ms, p=.14). Second, the distribution of SCM onset latencies, and timing of peak SCM activity, did not differ between fall and recovery trials (onset latency falls 105±12ms, recovery 104±13ms, Z-statistic=0.81; peak timing: falls 160±31ms, recovery 152±21ms, Z-statistic=0.66). This pattern of SCM activity is consistent with an automatic postural response, not a startle response (i.e. where SCM onset would be \leq 80ms). SCM activity may serve to protect and stabilize the head during balance responses, explaining the lack of habituation in SCM activity that would be expected if SCM activity were related to a startle response. A "protective" non-startle role is further supported by greater peak SCM activity during falls (falls 0.49±18ms; recovery 0.33±19ms, p=.043), potentially to avoid a head impact. CONCLUSION: Following large postural perturbations, startle responses do not appear to interfere with an otherwise successful balance response to mediate balance outcomes (i.e. fall versus recovery) among young adults. Rather, SCM activity may serve to protect and stabilize the head as part of the automatic postural response. Additional research is required to determine whether these results extend to older adults, and individuals with a history and/or fear of falls.





O.4.iv Cortical midfrontal theta activity scales with acceleration of whole-body mechanical perturbations and reactive stepping behavior

Teodoro Solis-Escalante¹, Mitchel Stokkermans², Michael Cohen², Vivian Weerdesteyn²

¹Radboud University Medical Center, ²Donders Institute, Radboud University Medical Centre

BACKGROUND: Whole-body mechanical perturbations elicit a negative potential (N1) in EEG recordings from midfrontal scalp areas, approx. 150 ms after perturbation onset. Previous studies have associated the N1 potential with sensory input processing, postural instability detection, and postural response initiation; yet, there is no consensus about its functional role. Analyzing the spectral characteristics of perturbation-related cortical activity may provide further insights, since different cortical rhythms can be associated with distinct cognitive and sensorimotor functions. AIM: To determine a possible relation of the magnitude of whole-body mechanical perturbations and their corresponding stepping behavior, with power modulations of midfrontal cortical rhythms. **METHODS:** In this experiment, we recorded high-density EEG from 6 healthy participants (28±2y.o.) reacting to support surface translations (120-160 trials). Their task was to stand upright and try to maintain both feet in place. We randomly varied the perturbation acceleration (0.125-2.5 ms-2) and direction (forward/backward), to elicit different reactive responses (step vs. feet-inplace; quantified from ground reaction forces). We used independent component analysis to separate cortical-level activity from artifacts. Per participant, we identified one component clearly representing the N1 potential, and quantified its single-trial latency and amplitude. We used grouplevel time-frequency maps of perturbation-related power modulations, to determine cortical rhythms of interest (low 0: 3-6 Hz; high 0: 6-12 Hz; high y: 60-90 Hz). For each rhythm, we calculated single-trial log-transformed power in a 100 ms window around N1 latency. We tested whether the power of each rhythm (or the N1 potential) were related to acceleration magnitude and stepping behavior using generalized linear models and stepwise regression. Testing was conducted at group-level (normalization: z-score), separately for stepping direction and rhythm. **RESULTS** (Figure 1): The best-fitting models for N1 (r2=0.19) and low θ (r2=0.24) included main and interaction effects of acceleration magnitude and stepping behavior in the backward direction, whereas in the forward direction there were only main effects of acceleration (N1: r2=0.27; low θ : r2=0.28). For high θ (backward: r2=0.08; forward: r2=0.10) and high y (backward: r2=0.04; forward: r2=0.07) the variance explained by acceleration was substantially lower. **CONCLUSION:** The low θ rhythm may represent an internal model of stepping probability, with direction-specific features (i.e., slope of the linear model) that correspond to differences in base of support (short/long) and availability of balance recovery strategies (ankle/hip). Interestingly, in either direction maximum low θ power occurs when stepping is inevitable (> 2ms-2). N1 shows similar, slightly weaker effect, perhaps due to interference from other cortical rhythms. Late onset and sustained enhancement of high y suggest a relation with reactive responses (e.g., muscle activation). FUNDING: Netherlands Organization for Scientific Research, VIDI grant to V. Weerdesteyn (91717369, Roads to recovery)

O.4.v Balance perturbation training for rehabilitation of dynamic balance in acquired brain injury victims: An exploratory interventional prospective trial and a neuroimaging investigation

Katherin Joubran¹, Lior Shmuelof¹, Simona Bar Haim¹

¹Ben-Gurion University

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BACKGROUND AND AIM: Acquired brain injury is a major cause of functional disability and is often characterized by a deterioration of dynamic balance. We aim to evaluate the effect of longterm unexpected constant balance perturbation training on dynamic balance and on the modularity in the motor control brain network pre and post-training. METHODS: In an exploratory clinical interventional trial, 34 subjects with chronic ABI received 22 sessions of perturbationtraining using Re-StepTM technology. Before and after training we assessed dynamic balance and resting state functional connectivity (FC) using fMRI. Analysis of the neural data was conducted at two levels: (i) model free Independent Component Analysis (ICA) (ii) Regions of interest (ROIs) analysis focusing on the representation of the lower limbs in the primary motor cortex and in the cerebellum. **RESULTS:** Following 3 months of perturbation training, balance control improved significantly (p=0.001). This improvement was greater than the improvement due to the exposure to the clinical examinations and to time passage alone (p=0.043). ICA analysis detected a reduction in the strength of the sensori-motor and cerebellar networks post-training. Following the identification of functional and anatomical regions of interest (ROIs), we ran a multivariate linear regression analysis in order to explain dynamic balance using the FC measures. Dynamic balance at baseline had a negative relationship with modularity (i.e., the inverse of FC) between the left thalamus and the right cerebellum at baseline (r=-0.44, p=0.011). Dynamic balance recovery was negatively associated with modularity at baseline between the right putamen and the left cerebellum, between the left thalamus and the right cerebellum and between the cerebellar ROIs (p=0.005, p=0.049, p=0.031 respectively). Finally, dynamic balance recovery was positively associated with changes in modularity after training between the right putamen and the left cerebellum and between the cerebellar ROIs (p=0.026, p=0.004). CONCLUSIONS: Perturbation training improves dynamic balance control in ABI subjects. Dynamic balance recovery can be predicted based on baseline modularity and can be explained by an increase in modularity (reduction in FC) in subcortical and sensorimotor networks. These effects could be a direct outcome of the brain damage or mediated by the motor deficits. FUNDING AND **ACKNOWLEDGEMENTS:** This research is supported by the Israel insurance association (R.A), Association of life insurance companies of Israel LTD. We would like to thank Dr. Moti Salti , Prof. Shelef Ilan, Prof. Jean-Jacques Vatine and Avital Elishay for their technical assistance.





O.4.vi Impaired sensorimotor transformations for balance in Parkinson disease are associated with future falls

J. Lucas McKay¹, Kimberly Lang², Sistania Bong¹, Madeleine Hackney², Stewart Factor², Lena Ting¹

¹Emory University and Georgia Tech, ²Emory University

BACKGROUND AND AIM. Parkinson's disease (PD) causes balance problems and falls, but we know very little about how it affects balance pathways. When balance is disturbed in animals and healthy young people, muscles activate to stabilize the Center of Mass (CoM) in proportion to CoM motion approximately ~100 ms after perturbation onset. This reactive balance activity depends on brainstem and spinal networks, with important roles for subcortical structures including thalamus and subthalamic nucleus (STN). Previously, we have quantified the transformation from CoM motion to muscle activity in healthy young subjects using our sensorimotor response model (SRM). The SRM characterizes muscle activity with feedback gains on CoM acceleration, velocity and displacement (ka, kv, and kd); and a sensory-neuroconduction delay (λ). Here, we tested whether: 1) The sensorimotor transformation governing reactive balance is disrupted in PD patients compared to matched neurotypical individuals; 2) Abnormalities in the balance sensorimotor transformation are associated with previous and future falls in PD patients. Methods. We used SRM analysis to quantify and compare sensorimotor control of balance during multidirectional translation perturbations in PD patients (N=44; age 68±7 y, PD duration 7 ± 5 y) and matched neurotypical individuals (N=16; 66±8 y). We also compared responses to a reference sample of healthy college students (N=6; 21 ± 2 y). We subsequently tracked a subset of PD patients (N=21) for falls monthly for 1 year. Results. While the activity of agonist muscles initially lengthened by the perturbation was explained by stabilizing CoM feedback similar to that observed previously in young healthy subjects (initial burst ≈100-150 ms after onset followed by a plateau period \approx 400-600 ms duration; exemplar cases in Fig 1A, above, green; Variance Accounted For [VAF] values 68-79%), among PD patients, antagonist muscle activity at ≈100-150 ms was abnormally increased, and was only explained by destabilizing CoM feedback (Fig 1A, below, red). We quantified destabilizing CoM acceleration feedback with new SRM feedback gain ka'. At the group level, ka' was elevated in PD compared to neurotypical subjects (86%, P<0.001; Fig 1B). Among PD patients (Fig 1C), ka' was elevated among those with fall history (47%, P=0.032) and among those who went on to fall after study entry (71%, P=0.007). **CONCLUSIONS.** To our knowledge, this represents the first evidence that PD is associated with abnormal temporal muscle activation during balance. Sensorimotor balance transformations identified before in healthy young individuals and animals are intact but are dysregulated such that muscle activity is tightly linked to sensory inputs from balance perturbations, but more broadly distributed across muscles. Impaired sensorimotor control may be an important link in the causal pathway between PD and falls in the community.





O.4.vii Effects of a single bout of cardiovascular exercise on balance learning: A comparison of different exercise intensities

Philipp Wanner¹, Theresa Müller¹, Klaus Pfeifer¹, Simon Steib¹

¹Friedrich-Alexander University (FAU) Erlangen-Nürnberg

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BACKGROUND AND AIM: Recent evidence suggests that single bouts of cardiovascular exercise performed in close proximity to motor practice can enhance skill acquisition (online learning) and consolidation (offline learning) [1]. High-intensity bouts have been suggested to be particularly effective in improving consolidation, whereas moderate-intensity bouts may enhance skill acquisition. However, this suggested dose-response relationship has not been investigated systematically. Furthermore, first studies indicate that these positive effects may not apply for motor skills requiring the control of multiple effectors, such as balancing tasks. Thus, the aim of this study was to investigate the effects of cardiovascular exercise i) carried out immediately prior to motor practice, and ii) performed at different exercise intensities on learning a novel balancing task. METHODS: 49 healthy young adults (age: 25.41±2.86; BMI: 23.09±2.36) were randomized into one of three groups performing either 1) high-intensity interval exercise at 90%/60% Wmax (EX-H; n=15), 2) moderate-intensity interval exercise at 45%/25% Wmax (EX-M; n=17), or 3) continuous minimal-intense exercise at 25 W (CON; n=17) for a total of 17 minutes immediately prior to practicing a motor skill. The motor task required participants to stand on a tiltable (25°) platform (stabilometer), and to balance it in a horizontal position for 30 seconds. For each experimental condition, subjects performed 15 trials (5 blocks of 3 trials), followed by a retention test (1 block of 3 trials) 24 hours later. Time in balance (platform within ±5° from horizontal) was calculated for each trial and within- and between-group differences in online learning (skill improvement from baseline to last acquisition trial) and offline learning (performance change from last acquisition to retention block) analyzed using repeated-measures ANOVA. RESULTS: Significant online learning effects were observed in all participants (F8.7,398.9 = 26.6; p < .001) with no differences between experimental conditions (F2,46 = 0.3; p = .733) (Figure 1, A). Similarly, there were no differences in offline learning gains between groups (F2,46 = 1.115; p = .337) (Figure 1, B). CONCLUSION: Motor skill acquisition as well as consolidation was not improved by an acute bout of exercise, irrespective of intensity. The present findings do not confirm the positive effects of high-intensity cardiovascular exercise on motor learning, when exercise is performed immediately prior to skill practice. Balancing tasks require the control of multiple effectors as well as the integration and coordination of extensive perceptual information in the prefrontal cortex [2]. Besides the promoting effects of an acute exercise on neuroplasticity, highly elevated catecholamine due to a cardiovascular exercise bout has shown to have negative effects on the prefrontal cortex function and thus may explain the lack of beneficial effects on learning a balancing task [2]. ACKNOWLEDGEMENTS AND FUNDING: None. REFERENCES:[1]

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O.4.viii Neuromodulation of lumbosacral spinal networks enables independent standing after complete paraplegia

Dimitry Sayenko¹, V. Reggie Edgerton², Yury Gerasimenko²

¹Houston Methodist Research Institute, ²University of California, Los Angeles

BACKGROUND AND AIMS: Spinal cord injury (SCI) is a dramatic disorder resulting in paralysis and dysfunction of multiple physiological systems. It has been demonstrated that below a paralyzing injury, spinal circuitries have a functional potential that far exceeds what has been thought possible. Activity-based therapy combined with spinal electrical stimulation can promote motor function and restore mobility, resulting in dramatic effects on the wellbeing of individuals even after motor complete SCI. The objectives of this study were to (1) determine whether individuals having been chronically paralyzed for more than a year can regain independent standing with the aid of non-invasive electrical spinal stimulation, and (2) investigate whether postural control can be further improved following repeated sessions of stand training. METHODS: Using a double-blind, balanced, within-subject cross-over, and "sham"-controlled study design, 15 individuals with chronic SCI of various severity received transcutaneous electrical spinal stimulation (TSS) over the lumbosacral area to regain standing without external assistance. The primary outcomes included the qualitative comparison of need of assistance on each knee and the hips during standing without and in the presence of stimulation in the same participants, as well as the quantitative measures, such as the level of each knee assistance and amount of time spent standing independently. **RESULTS:** None of the participants could stand unassisted without stimulation or in the presence of "sham" stimulation. With stimulation, however, all participants could maintain upright standing with minimum and some (n=7) without any external assistance. Quality of balance control was practice-dependent, and improved with subsequent training sessions. Electrophysiological and functional properties of self-initiated postural adjustments during standing enabled by spinal stimulation, revealed functionally relevant responses that facilitated maintenance of upright standing with balanced posture (Fig. 1). **CONCLUSIONS:** After years following complete paralysis, the ability of self-assisted full weightbearing standing was recovered by the enabling effect of non-invasive electrical neuromodulatory approach, and improved using repeated training sessions. The observed functional and electrophysiological effects were similar qualitatively and quantitatively to those seen in experiments with epidural stimulation. The physiological impact of our findings encompasses multiple functional systems that may contribute to the independence and quality of life in a broad population of individuals with SCI, as well as with other neurological disorders and injuries. The

present data demonstrate that extensive neuroplastic changes of spinal and potentially supraspinal networks can occur using TSS administered in association with motor tasks. **ACKNOWLEDGEMENTS AND FUNDING:** Paralyzed Veterans of America (PVA) Research Foundation (Grant #3068); National Institutes of Health (NIH) SBIR grant R43EB018232.

O.5 Coordination of gait

O.5.i Muscle synergy complexity in children with cerebral palsy during the development of walking

Annike Bekius¹, Coen Zandvoort¹, Jennifer Kerkman¹, Andreas Daffertshofer¹, Annemieke Buizer², Jaap Harlaar³, Nadia Dominici¹

¹Vrije Universiteit Amsterdam, ²Amsterdam UMC, Vrije Universiteit Amsterdam, ³Delft University of Technology

BACKGROUND AND AIM: Cerebral palsy (CP) is a developmental motor disorder, caused by non-progressive lesions in an immature brain, which affects the development of movement and posture. In typically developing (TD) children the number of muscle synergies involved in walking increases throughout the motor development from two during neonate stepping to four in toddlers when they start to walk independently. In children with CP who walk independently, fewer muscle synergies are required to describe their muscle activation during walking than in TD children. This suggests that CP children use another motor control strategy. Unclear is, when such a strategy emerges. We, hence, investigated whether, already in the early stage of motor development, the complexity of muscle synergies in CP children is different from TD children. METHODS: We recorded whole-body kinematics and bilateral electromyography (EMG, 22 lower limb muscles) during treadmill and over-ground walking in fifteen CP (6 unilateral, 9 bilateral) and ten TD children, before and after they started to walk independently (age range: 3-47 months). The majority of CP and TD children was recorded repeatedly in a longitudinal study. Patients were included based on high-risk of developing CP with abnormalities in brain magnetic resonance imaging. Muscle synergies were estimated using non-negative matrix factorization of the EMG envelopes pooled across steps. We defined the number of synergies by examining the muscle weights, basic temporal activation patterns, total variance accounted for, and added variance for each synergy. Thereafter, we compared this number between CP and TD children based on the same age and similar walking experience. **RESULTS:** The number and pattern of muscle synergies changed with increasing walking development (i.e. from supported to unsupported walking) in both CP and TD children. After the first independent steps, several CP children required three muscle synergies to describe the bilateral muscle activation compared to four synergies found in TD children. Unilateral analysis in the group of independent walkers with



unilateral CP revealed three muscle synergies for the affected side compared to four for the unor less-affected side. No clear differences between sides were found for bilateral CP. These results were consistent across consecutive recordings (separated by 4-6 months) in each child. Severely affected CP children (GMFCS II/III), who walked with hand or trunk support, required two or three muscle synergies instead of four in age-matched TD children who walked independently. **CONCLUSIONS:** Our results suggest that children with CP use a 'simpler' motor control strategy during walking compared to TD children already at the early stage of their motor development. This appears to be specific to the affected side in unilateral CP children and might be related to the severity of CP. An increase in the number of subjects over the course of this longitudinal study

will give further insights into the modulation of muscle activation in young children with CP.

O.5.ii Humans use multi-objective control to regulate lateral foot placement when walking

Jonathan Dingwell¹, Joseph Cusumano¹

¹Pennsylvania State University

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BACKGROUND & AIM: Falls are common and perilous events for the elderly and many patients with locomotor impairments. When humans walk, they are more unstable side-to-side. Also, humans typically walk on paths (sidewalks, hallways, etc.) that limit lateral movement. How people regulate lateral stepping movements in such contexts is unknown. Due to biomechanical redundancy, there are infinite choices for where to place each foot at each step. Computational models are critical to disambiguate these possibilities. Here, we extend a Goal Equivalent Manifold (GEM) framework (Dingwell et al., PLoS Comput. Biol., 2010; John et al., PLoS Comput. Biol., 2016) to determine how humans exploit available redundancies to achieve these tasks. **METHODS:** We consider the left and right feet to act as end-effectors that enact control. We pose models to regulate stepping movements to achieve any of 3 hypothesized goals, either alone or in combination, to maintain: lateral position (zB), lateral speed or heading (ΔzB), and/or step width (w). Stochastic control models were developed from pre-defined goal functions (Cusumano & Dingwell, Hum. Mov. Sci., 2013) that tried to minimize errors relative to each hypothesized goal(s). For each model, we simulated 20 walking trials of 1000 steps each. We compared model predictions to human experimental data to test competing hypotheses about how humans regulate lateral stepping from each step to the next. RESULTS: Humans exhibited variability across all stepping variables. Models that controlled only one variable (zB, ΔzB , or w) could not replicate human stepping dynamics. Furthermore, more than one of the optimal controllers derived for the variables independently cannot be applied simultaneously because each predicts a different foot placement. We thus derived multi-objective control models of lateral stepping that trade-off control of any 2 of these 3 proposed candidate control variables. The resulting controllers enacted each new step as a weighted average of the 2 foot placements predicted by each individual controller.





For each possible pair of 2 candidate control variables (zB, Δ zB, or w), we varied the relative weighting (from 0% to 100%) of which was controlled more. Control models that tried to control either (zB & Δ zB) or (Δ zB & w) failed to replicate experimental findings, regardless of the relative proportion of control. However, models that traded-off control of (zB & w) replicated all relevant experimental stepping dynamics when the proportion of control was weighted ~87%-97% towards w-control. **DISCUSSION:** Regulation of lateral stepping movements is inherently multi-objective and balances task-specific trade-offs between competing task goals. To determine how people walk in their environment requires understanding both walking biomechanics and how the nervous system regulates movements from step-to-step. ACKNOWLEDGEMENTS & FUNDNG: DoD/CDMRP/BADER Consortium W81XWH-11-2-0222; NIH R01-HD059844 & R01-AG049735.

O.5.iii Walking with narrow steps: Are we more stable through increased sensory contributions? A galvanic vestibular stimulation study

Sjoerd Bruijn¹, Jaap van Dieën¹, Rina Magnani², Patrick Forbes³

¹Vrije Universiteit Amsterdam, ²Goiás State University, ³Erasmus MC

BACKGROUND AND AIM: Conventional wisdom suggests that walking with a narrower step width decreases gait stability due to a reduced base of support. McAndrew Young and Dingwell (2012) have shown, however, that medio-lateral local dynamic stability increases when walking with narrow steps. A potential explanation for this apparent conflict could be that walking with narrow step widths uses increased sensory contributions or control, leading to a higher stability. Here, we tested the hypothesis of increased sensory contributions during narrow base walking. Methods 14 subjects walked on a treadmill at 0.6 m/s under the guidance of a metronome to maintain a stepping frequency of 78 steps/min. Subjects walked with 3 different step widths; normal, narrow and wide. A stochastic electrical vestibular stimulus (0-25 Hz; RMS 1.35 mA; amplitude 5 mA) was delivered while EMG was recorded bilaterally from the medial gastrocnemius, gluteus medius, and erector spinae muscles. Kinematics of the feet and trunk, as well as ground reaction forces (GRF) were also recorded. Step width, local dynamic stability, vestibulomuscular coherence and vestibulo-GRF coherence (ML direction) were calculated. **RESULTS:** Similar to previous work, we found local dynamic stability increased during narrow base walking compared to wide base and normal walking. During normal walking, significant vestibulomuscular coherence was observed in the medial gastrocnemius, gluteus medius and erector spinae, and significant vestibulo-GRF coherence was observed in ML forces. During wide base walking, vestibulomuscular coherence in all muscles and vestibulo-GRF coherence decreased, in line with the view that vestibular contributions are reduced with an increased base of support. During narrow base walking, the vestibulo-GRF coherence more than doubled responses observed during normal walking. Vestibular contributions to muscle activity, however,



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increased in erector spinae, remained constant in gluteus medius, and decreased in gastrocnemius. **CONCLUSIONS:** Our results demonstrate that vestibular input to balance during locomotion varies inversely with the mediolateral step width. The increased vestibulo-GRF coherence during narrow walking supports the possibility that vestibular sensory contributions increase to maintain a higher local dynamic stability. The muscle responses evoked by the electrical stimulus, however, indicate that this is achieved through a complex interaction of the different muscles involved in this control. Specifically, control of the upper body through changes in angular momentum may increase to compensate for the reduced mechanical contribution of lower-limb muscles when walking with a narrow base. While our study suggests a change in sensory contributions for stability during narrow base walking, insight from other recording techniques (for instance cortical imaging) could be used to confirm these findings. References McAndrew Young, P. M. and J. B. Dingwell (2012). "Voluntarily changing step length or step width affects dynamic stability of human walking." Gait Posture 35(3): 472-477.

O.5.iv The spine in gait - a differentiated analysis of spinal rotary motion

Ulrich Betz¹, Janine Huthwelker¹, Jürgen Konradi¹, Claudia Wolf¹, Ruben Westphal¹, Kjell Heitmann², Helmut Diers¹, Philipp Drees¹

¹University Medical Center of the Johannes Gutenberg University Mainz, ²DIERS International GmbH

BACKGROUND AND AIM: Differentiated analyses of spinal motion during gait were hardly possible so far. Therefore, the functional model is mainly based upon visual observations and scarce investigations of isolated vertebral bodies (VB). Generally, at initial contact (IC) the equilateral side of the pelvis is assumed to be maximally forward rotated while the shoulder girdle demonstrates a counter rotation. These opposing movements continue throughout the spine, resulting in a contrary rotation of the upper and the lower spine. T7 is considered to be a point of intersection that mediates between the different directions of movement resulting in no or at least reduced rotary motion. Surface topography (ST) enables non-invasive gait analyses of VB from C7-L4 and the pelvis. Originally developed for static analyses the system has proven to be valid and reliable. Due to technical progress and further development ST is now applicable under dynamic conditions. To review the current functional model we present first results of rotary motion for every VB (C7-L4) and the pelvis across a whole standardized gait cycle (SGC). METHODS: Three gait cycles (GC) of 134 healthy, pain free participants aged 18-66 years (mean 39.88; SD 12.44) have been examined. While walking on a treadmill at 5 km/h, participants were recorded using the DIERS Formetric III 4DTM. For each frame of approx. 300 per subject the rotational position of C7-L4 and the pelvis was calculated resulting in a continuous course of the individual VB and pelvis movement. A treadmill-integrated foot pressure measuring plate allowed





for detections of GC. Using an interpolating spline application the observations were transformed to SGC, in which the movements are related to 0-100% of SGC. RESULTS: The averaged course of movement of individual VB (C7-L4) and the pelvis in SGC is displayed at Figure 1. The averaged maximum of pelvic rotation to the left is 4.17° (SD 2.98°) and 2.75° (SD 2.75°) to the right. The amplitudes of rotary motion for pelvis and lumbar spine (LS) are almost identical, but reached their respective maximum shifted in relation to time. The thoracic spine (TS), however, demonstrated different amplitudes of rotary motion (T12-T8 ascending, T7-C7 descending), but all segments reached their maximum values almost contemporaneously. T7 revealed the largest averaged amplitude of rotary motion to the left 7.11° (SD 5.11°) and T8 to the right 8.78° (SD 5.41°). While TS is moved very similarly by the participants, we found large individual differences in the movement of pelvis and LS. The point of time in SGC when the equilateral side of the pelvis is maximally forward rotated varies, distributed almost equally, from shortly before IC (0.99 % SGC) until beginning of terminal stance (0.36 % SGC). CONCLUSIONS: Pelvis and LS as well as TS acted as a functional unit respectively and demonstrated diametrically opposed rotary movement patterns. The results based on ST challenge the current functional understanding of spinal dynamics in gait.

O.5.v Spatial updating of remembered goal position during barrier avoidance

Brittany Baxter¹, William Warren¹

¹Brown University

BACKGROUND/AIM When circumventing a barrier on-line, Baxter & Warren (2017; 2018) found that participants tend to walk around the end of the barrier (waypoint) that minimized (i) the deviation from the visible goal (goal angle α), and (ii) the distance of the waypoint (d). Yet we must often walk off-line to the remembered location of a goal that is not visible. Here we manipulate the visibility of the goal behind a translucent or opaque barrier, while placing the distance d and goal angle α in conflict. Minimizing α produces a shorter path to the goal, while selecting the near end of the barrier minimizes the time that the goal is occluded -- but results in a longer total path. With the translucent barrier the goal and ground plane are continuously visible, whereas the opaque barrier requires spatial updating of one's position relative to the remembered goal location. METHODS Participants (N=14) walked in an immersive virtual environment wearing a headmounted display, while head position was recorded (90 Hz). On each trial, they started walking toward the goal pole, then a barrier (3m wide by 1.2m high) appeared obstructing the path. In half of the trials the barrier was opaque, occluding the goal pole, and in the other half the barrier was translucent. Participants were instructed to walk to the goal while avoiding the barrier naturally. The barrier's orientation (45° and 75° from frontal) and lateral offset (± 0.2 and ± 0.4m) were randomly varied. The α and distance to each waypoint were transformed into difference scores





($\Delta \alpha$ and Δd). The left/right response was analyzed using a mixed-effects logistic regression model with by-participant slope and intercept (Barr et al., 2013). RESULTS Fixed-effect variables, Δd and $\Delta \alpha$, significantly predict whether the average participant circumvents the barrier to the right (p<0.05). When the right waypoint is 10 cm closer than the other, the odds of passing to the right are 1.09 times higher than the left. When the right waypoint has a smaller α , the odds of passing to the right are also higher (OR = 1.9). Whether the barrier was opaque or translucent, however, did not affect the left/right response (p=.79). CONCLUSIONS The results indicate that the influence of distance d and goal angle α trade off in waypoint selection for barrier avoidance. The odds ratios for Δd and $\Delta \alpha$ are robust across several barrier experiments (Baxter & Warren, 2017, 2018). Participants sometimes prefer the nearer waypoint despite a longer path to the goal, consistent with online route selection. Participants can spatially update their position relative to a remembered goal location with the opaque barrier, just like the translucent barrier. Path integration thus offers a bridge between on-line and off-line control. Supported by Center for Vision Research Pilot Grant, the Peter D. Eimas Graduate Research Award, and NSF BCS-1431406 REFERENCES Barr, Levy, Scheepers, & Tily (2013). Random effects structure for confirmatory hypothesis testing: Keep it maximal. Journal of memory and language, 68(3), 255-278. Baxter & Warren (2018). Optical Variables Influencing Barrier Avoidance. Poster, Vision Sciences Society Conference; FL, USA. Baxter & Warren (2017). Waypoint selection in barrier avoidance. Poster, ISPGR, FL, USA.

O.5.vi Type of prosthesis influences functional performance and quality of life in patients with transtibial amputations

Ophelie Puissegur¹, Gordon Stevens², Elizabeth Ginzel², Rita Patterson¹, Nicoleta Bugnariu¹

¹University of North Texas Health Science Center, ²Baker O&P

BACKGROUND AND AIM The K-Level classification of prosthetic feet is used in conjunction with a similar classification of functional level of patients with transtibial amputations to determine the prosthetic feet that are prescribed and reimbursed. Patients classified as functional level 2 (household ambulators), receive a K2 prosthetic foot and not the higher functioning K3 prosthetic reserved for those who are considered community ambulators. We evaluated effects of type of prothetic feet on functional performance and quality of life in patients with transtibial amputations secondary to diabetes, vascular disease or trauma. **METHODS** Patients ambulating with either K2 or K3 prosthesis participated. The V-gait CAREN system was used to measure standing balance sway, gait speed, kinematics and kinetics during level walking and on an 4.8 degrees ramp. Participants were then randomized into groups for a 2-week trial period of wearing a prosthetic foot that was either at, above or below the current functional level of the patient. Outcome measures included: SF 36, Reintegration to Normal Living Index, Timed Up and Go, Short Physical





Performance Battery, Dynamic Gait Index and Activity Specific Balance Confidence Scales, and the Physiological Cost Index calculated for level and ramp walking. RESULTS Baseline quality of life, balance and gait measures were significantly lower for patients ambulating with K2 vs K3 feet (p<0.05). The Physiological Cost Index increased 20% from level ground to ramps. Switching from K3 to K2 resulted in significantly increased sway during standing balance, decreased functional limits of stability, decreased gait velocity even on level ground and increased compensatory hip motions and moments. Switching from K2 to K3 resulted in significantly improved standing balance and increased gait velocity on level ground (p<0.5). Immediate effects of switching from K2 to K3 foot were: decreased sway in standing balance, improved functional stability limits and increased gait velocity. After a 2 week trial period, patients wearing a prosthetic foot above their initial functional level improved walking kinematics, were able to perform ramp trials and reported increased guality of life. CONCLUSION Results confirm that K3 prosthetic foot provides additional benefits for balance and gait function and quality of life compared to K2. Physical therapists working closely with prosthetists need to advocate for prosthetic prescriptions practices that have potential to improve functional status and quality of life. Providing higher level prosthetic feet to patients who are classified at lower functional level can improve their balance, prevent serious costly injuries caused by trips and falls, and facilitate transition to higher functional status. ACKNOWLEDGEMENTS AND FUNDING This work was funded by an AOPA Research Award administered by the Center for Prosthetics and Orthotics Learning and Outcomes/ Evidencebased Practice and NSF grant 1208623

O.5.vii Deficient tibialis anterior activity following inward perturbation during walking predisposes elderly to use stepping rather than ankle strategies to control balance

Maarten Afschrift¹, Friedl De Groote¹, Ilse Jonkers¹

¹KU Leuven

Introduction: The influence of aging on reactive control of balance during walking has been mainly investigated in the sagittal plane, whereas balance control in response to frontal plane perturbations is largely unexplored in the elderly. This is remarkable, given that walking mainly requires active control in the frontal plane [1]. An extensive gait perturbation protocol was used to test whether reactive control of walking balance changes with aging and whether these changes are more pronounced in the frontal than in the sagittal plane. We hypothesize that alterations in reactive muscle activity cause an age-related shift from ankle [2] to stepping strategy [3] in response to perturbations in the frontal and sagittal plane, and that the alterations in the frontal plane will be larger than the alterations in the sagittal plane. **METHODS:** Balance of 18 healthy young (age 21 + 2 years) and 10 older adults (age 71 + 4 years) was perturbed during walking on a treadmill in four directions and in four phases of the gait cycle (figure 1a). Medio-lateral





perturbations were induced by a sudden platform translation to the left or right and anteriorposterior perturbations were induced by a sudden increase or decrease in both belt speeds. The response to the perturbation was measured using full-body motion capture, ground reaction forces and muscle activity of 16 major lower-limb muscles. A generalized linear mixed effect model was used to test the hypothesis by comparing the differences in adjustment in foot placement (i.e. stepping strategy), COP movement (i.e. ankle strategy) and reactive muscle activity between the young and older subjects. Forward simulations with OpenSim gait2392 Model was used to evaluate the effect of reactive muscle activity on foot placement and COP movement. **RESULTS:** Only for a small subset of the perturbations, reactive muscle activity and kinematic strategies differed between young and older subjects. When perturbation magnitude increased, the older adults relied more on a stepping strategy and less on an ankle strategy for inward directed perturbations, given the increase in inward stepping (stride width, figure 1b, p<0.001), decreased outward COP movement in the foot (figure 1d, p=0.01). In addition, tibialis anterior activity increased less in the older compared to the young subjects. (figure 1c, p<0.001). Using simulations, we related tibialis anterior activity to outward movement of the center of pressure in the stance foot and confirmed its contribution to the ankle strategy. Hence, a failure to generate timely and sufficient tibialis anterior activity in the elderly necessitates adjustment of foot placement. **CONCLUSIONS:** We concluded that deficient tibialis anterior activity predisposes elderly to use stepping rather than lateral ankle strategies to control balance. [1] Connor, Journal of Neurophysiology (2009) [2] Reimann, PLoS One, (2017) [3] Hof, Journal of experimental biology. (2010)

O.5.viii Influence of required coefficient of friction on rate of shoe wear

Sarah Hemler¹, Jessica Sider¹, Kurt Beschorner¹

¹University of Pittsburgh

BACKGROUND AND AIM: Falls resulting from slipping are one of the leading causes of injury. Research has shown that shoes' ability to prevent a slip event degrades over time [1]. Preliminary evidence suggests that shoes do not wear at the same rate for all individuals. Thus, identifying characteristics that predict wear rate for shoes may be useful in individualizing footwear replacement programs. Required coefficient of friction (RCOF), is a measure for how much friction is utilized during walking, and has previously been used as a metric individual risk of slipping [2]. We assert that this metric also predicts the rate at which a shoe is worn down. Specifically, we expect that increased frictional demands during gait are correlated with faster shoe wear. **METHODS:** Eleven subjects completed gait assessments wearing two types of slip-resistant shoes while walking over force plates; peak RCOF was measured for each subject and shoe [3]. Then, subjects wore each pair of shoes in their workplace for one month. At baseline and after the shoes were worn, silicone rubber molds of the heel tread were made. The tread volume of each mold was measured by filling the tread imprints with water and weighing the mass change. The volumetric difference between each month of wear was calculated and normalized to walking





distance as measured by a pedometer attached to the shoes. This parameter was termed wear rate [mm3/km]. Only data for which the subjects walked at least 75 km were included [4]. As such, there were three full data sets that included both types of shoes and six that included only one shoe. Statistical methods consisted of repeated measures ANOVA with incomplete data using maximum likelihood method. This method is suited for repeated measures with incomplete data [5]. The dependent variable, wear rate, was log transformed to achieve normal residuals, and the independent variables were shoe type and peak RCOF. RESULTS: Peak RCOF ranged from 0.09 to 0.22. Wear rate was positively correlated with RCOF (p = 0.0247) across all shoes and subjects. It should be noted that the trend was largely driven by two subjects with low peak RCOF values and correspondingly low wear rates. CONCLUSIONS: This research provides preliminary evidence that an individual's peak RCOF is related to their wear rate. Therefore, peak RCOF may be able to predict individualized shoe replacement schedules. Given the limited number of subjects at present, the results should be monitored as the data set for this study becomes more complete. ACKNOWLEDGEMENTS & FUNDING: This work was funded by a grant from the National Institute for Occupational Safety and Health (NIOSH R01 OH 010940) and the National Science Foundation (NSF 16-104). 1. Verma, et al. (2014). Ergo. 2. Beschorner, et al. (2016). Gait & Pos. 3. Chang, et al. (2011). Human Factors. 4. Hemler, et al. (2018). Proc STLE 2019. 5. Gornbein, et al. (1992). Stat methods in Med Res.

O.6 Cognitive, attentional and emotional influences

O.6.i The effects of dual tasking and aging on event related potential (ERP) components of gait cycle

Inbal Maidan¹, Shiran Shustak¹, Dmitry Patashov², Eran Gazit¹, Boris Shapiro², Aviran Levy², Nir Giladi¹, Jeff Hausdorff¹, Anat Mirelman¹

¹Tel-Aviv Sourasky Medical Center, ²Holon Institute of Technology

BACKGROUND AND AIM: Walking in everyday life requires coping with challenging conditions such as dual tasking, and is thus considered to be controlled by higher cognitive processes. The effects of dual tasking on gait and their association with fall risk in older adults have been widely studied. In recent years, evidence linking the changes in gait during dual tasking to changes in brain activation has started to emerge. Electroencephalogram (EEG) is a neuroimaging method that can be useful in investigating brain activity during real, dual task walking. Our aim was to evaluate the effects of dual tasking on the event related potential components of the gait cycle. **METHODS:** 10 healthy young adults (age: 33±6.5yrs; 50% women) and 10 healthy older adults (age: 67.1±5.52yrs; 60% women) walked on a treadmill with audio oddball task (dual task) and





without (simple walk), while wearing a 20 channel, wireless EEG cap and accelerometers on the right and left ankles. Each heel strike extracted from the accelerometers was used as the event from which electrical brain activity pattern was calculated. Amplitude and latency of the ERP components from channel Pz were compared between and within groups while controlling for gait speed using linear mix model analysis. **RESULTS:** The ERP components of gait cycle included a positive deflection that peaked around 25-35% of gait cycle (P1), negative deflection that peaked around 50-60% of gait cycle (N1), and second positive deflection that peaked around 70-80% of gait cycle (P2). Older adults showed higher amplitudes of all peaks, compared to young adults (P1: p=0.012, N1: p=0.025, P2: p=0.012) during usual and DT. In addition, for both groups, higher amplitudes were observed during walking with oddball (dual task) as compared to usual walking (P1: p=0.072, N1: p=0.014, P2: p=0.014). The latency of these ERP components were similar in the two groups (P1: p=0.610, N1: p=0.584, P2: p=0.438) and during usual and dual-task walking (P1: p=0.357, N1: p=0.159, P2: p=0.209). P1 amplitude was correlated with gait speed in the young adults (r=0.700, p=0.024), but not in the older adults (p=0.819). In contrast, among the older adults, P1 and N1 amplitudes were correlated with MOCA scores (p=0.715, r=0.020; p= -0.738, r=0.015). CONCLUSIONS: These findings provide direct evidence on the effects of aging and task complexity on electrical brain activity during walking. The ERP amplitude mirrors the amount of neurons activated during the processing of incoming information. Therefore, the higher amplitudes seen during dual tasking in both young and older adults likely reflects the extended resources required for walking in challenging conditions. This effect was even larger in older adults indicating an ageing effect potentially reflecting a deterioration of brain capacity in ageing.

O.6.ii The neural signature of impaired dual tasking in Idiopathic REM sleep behavior disorder patients: An fMRI study

Kaylena Ehgoetz Martens¹, Elie Matar¹, James Shine¹, Joseph Phillips², Matthew Georgiades¹, Ronald Grunstein¹, Glenda Halliday¹, Simon Lewis¹

¹University of Sydney, ²University of Western Sydney

BACKGROUND & AIM: Dual task walking is known to require increased mental engagement, and can be used to assess subtle cognitive decline in older adults. Indeed, gait has been proven to be a better predictor than baseline cognition, since during dual tasking, gait shifts from being automatically to more consciously controlled, and thus demands increased sharing of attentional resources. As such, dual task gait can shed light on subtle cognitive deficits and any compensatory neural mechanisms which may be at play to overcome early neurodegeneration. Idiopathic REM sleep behavior disorder (iRBD), characterized by dream enactment, has been flagged as a prodromal stage of neurodegeneration, at high risk of developing synucleinopathies such as Parkinson's disease and Lewy Body Dementia. While longitudinal studies have shown





cognitive dysfunction progresses over time in iRBD, no studies to date have investigated the effects of dual tasking on gait in iRBD, nor the related neural signature associated with ongoing neurodegeneration. The current study aimed to investigate the neural signature associated with dual task interference in iRBD patients and to shed light on potential deficits and compensatory mechanisms at play early in the neurodegeneration process. METHODS: 23 controls and 29 iRBD patients had functional MRI scans as they performed a validated dual task virtual reality gait paradigm using foot pedals. A subcohort of 17 controls and 24 iRBD patients completed normal and dual task gait assessments on a pressure sensor carpet. To investigate specific brain regions that had greater or less BOLD response, epochs of 'walking' with high versus low cognitive load were contrasted. A seed-based functional connectivity analyses was performed using the multiplication of temporal derivatives metric to compute the average correlation between 31 regions of interest over time and fitted to a general linear model to contrast High versus Low cognitive load. RESULTS: iRBD patients showed deficits in dual tasking with greater step time compared to controls during overground 'real' walking. Functional MRI revealed that iRBD patients had reduced BOLD signal in the dorsal caudate nucleus, and significantly different corticostriatal functional connectivity patterns from controls when dual tasking in conditions of High versus Low cognitive load. Whilst controls showed greater connectivity between frontoparietal and motor networks, iRBD patients exhibited less change in this connectivity as a function of cognitive load. **CONCLUSIONS:** These findings demonstrate evidence of dual task gait deficits in iRBD patients, underpinned by disrupted corticostriatal connectivity. Minimal differences in the level of functional connectivity between dual tasking conditions of High and Low cognitive load, suggests that iRBD patients recruit cognitive networks to control gait even when the cognitive demands are Low. This indicates a compensatory strategy for early cognitive decline in iRBD. ACKNOWLEDGEMENTS **AND FUNDING:** This study was supported by a Sydney Fellowship (KEM) from the University of Sydney, and the National Health and Medical Research Council (GMH; RRG; SJGL, JMS; EM).

O.6.iii An invisible hand: Automatic preparation for arresting a fall when viewing a handrail

David Cole¹, Butler Blake¹, Mahmoud Mansour¹, Sarah Schwartz¹, David Bolton¹

¹Utah State University

BACKGROUND AND AIM: Mere observation of our immediate surroundings can potentiate action, as evidenced by visually-primed activity in the motor cortex. By automatically and unconsciously casting our environment in motor terms, we can rapidly release goal-directed movements. In effect, we can partially circumvent the speed-accuracy tradeoff attributed to reflexes and operants. A potentially important but unexplored application of this so-called affordance effect is in postural control. During loss of balance, action must be both rapid and





contextually appropriate. In this paper, we report the first extension of the affordance effect to a postural context. **METHODS:** A convenience sample of 63 young adults participated in each of three conditions. First, to measure the affordance effect under low-level postural threat, a cable held participants in a 10° forward lean. Liquid-crystal lenses occluded their vision while motorized partitions randomly blocked either their footway or a handrail. Post-vision (i.e., sight of actions that the environment afforded), single-pulse transcranial magnetic stimulation (TMS) targeted an intrinsic hand muscle. The resulting motor-evoked potential (MEP) indexed corticospinal excitability, which we predicted would be greater in sight of the handrail, supporting the affordance effect. Second, to measure the affordance effect in the context of postural perturbations and motor demands, the cable unpredictably released participants following TMS, requiring either a step or a grasp. Third, as a manipulation check, we sought to directly replicate the affordance effect in a seated context. Participants sat within reach of the

rail, which was randomly blocked, while the cable system and footway were irrelevant. **RESULTS:** A 2 × 2 (Posture[threat, perturbation] × Affordance[footway, handrail]) repeated measures ANOVA supported an interaction (p = .024) wherein the handrail produced larger MEPs only under postural threat alone. A one-tailed t-test confirmed our manipulation's validity (p = .006). **CONCLUSIONS:** In summary, the affordance effect transfers to a postural context, but perturbations may mask or, puzzlingly, attenuate it. Experimentally parsing these possibilities is a future direction, along with analyzing the effects of cognitive load and decline on the affordance effect during postural threat. **ACKNOWLEDGEMENTS AND FUNDING:** N/A

O.6.iv Embodiment of painful situations and its postural correlates

Thierry Lelard¹, Olivier Godefroy¹, Said Ahmaidi¹, Pierre Krystkowiak¹, Harold Mouras¹

¹Université de Picardie

BACKGROUND AND AIM: Embodiment is made possible by the ability to imagine ourselves in a particular situation and can be considered as sensorimotor simulation. Embodiment is an automatic process, subject to individual differences, is flexible, and can be activated more efficiently following simple manipulations of motor activation or attention to body parts. In our previous studies, we have demonstrated postural changes in response to painful situations, but the effect of an implicit instruction has not been studied yet. The aim of the present study was to record differential responses according to whether or not subjects were instructed to imagine themselves in a painful or non-painful situation. Painful stimuli and instructions to mentally simulate the displayed situation were hypothesized to induce postural changes that could be demonstrated by changes in the center of pressure (COP) trajectory compared to viewing the same stimuli with no instructions. **METHODS:** Thirty-one participants were recruted in this study. Visual stimuli depicting scenes defining either painful or non-painful or non-painful or non-painful or non-painful or non-painful success were recruted in this study. Visual stimuli





Participants were instructed to stand quietly on a posturographic platform. Physiological measurements (heart rate HR) and postural responses (COP displacements) were recorded in response to the stimuli. During the first session, participants had no instructions whereas in the second session they had instructions to imagine themselves in the situation. A time-course analyses (1 s sliding window) was conducted for postural and physiological parameters. **RESULTS:** We reported an interaction effect (Instruction x Stimuli x Time) for COP position. Indeed, we demonstrated that instruction to imagine themselves in a painful situation induced posterior displacement of the mean position of the COP. These differences appear at different times during presentation of painful situation (4 s; 9-12 s) when we compared the observation (no instructions) with the mental simulation (instructions). HR was higher in the mental simulation condition than in the observation condition and lower for painful stimuli than for non-painful stimuli. **CONCLUSIONS:** Embodiment of painful situations by postural control The results of time-course analyses demonstrated modulations and physiological changes depending on whether or not the participants were instructed to imagine themselves in the situation.

O.6.v Shift in attentional allocation during cognitive-motor dual-tasking following cognitive or physical training in healthy older adults

Karen Li¹, Rachel Downey¹, Louis Bherer², Thien Tuong Minh Vu³, Kristell Pothier⁴, Brittany Intzandt¹, Tudor Vrinceanu², Thomas Vincent⁵, Anil Nigam⁵, Antony Karelis⁶, Laurent Bosquet⁷, Nicolas Berryman⁸

¹Concordia University, ²Université de Montréal, ³Centre hospitalier Université de Montréal, ⁴University of Tours, ⁵Centre de recherche de l'Institut de cardiologie de Montréal, ⁶Université du Québec à Montréal, ⁷Université de Poitiers, ⁸Bishop's Universit

BACKGROUND AND AIM. Walking while simultaneously performing a cognitive task (cognitivemotor dual-tasking) predicts falls risk and cognitive impairment in older adults. While dual-task performance can improve following cognitive or physical training, less is known about how training modulates attention between cognitive and motor domains during dual-tasking. Additionally, it is unclear how individual differences in cognitive and physical functioning in older adults predicts change in dual-task performance following training. **Methods.** To investigate this, seventy-four healthy older adults were randomized to one of three training arms: Cognition (COG) = 27, Aerobic Exercise (AE) = 28, Gross Motor Abilities (GMA) = 27, delivered over 12 weeks (1 hour, 3 x/week). Single and dual-task performance (gait speed, m/s; cognitive accuracy, %) was evaluated before and after training, using the 2-back task as a concurrent cognitive load. **Results.** Compared to baseline levels, we observed few changes in gait speed during dual-tasking following training (d = 0.06). However, dual-task cognitive accuracy improved (d = 0.51), which could suggest increased attentional efficiency. Individuals with lower baseline cognitive status (Montreal





Cognitive Assessment, dual-task 2-back accuracy) and physical functioning (Timed Up and Go) showed greater improvements in cognitive accuracy dual-task costs. There were no differences across training groups. **Conclusions**. Results suggest that regardless of the type of intervention, training can shift attentional allocation between cognitive and gait domains during dual-tasking. Our results are clinically useful as they suggest that cognitive remediation or physical exercise for dual-tasking may be particularly beneficial to individuals with poorer cognitive and physical functioning. As cognitive-motor dual-tasking is common, the observed plasticity of attentional allocations for improving the health and well-being of older adults.

O.6.vi Postural threat effects on perceptions of lower leg somatosensory stimuli during standing

Taylor Cleworth¹, Ryan Peters², Romeo Chua³, J. Timothy Inglis³, Mark Carpenter³

¹University of Waterloo, ²University of Calgary, ³University of British Columbia

BACKGROUND AND AIM: Height-induced postural threat affects emotional state and feet-inplace standing balance behaviour [1]. A threat to balance also affects sensory [2] and cortical processes [3] during balance tasks, and conscious perceptions of balance-related movements [4]. The changes in perception with threat may be related to a change in perpetual thresholds, response scaling, or both. The purpose of this study was to examine the changes and potential mechanisms underlying conscious perceptions of balance-relevant information during heightinduced postural threat. METHODS: 45 healthy young adults (24 female), free from any neurological or orthopedic impairments, performed one of three experiments where they stood on a support-surface at LOW (0.8m) and HIGH height (3.2m) with gaze directed to a visual target at eye level ~1.8m away. In Exp 1, participants stood for 7min with their left foot on a tilting platform, which continuously rotated in the pitch plane, and their right foot beside on a stable surface. Participants were asked to track the movements perceived in their left ankle using a handheld rotary encoder. In Exp 2, participants stood in the same orientation as Exp 1; however, they were asked to indicate when they perceived an ankle dorsi- or plantarflexion. In Exp 3, participants stood on a stable platform through which a probe could protrude through making contact with the foot sole. Participants were asked to indicate when they perceived a 3Hz and 40Hz vibratory stimulus. Actual and tracked movement amplitudes were calculated in Exp 1, while detection thresholds were calculated for ankle rotations and foot sole vibrations in Exp 2 and 3, respectively. **RESULTS:** In all experiments, participants reported increased levels of fear and anxiety, while decreasing balance confidence at height (p<0.05). In Exp 1, left ankle rotation amplitude did not change between height conditions. However, the amplitude of perceived ankle rotations increased significantly in the HIGH compared to LOW condition (p=0.028). In Exp 2, there was a significant effect of height on perceptual thresholds calculated for ankle rotations (p=0.018), with higher



ispgr

perceptual thresholds observed in the HIGH (0.103°±0.02°) compared to LOW condition (0.081°±0.013°). In Exp 3, there were no significant height effects on the thresholds calculated for 3Hz or 40Hz foot sole vibrations (3Hz: p=0.259; 40Hz: p=0.716). **CONCLUSIONS:** Perceived threat can influence the amplitude of above-threshold ankle rotations, and reduce sensitivity to an ankle rotation without any change to foot sole sensitivity. Together, these results suggest height-related changes in somatosensory-based perceptual gain may be related to modified response scaling rather than to thresholds. These results highlight the effect of postural threat on neurophysiological and cognitive components of balance control, and provide insight into clinical balance assessment and intervention. **ACKNOWLEDGEMENTS AND FUNDING:** Funded by NSERC. **REFERENCES:**[1] Davis et al, Gait Posture, 2009; [2] Horslen et al, J Physiol, 2018; [3] Adkin et al, Neurosci Lett, 2008; [4] Cleworth & Carpenter, Neurosci Lett, 2016.

O.6.vii Can split-belt treadmill training improve dual-task turning performance in patients with Parkinson's disease with freezing of gait

Nicholas D'Cruz¹, Pieter Ginis¹, Jana Seuthe², Christian Schlenstedt², Alice Nieuwboer¹

¹KU Leuven, ²Christian-Allbrechts-University of Kiel

BACKGROUND AND AIM: Motor-cognitive dual tasks (DT) pose several difficulties for patients with Parkinson's disease with Freezing of gait (PD+FOG) as it requires continuous adaptation and switching of attention. Targeted motor-cognitive DT training has been shown to improve DT performance in PD+FOG with limited retention and transfer effects. Split-belt treadmill training (SBT) implicitly requires online monitoring and adaptation of gait, however the potential to induce learning and influence DT performance is unknown. Therefore in this study, we investigated whether motor adaptation training by means of SBT could improve motor-cognitive DT performance in PD+FOG. METHODS: To date, thirty-nine PD patients with FOG and twenty-seven age-matched healthy controls (HC) participated in a single training session at two centers (KU Leuven, Belgium and CAU of Kiel, Germany). They were randomized to four 30-minutes (6x5min) intervention groups: A) SBT belts' speed ratio 1:2; B) SBT belts' speed ratio 3:4; C) SBT changing belts' speed ratios; D) Tied-Belt. For the SBT conditions (A-C) the belt's speed was reduced of the leg with the longer step length measured during overground gait analysis. A one-minute 360° turning at the spot test with alternating directions and while simultaneously performing an auditory stroop task was performed pre- and post-training as well as at 24h retention. A linear mixed models analysis was applied to investigate the effect of training condition over time. **RESULTS**: Preliminary analysis showed that PD+FOG and HC both improved in DT Turning from Pre-training to 24h Retention (DT Peak Turning Speed: Main effect of Time F=6.07; p>0.01; Relative change from baseline to Retention: PD+FOG 6.1%; HC 7.9%). Although PD+FOG showed deterioration from Pre- to Post-training, likely due to fatigue and dopamine exhaustion, offline consolidation was





preserved (DT Peak Turning Speed: Post-training to Retention - relative change: PD+FOG 8.1% vs HC 2.6%). Performance on the auditory Stroop task also showed improvements from Pretraining to retention, trending towards greater improvements for SBT vs Tied Belt training in the whole group (Faster Response Time - Training*Time effect F=1.59; p=0.22; relative change from Baseline to retention 3.3%) and for PD+FOG subgroup (Lower Response Time variability - Training*Time effect F=2.09; p=0.16; relative change from Baseline to retention 7.6%) **CONCLUSIONS:** A single SBT session was seen to induce learning in HC as well as PD+FOG, with motor adaptation effects showing trends of transfer and automaticity to DT turning situation. This improved automaticity possibly frees up attentional resources as improvements were found in the cognitive task as well. Future work should investigate these mechanisms as well as the longer term effects of SBT on motor-cognitive DT performance.

O.6.viii Look where you are thinking

Yogev Koren¹, Yisrael Parmet¹, Ilay Sofer¹, Ohad Ben-Shahar¹, Rotem Mairon¹, Simona Bar-Haim¹

¹Ben-Gurion University

BACKGROUND: When negotiating complex terrains, humans use vision, proactively, to tailor their walking pattern to upcoming ground. Compared to usual walking, complex-terrain walking has been associated with increased prefrontal cortex (PFC) activity. In the present study, we investigate PFC activity and the visual exploration pattern under an unusual walking condition in which visually the terrain is perceived as flat, yet each foot placement is on a new, unexpected terrain, thus causing a mismatch between visuospatial perception and lower-extremity proprioception. Aim: To investigate the causal relation between walking stability and both PFC activity and the visual exploration pattern. **METHODS:** This was a prospective, cross-sectional study, involving eleven healthy young adults. Participants walked in two conditions: normal walking and perturbed walking. The experiment took place in a quiet, well-lit hallway approximately 30 meters long. To monitor PFC activity, we measured the change in oxy and deoxy hemoglobin concentrations (Ä[HBO] and Ä[HHB] respectively) using two portable functional near-infrared (fNIRS) devices. To characterize the visual exploration pattern, we used a wireless eye-tracker, which provides the location of the instantaneous gaze-fixation on the projected two-dimensional space in front of the participant. Based on the geometry of the hallway, we calculated the vanishing-point (VP), i.e. a point on an image plane where the two-dimensional projections of parallel lines in three-dimensional space appear to converge. The VP served as a fixed reference point for all gaze-fixations detected by the eye-tracker. RESULTS: In the normal walking condition, participants walked significantly faster (MD 0.169 m/s ± SE 0.013, p<0.001) and looked further ahead (MD 7.32 percent ± 1.76SE, p<0.001) onto the future path (i.e. closer to the VP) than they did in the perturbed condition. [HBO] increased and [HHB] decreased during perturbed walking





(MD 0.277imol ± 0.095SE, p=0.004; -0.063imol ± 0.031SE, p=0.043, respectively). Mean gazefixation distance from the VP was negatively correlated with Ä[HBO] in the normal walking condition (R2= -0.564, p=0.004). **DISCUSSION:** We interpret the decrease in walking velocity, caused by the perturbations, as indicative of a change in walking strategy (i.e. cautious gait) due to an increase in the perceived challenge. This notion is supported by the increase in PFC activity, as indicated by the increase in [HBO] and decrease in [HHB], signifying that walking-control has shifted from "automatic" to executive control. Gaze-fixations were also affected by this increase in perceived challenge and were more often directed at the walking surface (i.e. downward-gazing), presumably to acquire information about the terrain. We interpret the negative correlations found between gaze-fixation distance and the change in hemoglobin concentrations as indicative of an increase in PFC blood volume, due to the head inclination, and not due to brain activity. **CONCLUSIONS:** Walking with mechanical, unpredictable perturbations shifts walking from "automatic" to executive control, possibly due to the need to acquire visual information about the walking surface.

