Abstract Book

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Keynote Abstracts

Sunday, June 25

Grégoire Courtine
Swiss Federal Institue of Technology (EPFL), Switzerland

Locomotor Neuroprosthetics

Over the past decade, we developed a multipronged intervention that restored supraspinal control over leg movements in animal models of spinal cord injury. The intervention acts over two time windows. Immediately, electrochemical neuromodulation of spinal circuits enables motor control of the paralysed legs. In the long term, will-powered training regimens enabled by electrochemical neuromodulation and robotic assistance promote neuroplasticity of residual connections—an extensive rewiring that reestablishes voluntary control of movement. To identify the physiological principles underlying the therapeutic effects of this intervention, we used computational modelling, inactivation techniques and genetic manipulations. We found that our electrochemical neuromodulation therapy enables motor control through the modulation of muscle spindle feedback circuits. This framework steered the design of spatially selective spinal implants that specifically target these circuits to modulate muscle synergies responsible for flexion and extension of the legs. To reproduce the natural activation pattern of these muscle synergies during locomotion, we interfaced the leg motor cortex activity with electrochemical neuromodulation therapies in non-human primates. This wireless brain spinal interface instantly restored robust locomotor movements of a paralyzed leg in a non-human primate model of spinal cord injury. Preliminary clinical studies suggest that these concepts and technologies are directly translatable to therapeutic strategies to augment motor recovery after spinal cord injury in humans.

Monday, June 26

Susan Whitney
University of Pittsburgh, USA

Vestibular rehabilitation: A multidisciplinary collaboration

This session will demonstrate how clinician-scientists can work with experts in technology to improve the human experience with persons with balance and vestibular disorders. A review of instruments that have been developed to provide care and measure the effectiveness of care for persons living with balance and vestibular disorders will be provided. In addition, the effectiveness of vestibular physical therapy will be described.

Tuesday, June 27

Steve Collins
Carnegie Mellon University, USA

Designing exoskeletons and prostheses that enhance human performance

Exoskeletons and active prostheses could improve mobility for hundreds of millions of people. However, two serious challenges must first be overcome: we need ways of identifying what a device should do to benefit an individual user, and we need cheap, efficient hardware that can do it. In this talk, we will describe a new approach to the design of assistive devices, based on versatile emulator systems and algorithms that automatically customize assistance. We will discuss exoskeletons that use no energy themselves, yet reduce the energy cost of human walking, and efficient, electroadhesive actuators that could make wearable robots an order of magnitude cheaper and more efficient. Finally, we will consider the implications of these technologies for clinical practice and commercial products.

Wednesday, June 28

Alice Nieuwboer
KU Leuven, Belgium

The enigma of facing impaired basal ganglia for gait control and rehabilitation

In the past 10 years, research in our laboratory has focused on investigating the behavioral and neuronal determinants of walking deficits in Parkinson's disease (PD) and whether these problems can be overcome with neurorehabilitation. The role of the basal ganglia, as providing a stimulus filtering function and as a learning center of automaticity, is very much highlighted in the typical gait disorders of PD. Our work has shown that freezing of gait can be conceptualized as a loss of automatic spatiotemporal control, which culminates in an inability to release an intended motor response. We claim that this problem reflects a wider motor control disturbance, rather than just a gait deficit. We and others have also shown that freezing of gait is behaviorally complex as it is mediated by cognitive and emotional factors as well as by postural instability. At the neurological systems level, we demonstrated that freezing-related dual task performance was associated with decreased functional connectivity within the striatum and between the caudate and superior temporal lobe. Structurally, we found greater alterations in the cortico-striatal network in freezing than in non-freezing cohorts. This brings an interesting paradox to the fore namely that freezers are more impaired in the neural networks through which they can re-acquire motor skills and are less proficient in practice while switching between task demands. As a result, freezers show reduced early adaptation during motor learning and impaired late consolidation of motor memory. Furthermore, the impact of providing intermittent and continuous cues and feedback to restore the walking pattern is different in patients with and without freezing of gait. This points to the future agenda for gait research in PD. We suggest that developing easy-to-use biomarkers which herald the reaching of the freezing milestone in the disease evolution is a critical step forward to instigate timely and individualized training protocols. In addition, we anticipate that rehabilitation technology will play a major role in freezing prevention using wearable sensors to tap the remaining compensatory brain circuits. Future longitudinal studies need to address whether slowing down the severity of gait deficits can be achieved using these methods against the background of basal ganglia neurodegeneration.

Thursday, June 29

William McIlroy
University of Waterloo, Canada

The remarkable control of balance reactions and the associated implications for clinical assessment and rehabilitation.

The challenge and control of maintaining stability in humans can be uniquely influenced by our adaptations related to habitual bipedalism. Achieving effective and efficient stability control arises from a blend of anticipatory control and stimulus-evoked reactions. The latter will be the primary matter of attention for this presentation with specific focus on the remarkable complexity of the control of dynamic reactions to whole body instability. The healthy neuromuscular control of such behavior exhibits a remarkable degree of flexibility that is dependent on a spectrum of sensory inputs (modality and somatotopy) and CNS transformations that result in elegant patterns of effector activity to achieve the essential precision in movement and force needed to regain stability. While such sensorimotor transformations are themselves quite impressive, it the success in the face of the challenge of temporal urgency that truly distinguishes these reactions. This presentation will review current understanding of the underlying neuromotor control of these critical reactions as well as the changes over the life-span. Such understanding has implications for the approaches used to assess reactive control in clinical settings and the training techniques used to improve impaired control. The discussion of clinical assessment and rehabilitation approaches will focus on current approaches as well the potential impact of new techniques and technologies.

Symposia Abstracts

Symposium I Monday June 26, 3:30 – 5:15, Las Olas I-III

Balance and gait changes in preclinical stages of neurodegenerative movement disorders - Commonalities, specificities, open questions and future steps

Co-Chair: **Winfried Ilg Hertie,** Institute for Clinical Brain Research, Tübingen, Germany
Co-Chair**:** **Jeffrey M. Hausdorff,** Center for the Study of Movement Cognition and Mobility Tel Aviv Sourasky Medical Center

Anat Mirelman, Tel Aviv Sourasky Medical Center, Israel

Motor measures in the prodromal and diseased state of Parkinsons disease

BACKGROUND AND AIM : Prodromal motor features in Parkinson?s disease (PD) likely develop gradually, years before diagnosis. A great deal of effort has been devoted to detecting PD symptoms in prodromal states in at risk populations such as those with a family history of PD, subjects with changes in dopamine transporter or hyperechocogenicity, or individuals who carry genetic mutations with known associations to PD. The leucine-rich repeat kinase 2 (LRRK2) is an important genetic determinant of PD. The autosomal dominant G2019S mutation in exon 41 is associated with an increased frequency of PD in Ashkenazi Jews, in whom rates approach as high as 26% in familial and 15% in apparently sporadic PD. The asymptomatic first-degree relatives of Ashkenazi Jewish PD patients who carry the LRRK2 G2019S mutation, of whom about 50% may carry the G2019S mutation, clearly represent a population at increased risk of developing PD, although penetrance is incomplete. Non-motor biological markers (e.g., olfaction, autonomic dysfunction, sleep disorders) have been used to identify early prodromal signs, however, these non-motor features are not yet sufficiently accurate, robust, sensitive, or specific. Because PD is still diagnosed by its motor features, it is reasonable to assume that subtle changes in motor function will be present prior to the appearance of the cardinal motor signs required for diagnosis. RESULTS: Carriers appear to have higher gait variability, more arm swing asymmetry and worse axial control than non-carriers. The poorer performance of the LRRK2-G2019S mutation carriers may be consistent with subtle abnormalities in the central gait network as manifested during the challenging conditions, thus demonstrating decreased compensatory reserve. Recently, we started a longitudinal study to explore the predictive value of these measures in early identification of disease. The initial results of this prospective study support the idea that these motor markers may help to identify PD before it is currently diagnosed. METHODS: In this talk, we will present the rationale behind exploring motor measures in populations at risk for developing PD as well as evidence from our group and others on potential utility of different motor measures such as gait variability, arm swing and axial rotation as early markers of disease. We include in our studies healthy adults who carry the LRRK2-G2019S mutation and age matched healthy adults with non-known mutations. Assessment are conducted under usual and during challenging conditions such as dual-tasking and fast walking in order to unmask subtle changes in performance. CONCLUSIONS: Growing evidence suggests that motor measures can be valuable in identifying subtle changes in individuals at risk for PD and provide valuable information on disease progression and potential disease phenotypes.

Joan O'Keefe, Rush University Medical Center, USA

Potential preclinical gait and balance markers for developing Fragile X- Associated Tremor/ Ataxia Syndrome (FXTAS)

BACKGROUND: Carriers of a "premutation " size 55-200 CGG repeat FMR1 gene expansion are at risk for developing FXTAS, a neurodegenerative disorder marked by cerebellar ataxia, balance deficits, and cognitive impairment. Risk factors for developing FXTAS are not completely understood and early preclinical detection methods are needed. In previous studies we found that premutation (PM) carriers without FXTAS demonstrated significantly delayed postural reflexes and disrupted sensory weighting for balance control compared to controls. In a smaller cohort we found a trend toward increase double support time in asymptomatic PM carriers which was not different from carriers with FXTAS. Presently we conducted gait and balance "stress" tests including those with a dual task (DT) cognitive interference paradigm which we hypothesized would reveal early motor impairments in asymptomatic PM carriers. Such quantitative measures may be useful in predicting risk for developing FXTAS and characterizing its progression and response to interventions. METHODS: PM carriers without FXTAS (n = 14; mean age 62.4 ± 9.4 years), PM carriers with FXTAS (n = 9; mean age 67.1 ± 10.1) and age matched controls (n = 22; mean age 60.0 + 10.8 years) underwent gait and balance testing. Quantitative assessment of gait and turning via a 2 minute walk test and postural control (iSWAY) were performed utilizing an inertial sensor system (APDM; Oregon). Gait analysis was performed during a self-selected pace, fast as possible pace, and DT condition. Stance (feet apart/together), vision (eyes open/closed), surface stability (firm/foam surface), and cognitive demand (ST/DT) were altered to modulate the postural challenge. DT conditions for balance and gait consisted of a simultaneous verbal fluency task. RESULTS: PM carriers with and without FXTAS exhibited worse balance on the iSWAY than control subjects, with more difficult conditions (feet together/eyes closed/foam) yielding the most highly significant results ($p = 0.04$ to < 0.0001). During fast paced gait, carriers without FXTAS demonstrated significantly reduced total distance traveled ($p = 0.03$), reduced cadence ($p = 0.04$), and longer turn step time ($p = 0.046$). They also had significantly slower stride velocities than controls during DT walking ($p < 0.0001$) and their DT cost for total distance walked was higher than controls ($p < 0.05$). CONCLUSIONS: PM carriers demonstrate worse gait performance at fast paced speeds and under DT conditions and worse balance under environmentally challenging conditions. This suggests that such balance and gait tests using state of the art quantitative measures may be sensitive to produce at risk markers for FXTAS. Identification of preclinical signs of motor impairments in FXTAS will potentially establish an intervention window for providing preventative rehabilitation strategies, disease modifying drugs, and earlier interventions.

Winfried Ilg, Hertie Institute for Clinical Brain Research, Germany

Individual changes in preclinical spinocerebellar ataxia identified via increased complexity of posture and gait tasks

BACKGROUND AND AIM: It has been shown for various neurodegenerative diseases that subtle movement changes might occur many years before clinical manifestation. This notion has not yet been well explored in autosomal-dominant spinocerebellar ataxias (SCAs) This preclinical phase of SCAs attracts increasing research interest as it could provide a promising window for early therapeutic intervention -both pharmaceutical and rehabilitative- before substantial irreversible neurodegeneration has occurred. Effectiveness of future intervention studies will largely depend on three prerequisites: (1) Quantification of motor deficits as early as possible; (2) a more detailed understanding of the earliest

dysfunctions in cerebellar control mechanisms; (3) the availability of measures which are able to quantify progression and intervention benefits in this preclinical stage. We hypothesized that complex stance and gait tasks allow to (i) reveal changes in the control of posture and gait already at early stages of the preclinical phase when clinical ataxia signs are still absent, and (ii) to quantify the progression of motor changes in the preclinical phase before disease onset. METHODS: We assessed preclinical SCA mutation carriers, SCA patients at early stage and healthy controls by quantitative movement analyses in a cross-sectional study design. We examined stance and gait tasks with increasing complexity to unravel preclinical changes. In detail, we assessed different stance conditions of increasing motor demand: standing still for 30 seconds with feet closed and (i) eyes open, (ii) eyes closed, (iii) eyes closed on a mattress. Additionally, we examined walking conditions of increasing motor demand: straight walking, tandem walking, and tandem walking on a mattress. Motor features were related to the genetically estimated disease onset, and used as input for multi-variate models of movement characterization. RESULTS: Body sway in stance and spatio-temporal variability in tandem walking differentiated between preclinical SCA subjects and healthy controls. Complex movement conditions allowed to discriminate even those mutation carriers without any clinical signs in posture and gait. Multivariate regression analysis categorized preclinical mutation carriers on a single-subject level with 100% accuracy within a range of 10 years to estimated onset. In addition, movement features in stance and gait correlated significantly with genetically estimated time to onset, indicating a gradual increase of motor changes with increasing proximity to disease manifestation. CONCLUSIONS: This study provides evidence for quantitative measures of preclinical motor changes in SCA, which allow to discriminate subjects even on a single-subject basis in complex motor tasks and which enable the quantification of preclinical disease progression.

Symposium II Monday June 26, 3:30 – 5:15, Las Olas IV-VI

Using smart technology in the prevention of age-related decline in balance, strength, physical activity and behavioral complexity

Chair: **Jorunn L Helbostad**, Norwegian University of Science and Technology, Norway
Beatrix Vereijken, Norwegian University of Science and Technology, Norway

Michael Schwenk, Robert Bosch Hospital, Germany

Personalized balance and strength activities and physical activity advices integrated in daily life

BACKGROUND AND AIM: The LiFE concept is an intervention with balance and strength activities integrated in daily life, shown to be effective in reducing falls in home-dwelling older adults [1]. The European Project "PreventIT" has adapted the LiFE programme for a younger cohort (aLiFE). aLiFE was developed during several consortium meetings including experts and end users and incorporates challenging strength and balance/agility tasks, as well as specific principles for increasing physical activity in young-old adults. The aim of this pilot study was to test the feasibility and acceptability of the aLiFE programme in the target population. METHODS: A 4-week pre-post test intervention study was conducted in three European cities (Stuttgart, Amsterdam, Trondheim). Included were community dwelling men and women aged 60 to 70 years. The aLiFE programme was delivered by specialist instructors during 4 home visits. Before and after the intervention, participants underwent an assessment of their mobility performance. After the intervention, participants answered a questionnaire/participated in semi-structured interviews to assess their opinions regarding the aLiFE training. Trial registration: ISRCTN37750605. RESULTS: Thirty-one subjects were recruited (63.3% female). Participants' mean age was 66.9 ± 2.4 years. One participant dropped out during the intervention period. No severe training-related adverse events occurred. After the intervention, the vast majority of the participants rated aLiFE positive (satisfaction score median: 6.0 points, out of maximum 7). Twenty-four participants (80.0%) rated the programme helpful for improving balance, 27 (90.0%) for improving strength, and 26 (86.7%) for increasing physical activity. Twenty-nine (96.7%) stated that they would recommend aLiFE to a friend. In semi-structured interviews, participants mentioned several positive aspects about the intervention including the aLiFE concept (i.e., option to integrate activities into daily life), aLiFE activities (i.e., adequate task challenge), aLiFE trainer (i.e., option to interact with an instructor for developing a personalized training regimen), fun, and usefulness of the intervention for improving health. Balance performance was significantly improved after the intervention (Community Balance and Mobility Scale Score Baseline: 66.0±12.7, Post assessment: 70.4±13.1; P=0.001). CONCLUSIONS: The aLiFE programme was found to be feasible and acceptable in the target population. aLiFE is currently further developed into an electronic version (eLiFE) delivered on smartphone and smartwatch, using motivational strategies to enhance behavioural change. 1. Clemson L, Fiatarone Singh MA, Bundy A, Cumming RG, Manollaras K, O'Loughlin P, Black D. Integration of balance and strength training into daily life activity to reduce rate of falls in older people (the LiFE study): randomised parallel trial. BMJ. 2012;345:e4547.

Anisoara Ionescu, Ecole Polytechnique Federale de Lausanne (EPFL), Switzerland

Complexity in behavior in older age. What does it tell us?

This presentation will address the main theoretical and practical considerations necessary for definition of complexity of physical behavior as a outcome measure: (1) existing evidence; (2) definition of temporal patterns according to various sensor configurations and multimodal data; (3) appropriate tools to quantify the meaningful information embedded in the temporal patterns.

Elizabeth Boulton, University of Manchester, UK

How to adopt health-related behaviour in older age.

BACKGROUND AND AIM: The health and wellbeing benefits of engaging in physical activity (PA), and of improving strength and balance, are well documented. The World Health Organisation's recommendations of 150 minutes per week of moderate intensity physical activity have been adopted across the world in policy and practice promoting PA. However, the number of older adults engaging in this level of PA remains low. METHODS: The European Project "PreventIT" (Grant Agreement No. 689238) has adapted the Lifestyle-integrated Functional Exercise (LiFE) programme, which reduced falls in people 75 years and over (BMJ 2012; 345:e4547), for a younger cohort (aLiFE). The aLiFE programme incorporates challenging strength and balance/agility tasks, as well as specific recommendations for increasing physical activity in young-older adults, aged 60-70 years. Personalised advice is given on how to integrate strength, balance and physical activities into daily life, in a way which should not be time consuming. aLiFE has been further developed to be delivered using smartphones and smartwatches (eLiFE), providing the opportunity to send timely motivational messages and real-time feedback to the user. Both aLiFE and eLiFE are behaviour change interventions, supporting older adults to form long term physical activity habits. PreventIT has taken the original LiFE concept and further developed the behaviour change elements, explicitly relating them to Social Cognitive Theory, habit formation theory and behaviour change techniques. RESULTS: The motivational elements of aLiFE and eLiFE have been mapped to Social Cognitive Theory and Behaviour Change Techniques (BCTs). Goal setting, planning, prompts and real-time feedback are used to deliver a person-centred experience for participants in the intervention. Over 1,200 motivational messages have been written, based on, and mapped to, psychological theory, using established BCTs and evidence regarding the importance of strength, balance and PA. These messages have been translated into three languages, with a sub-set back translated to English to ensure fidelity. Findings from the aLiFE and eLiFE pilot studies have been used to further refine the PreventIT motivational strategy, to ensure acceptability to this target group. A motivational assessment tool has been developed to enable us to investigate stated motivational drivers with actual performed behaviour within the feasibility RCT. CONCLUSION: Mobile technology such as smartphones and smartwatches can be used effectively to monitor behaviour and to deliver a personalised intervention. The PreventIT mHealth intervention focusses on behaviour change from initiation to long-term maintenance, addressing the different phases of adopting a healthier lifestyle. As such, it makes a strong contribution to the developing field of evidence-based mHealth.

Sabato Mellone, University of Bologna, Italy

Self-assessment by use of smart technology

BACKGROUND AND AIM: Billion people worldwide are users of mobile phones. With the new generation of older people, the technology is and will increasingly become a necessary part of older people's life. Smartwatches or wristbands have so far become most popular in the younger generation. The field of mobile technologies expands at a high speed. The advent of smartphones and smartwatches has created potential for both collecting and delivering time and context-sensitive health information, thus penetrating significantly into society. Both smartphones and smartwatches are examples of relatively cheap, unobtrusive and persuasive technology. They comprise various physiological and inertial sensors, transmission modules and processing capabilities, making them suitable for continuous all-day/anyplace health, mental and activity status monitoring. METHODS: Sensors embedded in smart phones and smartwatches are suitable as platforms for assessment of mobility, balance, and physical function. Development of self-assessment test batteries based on sensors in smartphones and smartwatches will be presented and discussed. This also includes use of virtual coaching functions for empowering and motivating people in need of guidance and care, and of real-time feedbacks on correct movements during testing. RESULTS: Recent developments in mHealth, the delivery of health care services via mobile communication devices, increase the availability of health services and make them cheaper. mHealth developments also support moving responsibility and control from the health care system to empower older people themselves. Especially when people are not yet in the risk phase, or not yet identified as 'patients', such tools can provide very powerful support for the avoidance or reduction of health risks. So far assessment tools based on these technologies have mostly been developed to be used by health care personnel. CONCLUSIONS: Smartness of the system relies on the capacity to take decisions and performs actions on the basis of the available data. Smart solutions must support the changing role of users to help them move from a rather passive, to have the ultimate control and at the same time enhancing their responsibility over their own health through sensors that detect and report back information on their daily living activities and actual functional level.

Symposium III Monday June 26, 3:30 – 5:15, Oceanside II

Noninvasive brain stimulation: a research and rehabilitative tool for gait and postural control.

Chair: **Talia Herman**, Tel Aviv University, Israel

Brad Manor, Institite for Aging Research, Harvard Medical School, USA

Modulating prefrontal brain activity to enhance dual task gait and posture in older adults

When standing or walking, we often perform additional cognitive tasks such as talking, reading or decision making. This "dual tasking" is critical to the safe and successful completion of activities of daily living. However, dual-tasking often results in reduced performance in one or both tasks, especially in older adults and in those with age-related disease. The observation that dual tasking comes at a "cost" to performance means that the involved tasks depend at least in part upon shared brain networks. Strategies designed to increase brain network excitability and/or efficiency thus hold great promise to improve dual task capacity across the lifespan. Transcranial direct current stimulation (tDCS) is one safe and non-invasive method that uses low-level electrical currents to temporarily and selectively change brain excitability. I will begin this talk with a description of a series of studies examining the immediate effects of 20-minute sessions of tDCS designed to facilitate the excitability of the left dorsolateral prefrontal cortex (dlPFC)--a brain region closely involved in higher level cognitive executive function--on dual task costs and other metrics of postural control and gait in relatively healthy younger and older adults. I will then present the results of a recent pilot randomized controlled trial testing the longer-term effects of a 10-session tDCS intervention targeting the dlPFC on dual tasking, clinical measures of physical and cognitive function, and fMRI-derived measures of brain function, in older adults with concomitant motor and cognitive deficits. Finally, I will present the results of a study designed to establish the effects of tDCS on the brain's responsiveness to walking-related sensory stimuli, in order to highlight a potential mechanism through which tDCS might facilitate the control of posture and gait in different environmental and/or task conditions.

Moria Dagan, Tel Aviv University, Israel

The short-term effects of modulating brain excitability on freezing of gait in Parkinson's disease: A pilot study using transcranial direct current stimulation (tDCS)

Background and aim: Freezing of gait (FOG) is one of the most disturbing and least understood symptoms of Parkinson's disease (PD). The utility of parkinsonian medications is limited for FOG and it frequently becomes dopamine resistant. Although consensus does not yet exist, there is strong evidence that FOG results from disturbances within cortical areas of the brain linked to motor function (i.e., the primary motor cortex, M1) and executive function (i.e., the dorsolateral prefrontal cortex, DLPFC). Noninvasive modulation of neuronal excitability via transcranial direct current stimulation (tDCS) imparts beneficial behavioral changes when applied separately to these brain areas. This study examined the effects of tDCS simultaneously targeting both M1 (leg region) and the DLPFC on FOG and its mediators in PD. Method: Individuals with diagnosed PD and self-reported FOG completed assessments of FOG, gait and cognition before and immediately after 20 minutes of tDCS designed to facilitate the excitability of M1, M1+left DLPFC, or neither (i.e., sham). All participants received each tDCS condition on separate visits; condition order was double blinded. The primary outcome was performance on a FOG-provoking test, with scores ranging from 0 to 45 (most severe). Secondary outcomes included the Timed Up and Go (TUG) test of mobility and the Stroop test of executive function. We also quantified spatiotemporal gait parameters during usual walking and while performing a serial subtraction dual-task. Results: Data were analyzed from 17 subjects (age 69±6 years; disease duration 8±5 years; UPDRS-III 41±15; FOG-Questionnaire 21±5; Mean±SD). tDCS targeting the M1+left DLPFC improved scores on the FOG-provoking test (from 11.8±10.8 to 8.1±7.7; $p<0.05$), the TUG (from 18.0±17.7 to 16.5±19.4 seconds; $p=0.03$) and the Stroop test (from 28.2±12.7 to 32.4±14.4; $p=0.002$). Conversely, performance in these tests was not affected by tDCS targeting M1 only or sham stimulation ($p>0.09$). Additionally, the mean and variability of several spatiotemporal gait features (e.g., stride length, gait speed, swing time) derived from usual walking trials improved ($n=10$; $p<0.05$) only after M1+left DLPFC stimulation. tDCS did not appear to influence these gait features in the dual-task condition. Conclusions: Our results indicate that simultaneous modulation of motor and cognitive brain areas may reduce the severity of FOG and its mediators in older adults with PD. This support the notion that prefrontal executive circuits play a key role in the mechanism of FOG. The finding that tDCS did not influence dual-task performance suggests that the encumbrance of dual tasking cannot be alleviated by a single session of stimulation in this population. Future studies are thus needed to 1) elucidate the tDCS-induced neurophysiological alterations that led to the immediate reduction in FOG severity, and 2) establish the duration of effects for both single- and multiple-session tDCS interventions.

Manuel Montero-Odasso, Western University, Canada

TMS as a potential intervention to enhance mobility and cognition

A significant portion of aging disabilities arise from two major syndromes: cognitive and mobility impairments. Clinically, these syndromes have been evaluated and treated as separate entities, creating gaps and obscuring common connections. Cognition and mobility declines have been linked to specific brain changes. Clinical studies shows that falls are doubled in the cognitively impaired, and that having slowing mobility predict cognitive decline and dementia. A common factor in both disorders is executive dysfunction that seems to be an early phenomenon in the pathway to mobility and cognitive disability. Non-invasive brain stimulation (NIBS) is a safe approach to modulate the excitability of brain cortical areas. Repetitive application of a magnetic field, that is, repetitive transcranial magnetic stimulation (rTMS), to the cortex results in enhancement or inhibition of cortical excitability depending on the frequency or strength of the field applied. Therefore, rTMS has a potential as an intervention to improve cognition and mobility performance, in older adults with executive dysfunction. This talk will review the principle and mechanism of rTMS and the potential effect on executive dysfunction and present our preliminary results of a proof-of-principle study targeting older adults with executive dysfunction to improve gait performance and cognition with (rTMS). We are testing the efficacy of rTMS to improve gait stability and variability, in forty older adults (>65 years) with executive dysfunction. We will evaluate if observed changes in gait and mobility are mediated by executive function enhancements and mood changes. rTMS can modify and enhance cognitive-mobility interaction in the short term after one session (via changes in cortical excitability) and in the long term (via neuroplastic changes) with repeated sessions. We postulate that enhancing some aspect of cognition can prevent mobility decline and reduce risk of falls.

Symposium IV Tuesday June 27, 3:30 – 5:15, Las Olas I-III

(E)motion: The effect of emotion on human posture and gait control in health and illness

Chair: **John Stins**, Vrije Universiteit, Netherlands

Brad Fawver, University of Utah, USA

Emotional influences on postural control and gait behavior in healthy young adults

It is widely accepted that emotional states can influence the efficiency and effectiveness of motor performance. A growing body of work has sought to characterize how discrete emotions that induce unique motivational orientations and/or psychophysiological response patterns differentially impact the execution of goal-directed behaviors. This presentation will provide an overview of the empirical evidence in this area, and I will discuss contemporary theoretical perspectives supported by the extant findings. Emphasis will be placed on how motivational orientations, and subsequent alterations in motor planning and control processes, affect postural and gait responses. The influence of emotionality on motor behavior is traditionally investigated by eliciting affective states using exogenous (or externally generated) stimuli, such as emotional pictures, or through endogenous (or self-generated) methods. Using these approaches in healthy young adult populations, we have quantified the impact of emotion on motor performance within a variety of whole-body movement paradigms (e.g., gait initiation). These experimental tasks implicitly regulate distance from emotional stimuli, allowing more appropriate measurement of underlying approach-avoidance motivations and straightforward testing of existing theoretical frameworks. During these protocols, kinetic and kinematic measures provide a reliable index of individuals' ability to plan their actions, react to movement onset cues, and control motor output. This work has significant implications for the improvement of gait dysfunction in groups with psychological conditions (e.g., anxiety/stress disorders, fear of falling) or motor diseases (e.g., Parkinson's). Moreover, the hope is that continued research in this area will facilitate the development of efficacious strategies that help individuals up- or down-regulate motor output to meet performance demands and adapt to environmental/situational constraints. I will briefly highlight some of these applications and provide a foundation for further discussion by other presenters in this symposium.

Mihalis Doumas, Queens University, Canada

Influence of social evaluative threat during a mathematical anxiety task on standing balance

BACKGROUND AND AIM: The postural control system is able to produce adaptive responses when environmental conditions change. For example, when standing on an elevated surface similar to standing at the edge of a building, a reduction in postural sway and increased ankle stiffness is observed (e.g. Carpenter et al. 2001). This response has been attributed to the fear and anxiety induced by the elevated surface. However, little is known about whether this response is an elevated-surface-specific (or task-specific) mechanism or a general threat-related mechanism that can also be induced by cognitively-induced anxiety and threat. The aim of the present study was to assess threat-related adaptive changes in postural sway using mathematical anxiety and social evaluative threat, both of which have been shown to induce a high stress response. METHODS: Thirteen young adults (age range 19-26 years, 9 female) participated in the study. Participants were asked to perform a simple arithmetic task, comprising additions of pairs of one- two- and three-digit numbers appearing on a screen. After establishing a baseline level of performance in the arithmetic (seated) and the balance tasks (standing on a sway referenced surface), the experiment’s three main blocks commenced. In block 1, participants performed the arithmetic task while standing. In block 2 (mathematical anxiety), they performed the same task but a progress bar appeared across the screen in each trial. The progress bar comprised a green part followed by a red part. The duration of the red part of the progress bar was 70% of participants? mean reaction time in the previous block, but they were told that it was the average reaction time in their age group, in order to increase anxiety levels. After the end of block 2 the participant was told that his/her performance was poor relative to other participants tested and that he/she had to try harder. Then block 3 commenced. Stress was evaluated in the end of each block using self-report. RESULTS: Self-reported stress linearly increased up to block 3 (social evaluative threat) confirming that our stress manipulation was successful. Reaction times were significantly faster when the progress bar was introduced and became significantly slower when the social evaluative threat was added. Postural sway amplitude and standard deviation in the anterior-posterior direction decreased as stress increased. CONCLUSIONS: Our results suggest that the adaptive postural responses observed under conditions of threat may not be limited to posture-related threat but may also generalize to high threat and stress induced in non-posture-related contexts. Future research comparing different types of threat would be useful in evaluating the common characteristics of this adaptive postural response.

Laura Avanzino, University of Genoa, Italy

Effect of emotion on gait in Parkinson disease

BACKGROUND AND AIM: Gait dysfunction is one of the most disabling motor symptoms of Parkinson?s disease (PD). Freezing of gait (FOG) is a symptom that affects over 50% of patients and increasing evidence suggests that non-motor systems (i.e., limbic cortico-basal ganglia-cortical circuits) might be involved in its underlying mechanisms. Indeed, it has been showed that the autonomic nervous system might be activated during FOG with an increase in heart rate due to stress or increased anxiety. Recently, by directly comparing FOG episodes in anxious and non-anxious situations it has been showed that that anxiety is an important mechanism underlying FOG. The aim of the present research is to provide direct evidence about the involvement of the limbic basal ganglia circuit in FOG pathophysiology. To this aim, we evaluated the impact of emotional stimuli on gait initiation in patients with PD, with and without FOG. METHODS. Thirty-six participants, divided into three groups (12 PD patients with FOG, 12 PD patients without FOG and 12 controls) stood on a sensorized mat and were asked to take a step forward when a pleasant image appeared on a screen placed in front of them and a step backward in response to an unpleasant image (congruent task) or to take a step backward when a pleasant image appeared on the screen and a step forward in response to an unpleasant image (incongruent task). The experiments were made in two separate days and the order was randomized. Reaction time and step size were recorded by means of a sensorized mat (GaitRite). RESULTS: In PD patients with FOG, gait initiation was influenced by emotion-inducing stimuli. Indeed, in PD patients with FOG, for steps forward, the reaction time was longer and the step size was shorter than in the other groups only in the incongruent task (i.e., to take a step forward in response to an unpleasant image). CONCLUSIONS: The results confirmed that negative emotions exert an influence on motor control. In PD patients with FOG the valence of emotional stimuli influenced not only step preparation (reaction time), but also step execution (step size) supporting the theory on the role of the non-motor systems (e.g., limbic system) in the pathophysiological mechanisms of FOG. FOG is likely to be caused by a complex interplay between motor, cognitive and affective factors, rather than being a pure motor problem. These results offer speculations to novel therapeutic approach.

Jeffrey Staab, MOVE Research Institute, Netherlands

Clinical applications of a model of threat assessment, posture, and gait control

BACKGROUND AND AIM: Descriptions of patients who experienced problematic interactions between anxiety and posture and gait control date back at least 150 years. Many of these reports identified clinical features that are quite recognizable in the modern era. Over the last 20-30 years, research conducted by investigators around the world has identified several mechanisms that link threat

assessment to control of locomotion in normal individuals and patients with vestibular and balance disorders. METHODS: Key studies linking state anxiety, trait anxiety, and anxiety disorders to posture and gait control, vestibular symptoms, and balance disorders were identified. Studies included normal individuals and patients with various vestibular and balance disorders who were investigated with psychological assessments, physiologic measures, and brain imaging techniques. RESULTS: Research findings supported development of an integrated model linking threat assessment processes in the brain to control of posture and gait in health and disease. Four major mechanisms are contained in the model: (1) trait anxiety as a risk factor for alterations in posture and gait control, (2) bottom-up stiffening of stance and gait in response to postural threat in normal individuals and patients with vestibular and balance disorders (3) excessive visual dependence in patients with persistent dizziness after acute vestibular events, and (4) alterations in brain activity and connectivity suggesting reduced cortical modulation of hyperactive vestibular responses to space-motion stimuli in patients with chronic dizziness. CONCLUSIONS: A model containing four major mechanisms linking threat assessment and locomotion provides a framework for understanding the effects of anxiety on posture and gait control.

Symposium V Tuesday June 27, 3:30 – 5:15, Las Olas IV-VI

Implementation research in balance, mobility and fall prevention: How do we move the evidence into action?

Chair: **Kathryn Sibley**, University of Manitoba, Canada

Kathryn Sibley, University of Manitoba, Canada

Using Implementation Theories, Models and Frameworks to Move Posture and Gait Research in to Action: An Example Using Balance Assessment in Physiotherapy Practice

Background and Aim. Theoretically-informed implementation is increasingly endorsed to advance this evolving field away from "an expensive version of trial-and-error" toward insights in which the mechanisms of implementation are more likely to succeed. Proponents argue that the use of theories, models and frameworks in designing implementation interventions provides generalizable approaches for developing research questions and interventions and allow for an incremental accumulation of knowledge. However, explicit use of implementation theory for balance and mobility research, and rehabilitation research more broadly, has historically been low. The objective of this presentation is to describe one prominent implementation process framework ¬-the Knowledge-to-Action (KTA) framework - and how it has been applied to research on balance assessment in physiotherapy practice. Methods. The KTA Framework, a meta-framework that combines the critical features of over 30 planned-action theories, is also a pragmatic model that provides step-by-step direction for implementation. The KTA framework's 2-pronged approach (the knowledge creation phase and action cycle) guided research questions to identify knowledge-to-practice gaps and barriers and facilitators to knowledge use; synthesize primary research results; and develop, implement and evaluate interventions to increase knowledge use. Results. The KTA- guided studies have explored current trends in balance assessment and factors influencing practice across Canada, the synthesis of theoretical content underlying validated measures of balance, and the development, monitoring and evaluation of a tailored behavior change intervention to increase reactive balance measurement among physiotherapists that targeted identified barriers and facilitators to reactive balance assessment. Results showed the rate at which therapists used standardized balance measures was less than optimal and identified both knowledge-to-practice gaps and individual and organizational barriers to implementing best assessment practices. These findings highlighted the need for synthesis of evidence on potential measurement solutions to address those gaps prior to the development of corresponding intervention strategies. Synthesis results along with identified barriers and facilitators to practice were used to select a measure and behavior change techniques to test in a multi-site behavior change study. Discussion. The comprehensive KTA framework was useful in guiding the direction of this ongoing research program. Of note: the sequence of the individual KTA steps was modified to improve the efficiency of intervention development, there was a need to go back and forth between the 2 phases of the KTA framework, and additional behavior change theories were consulted. Continued research is needed to explicitly evaluate the efficacy of applying KT theory to best practice in health care.

Stephen Lord, Neuroscience Research Australia, Australia

Translation of Fall Prevention Research into Policy and Practice: the Australian Experience

This presentation will discuss fall prevention implementation initiatives undertaken in Australia that have built on posture and gait research evidence. Three examples of implementation into policy and practice will be presented. The first relates to the development and validation of the QuickScreen fall risk assessment tool, a simple assessment now used by over 1000 clinicians across Australia. Key features of the successful clinical translation have been the low cost of the assessment tool, the dissemination of its utility to fall prevention networks, the provision of training for the administration of the tool and the liaison with policy makers to facilitate its wide availability. ? The second describes the systematic roll out of the Stepping on exercise intervention for fall prevention (1). In collaboration with an Australian State Health Department, Stepping On has been made widely available to older people living within New South Wales. Importantly, this roll out has been staged to allow for a stepped wedge evaluation of the program's effectiveness. ? The final example is the implementation of systematic review evidence of effective components of exercise interventions for fall prevention (2) into exercise guidelines, and the promulgation of community exercise programs that incorporate evidence-based formats via a well-resourced website (www.activeandhealthy.nsw.gov.au). The above and other initiates have been facilitated by the participation of researchers in the drafting of evidence-based fall prevention guidelines, the establishment of state-based fall prevention networks and the Australian and New Zealand Falls Prevention Society. Potential barriers to continued implementation include the lack of core, ongoing funding for translational initiates, loss of corporate knowledge in research and policy sectors and withdrawal of funding support due to government policy changes and priorities. References 1. Clemson L et al. J Am Geriatr Soc 2004;52:1487-94. 2. Sherrington C et al. J Am Geriatr Soc 2008;56:2234-43.

Debra Rose, California State University, USA

Translating Fall Risk Reduction Knowledge into Action: A U.S. Perspective

Background and Aim: The use of conceptual frameworks to guide the development, implementation, and sustainability of fall risk reduction programs is rarely applied or clearly articulated in the fall research literature. The focus of this presentation will be to discuss the extent to which current fall prevention program initiatives in the United States have been successful in translating fall prevention knowledge into action and the criteria used to evaluate whether a fall prevention program is considered to be evidence-based and subsequently recommended for widespread adoption by community-based agencies. Methods: Findings from the FallsFree® Initiative will be used to illustrate key concepts of the

KTA framework and identify gaps and current challenges to building a successful fall prevention infrastructure in the USA. Results: A large gap continues to exist between research and practice - many interventions evaluated in controlled research settings are rarely evaluated in real-world settings, may only address one dimension of a complex multidimensional phenomenon, or are inadequately disseminated and translated to ensure broader uptake among "more typical older adult" groups and across different organizational infrastructures. Conclusions: Recommendations include the development of assessment tools and programs that are based on theoretical frameworks, address the multifactorial nature of falls, are amenable to modification, and integrate behavior change strategies aimed at promoting long-term adherence to engaging in fall protective behaviors. Examples of intervention programs, not limited to the area of fall risk reduction that can serve as a model for guiding successful knowledge translation into action research will also be discussed.

Chris Todd, University of Manchester, UK

Bridging the implementation gap in activity promotion using behaviour change techniques implemented using novel technologies.

Engaging older people in exercise to prevent falls has for some time been recognized as problematic. Our early work demonstrated that older people were not motivated by fall prevention but rather that activity promotion should be aimed at maintenance of independence (Don?t mention the F-Word). Subsequent work explored psychosocial drivers of uptake and adherence and the role of trainers and class composition. What becomes clear is we need strong psychological theoretic models which predict behaviour and help us shape interventions to change behaviour. We then need ways to deliver these interventions on a routine basis at scale. Recent technological developments provide the opportunity to deliver such interventions to older people in real time. Two contrasting examples of recent work will be presented. In the first example, ProFouND uses ICT to help in the delivery of cascade training of Otago exercise. Here technology is a facilitator of traditional face to face exercise training. In the second example PreventIT uses ICT, smartphones and wearables to deliver an activity programme using the Health Action Process Approach and Behaviour Change Taxonomy to design the motivational programme delivered via the technology. We reflect on the challenges involved in these two examples in terms of the two gaps in translation: the first gap between basic science and applied products and ideas; the second gap between products and ideas and implementation in clinical practice.

Symposium VI Tuesday June 27, 3:30 – 5:15, Oceanside II

Peeking inside the brain - How to study the neural control of walking?

Chair: **Vivian Weerdesteyn**, Radboud University Medical Centre, Netherlands

Brett Fling, Colorado State University, USA

Locomotion in the scanner: Understanding how you move by imaging your brain while you don't

Although diagnostic assessment via clinical magnetic resonance imaging (MRI) has been in use for decades, only recently have advanced MR techniques been utilized in the research setting to investigate neural mechanisms underlying gait and balance control, to identify biomarkers for disease progression, and to assess therapeutic intervention efficacy. Functional MRI (fMRI) has been used extensively in a variety of stimulus-response paradigms to identify regions of task-specific neural activity. More recently, functional connectivity MRI (fcMRI) has revealed that the brain is very active even in the absence of explicit input or output. That is to say, spontaneous fluctuations in neural activity is not random noise, but is specifically organized in the resting human brain and serves as a potentially important and revealing manifestation of spontaneous neuronal activity providing insight into the intrinsic functional architecture and topography of the brain and potential physiological correlates of disease and mobility impairment. Finally, emerging literature is making use of diffusion weighted imaging within the MR environment to identify associations between white matter microstructural integrity and locomotor control. Diffusion imaging measures the diffusion or movement of water molecules within the brain. White matter demonstrates a high degree of diffusion parallel to the axons, with limited diffusion along orthogonal directions, reflecting the structural integrity of white matter and allowing indirect assessments of myelination and axonal density. Combining functional MR approaches with diffusion imaging allows for a comprehensive assessment of neural structure and function. While exciting advances have been made, the study of gait and balance with MR-based methods is clearly hampered by the inability to actually stand and/or move within the MRI environment, which would allow recording brain activity evoked by actual locomotion. To address this limitation, several approaches have been developed to provide indirect evidence of supraspinal involvement in locomotion. These approaches have identified brain activity patterns during imagined actions such as standing, walking, and running, as well as neural activity while actually performing voluntary or passive lower limb movements inside the scanner. The latter studies have incorporated diverse levels of complexity from the evaluation of isolated, unilateral, and repetitive ankle and knee movements to more complex tasks that require coordinated movements of multiple joints reflective of stepping or pedaling actions. This talk will provide insight into the structural and functional brain circuitry that underlie locomotor control identified via MR-based methodologies. In addition, I will discuss recent work detailing structural and functional neural mechanisms that are, at least in part, responsible for impairments in locomotor control that accompany healthy aging and select neurologic populations.

Noel Keijsers, Sint Maastenskliniek, Netherlands

Shedding light on neural control of gait

In the nineties, the first experiments of measuring brain activity during motor control using functional near-infrared spectroscopy (fNIRS) were conducted. FNIRS is a non-invasive neuroimaging technique, which indirectly detects cortical activation by measuring hemodynamic changes. In the last decades, fNIRS has also been used to study the neural control of gait. This talk will focus on the possibilities of examining the neural control of gait in healthy controls and patients during normal and complex gait using fNIRS. Despite the increased use of fNIRS as a neuroimaging technique, there are still several issues to be resolved. The most important pitfalls using fNIRS during gait are positioning of the optodes, spatial resolution, inter-subject variability of the hemodynamic response, systemic interferences, limited penetration depth and absorption of the light by the hair. We will demonstrate that the spatial resolution of fNIRS is defined by the ability to distinguish between two closely located area's such as the motor cortex for hand and foot. Furthermore, the advantage of other neuroimaging techniques (TMS, MRI) to optimize the location of fNIRS optodes will be evaluated. Systemic interference removal techniques will also be discussed, and tips and tricks from our own experience will be presented to optimize fNIRS experiments. Several studies have been performed to study the neural control of walking using fNIRS. Miyai and colleagues [1] were the first to demonstrate significantly increased oxygenated hemoglobin levels in supplementary motor (SMA), primary motor (M1) and somatosensory area (S1), indicating involvement of these cortical areas during gait. Interestingly, this increase in oxygenated hemoglobin was mainly seen prior to and at the start of gait. During precision stepping we showed an increased activity in the prefrontal cortex [2], which was also found in other studies focusing on gait under challenging conditions. The activation patterns in the cortical area of motor cortex are more inconsistent among the studies, which is most likely caused by differences in methodology and analysis methods. The last part of this presentation will focus on the use of fNIRS in patients with gait problems and evaluation of cortical recovery during gait rehabilitation. So far, pre and post gait training studies measuring cortical activity using fNIRS are scarce. Miyai showed in a small number of 8 stroke patients that asymmetry in sensorimotor cortex reduced during gait rehabilitation [3]. In conclusion, fNIRS has shown its applicability in studying the neural control of gait in healthy subjects and patients. However, we should be careful with the interpretation of the current available literature since systemic interferences removal techniques have not always been used. FNIRS seems the neuroimaging technique best applicable in a practical manner. [1] Miyai, Neuroimage 2001;[2] Koenraadt, Neuromimage 2014;[3] Miyai, Stroke 2003

Dan Ferris, University of Michigan, USA

Using EEG to study your brain on the run (or walk)

BACKGROUND AND AIM: The number of research studies using scalp electroencephalography (EEG) to record electrocortical signals during walking and running has greatly increased over the last six years. This is largely due to advances in EEG hardware and signal processing algorithms. Using new EEG systems, analysis software, and approaches to source localization within the brain, EEG can now provide unprecedented insight into brain function during human walking and running. METHODS: We combine high-density active EEG electrodes with Independent Component Analysis (ICA) and inverse head models of electrical propagation within the head to isolate and filter muscle, eye, and motion artifacts. By studying walking and running under different conditions of motor and cognitive tasks, we can determine when and which brain areas are synchronized to body movement and/or mental calculations. We have validated our approach using an electrical head phantom mounted on a robotic motion platform to determine how well we can determine the ground truth of brain electrical activity. RESULTS: My laboratory has published many studies over the last six years examining how electrocortical activity changes to different experimental conditions. I will summarize results from some of the studies and end with a discussion on the limitations of using EEG during human locomotion. CONCLUSIONS: EEG provides a reliable and innovative means to assess brain activity related to the control of human locomotion but great care needs to be given to preventing non-brain sources from interfering with analysis of electrocortical activity.

Symposium VII Wednesday June 28, 11:00 – 1:00, Las Olas I-III

Vestibular and cerebellar control of posture and gait - Neurophysiology and Clinical Applications

Chair: **Roman Schniepp**, Ludwig-Maximillians Universitat Munchen, Germany

Klaus Jahn, Schoen Klinik, Germany

Supraspinal control of posture and gait: Cerebello-vestibular aspects

BACKGROUND AND AIM: The network for supraspinal control of posture and gait in humans has been elucidated over the last years. This network includes premotor frontal cortex for task planning and initiation, basal ganglia for motor and the thalamus for sensory modulation, the homologues to the pacemakers for gait pattern and speed regulation in the interfastigial cerebellum and bilateral midbrain tegmentum (cerebellar and mesencephalic locomotor regions; pedunculopontine nucleus), as well as their descending target regions in the pontine reticular formation. The cerebellum and the vestibular systems ? both closely related to each other ? belong to the most crucial parts of this network, in particular during locomotor tasks, different from undisturbed steady state locomotion. The cerebello-vestibular network is also crucial for postural stability and the prevention of falls. METHODS: This talk will summarize the basic sensorimotor control principles of supraspinal locomotor centers, based on imaging approaches in PET and MRI techniques. Special interest will be placed for the discussion of alterations of supraspinal vestibular feedback loops in the context of aging and in patients with different forms of sensory deficits. Moreover, task specific cerebellar locomotor control principles will be presented based on fMRI and PET findings that are translated to neurophysiological findings during stance and gait. A model of cerebellar integration of vestibular signals into the locomotor and oculomotor system will be outlined and discussed. RESULTS: Steady state locomotion as well as more demanding locomotor tasks preferentially involves the brainstem and cerebellar network. Any change in activity requires premotor cortical activity. Postural tasks and slow locomotion use multimodal sensory input (via thalamus and cerebellum). Further, as soon as the task involves spatial orientation aspects, the hippocampal formation and the parietal cortex become active. As shown by different approaches, spatial orientation and navigation also depends on vestibular signals. Patients with complete loss of vestibular afferent input do have deficits in finding places. CONCLUSIONS: The cerebellum serves (1) as a pacemaker for rhythmic locomotor activity: patients with cerebellar dysfunction walk with high variability; and (2) as an integrator of sensory functions into postural control during stance and gait. The vestibular signals, synchronized to the step cycle, enter the brain network via the cerebellum and together with vision and somatosensation adapt the gait pattern to different environments. Together, the cerebello-vestibular circuits build widely distributed connections to networks involved in balance control, navigation, and even in cognition.

Roman Schniepp, Ludwig-Maximillians Universitat Munchen, Germany

Vestibular and cerebellar locomotion control? from basic principles to clinical and scientific implementations

Background and Aim: Human upright gait is controlled by vestibular and cerebellar locomotor control schemes. Disturbances in both systems lead to gait ataxia with the result of an impaired everyday mobility and a higher risk for falls. This presentation will emphasize the current agenda of basic principles of vestibular and cerebellar gait control as well as the technical opportunities to quantify these. Moreover, a discussion on the opportunities for clinical and scientific implementations will be stimulated. Methods: The presentation will focus on five different aspects: (I) Neurophysiological findings will be reviewed and basic control principles of vestibular and cerebellar gait control will be extracted. (II) The influence of vestibular and cerebellar dysfunction on fall risk will be highlighted retrieved by findings in epidemiological studies. (III) The association of central and peripheral vestibular dysfunctioning on sociopsychological features and on gait performance will be discussed (cross sectional study in 600 patients with vertigo and dizziness). (IV) Preliminary results of a longitudinal study on the relationship between gait performance, posturography measurements, off-laboratory mobility measurements and fall risk in 340 patients with vertigo and dizziness will be presented. Results: (I) An increase of movement pattern variability is the hallmark of gait ataxia in patients with vestibular and cerebellar disorders. It reflects the quality of coordinated movements and is thus linked to dynamic instability. (II) Dynamic instability depends on the walking speed in the context of a speed-dependent specification of vestibular signal integration into the locomotion network. (III) Increased levels of gait variability are linked to a higher risk of falls in patients with vestibular or cerebellar disorders, also in a speed dependent manner. (IV) Neuro-otologic functions are not correlated to increased fall risk. (V) Psychometric disorders, such as dizziness-related anxiety and depression mainly influence walking pace variables, but not dynamic instability. (VI) Off-laboratory measurements indicate typical, but not specific patterns of mobility alterations in both patient groups. These alterations have no additional value for the fall risk estimation. Conclusions: Vestibular and cerebellar locomotor control schemes are important for maintaining dynamic balance during walking. Dysfunctions of both systems are associated to a higher risk for falls. The vestibular and cerebellar systems interact for the control of dynamic stability. The critical sites appear to be midline cerebellar structures (flocculus/ paraflocculus) and the anterior parts of the cerebellar hemispheres. Gait variability reflects the stability of the gait pattern and serves as quantitative marker for the quality of dynamic balance and for limb coordination. It is related to increased risk for falls in patients with cerebellar and vestibular disorders.

Max Wuhr, Ludwig-Maximillians Universitat Munchen, Germany

New paradigms of vestibular stimulation to enhance impaired balance control in patients with vestibular dysfunction

BACKGROUND AND AIM: There is increasing evidence that information processing in a variety of sensory systems can be enhanced by adding an imperceptible amount of noise to the system. The rationale behind the phenomenon is a mechanism known as stochastic resonance (SR) wherein the response of a nonlinear system to input signals can be optimized by the presence of a particular non-zero level of noise. This presentation will give an overview on recent studies that examined the beneficial effects of noise-enhanced vestibular function on impaired balance control in patients with vestibular dysfunction. METHODS: Examination of the effects of an imperceptible white noise galvanic vestibular stimulation (nGVS) on vestibular perceptual and reflex thresholds as well as balance control during standing and walking in patients with vestibular dysfunction. RESULTS: nGVS effectively lowers vestibular perceptual thresholds and facilitates vestibular reflex responses to weak input stimuli thereby indicating the presence of SR-like dynamics in the human vestibular system. Application of nGVS in patients with vestibular dysfunction leads to an improvement in objective and subjective balance during standing and walking. DISCUSSION: Decrements in vestibular function due to aging or disease severely affect balance, orientation, and visual fixation abilities of afflicted individuals. Currently the therapeutic regimen in patients with bilateral vestibular dysfunction is limited to physical therapy. Within this context, noisy vestibular stimulation might provide an alternative future approach to reduce postural imbalance and the incidence of falls in this population.

Winfried Ilg, Eberharnd-Karls Universitat Tubingen, Germany

Motor Training in Degenerative Spinocerebellar Disease: Ataxia-Specific Improvements in posture and gait by coordinative physiotherapy and exergames

BACKGROUND AND AIM: The cerebellum is known to be essentially involved in gait and posture control and plays a critical role in motor learning. Despite increasing evidence that intensive motor training can be beneficial also for patients suffering from with degenerative cerebellar disease, it remains not yet fully understood under which constraints patients with degenerative cerebellar disease do profit. It also

remains unclear by which mechanisms these patients might improve and, moreover, to which extent the improved control capabilities like dynamic balance transfer to movements which have not been explicitly included in the training schedule. In this talk we discuss the state of the art and present evidence from different training studies in patients with degenerative spinocerebellar disease. These studies demonstrate that coordinative training based either on physiotherapy or on exergames can lead to a significant benefit in patients with degenerative ataxia, even patients with advanced neurodegeneration. Effects were assessed by clinical rating scales, a goal attainment score for achievements in activities of daily life, and quantitative movement analysis of posture and gait. METHODS: The focus of the methodical description will be on quantitative movement approaches for the identification of training-induced improvements in ataxia-specific control capabilities like dynamic balance and intra-limb coordination in complex movement sequences. The goal of such approaches is to reveal whether transfer of improved motor skills to other movements is possible despite underlying progressive cerebellar disease. RESULTS: As an example, we present a quantitative analysis of rapid goal-directed stepping sequences while playing a commercial exergame version of a choice stepping reaction time task called "Light Race". Following the exergames intervention, cerebellar subjects show not only an increased step frequency and decreased movement variability, but also improved inter-joint coordination and dynamic stability. This demonstrates changes in control capabilities specifically dysfunctional in cerebellar disease. These improvements correlated with changes in gait and goal-directed leg placement outside the game play. In addition, we will present data of a currently ongoing study assessing the effects of exergame training in preclinical ataxia subjects (mutation carriers of autosomal-dominant spinocerebellar ataxias before the clinical manifestation of ataxia). CONCLUSIONS: These studies deliver evidence that - despite progressive cerebellar damage - subjects with degenerative cerebellar disease are still capable to improve complex movement sequences, taking advantage of long-term training. Improvements transfer also to other movements, indicating a generalization effect of the underlying control capabilities.

Symposium VIII Wednesday June 28, 11:00 – 1:00, Las Olas IV-VI

Gamification to invoke behavioural changes. New challenges for rehabilitation in the daily living environment

Chair: **Edouard Auvinet**, Imperial College, London, UK

Nina Skjæret Maroni, Department of Neuroscience, NTNU, Trondheim, Norway,

Exergaming in exercise and rehabilitation: The past, the present, and the future

In the 1970s and 80s video game arcades became a popular after school activity, gathering children of all ages to play video games using vigorous body movements. In the beginning of the 21th century, however, computer-based videogames became a sedentary living room activity, and considered one of the contributors to increased childhood obesity. With the promotion of the Playstation-based Dance Dance Revolution (DDR) videogames as a weight loss tool in 2004, videogames have again become a means to get up and move. These movement-controlled videogames were quickly recognized as a potential tool to provide enjoyable, easy access, low threshold exercise. Today, exercise-based videogames, so-called exergames, are used extensively in exercise and rehabilitation settings. The current presentation illustrates the many advantages exergames hold over more traditional exercise regimes. Not only can exergames be fun and social activities, they also hold the potential to be function-specific, and can provide an exercise environment with changing game-contexts that can include a variety of different tasks and different difficulty levels. The technology also holds the potential to provide real-time feedback on the exercises by providing for instance a game score, and to automatically adapt difficulty level. Several studies and reviews the last couple of years have found that older adults can benefit from a videogame-based exercise program to improve balance and postural stability, and confidence with functional activities, as well as improvements in physical and cognitive fall risk factors. However, with the continued release of new technology, the field is constantly evolving, giving rise to several research challenges to establish good guidelines for use of this technology as an exercise and rehabilitation tool across ages and diseases. The presentation will put focus on some of the guidelines proposed to be used both in the design of exergames and for usage in clinical practice. The presentation concludes with the ongoing developments of game technology using mobile platforms that can make exergames become more implemented in everyday life activities. This ubiquitous gaming integrates the player's physical location into a game world, and offers new potential for unsupervised exercise and rehabilitation of functional activities in a real-life situation. This new technology might also make trained motor skills more transferable to daily life situations than those acquired by traditional screen-based exergames.

Claudine Lamoth, University of Groningen, Netherlands

Gamification to invoke behavioural changes. New techniques for home-based functional training

The application of game elements in a non-game context, so-called gamification offers new potential for unsupervised rehabilitation of functional activities in a real-life situation. For instance, using augmented reality (AR) techniques, it is possible to provide therapy in a real world scenario that has been augmented with virtual gaming elements. In addition mobile exergames that run on smartphones might stimulates the player to move through an environment and provide feedback that enhances physical activity. In the present presentation I will introduce two on-going projects, which use gamification principles for home-based functional training. The first project is about the development of an Adaptive Trainer using Augmented Reality Gaming for Exercise Therapy (ATARGET). The main theme of ATARGET is rehabilitation from stroke, being one of the major causes of upper limb impairment. Following a stroke, patients suffer from a loss of range of motion, impaired force generation, chronic pain, and disordered movement coordination. These symptoms limit physical, social, and economical independence. Rehabilitation should start as early as possible and include the elements of high intensity and frequency, task-oriented functional training and personalization. A viable approach to provide the above therapeutic elements and to make the treatment accessible at home is to apply gamification principles to the training. In ATARGET a game is designed for stroke patients to improve upper limb motor function and motivation for training by making adaptive game changes, while playing; implemented using artificial intelligence based software. During therapy the patients interact with a real living environment via augmented reality glasses, created by combining 3D display a motion capture techniques, traceable physical objects. Game difficulty is adjusted by online analysis of the subject?s movements After discharge to home from rehabilitation after hip surgery frail older adult often stay sedentary. For this geriatric group no specific exercise interventions exist. Using gaming principles, daily activities like making coffee, are stimulated and behavioural changes are invoked. The focus is on facilitating functional movements and activities. First semi-structured interviews were performed from design principles were developed. During co-creation sessions the general principles of the game application were tested and adjusted. Individual goals are set and embedded in a game environment using a tablet, an accelerometer and a step counter. Feedback was provided about goal achievements. A group of healthy older and a group of older adults who had hip surgery and was discharged to home used the intervention for six-weeks. Goal Attainment Scaling was used to evaluate the six-week home intervention.

Dag Svanæs, Department of Computer and Information Science, NTNU, Throndeim, Norway

Adding a Layer of Magic: Behavioural Change through Gamification of Patients´ Everyday Living Environment

BACKGROUND AND AIM: Exergames are progressively used to increase physical activity and improve health and physical function in older adults, both in rehabilitation settings and as home-based exercise. Most current exergames use motion capture techniques (e.g. Kinect) or hand-held devices (e.g. Nintendo Wii) for input, and a large display (e.g. TV) for output. Although large positive effects have been achieved with exergames running on such hardware platforms, they pose certain limitations on what exercises can be done, in what place and in what circumstances. Display-based exergame platforms require that the patient constantly faces the display, making it hard to design for exercises that require rotation or bending of the body. In addition, the platforms require that you play the game in one particular part of your living environment, and that gameplay is the main activity while playing. METHODS: These limitations have motivated our search for technology platforms that (1) do not require the patient to constantly face a display, (2) can be played in a number of different places in the patient´s living environment, and (3) can be played concurrently with everyday activities. RESULTS: One approach to achieve these goals is to gamify the patient´s living environment through interactive internet-of-things technology. This can be done through a network of wireless distributed sensors such as active areas on the walls and in the floor, and output through light, movement and sound in the environment. Simple games, such as following a sound around the apartment, or walking the stairs to get points, can be implemented on such platforms. An inspiration for such games is the magical environments found in fairy-tales and fantasy movies. We will present some early examples of such pervasive "magical" exergames, and our first attempt at a set of design guidelines for this class of exercise games. We will further argue for the necessity of a user-centred design process for these games, with a high degree of patient and therapist involvement, and show how existing best-practice in interaction design can be utilized for this purpose. The latter includes a focus on the lived human body and its relation to its environment, inspired by the phenomenology of the French philosopher Merleau-Ponty and the ecological psychology of J. J. Gibson, respectively. We will end by presenting a research agenda for this class of exergames, both from a game design and from a medical perspective. CONCLUSIONS: Pervasive gaming platforms utilizing current internet-of-things technology has the potential to overcome some of the limitations on current exergames posed by display-based gaming platforms. The successful design of such games requires a user-centred design process and a focus on the human body and its relation to its environment.

Symposium IX Wednesday June 28, 11:00 – 1:00, Oceanside II

Muscle synergy analysis: a promising tool for diagnosis and evaluation of balance and gait control deficits in people with neurological disorders.

Chair: **Digna de Kam**, Radboud University Medical Center, Netherlands

Digna de Kam, Radboud University Medical Center, Netherlands

Deficient motor modules on the paretic side result in direction-specific instability after stroke.

BACKGROUND AND AIM: Postural instability is a risk factor for falls in people after stroke. Defective muscle coordination of balance recovery responses may contribute to their greater fall risk. We investigated the association between postural response coordination deficits and perturbation-induced body sway in stroke survivors. METHODS: Ten people after unilateral stroke (> 6 months) and 9 healthy controls were subjected to translational balance perturbations in 12 directions resulting in a feet-in-place balance correcting response. Activity of eight muscles was recorded bilaterally: erector spinae (ERSP), gluteus medius (GLUT), biceps femoris (BFEM), semitendinosis (SEMT), soleus (SOL), rectus femoris (RFEM), peroneus (PER) and tibialis anterior (TA). We extracted muscle synergies for each leg using nonnegative matrix factorization on the initial EMG activity (3 consecutive 75 ms time bins) following the platform's motion. We also determined perturbation-induced body sway using a single-link inverted pendulum model. We used a repeated measures general linear model to compare the activation of muscle synergies that we identified in patients and controls, in order to pinpoint abnormal directional tuning of postural responses in stroke survivors. Finally, we performed regression analyses to characterize the correlation between body sway and stroke-related deficits in the activation of motor modules. RESULTS: While three muscle synergies (W1-W3) were consistently found in healthy controls, some of these muscle synergies were either absent or abnormally activated in patients' paretic legs. Specifically, muscle synergy W3 (BFEM, SEMT, ERSP), which responded to forward perturbations, was missing in 4 out of 10 paretic legs. Consequently, forward perturbations induced larger body sway in individuals without W3 than those with it ($p=0.02$). Another deficit in patients' paretic legs was the abnormally low initial activity of W2 (TA, PER, RFEM), which responded to posterolateral perturbations ($p<0.05$). Accordingly, the lower initial W2 activity was strongly associated with increased body sway following posterolateral perturbations ($R^2=0.68$, $p<0.01$). Lastly, the stroke-related deficits in muscle coordination were heterogeneously distributed across patients, indicating that stroke survivors suffer from distinct deficiencies in their muscle coordination. CONCLUSIONS: We identified stroke-related deficits in muscle coordination of postural responses that each resulted in a pattern of direction-specific postural instability. The heterogeneous distribution of these deficits across patients suggests that different pathophysiological mechanisms may underlie each of the deficits. The structural deficits in paretic W3 hint at greater cortical involvement for this muscle synergy. In addition, identifying patient-specific postural control deficits is crucial for the development of targeted interventions to improve postural stability in stroke survivors.

Andrew Sawers, University of Illinois, USA

Neuromuscular determinants of slip-induced falls in older adults

BACKGROUND AND AIM: A central question relevant to the prevention of falls is: what distinguishes situations when we recover our balance from those that we do not? Specifically, how does the robust neuromuscular control of walking and balance break down during a fall? Previous work has focused on muscle coordination during successful balance recoveries, or the mechanics of falls. Here, for the first time, we identify differences in muscle coordination between falls and recoveries. METHODS: We extracted muscle synergies, groups of spatially fixed co-active muscles, and identified onset latencies and peak activity from a set of bilateral leg EMG recordings taken from 15 community-living older adults who fell (71 ± 2 yr, 13 women) and 13 who recovered (71 ± 5 yr, 5 women) after an unexpected mechanically induced slip while walking. Gait-related variables at slip onset (i.e. speed, stability) and slip parameters (i.e. peak velocity, distance) were also calculated. The number of muscle synergies, gait related variables, and slip parameters were compared between slip outcomes with 1-sided t-tests.

Differences in onset latencies and peak activity were tested with separate MANOVAs. RESULTS: During slip trials, subjects who fell recruited fewer muscle synergies (3.7 ± 0.9, range: 3-6) than those who recovered (4.7 ± 0.9, range: 4-6, $p < 0.01$), suggesting a smaller motor repertoire with which to respond to the slip and prevent a fall. While no differences in peak muscle activity were found, subjects who fell had delayed knee flexor (fallers: 170 ± 61 ms; non-fallers: 120 ± 16 ms, $p < 0.01$) and extensor (fallers: 239 ± 43 ms; non-fallers: 186 ± 41 ms, $p < 0.01$) onset latencies in the slip/leading leg compared to subjects that recovered. Additionally, differences in the composition and recruitment of muscle synergies containing knee muscles were observed between slip outcomes, suggesting that coordination of muscle activity around the knee may be critical to avoiding falls from slips. Subjects who fell during the slip trial recruited a unique ?all-on? muscle synergy characterized by extensive co-activity across all (bilateral) muscles. Several features of this synergy (i.e. first trial response, extensive flexor-extensor co-activation) suggest that it may reflect motor output consistent with a startle response. If so, this would imply that the startle response disrupts rather than preserves stability. Finally, slip parameters and gait-related variables at slip onset did not differ between slip outcomes. Thus, these differences in muscle coordination may reflect differences in neuromuscular control of movement rather than biomechanical constraints imposed by the perturbation or initial gait mechanics. CONCLUSIONS: These results are the first step in determining the causation of falls from the perspective of muscle coordination. They suggest that there may be a neuromuscular basis for falls that could provide new insights into their treatment and prevention.

Jessica Allen, Emory University, USA

Recruiting common muscle synergies across gait and balance behaviors is associated with better motor performance in neurologically impaired populations

BACKGROUND AND AIM: Muscle synergy analysis related to mobility in clinical populations commonly focuses on walking behaviors. Although a higher number of muscle synergies has been associated with walking speed post-stroke, large differences in gait speed are observed in individuals with identical number of synergies for walking. Similarly, many individuals with Parkinson's disease (PD) have walking deficits yet no reduction in synergy number. Whereas maintaining balance is critical for mobility, little is known about muscle synergies for balance in either population. While neurotypical adults recruit common muscle synergies across balance and walking, we hypothesized that muscle synergies for walking and balance would be differently affected in neurological disorders, resulting in fewer common muscle synergies recruited across behaviors. Here, we tested whether the number of common muscle synergies recruited in walking and reactive balance is related to motor performance cross-sectionally in individuals post-stroke and longitudinally in individuals with PD before and after rehabilitation. METHODS: Muscle synergies were found using nonnegative matrix factorization from electromyography recorded while walking at preferred speed and during standing reactive balance in two cohorts: a cross-sectional cohort of 5 chronic stroke survivors (2 female, 58.4 ± 10.6 years, 4 right-side hemiparesis), and a longitudinal cohort of 6 individuals with PD (5 male, 64.0 ± 16.6 years old) before and after a dance-based rehabilitation intervention. The number of muscle synergies recruited during each behavior was chosen such that the overall variability accounted for was greater than 90%. The number of muscle synergies common to both behaviors was identified using Pearson's correlations. RESULTS: In both stroke and PD, better motor performance was associated a larger number of muscle synergies common to walking and reactive balance. In the stroke cohort, three paretic leg muscle synergies during walking were identified across all participants despite a wide range of walking speeds (0.3 to 1.4 m/s). In contrast, the number of walking muscle synergies also recruited during reactive balance ranged from 0 to 2, resulting in a moderate positive relationship (R^2=0.49) with walking speed. Similarly, improved motor performance after rehabilitation in the PD cohort was not associated with increases in muscle synergy number. Instead, improved motor performance was associated with an increase in common muscle synergies across walking and reactive balance. CONCLUSIONS: We provide initial evidence that the ability to recruit common muscle synergies across walking and balance is related to motor performance across different neurological disorders. Therefore, examining how muscles are coordinated across multiple behaviors may have important implications for rehabilitation interventions aimed at improving muscle coordination deficits causing reduced mobility.

Katherine Steele, University of Washington, USA

Walk-DMC: Dynamic motor control predicts function and treatment outcomes in children with cerebral palsy

BACKGROUND AND AIM: New tools are needed to characterize the impact of neurologic injury on movement and function. Every brain injury is unique, which makes optimizing treatment and improving movement a challenging endeavor for clinicians and patients. The aim of this research was to evaluate whether muscle synergy analysis could be used as a tool to better characterize impaired motor control after neurologic injury, specifically for children with cerebral palsy (CP). An advantage of synergy analysis is that it relies on electromyography (EMG) data, which is already collected as standard of care for many children with CP. We hypothesized that children with synergies more similar to typically-developing (TD) peers would demonstrate less functional impairments and have better outcomes after treatment compared to children with more impaired synergies. METHODS: We analyzed EMG data during walking for children with CP who previously received gait analysis at Gillette Children's Specialty Healthcare, as well as a group of TD peers who serve as the control database for the lab. Synergies were calculated using nonnegative matrix factorization for up to five muscles on the leg (rectus femoris, medial hamstrings, lateral hamstrings, anterior tibialis, gastrocnemius). For each child, we calculated the Walking Dynamic Motor Control Index (Walk-DMC), a summary measure of synergy complexity that gives a z-score of the variance accounted for by one synergy compared to TD peers. A Walk-DMC of 100 indicates synergy complexity similar to TD peers, while each 10 point decrement indicates a one standard deviation reduction in synergy complexity compared to TD peers. We analyzed synergies for 633 children with CP and compared Walk-DMC to functional impairment and selective motor control. For 473 children with multiple gait analyses, we further analyzed whether Walk-DMC was correlated to changes in gait after conservative treatment, orthopaedic surgery, or selective dorsal rhizotomy. RESULTS: Children with CP used less complex synergies during gait compared to TD peers, with an average Walk-DMC of 86.2. Walk-DMC decreased significantly with increasing functional impairment, as measured by the Gross Motor Functional Classification System (GMFCS). Children in GMFCS Level I (least impairment) had an average Walk-DMC of 92.4, as compared to 79.2 for children in GMFCS Level IV. Walk-DMC was significantly correlated with clinical exam measures of selective motor control ($r=0.44$). Children with a greater Walk-DMC were also more likely to have positive improvements in gait after treatment, regardless of treatment group. In a forward stepwise regression analysis, Walk-DMC was significantly correlated with post-treatment Gait Deviation Index, walking speed, and scores on the Pediatric Outcomes Data Collection Instrument Sports & Physical Fitness Scale. CONCLUSIONS: Dynamic motor control is related to functional impairment and treatment outcomes for children with CP.

Symposium X Thursday June 29, 3:30 – 5:15, Las Olas I-III

“Good vibrations” or are they? Is the activation of skin a worthwhile endeavour for wearable devices and interventions?

Chair: **Tim Inglis**, University fo British Columbia, Canada

Leah Bent, University of Guelph, Canada

How cutaneous mechanoreceptors in the foot are able to contribute to functional movement

There are four subclasses of mechanoreceptors in the skin, each able to provide unique information regarding input from the environment or internal movement relating to slip, pressure, vibration and stretch (Macefield, 2005). Much of what we know regarding these receptors has been realized through investigations into afferent firing in the hand in both human (Johansson et al 1982) and in primate (Suresh et al 2016) studies. Our work has focused on the skin on the foot dorsum and sole to better understand how this sensory source can contribute exteroceptive and proprioceptive information for balance and gait. Using the technique of microneurography we recorded from single afferent fibres innervating skin across different regions of the foot dorsum and sole. Through these means we can assess how individual subclasses respond to specific inputs; including different vibration frequencies and stretch, as well as identify now variables such as hardness and thickness of the skin may alter the afferent firing properties (Strzalkowski et al 2015). We explore how both receptor density and dermal mechanical properties may influence the known difference in afferent response across foot sole locations. Our results indicate that, while the range of frequencies are similar to the hand, subclasses of receptors are not as easily targeted in the foot. Additionally, there is an effect of skin mechanics on afferent threshold. These findings will both have implications on future work looking to isolate and activate specific types of skin receptor through vibration. Many clinical applications use sensory perception as a marker of skin function. The ability to perceive a cutaneous input is dependent on afferent threshold, receptor density and central contributions. However, perception is just part of the equation when it comes to skin contributions to functional tasks. We must also consider the potential for afferents to effect changes on the motor system. In particular, the ability to alter the excitability of the motor neuron pool to specific muscle groups. Cutaneous input has the ability to provide meaningful input to the spinal cord regarding slips and contact with obstacles. These rapid reflexes, evoked from activation of skin on the foot, are seen in both the lower limbs and upper limbs (Fallon et al 2005, Bent Lowrey 2013). Ultimately, the implications of the mechanistic work here is the ability to apply this knowledge to further understand how to activate these mechanoreceptors in situations of reduced input. It is known that the aging process adversely affects the sensitivity of mechanoreceptors in the feet (Peters et al 2016). Applications to mitigate these effects have been explored through augmentation of skin input via specialized shoe insoles (Lipsitz et al 2015, Perry et al 2008). Knowing HOW these subclasses of mechanoreceptors respond to artificial and natural input is fundamental in order to push forward the field of sensory rehabilitation.

Christopher Nester, University of Salford, UK

Cutaneous implications of orthotics and footwear use

Many believe the application of load to the human foot is well understood the distribution of plantar load during walking is well documented (1), and we know how orthoses and footwear change the distribution (2). However, there is good reason to be sceptical as we seek to understand these loads as "sensory inputs" and thereafter manipulate them. At each point of plantar contact compression and shear loads are applied but the latter are extremely challenging to measure (3). The effects of these forces are interrelated too. For example, tensile forces may stretch the skin and in doing so increase its compression stiffness, thus changing the load transfer between external device and foot. This interaction has never been studied. Furthermore, the spatial orientation of the plantar force sensors is often unclear, since shoe soles are not flat and flex constantly during walking. Plus, feet move relative to shoes and thus sensors. This is further complicated when foot orthoses create complex contours at the foot/load interface. This can mean forces measured normal to the sensor surface are actually shear loads applied to the foot but compression forces applied to the skin (e.g. in the sides of a heel cup). Compared to plantar loading, far less is understood about dorsal loading and here too only in compression forces (4). The lower loads on these surfaces might have specific advantages, such as an improved ability for footwear materials to slide across the skin surface and thus provide shear sensory input. Also, since different dermatomes are affected, this could be a location for additional input when plantar sensation is affected in isolation. A further feature of how external devices affect plantar load and sensory input is application of load to otherwise non weight areas, such as the medial arch (2), or alterations in the timing of loading, such as under the forefoot in elevated heels (5). How these sensory inputs combine with mechanical effects (changes in joint moments) and non-cutaneous sensory inputs (e.g. receptors in joint capsules) is not understood. We do know, however, that muscles change in response to the mechanical and sensory perturbations created by footwear (6) and orthoses (7), but the precise function of sensory input compared to mechanical inputs is not clear. Finally, there are now means to modulate loads applied to the skin surface in new ways, using vibration or textures for example (12, 13). There are thus new opportunities for modifying sensory input and we believe movement control but only a weak scientific basis upon which to make progress. 1. McClymont J et al R Soc Open Sci. 2016 Aug 17;3(8):160369. 2. Chapman GJ, et al. Gait Posture. 2013 Jul;38(3):443-9. 3. Rajala S et Clin Biomech (Bristol, Avon). 2014 May;29(5):475-83. 4. Hagen M et al. Res Sports Med. 2010 Jul;18(3):176-87. 5. Luximon Y. Hum Mov Sci. 2015 Jun;41:307-19. 6. Forghany S. Gait Posture. 2014 Jan;39(1):205-12. 7. Murley GS et al. Clin Bio

Paul Zehr, University of Victoria, Canada

Cutaneous sensation from the top and bottom of the foot influences locomotor control from nose to toes

The integral role of afferent feedback in the control of rhythmic motor output has been well documented in recent decades. Work in quadrupeds and humans has illustrated that information from proprioceptors is required for finely coordinated locomotion and that specific feedback from cutaneous mechanoreceptors strongly influences gait parameters. Cutaneous feedback from the plantar surface of the foot is an important contributor to the rehabilitation of locomotion after neurotrauma and sensation from the foot dorsum is crucial to the stumbling corrective reaction. Stimulation of cutaneous nerves innervating the foot during stance and swing result in functionally relevant, phase- and nerve-dependent neuromechanical changes in kinematics, kinetics and ongoing muscle activity of walking all across the body. Work focusing on stimulation of discrete skin regions of the plantar and dorsal surfaces of the foot has revealed that neuromechanical responses are also topographically organized. Feedback from discrete skin regions of the feet contribute to 'sensory steering', which has implications in rehabilitation and athletic training.

Kristen Hollands, University of Salford, UK

"Good vibrations" or are they? Is the activation of skin a worthwhile endeavour for wearable devices and interventions?

Although it is well-established that the control of balance and gait relies on multiple sensory inputs the role of sensation from the skin on the soles of the foot has received relatively little attention. Recent advances in recording techniques (e.g. microneurography) have allowed insight into how these mechanoreceptors function but very few studies have applied this knowledge to understand the role of these sensors in controlling gait and posture. In particular, we have a very limited understanding of the role of foot skin sensation in the recovery of balance and gait in patient populations with neurologic conditions. This talk will examine the most recent evidence from clinical and biomechanical studies of neurologic patient groups for the role of skin sensation from the feet to contribute to rehabilitation and recovery of balance and gait. After brain injury as many as 34-85% of people experience reduced, lost or exaggerated sensation of touch on the skin (somatosensation) [1]. Some studies have identified that the presence of somatosensory impairments following brain injury are detrimental to balance and the likelihood of regaining independent mobility [2]. Deficits in somatosensation may therefore be an underling factor in the high incidences of falls experienced by people with brain injury [3]. Studies of foot skin sensation and its relationship to balance performance have been conducted in stroke survivors [4] and healthy older adults [5]. These studies show, arguably, limited correlations between foot skin sensation and standing balance control. However, other studies show opportunity for foot skin sensation to contribute to the ability to alter foot placement when stepping over obstacles or recovering from a trip [6]. It could therefore be proposed that foot sensation contributes to balance and gait control under more dynamic balance conditions than quiet stance and/or at specific time points (e.g. swing when the foot may come into contact with an obstacle) or locations on the feet. With this in mind, how effective might current sensory stimulating insole designs, which, most commonly, act by way of constant texture or vibration, be for rehabilitating or enhancing balance and gait control? In order to answer this question evidence of effectiveness of somatosensory rehabilitation paradigms and for sensory stimulating insoles on balance and gait outcomes will be discussed and directions for future research and development of rehabilitation interventions incorporating somatosensory stimulation considered. 1) Khan, F., et al., J Rehabil Med, 2016. 48(5): p. 442-8. 2)Patel, A., et al., Arch Phys Med Rehab 2000. 81(10): p. 1357-63. 3) Hyndman, D., et al., Arch Phys Med Rehab., 2002. 83(2): p. 165-70. 4) Parsons, S.L., et al., Top Stroke Rehabil, 2016. 23(5): p. 326-32. 5)Machado, A.S., et al., Arch Gerontol Geriatr, 2016. 63: p. 67-71. 6) Potocanac Z., et al., Exp Brain Res, 2014. Nov;232(11):3579-90.

Symposium XI Thursday June 29, 3:30 – 5:15, Las Olas IV-VI

Digging into data: What sensor signals from real-world falls can tell us

Chair: **Ngaire Kerse**, University of Auckland, New Zealand

Jochen Klenk, University of Bologna, Italy

What can we learn from real-world falls: description of movement and kinematics

The movement and kinematics of the human body during real-world falls is poorly understood. Fall definitions, fall risk models and fall detection algorithms are based on several assumptions about falls, which have not yet been proven true, mainly due to a lack of real-world falls data. The FARSEEING project has compiled a database of more than 200 real-world falls from older people, to bridge this gap.

Several settings and disease groups have been included, mainly geriatric rehabilitation, Parkinson's disease, cerebellar and sensory ataxia. Inertial sensors including accelerometers, gyroscopes and magnetometers were attached to the lower back (L5 position) in subjects with a known fall history. The part of the sensor signal including the fall has been identified based on fall reports. We extracted qualitative and quantitative parameters from all validated fall signals, including pre-fall activities, initial and final fall direction, and maximum vertical acceleration. Data-fusion algorithms have been used to estimate the sensor orientation during different fall phases. In this talk we will present the latest results of our analyses and compare them with current assumptions and data from simulation and video studies. The results will be used to discuss the validity of current fall definitions and the consequences for fall risk models. Furthermore, measured variables and reported information from the fallers will be compared to assess reporting quality.

Luca Palmerini, University of Bologna, Italy

Fall detection based on automatic algorithms that can learn the characteristic patterns and features of real-world falls: issues and results.

Technology is paramount in helping detect falls. Currently however, state of the art algorithms for fall detection using wearable sensors are still not performing accurately enough. Moreover, there is not a standard way yet to assess performance with a lot of heterogeneity among studies, making it difficult to compare them and understand what actually the best procedure to use is. Most importantly, most of the current approaches are validated on simulated falls that were already shown to be significantly different from real-world falls (Klenk et al 2011). Therefore, in order to develop systems that will be effective for fall detection in real life, the design of automatic algorithms which can learn the characteristic patterns and features of real-world falls is paramount. However, there are several issues in the construction of such a framework for fall detection. Among these issues, there can be heterogeneity of activity profiles of different subjects, problematic signals (signals that the algorithms cannot correctly identify), sensors' technical limitations such as saturation, heterogeneity in the choice of number, type and position of sensors, choice of a standard evaluation criteria, verification of falls and many others. We developed a complete framework for fall detection of real-world falls from the FARSEEING database (Klenk et al, 2016). We extracted traditional and novel features (Palmerini et al 2015) from the recorded signals in several real-life settings. Statistical and machine learning algorithms for automatic classification were applied to this data in order to automatically detect falls. We will show the issues and difficulties encountered during this process and we will show the methodology we developed in order to face these issues. We will present the latest results for fall detection of real-world falls highlighting the gaps that are still present in order to get to an effective, reliable and sustainable fall detection. We will present, discuss and investigate possible causes for representative examples of situations where the automatic algorithms are not, for now, able to distinguish between a fall and a normal activity.

Omar Aziz, Simon Fraser University, Canada

A machine learning based fall detection algorithm: A validation study using real-world fall and non-fall accelerometer data

INTRODUCTION: Falls are a major cause of injuries and deaths in older adults. Even when no injury occurs, about half of all older adults who fall are unable to get up without assistance and remain on the ground for an extended period of time. Wearable sensor based systems have been developed to automatically detect falls, and alert care providers of such events to hasten the delivery of medical assistance. However, despite exhibiting high classification accuracy in laboratory experiments, such sensor-based fall detection systems have yet to achieve high user acceptance and market penetration. One barrier to acceptance for such systems is the lack of evidence of their effectiveness in real-world falling scenarios in older adults. Therefore, the aim of this study is to examine the accuracy of our machine learning algorithm developed using accelerometer signals collected from a laboratory experiment, on the real-world fall and non-fall accelerometer data. METHODS: A fall classification model was first trained using accelerometer data from 10 subjects (aged 22-32) who participated in our laboratory experiment simulating the most common causes of falls, observed in a library of video sequences of 227 real-life falls in older adults residing in long-term care facilities [1, 2]. The accuracy of the trained model was then tested on the real-world fall and non-fall datasets recorded with five young (aged 22-32) and 19 older adults (aged 56-94). With young adults, 28 hours of data were recorded as they went about their normal daily activities; no fall event was reported during that time. Among older adults, however, 10 falls were reported during the 386 hours of sensor data recording. While data with all young adults and 10 older adults were recorded at 128 Hz, using a tri-axial accelerometer (range ±6 g, APDM Inc., Portland, OR) worn at the waist, the data from remaining nine older adults were recorded at 100 Hz, using a tri-axial accelerometer (range ±2 g, Dynaport MiniMod, McRoberts, The Hague, NL) worn also at the waist. RESULTS: We found that our machine learning based fall classification model detected 8 out of 10 falls, and provided false positive rate that ranged from 0 to 0.3 false alarms per hour on the non-fall data recorded from older adults. Furthermore, our system did not report any false alarm on the 28 hours of recorded data from young adults. CONCLUSION: While our machine learning based fall detection system showed higher fall detection accuracy and substantially lower false positive rate than most of the existing fall detection systems, there is need for continuous efforts to collect real-world data within the target population to perform fall validation studies for fall detection systems on bigger real-world fall and non-fall datasets. REFERENCES: [1] Aziz, O. et al. MBEC. 1-11. 2016. [2] Robinovitch, S. et al. Lancet. 47-54. 2013.

Lars Schwickert, Robert Bosch Hospital, Germany

Get up! Resting and recovery after real falls.

BACKGROUND AND AIM: Falls are a major cause of injury and disability in older people. Besides direct consequences due to the impact of a fall, the inability to get up after falls is a common life threatening condition in older people. Yet, little is known about fall patterns including successful recovery after a fall and patterns with no recovery provoking long lies. One major obstacle to achieving a deeper understanding has been a lack of objective data from real-world fall events. Therefore, new insight into real-world fall signals from body-worn sensors will be given. Different kinematic features and patterns describing resting after a fall and falls with successful and unsuccessful recovery will be analyzed. The results will sharpen the picture of real-life falls and thereby help to describe, detect and understand critical incidents that require an automatic fall alarm to be sent. METHODS: The FARSEEING project has compiled a database of more than 300 real-world falls. A fall report, following a fall, was used to extract the fall signals. Smartphones including inertial sensors were worn in a waist belt at the L5 position by subjects with a known fall history. Several settings and disease groups have been included, mainly geriatric rehabilitation and Parkinson's disease. Signals including successful recovery and long lies after real-world falls were selected by at least two signal analysis experts from the FARSEEING database. Different recovery patterns were analyzed and acceleration and trunk orientation was evaluated as a basis for further fall analysis. The selected falls were labelled according to a specific fall model. RESULTS: Results extracted from real-world fall signals show that fall patterns including successful recovery after a fall can be distinguished from patterns with no recovery and long lies. The maximum duration of resting after a successful recovered fall was at 20 seconds. This differed significantly from non-recovered falls with considerably longer resting durations. Orientation merged with acceleration data can improve the understanding of post-fall body positions and thereby help detect and understand critical incidents that require an alarm to be sent off. CONCLUSIONS: Analysis of real-world fall signals with and without successful recovery showed different patterns. Recovery analysis will give insight into successful movement patterns helping to preventing long lies. Kinematic analysis and further pattern recognition can help to design tailored long-lie prevention interventions and improve fall-detection algorithms.

Symposium XII Thursday June 29, 3:30 – 5:15, Oceanside II

Can electrophysiology enhance our understanding and treatment of gait and posture in ageing and neurodegeneration?

Chair: **Meir Plotnik**, Sheba Medical Center, Israel

Evyatar Arad, Sheba Medical Center, Israel

Methodological aspects of recording and analyzing electroencephalographic signals during locomotion

Movement artifacts (MA) in electroencephalographic (EEG) signals originate from mechanical forces applied to the scalp electrodes, inducing small electrode movements relative to the scalp which, in turn, cause the recorded voltage to change irrespectively of cortical activity. These mechanical forces, and thus MA, may have various sources that are inherent to daily activities (e.g., ground reaction forces, head movements, etc.). In this talk, experimental measures to minimize MA in EEG and hardware advancements designed for MA reduction will be introduced. Furthermore, we will describe our study, aiming to (i) quantify MA in EEG during walking at different speeds and to (ii) asses our ability to prune it at various intensities (i.e., walking speeds) using state-of-the-art signal processing algorithms. Finally, we will present and discuss algorithms from statistical physics used to characterize cortical network activity and dynamics based on EEG data recorded during locomotion, and how these techniques can be used to delineate cortical functions related to gait. In our study, participants wore a 32-channel EEG cap while walking at various speeds both over-ground and on a treadmill. Data preprocessing included separating the EEG signals into statistically independent additive components using independent component analysis (ICA). MA was identified and quantified for each component by computing the spectral energy around a trial-specific stepping frequency. Based on this information, we developed an approach to remove MA contaminated components from the EEG signals. Figure 1 exemplifies a comparison of EEG signals before and after MA reduction, at various walking speeds (0.4 - 2.2 m/s). Our analyses suggest that the methodology effectively removes MA, even at high walking speeds. Acknowledgments: Israeli Ministry of Science and Technology, Grant # 3-12072 German Israel Foundation Grant # I-1298-415.13/2015 Israel Science Fund Grant # SF_1657_2016

Jesse Jacobs, Liberty Mutual Research Institutue for Safety, UK

Electroencephalography reveals unexpected insights about the mechanisms of impaired postural modulation by central set with Parkinson's disease

BACKGROUND AND AIM: People with Parkinson's disease (PD) do not modify their posture based on knowledge about task circumstances (i.e., based on central set). We aimed to investigate the hypothesis that impaired modulation of neural preparation underlies this impaired postural modulation. METHODS: In two separate studies and subject samples, we evaluated the electroencephalographic potentials of contingent negative variation (CNV) and beta event-related desynchronization (bERD) prior to externally induced postural perturbations of predictable versus unpredictable amplitude and prior to voluntary step initiation of predictable versus unpredictable selection of the stepping limb. RESULTS: Subjects with PD did not modulate the initial center-of-pressure displacement based on predictability of perturbation amplitude, nor did they modify the amplitude or number of anticipatory postural adjustments to the same extent as subjects without PD when stepping with versus without prior knowledge of the cued stepping limb. Despite this impaired postural modulation, compared to subjects without PD, the subjects with PD exhibited similar CNV modulation and enhanced bERD modulation prior to both external perturbations and voluntary step initiation. CONCLUSIONS: In cued conditions, impaired postural modulation with PD is not due to an impaired ability to modulate preparatory cortical activity, but perhaps due to greater influence of preparatory cortical activity to maintain unmodulated postural behavior.

Meir Plotnik, Sheba Medical Center, Israel

Bi-Hemispheric Phase Synchronization in Subjects with Parkinson's disease During Stance, Gait and Upper Limb Motor Tasks

BACKGROUND: Gait and postural disturbances, predominant clinical features of Parkinson's disease (PD), significantly affect patients' quality of life. The neural pathophysiology that underlies walking impairments in PD is not fully understood. The present study focuses on the contribution of inter-hemispheric and intra-hemispheric cortical dynamics to gait pathologies in PD. Since PD related impairments, symptomology and gait have asymmetric presentation we hypothesize that the inter-hemispheric synchronization will differ in PD as compared to healthy adults in particular during bilateral motor activation (e.g., free over ground walking). METHODS: We examined 15 patients with PD (age 67.7 ± 8 y; 3 women) and 8 healthy elderly controls (NPD) age 63 ±8.5 y; 5 women) while performing 1) one minute of quiet standing; 2) back-and-forth straight-line corridor walking; and 3) alternating and simultaneous hand tapping. EEG signals were recorded with a 32-electrode array (sampling rate 2048 Hz). The Fourier-mode phase synchronization (PS) method was used to quantify synchronization in periodic cortical activation between the two brain hemispheres (inter-hemispheric PS - IPS) and within each hemisphere (intra-hemispheric). PS ranges from 0 to 1, representing null to maximal synchronization, respectively. The theta (3.9-7.8 Hz), alpha (7.8-15.6 Hz) and beta (15.6-31.2 Hz) bands were studied. In addition, the relative difference between the left and the right intra-hemispheric PS values was calculated and defined as an Asymmetry Index (AI). RESULTS: IPS was significantly stronger among PD patients versus NPD subjects during standing, walking and turning in all bands (ANOVA; $F_{1, 20} \geq 28.9$; $p < 0.001$; e.g., Fig 1 left). Significantly lower IPS was found in the frontal theta band during the turning task (as compared to walking) in both groups ($p = 0.02$). Alternating and simultaneous hand tapping also led to a significantly increased IPS in the PD group compared to the control group in all bands. Only in the temporal lobe, the PD group exhibited significantly lower asymmetry (as reflected in the AI) compared to the control subjects in all the tasks ($p=0.002$; Fig 1 right). Significantly lower AI values were found in the frontal alpha band during simultaneous tapping task (as compared to the alternating tapping task) in both groups ($p=0.02$). CONCLUSIONS: Our findings suggest that excessive bi-hemispheric cortical synchronization may contribute, or alternatively be consequential to stance and gait disturbances in PD. To some extent, a high IPS comes in tandem with a more symmetrical activation of the two hemispheres. This study is one of a group of studies that addressed cortical activity (here expressed by EEG) while walking in patients with PD. This is the only one looking at inter-hemispheric synchronization, contrasting walking with other bilateral movements. Acknowledgments: German Israel Foundation Grant #I-1298-415.13/2015

Simon Lewis, Sheba Medical Center, Israel

Utilising neurophysiology to develop novel treatments for Freezing of Gait in Parkinson's Disease

Parkinson's disease (PD) affects 1-2% of people over 60y and over half of all patients will develop Freezing of Gait (FOG) where they have a paroxysmal inability to move their feet despite wanting to walk. This can lead to falls and not infrequently, nursing home placement. Recent studies utilising virtual reality gait paradigms (VR) in combination with functional neuroimaging have given some insights into the underlying neural correlates of the phenomenon of FOG in PD. These findings suggested that surface recordings taken from ambulatory EEG may also be used as a biomarker of the symptom and perhaps could even be able to predict individual events. Understanding the interplay between cortical and sub-cortical events during freezing has subsequently led to the evaluation of single cell recordings taken at the time of Deep Brain Stimulation surgery in patients performing VR. It is hoped that in future it might be possible to harness real-time neurophysiological data from recording/stimulating electrodes in conjunction with closed loop DBS to reduce FOG in PD.

Poster Abstracts

Monday, June 26, 2017

A Activity monitoring

1-A-1 Validation of the ActiGraph GT3X+ for measurement of physical activity in older adults in a semi-structured protocol using video analysis

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Introduction: Accurate classification of physical activity requires the use of validated and reliable measurement devices. This study thus reports an evaluation of the validity of the ActiGraph GT3X+ monitor for the classification of physical activity in older adults while performing a semi-structured protocol in a laboratory setting. Methods: A total of 20 older adult participants, 68-90 years (76.4±5.6 years), were recruited from the Trondheim area in Norway. The subjects were recorded performing a semi-structured protocol of everyday physical activities while wearing an ActiGraph GT3x at the waist and recorded at 25fps using wall-mounted video cameras and annotated using the Anvil software (v5.1.13), the protocol is described in detail by Bourke et al. (Bourke et al.). The algorithmic output from the ActiGraph GT3x estimates standing, sitting and lying based on inclination. It also provides a separate algorithmic out of step count. Both algorithm outputs were exported in 1 second epochs. These algorithms were compared to the video annotated movement at a precision of 0.04s. Results: Table 1 presents a visualisation of the performance of the ActiGraph GT3x sensor versus video recordings at 25fps. Table 1. The confusion matrix of the actual output from the video recordings versus the predicted output from the ActiGraph GT3x. ActiGraph GT3x Activity Classification Algorithm sitting standing lying Undefined walking non-walking Video Analysis sitting 31.1% 18.4% 2.0% 99.2% 11.2% 28.6% transition 6.1% 28.5% 5.6% 0.0% 25.9% 15.3% shuffling 6.0% 6.5% 0.0% 0.0% 10.2% 4.5% standing 48.9% 24.3% 0.0% 0.0% 19.9% 39.6% leaning 0.1% 0.1% 0.0% 0.0% 0.2% 0.1% walking 5.6% 19.5% 0.0% 0.0% 28.3% 7.0% picking 0.2% 0.4% 0.1% 0.0% 0.4% 0.2% kneeling 0.5% 0.4% 0.0% 0.0% 0.5% 0.4% lying 1.6% 2.0% 92.4% 0.8% 3.3% 4.4% Table 2 presents the sensitivity and specificity of the ActiGraph GT3x. Table 2. standing sitting lying walking Sensitivity 39.12% 55.80% 56.68% 57.05% Specificity 37.25% 61.69% 99.80% 78.51% The ActiGraph correctly classified standing 24.3%, sitting 31.1% and lying 92.4% for each category. Walking was correctly classified during walking 28.3% and shuffling 10.2%. Discussion: This validation study provides detailed insight into the categories that the ActiGraph classifies as part of its 3 main categories in the inclinometer algorithm, namely: standing, sitting, lying and also in the step detection algorithm. It is clear from the results of this study that the use of inclination alone is insufficient to distinguish accurately between standing and sitting. The stepping detection algorithm is also insufficient to accurately detect periods of walking and often registers steps even when in a standing and sitting position. Conclusion: We have validated the ActiGraph GT3x activity monitor using an older adult population. It is clear that further improvements can be made in both algorithms and that inclination alone is insufficient for the detection of static postures using a waist worn sensor.

References: Bourke, Alan Kevin et al. "Validation of Existing Systems and Development of New Algorithms for Body-Worn Activity Classification Systems for Independent Living Older Adults. - Description

1-A-2 Accelerometer based measurement of Ambulatory Physical Activity in the community after treatment for lower extremity musculoskeletal cancer ? A feasibility and validation study

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Background and Aim: Physical activity (PA) levels are linked with survival in cancer [1] and reduced in patients with musculoskeletal cancer [2]. Capturing PA is therefore important. Self-reported outcomes and clinic tests are not representative of PA levels in the real world [3]. The aim of this study was therefore to measure PA using a tri-axial accelerometer (Axivity, AX3) suitable for use in patients with lower extremity musculoskeletal cancer to quantify ambulatory PA over 7 days in a community setting. Methods: A prospective cross-sectional study was conducted. Ambulatory PA was quantified using an accelerometer on the mid-thigh. Participants wore the device over a period of 7 days at home. Summary measures of volume (total steps/day, bout count/day, hours walked per day, mean walk time in seconds), pattern (alpha) and variability of ambulatory activity (the latter two being measures of bout distribution) were derived from the 7 day raw accelerometer data using validated algorithms in Matlab. Measures were compared to clinical scales (Toronto Extremity Salvage scale (TESS) to establish convergent validity. p value <0.05 was considered significant. Results: Of 40 patients recruited, 34 adults of mean age 43 (19-89) years treated for musculoskeletal cancer in femur (19), pelvis/hip (3), tibia (9), or ankle/foot (3) had PA data suitable for analysis. 27 had undergone limb sparing surgery and 7 amputation. Median TESS values were 83.62 (8.33 - 100). The accelerometer was acceptable to patients and ambulatory PA was feasible to quantify from an accelerometer. The total steps/day were 10953 (1400 - 33779), bout count/day 463 (61 - 2518), hours walked/day 3.16 (0.43 - 11.71), mean walk time in seconds 19.13 (9.70 - 39.11), alpha 1.585 (1.46 - 1.84) and variability 0.916 (0.70 - 1.16). TESS was a significant predictor of alpha, mean walk time and variability (p<0.05), confirming convergent validity. Conclusion: This study confirms the feasibility and validity of quantifying ambulatory PA as an objective measure of community based assessments in patients treated for lower extremity musculoskeletal cancer. This has the potential for development into a clinically useful tool with significant advantages over patient reported measures and older uniaxial accelerometers. REFERENCES 1. Barbaric, M., et al., Effects of physical activity on cancer survival: a systematic review. Physiother Can, 2010. 62(1): p. 25-34. 2. Furtado, S., et al., Objective Clinical Measurement of Physical Functioning After Treatment for Lower Extremity Sarcoma?A Systematic Review. European Journal of Surgical Oncology, 2016. In Press. 3. Rosenbaum, D., et al., Physical activity levels after limb salvage surgery are not related to clinical scores - Objective activity assessment in 22 patients after malignant bone tumor treatment with modular prostheses. Journal of Surgical Oncology, 2008. 98(2): p. 97-100. Funded by Children with Cancer, Sarcoma UK and Shears Foundation

1-A-3 Alterations in Community Stepping and Step Quality among Older Adults with Mild Cognitive Impairment

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BACKGROUND: Recent work demonstrated that the gait pattern of people with mild cognitive impairment (MCI) differs from that of age-matched cognitively intact controls (CIC) and, in general, that walking ability, as measured in the clinic, does not reflect actual daily performance. We evaluated if the amount and quality of daily-life walking differs in older adults with MCI, compared to CIC. METHODS: Briefly, the inclusion criteria were (1) age 60-90 years, (2) able to walk at least 5 minutes unassisted, (3) stable medications, and (4)>2 falls in the past 6 months. Subjects with MCI were included if they scored 0.5 on the Clinical Dementia Rating Scale. To assess step quantity and quality, subjects wore a tri-axial accelerometer on the lower-back for 7 days. RESULTS: Age and gender were similar (p>0.10) in MCI (n=36, 77.83±6.42 yrs; 27.77% men) and CIC (n=100, 76.01±6.15 yrs; 22% men). As expected, Montreal Cognitive Assessment (MoCA) scores were lower (p<0.001) in MCI (21.31±4.05), compared to CIC (25.81±2.64). Steps per day were lower (p=0.004) in MCI (6932.11±3571.79), compared to CIC (9225.69±4132.41). Seven-day walking time was also lower (p=0.003) in MCI (12.8±5.7 hrs), compared to CIC (16.5±6.5 hrs). Within-bout walking (e.g., stride regularity) was less consistent (p=0.024) in MCI (0.51±0.14), compared to CIC (0.58±0.14). Similarly, in the frequency domain, the peak amplitude of the vertical acceleration was smaller (p=0.015) in MCI (0.62±0.21g), compared to CIC (0.72±0.21g). After adjusting for MoCA scores, group differences in stepping quantity and quality were no longer significant (p>0.320), supporting the idea that cognitive function mediated the group differences. CONCLUSIONS: Older adults with MCI walk less and with a more variable walking pattern, as compared to cognitively-intact subjects matched with respect to age and gender. These findings extend previous clinical work and suggest that MCI affects the quantity and quality of community ambulation.

B Adaptation, learning, plasticity and compensation

1-B-4 Effect of unpredictable gait perturbation training on balance in individuals post-stroke

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Balance during gait is generally affected post-stroke. While balance perturbation training is a promising rehabilitation approach, limited research is available on this approach for post-stroke hemiparesis. The aim of this study was to evaluate the effects of training using unpredictable perturbations during gait, on dynamic balance in individuals post-stroke. Methods: Seven individuals (2 women, 54 ± 9 years old, time post-stroke: 9.2 ± 11.9 years) attended the 9 session training program over 3 weeks. A split belt treadmill was used to produce perturbations by changing the speed of one of the belts during stance phase of gait. One-hour training sessions included faster-belt and slower-belt perturbations that were applied repeatedly and then randomly on the non-paretic and the paretic sides, during one stance phase, with unpredictable onsets every 8 to 20 steps (about 175 perturbations per session). The intensity of the perturbations, relative to the treadmill gait speed, was increased progressively between training sessions depending on the tolerance and balance abilities of the participants. Dynamic balance, balance confidence, gait speed, and knee extensors muscle strength were evaluated using the Mini-BESTest, ABC Scale, 10 meter walk test (10MWT) and isometric dynamometry, respectively, immediately before and after training and compared with paired t-tests. Results: Participants demonstrated significant improvements as a result of the training program on the Mini BESTest (+2.4 /28 points, p=0.018), 10MWT at faster speed (+0.15 m/s, p=0.018) and maximum strength generation on the paretic (90.1 vs 106.6 Nm, p=0.043) and non-paretic knee extensors (143.9 vs. 165.6 Nm, p=0.021). No significant changes on 10MWT at self-selected speed (p=0.46) and ABC scale (p=0.10) were observed. Conclusion: Results support the effectiveness of unpredictable gait perturbation training in improving gait and dynamic balance after stroke. Recruitment is ongoing to increase the sample size and to include a control group who will receive gait training without perturbation to confirm the importance of perturbation to improve gait and dynamic balance.

1-B-5 Does an external attentional focus improve motor learning after stroke? Results of a randomized controlled trial.

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Background and Aim: Healthy adults achieve greater improvements in single- and dual-task motor performance when they focus on movement effects (externally), rather than on movement execution (internally). This is often attributed to external focus instructions being less cognitively demanding. In theory, external focus instructions should be particularly effective for motor relearning of stroke patients, as they often exhibit cognitive deficits. In this single-blind randomized controlled trial we compared the effects of internal and external focus instructions on learning a balance task post-stroke. Methods: Sixty stroke patients, admitted for inpatient rehabilitation, were randomly allocated to an internal (N=29) or external (N=31) focus group. Patients practiced to stabilize a balance board with an adjustable rotational stiffness in the frontal plane. Instructions were to focus on the feet (internal) or on the balance board (external). Practice sessions were performed 3 times per week, for 3 weeks. At baseline (T0) the threshold rotational stiffness was determined at which patients were just able to stay balanced (i.e., sway < 2.5 degrees for 70% of trial duration). We also assessed patients? single- and dual-task performance (i.e., tone counting) at the T0 threshold stiffness (i.e., RMS sway in degrees). This procedure was repeated after 1 (T1) and 3 weeks of practice (T2). The assessor was blinded for group allocation. General estimating equations were used to assess which focus group showed the greatest improvements. Results: Preliminary results (N=59) show that threshold rotational stiffness decreased similarly for both groups (Wald-÷2=.7, p=.72). With regard to single-task performance (RMS sway), a significant group by test interaction was found (Wald-÷2=6.8, p=.03). The external focus group initially showed greater reductions in single-task sway magnitude than the internal group at T1, but both groups eventually demonstrated similar improvements at T2. Finally, groups showed similar improvements in dual-task performance (Wald-÷2=3.1, p=.21). Conclusions: No clear benefit was found of external focus instructions for improving balance after stroke. Although external focus instructions were more effective in early learning, this benefit disappeared with prolonged practice. This latter finding may explain the discrepancy in results between this study and studies in healthy adults, which mostly involve short practice periods (days rather than weeks). For the present study, further (a-priori planned) analyses will reveal whether patients? baseline motor abilities, cognition, and focus preference influence which focus instruction is more effective.

1-B-6 Postural asymmetry does not influence the resultant vertical component of ground reaction forces during sit-to-stand

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Background Weight-bearing asymmetry is a common characteristic of post-stroke individuals when executing sit-to-stand (STS) movements. Spontaneously, these individuals put less weight on the paretic limb during STS. In healthy subjects, successfully perform STS requires to produce an adequate maximal resultant vertical ground reaction force (GRF) at the right time during the task. Moreover, failed attempts in STS movement result of an inadequate time-amplitude maximal resultant vertical GRF development. This study aimed to test the hypothesis that the invariance of resultant maximal vertical GRF in healthy subjects is also found in hemiparetic stroke subjects despite of their well-known weight-bearing asymmetry. Methods Eleven individuals with sub-acute stroke (mean (±SD) time post-stroke: 80.4 (± 46) days) and nine age-matched healthy volunteers participated in the study (control group).

Both groups executed three STS movements from an armless and backless stool, height adjusted to obtain 90° of knee flexion. They were instructed to stand up at natural speed with their arms raised straight ahead and hands folded. A force plate positioned directly beneath each participant's bare feet allowed recording the vertical component of GRF at 50-Hz while kinematic data at the trunk and lower limbs were recorded with a VICON system. The hip angular velocity signal was used to determine STS duration. Non-parametric statistics and intercorrelation functions were used to compare total vertical GRF characteristics between the two groups and coherence of the vertical GRF between sides. Results The stroke group took more time to execute STS (3273±819ms vs. 2467±652ms; p=0.03) and their weight distribution was asymmetrical (paretic limb: 35.5±6.6% of total body weight (BW) vs. non-paretic limb: 64.5±6.6% BW, p=0.003) compared to control group (right limb: 51.6±3.3% BW vs left limb: 48.4±3.3% BW, p>0.05). The values of resultant maximal vertical GRF did not differ between groups (stroke: 123.8±6.7% BW vs control: 120.2±3.5% BW, p=0.82) as their occurrence (stroke: 30.1±7.2% vs. control: 34.7±7.2% of STS duration; p=0.08). The intercorrelation analyses revealed that vertical GRF were still coordinated in stroke subjects (Correlation coefficient (CC)=0.83) but lesser than in healthy subjects (CC=0.94, p=0,007) with corresponding temporal delays of 1.0ms and 78ms, respectively. Conclusion As controls, individuals post-stroke show invariant in STS task realization. Mainly, the maximal resultant vertical GRF seems to be an important control parameter regardless of the weight-bearing asymmetry. This might reveal a motor learning strategy allowing stroke subjects to produce timed and sufficient maximal resultant vertical GRF to successfully perform the STS movement and reach the standing position.

1-B-7 When You Adapt, You Retain: Locomotor Adaptation in ACLR and Implications for Rehabilitation

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Despite rigorous surgical and rehabilitative efforts, neuromuscular and biomechanical alterations often persist in persons after anterior cruciate ligament reconstruction (ACLR). Over the course of rehabilitation, motor adaptation occurs as a response to these neuromuscular and biomechanical changes. Recent research has shown cognition may also play a role in motor adaptation and thus rehabilitation outcomes. More specifically, cognition may impact the rate at which individuals are able to regain neuromuscular and biomechanical control. The split-belt treadmill has been used to assess motor adaptation and learning in a variety of populations, including ACLR individuals. The purpose of this study was to assess differences in cognition, aftereffects and retention between ACLR individuals and healthy young adults (HYA), as well as between fast, slow, and non-adapters. Adaptation, aftereffects, and retention were assessed on a split-belt treadmill for 15 participants with an ACLR and 15 age- and gender-matched HYA. Asymmetry scores were calculated for each gait parameter and the rate of step length adaptation was assessed by determining the number of steps required to return to baseline symmetry conditions. Participants were sorted into one of three adaptation groups: fast, slow, and non-adapters. Fast and slow adapters were characterized by adapting step length before or after 160 steps, respectively. Non-adapters did not return to baseline conditions within the allotted 15 minutes. To assess cognitive performance, participants completed an electronic card flip, adaptation and retention of a pursuit rotor task, and Trails A and B. Two-way multivariate ANOVAs were used to determine if there were significant differences in aftereffects, retention and cognition between adaptation groups and injury groups. Both fast and slow adapters had significantly better step symmetry retention than non-adapters (p=0.001 and 0.022, respectively), but fast and slow adapters were not different from each other. All three adaptation groups had similar aftereffects and performed equally on cognitive tasks. ACLR individuals performed better than HYA during pursuit rotor retention and Trails A and B (p=0.034, 0.008, and 0.056 respectively). Cognitive performance was not different between the three groups suggesting these faculties may not significantly contribute to the rate of adaptation in step length asymmetry in young adult populations. Further, while cognitive performance was better in the ACLR group, adaptation, aftereffects and retention were not different compared to HYA. Interestingly, the inability to achieve baseline symmetry during adaptation led to poorer retention of the split belt walking pattern during subsequent exposure. This finding suggest that some individuals may need more time to incorporate new walking patterns into their locomotor repertoire.

C Aging

1-C-8 Psychometric properties of balance and strength measurements in independent living older adults using portable technologies

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In the last few decades, research related to balance and mobility in older adults has been conducted in lab-based settings. The lack of portability and high cost that is associated with the current gold standard methods to quantify body balance and muscle strength, limits their application to community settings such as independent living facilities (ILFs). The purpose of the study was to examine the test-retest reliability of static standing balance performance and lower extremity strength, using an inexpensive dual axis accelerometer and portable load cell, respectively. Methods: Subjects were recruited from a randomized trial that investigated the effect of group exercise programs conducted at ILFs on self-reported function and disability, and walking ability. A sample of 38 subjects attended two testing visits for the test-retest reliability assessment one week apart. For the balance assessment, an accelerometer placed on the back of the subjects at waist level measured body sway in the anterior-posterior (A-P) and medial-lateral (ML) directions. The static standing balance tests consisted of six different standing conditions designed to alter the sensory feedback and base of support by having subjects stand for 30s on level and foam surfaces with eyes open and closed, and standing in semi-tandem and tandem stance. The root-mean-square (RMS) and normalized path length (NPL) for sway in antero-posterior (A-P) and medio-lateral (M-L) directions were calculated. Muscle strength measurements of knee extension, hip abduction, and ankle plantar flexion were assessed with a portable load cell for three consecutive trials. Test-retest reliability was assessed using the intraclass correlation coefficient (ICC), and the minimal detectable change (MDC) was calculated from the ICC. Results: Reliability of balance performance using the accelerometer was good to excellent with ICC values ranging from 0.41 to 0.83 for RMS sway and from 0.49 to 0.81 for NPL sway. However, the ICC during semi-tandem stance in A-P direction was 0.35, indicating poor reliability. The ICCs for knee extensor and hip abductor strength were excellent, and good for ankle plantar-flexor strength (ICC= 0.95, 0.99, and 0.71, respectively). The MDC of the sway measurements ranged from 2.4 to 9.4 mG for the RMS and 5.2 to 13.8 mG/s for the NPL. The MDC of the strength measurements ranged from 18 to 38 N for knee extension and hip abduction strength, and 102 N for ankle plantarflexion strength. Conclusion: Using a portable accelerometer to quantify static standing postural control, and a portable uni-axial load cell to measure lower extremity strength provides reliable measurements in community settings, specifically in ILFs. Knowing the minimal detectable change will allow caregivers to document change in balance or strength status that may indicate need for rehabilitation to prevent declines in mobility. This study was supported by funds from the Patient-Centered Outcomes Research Institute (PCORI) (PCORI/CE-1304-6301)

1-C-9 The inter-rater reliability and agreement of compensatory stepping thresholds and strategies of older and young adults

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BACKGROUND AND AIM: Fall-risk assessments that evaluate the response to external perturbation have the potential to be ecological valid because they specifically evaluate the ability to recover from trips and slips in the laboratory. Trips and slips account for 59% of older adult falls in the community, a successful recovery from trips and slips can be accomplished with an upper body and arms response or by stepping response, depending on the magnitude of perturbation. The current study investigated the inter-observer Reliability and agreement of the compensatory stepping thresholds and balance strategies during unexpected loss of balance in standing in healthy young and older adults. METHODS: Twenty-four older adults and 23 young adults stood in a narrow base stance on a mechatronic device. They instructed to react "naturally" to unexpected lateral perturbations in a magnitude that systematically increased from low to high perturbation (a total of 18 perturbation magnitudes). 60-hz-high-resolution video cameras were used to record the trails. Two blinded observers have analyzed the videos separately. Step threshold and 11 balance recovery strategies were identified to unexpected lateral perturbations: 1) body balance without arms movement (UBB); 2) two arms lift (2AL); 3) perturbation direction arm lift (PDAL); 4) perturbation opposite direction arm lift (PODAL); 5) unloaded leg side step (ULSS); 6) loaded leg side step (LLSS); 7) cross over step (COS); 8) leg collision (Col); 9) abducted one leg (Abd); 10) multiple steps (MS); fall into harness. The stepping threshold was defined as the minimum translation displacement magnitude that elicited two compensatory steps. Kappa coefficient scores (k) for agreement between two testers were performed for the stepping threshold and the observed balance recovery strategies. RESULTS: We observed 1437 perturbed trails, 627 for older adults and 810 for young adults. The total inter-observer k score for all balance strategies for both groups together was excellent, k=0.871 (percentage of agreement of UBB=89.1, 2AL=94.5, PDAL=92.4, PODAL=88.9, ULSS=81.5, LLSS=94.1, COS=87, Col=83.3, Abd=94.2, MS=80, Fall=78). The inter-observer k score for older adults only was k=0.896 and k=0.835 for young subjects. Interestingly in low perturbation magnitudes inter-observer k scores were $0.616 \le k \le 0.785$ and $0.827 \le k \le 0.941$ for medium and high perturbation magnitudes. The k scores for the stepping threshold were 0.908 for both groups, 0.86 for older only and 0.94 for young adults. CONCLUSIONS: this new qualitative observational terminology for evaluating compensatory balance reactions following lateral perturbations it has excellent inter-observer reliability for young and older adults in medium and high perturbation magnitudes, and moderate for low magnitude perturbations. Observation of step threshold is a reliable outcome measure that may be a useful tool to assess dynamic balance function for diagnostic purposes as well as clinical intervention trials.

1-C-10 Auditory inputs contribute to balance control in healthy young and older adults: a simulated hearing loss experiment

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BACKGROUND AND AIM: Traditionally, 3 sensory inputs (visual, vestibular, and somatosensory) are associated with the control of balance and have been investigated for their potential contribution to increased risk of falls. Recent evidence suggests auditory inputs may also contribute to balance control. Epidemiological studies have shown hearing loss is associated with balance deficits and increased risk of falls in older adults. Although current evidence reveals an association between hearing loss and balance difficulty, the mechanisms behind how and why hearing loss affects balance are unknown. It is possible that hearing loss taxes cognitive resources in complex environments. We investigated the contribution of auditory inputs to balance control in healthy young and older adults by simulating hearing loss.

METHODS: Twenty healthy young and older adults, cleared of any sensory and neurological deficits participated in the study. Participants completed 1 min standing balance, walking, and responding to 10 surface translation perturbations at $2 m/s^2$ in AP direction while completing a standardized audiology test (BKB-SIN). The audiology test required the subject to repeat back sentences played through the headphones under normal hearing (control) and simulated hearing loss conditions, randomly assigned. Simulated hearing loss was achieved using a pair of Bose QuietComfort 35 wireless noise-cancelling headphones. Adobe Audition software using a FFT logarithmic curve was used to manipulate sound volume and frequencies of standardized sentences in order to simulate moderate hearing loss to levels documented in literature. Outcomes included: Center of Pressure COP sway variability, number of compensatory steps, COP-COM during first compensatory step after perturbation, performance of auditory task, and self-selected gait speed. Functional Gait Assessment, 6-Minute Walk and Short Physical Performance Battery were also administered. ANOVA was conducted for each of the dependent variables with respect to group and condition of auditory task. RESULTS: Compared to normal hearing, simulated hearing loss resulted in significantly increased COP sway variability significantly and more compensatory steps in response to perturbations in older adults. Preliminary results showed that in response to surface perturbations, the COP-COM distance was an average of 25cm and 15cm in young and older adults, respectively, reflecting the shorter, multiple steps taken by older adults. CONCLUSIONS: Simulated hearing loss negatively impacts postural control particularly in dual-task conditions when individuals simultaneously attend to auditory and postural tasks. The effect is stronger in older adults who have fewer resources to compensate for poor sensory input. Individuals with hearing loss may be at greater risk of falling than individuals without hearing loss. One possible explanation is that reduced or conflicting auditory information increases the cognitive load and taxes attentional resources particularly in older adults. ACKNOWLEDGMENTS AND FUNDING: Supported by Texas Medical Research Consortium (RI 6042 "Good hearing, Steady feet") and Neurobiology of Aging NIH training grant (T32 AG 020494)

1-C-11 Middle-aged adults have reduced ankle braking and push-off power in order to achieve the same gait speed as young adults

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BACKGROUND AND AIM Gait speed reflects underlying physiological processes and can predict longevity in older adults. Middle-aged (MA) and young adults (YA) have similar speed during unobstructed walking, while older adults (OA) walk slower. The decreased speed in OA is a result of a decrease in ankle energy generation at push-off (termed 'A2'; Winter, 1991). Given that physiological systems begin to decline in middle age, gait mechanics may demonstrate age-related declines before changes in gait speed are observed. The purpose of this study is to examine the underlying gait mechanics that regulate gait speed across the lifespan. METHODS Three age groups included: 20-35 years (YA, N=17), 50-64 years (MA, N=12), 65-79 years (OA, N=9) (mean ages 23.8, 55.5, and 69.5, respectively). Participants walked on a 15 m walkway 10 times at a self-selected pace. Gait speed and joint energy were calculated. RESULTS Gait speed was 1.4, 1.4, and 1.3 m/s for YA, MA, and OA, respectively ($F(2,35)=3.6$, $p=0.03$); OA walked significantly slower, but YA and MA speeds were not different. YA and OA had similar ankle energy absorption during early to middle stance (A1), while MA had less energy absorption ($p<0.01$, Fig 1A). The ankle push-off energy during late stance (A2) was largest in YA, while MA and OA were not different from each other ($p<0.01$, Fig. 1B). In other words, MA had less energy absorption in early stance, and less energy generation in late stance, resulting in the same gait speed as YA. No differences in hip pull-off (H3) or other joint powers were observed ($p\geq0.05$). The ankle push-off power burst (A2) is associated with gait speed, due to the piston-like propulsion that propels the body forward. Consistent with previous research, OA had a lower A2, likely for stability reasons, leading to reduced gait speed (Winter, 1991). With a similar gait speed in YA and MA, a similar A2 power burst was expected. However, MA had a smaller A2 than YA (Fig 1B) which was not different from OA, likely due to the destabilization resulting from a large A2. Since gait speed will be slower when A2 is lower, another power burst must be compensating, as observed in decreased ankle energy absorption during early to middle stance for MA (Fig 1A). A1 decelerates the body as the shank rotates over the stance limb. Thus, MA appear to accomplish the similar speed to YA, despite the lower push-off force (A2), by "braking" less (A1). As progressing age compromises balance, the OA demonstrated greater A1, likely to maintain control of the forward accelerating body. CONCLUSIONS When walking at a self-selected speed, middle-aged adults brake less and accelerate less compared to young adults. This strategy allows the same gait speed while reducing possible instability assoc

1-C-12 Relationship between structural neuroimaging measures and performance on functional mobility measures in community-dwelling older adults

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BACKGROUND and AIM: In addition to strength, range of motion (ROM), orthopedic and neurological co-morbidities, subtle changes in brain gray matter volumes and integrity of white matter tracts have been linked to declines in functional mobility in older adults. The purpose of this study was to explore the relationship between structural neuroimaging measures and impairments in functional mobility in community-dwelling older adults. The hypothesis was that decreased performance on functional mobility measures will be associated with decreased gray matter volumes and decreased integrity of frontal-subcortical white matter tracts. METHODS: Seventy (29 male, 41 female) community-dwelling older adults participated in the study (mean age 76, SD 5, range 70- 94 y). Subjects were screened to exclude a history of neurological, cardiopulmonary, or orthopedic disease that would limit their mobility. Structural MRI sequences including T1-weighted and T2-FLAIR weighted were completed and computer-automated algorithms were applied to compute the volume of regional gray matter, Brodmann areas (BA), and white matter hyperintensities (WMH). Mobility measures included gait speed, the Four Square Step Test (4SST), Five Times Sit to Stand (5xSTS), and gait speed with counting backwards by 3s. Pearson correlations were utilized to identify correlations between neuroimaging measures and functional mobility performance. Next, multivariate linear regression models were explored to determine the best set of neuroimaging variables to explain the performance on functional mobility measures. RESULTS: Each of the mobility measures were significantly correlated with multiple neuroimaging measures. The multivariate linear regression models resulted in neuroimaging measures accounting for a range of 4.9%-30% of the variance in the mobility measures. In the final models, greater volume of the parahippocampal gyrus (adjusted $r2=0.22$) and BA3 (adjusted r2 change=0.08) were related to faster time to complete the 4SST. Greater volume of BA 5 (adjusted $r2=0.17$) was related to faster gait speed with counting backwards by 3s. Greater volume of the parahippocampal gyrus (adjusted $r2=0.16$) and BA 47 (adjusted r2 change=0.05) were related to faster gait speed. Greater volume of the caudate nucleus (adjusted $r2=0.06$) was associated with faster time to complete 5xSTS. Although in few cases WMH were significantly correlated with performances on mobility measures, they did not account for significant variance in the multivariate model. CONCLUSION: Specific gray matter volumes were significantly correlated with scores on functional mobility measures and accounted for more variance than WMH. Areas accounting for significant variance in mobility measures were related to visuospatial skills, motor planning, and somatosensory processing. It is important to consider changes in these central nervous system areas that may affect changes in mobility in older adults. ACKNOWLEDGEMENTS

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1-C-13 Aging effect on step adjustments and stability control in visually perturbed gait initiation

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BACKGROUND AND AIM: The ability to make step adjustments in response to sudden perturbations is essential for fall avoidance during locomotion. It requires the ability to inhibit original motor planning, select and execute alternative motor commands in a timely manner. The present study investigated the aging effect on step adjustments and dynamic stability control during a visually perturbed gait initiation task. A novel approach was used such that anticipatory postural adjustment (APA) prior to subject's swing foot lifting were analyzed in real time and used to trigger the relocation of the stepping target (served as a perturbation). METHODS: Ten healthy older adults (68.0 ± 4.1 years, 6 female) and ten healthy young adults (21.5 ± 1.9 years, 4 female) participated in this study. Subjects were asked to stand upright on a force platform, initiate forward walking with their right foot, step on to a projected foot sized visual target located a step length ahead of them, and continue walking on the 5 m walkway. After the initial visual target display that triggered subjects' motor planning for gait initiation, the visual target was either unchanged, or randomly relocated laterally or medially by 10 cm. The relocation of the visual target disrupted the pre-planned step and triggered the online postural adjustments to alter foot landing position. Three trigger timing conditions (early, intermediate, late) for target relocation were performed based on real time force analysis of subjects' weight distribution during the gait initiation cycle (APA). Stepping accuracy, foot rotation at landing, and Margin of Dynamic Stability (MDS) at heel contact (first three steps) were analyzed and compared across test conditions and groups using a linear mixed model. RESULTS: Stepping accuracy decreased as a function of perturbation timing (Early - 95%, Late - 47%) as well as perturbation direction (Lateral - 87%, Medial - 64%), with older subjects exhibited significantly more undershoot in foot placement to late lateral perturbation (Young - 84%, Old - 53%). Perturbations that occurred late in the gait initiation cycle elicited reaching-like movement (i.e. foot rotation prior to landing in order to step on the target). MDS measures in the medial-lateral and anterior-posterior direction revealed both young and older adults exhibited reduced stability in the perturbed and immediate subsequent step. However, young adults returned to stable gait faster than older adults. CONCLUSION: The present study showed that step adjustments in perturbed gait initiation were affected by the perturbation timing and direction, with the medial stepping being more challenging to execute compared with lateral stepping. The lateral stepping task, however, yielded better separation between young and older adults. An age difference was also observed in the number of steps needed to restore stability post perturbation. These findings could be useful for future study of screening deficits in gait adaptability and preventing falls.

1-C-14 Mobility and cognition in nursing home residents.

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Background and aims: Long-term care models throughout the world are facing the rising challenge of the aging population. The aim of this study was to describe degree of impairments in mobility and in cognition in nursing home residents in Norway, and also to assess the relationship between mobility and cognition in this nursing home setting. Methods: We included 696 residents at admission to 47 nursing

homes in Norway. Inclusion criteria were expected stay for more than 4 weeks and age above 65 years. Younger persons with dementia were also included. Residents with life expectancy shorter than six weeks were excluded. Mobility was assessed using the Short Performance Physical Battery (SPPB) and the Nursing Home Life Space Diameter (NHLSD). The Clinical Dementia Rating Scale (CDR) was used to describe the degree of cognitive impairment and dementia. The relationship between degree of cognitive impairment and mobility was analysed using the Chi-square test for categorical data, and the Kruskal-Wallis test (KW-test) for non-parametric continuous data. Results: The mean age of residents was 84.4 years, and the majority were women (63.9 %). Cognitive impairment was very common and 86.4 % of the residents had some degree of dementia. Only 2.1 % (n=14) had no dementia (CDR score 0) and 11.5 % (n=76) had questionable dementia (CDR score 0.5). Close to half of the residents were not able to perform the balance test in SPPB (42.6%), and only 16.4 % of the residents were able to achieve the highest score. On the gait test in SPPB 23.6 % of the residents were not able to walk 4 meters, while 17.6 % had a walking speed of 0.83 m/s or higher. In the chair stand task, 62.5 % were not able to perform the task or spent more than 60 seconds doing it. The median score on NHLSD area was 22 (IQR 17) and the median score on NHLSD dependency was 36 (IQR 26). The majority of residents moved more than three times a day within their room and in their unit, and beyond their unit not more than at least once a week. There was no gradual, stepwise association between mobility and degree of dementia, but residents with severe dementia had significantly lower levels of mobility than residents with moderate dementia. Conclusion: Nursing home residents form a frail, but heterogeneous group both in terms of cognition and mobility. The previously reported relationship between mobility and cognition is not as clear as in home-dwelling persons, and interventions should be individually tailored for each resident to maximise his or her potential.

D Biomechanics

1-D-15 Effects of a Single Instruction Session on Balance Control During Motor Skill Learning of Krav Maga Punch Technique

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Background and Aim: Increasing impact force during a fist punch is a fundamental objective of the Krav Maga (KM) self-defense system. KM experts suggest that KM punch can be learned in a single session. Maintaining balance throughout the movement is a critical feature of successful performance, while it is taught that anterior displacement of centre of mass toward the target is important to increase punch impact force. We examined how a single instruction session affected centre of pressure (COP) displacement during the KM punch; we hypothesized that 1) instruction would result in increased posterior COP displacement and velocity during the movement, and increased posterior ground reaction shear force, which 2) would be associated with increased impact force. Methods: Healthy females (n=8, 23.8±2.6yo) with no martial arts/self-defense experience participated. Data collections are ongoing; 12 additional participants will be recruited. Two force plates (OR6-7, AMTI, MA) were used to measure ground reaction forces. A 6-DOF force cube (MC3A-1000, AMTI, MA) was used to measure punch impact force. Each participant performed five punch trials, recorded at two timepoints during a single visit: prior to formal KM instruction (Pre) and immediately after the instruction (Post). Between Pre and Post, a certified KM instructor provided a thirty-minute instruction session. Participants were instructed to punch as hard as possible during the Pre and Post testing. Peak posterior COP displacement and velocity, and peak posteriorly-directed GRF were used to quantify balance control during a punch. Peak impact force was used to assess punch performance. One-way repeated measures mixed effects ANOVA was used to assess pre/post differences in measures of interest. Results: Instruction resulted in larger COP excursion (F(1,7)=6.84, p=0.035 Figure 1A), larger COP velocity (F(1,7)=18.0, p=0.004 Figure 1B) and larger posterior GRF (F(1,7)=15.7, p=0.005 Figure 1C). Peak impact force was not different (F(1,7)=0.01, p=0.926; Pre: 517.132.5N and Post: 514.130.5N) between time points. Conclusions: Instructions include the notion of shifting body weight and pushing with the back foot during the punch, which would be observed as increased posterior displacement of the COP and increased shear force. Larger posterior COP displacement and velocity, and posterior GRF were observed after a single instruction session, supporting our first hypothesis and suggesting that basic KM skills can be learned in a single instructional session. Larger COP displacement and posteriorly directed GRF would be expected to be associated with greater centre of mass acceleration toward the target, putatively increasing punch impact force. However, no difference was observed in peak punch impact force, refuting our second hypothesis. Further research is required to explore factors associated with increased punch impact force.

1-D-16 Comparison of Stride Dynamics during Self-Paced, Fixed Speed, and Overground Walking
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Background: Treadmills are widely used to analyze gait dynamics. Because treadmills are set at a fixed speed, they constrain subjects to walk differently than while overground.1 In particular, multiple studies reported that during treadmill walking stride time dynamics become more random, i.e. consecutive strides become more independent. To help alleviate this constraint, an algorithm has been developed that allows the treadmill to change speed according to the subject's movement. Aim: To compare self-paced treadmill, fixed speed treadmill, and over-ground walking. Hypothesis: Stride time dynamics during self-paced treadmill walking will be less random compared to fixed speed treadmill and more similar to over-ground walking. Methods: Four healthy young adults (mean age 21.5) completed three 15- minute walking conditions in a randomized order: self-paced treadmill (SP), fixed speed treadmill (FS), and over-ground (OG). Prior to each 15-minute condition, all subjects completed a 5-minute walking adaptation period specific to the subsequent walking condition Preferred walking speed was calculated in the adaptation period prior to the FS condition. A 10- minute cognitive wash (Trail Making Test Part A&B and sitting for the remaining time) was performed between each condition. For both treadmill conditions, subjects walked on a split-belt instrumented Bertec treadmill with retroreflective markers and inertial measurement units on their lower limbs. During OG condition, reflective markers were removed and subjects walked on a 200m oval track. Stride-time dynamics were estimated using the detrended fluctuation analysis (DFA). The average and the coefficient of variation (CV) of stride-time intervals were also analyzed. No statistical tests were performed due to the low sample size; however, data collection is still in progress. Results: Mean stride time were 1.11 ± 0.12s, 1.14 ± 0.11s, and 1.12 ± 0.05s during the SP, FS and OG conditions, respectively. Coefficient of variation were 2.51 ± 1.58%, 2.52 ± 1.71%, and 1.81 ± 0.59% during the SP, FS and OG conditions, respectively. The DFA alpha values were 0.98 ± .04, 0.70 ± 0.01, and 0.83 ± 0.08 during the SP, FS and OG conditions, respectively. Conclusions: Mean stride times were very similar between the three conditions, suggesting similar neural timing mechanisms. SP was as stable as FS, as suggested by similar CV for both conditions. The stride-time dynamics were quite different between the three conditions, with expected low alpha values for the FS condition (i.e., closer to random), and highest values close to 1.0 for the SP condition. Subjects' outcomes on the fixed speed treadmill are in agreement with previous studies and indicate stride-dynamics of a constrained system. The heightened DFA values observed during SP condition could be due to an inherent characteristic of the self-paced algorithm that induces increased stride-time persistence. Further analysis will be conducted on stride length and stride speed to better understand the control strategies involved in these three conditions.

1-D-17 Biomechanics of the trailing limb during stair descent with the body facing diagonally forward

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BACKGROUND AND AIM: Eccentric muscle contraction of the ankle and knee extensors is mainly required during stair descent. Thus, stair descent is difficult for elderly people. Some elderly people descend stairs with the body facing diagonally forward (DF) in a step-by-step manner, suggesting that the DF stair descent has some advantages with respect to mechanical stress compared to forward stair descent. However, kinematic and kinetic characteristics of the ankle and knee joints during DF stair descent have not been sufficiently investigated. The purpose of this study was to examine the biomechanics during DF stair descent, by focusing on the trailing limb, which is important during stair descent in the step-by-step manner. METHODS: Ten healthy young subjects descended a staircase step-by-step with the body facing either forward (F condition) or diagonally forward right (DF condition). Under the DF condition, the leading limb (left leg) was located posterior to the trailing limb (right leg) in the sagittal plane. Under both conditions, the subjects descended at the same speed. This speed was such that the subjects felt comfortable descending under the F condition. Kinematic and Kinetic data were acquired by a three-dimensional motion analysis system and four force plates. Using the data acquired, the joint angle, moment, and total lower limb extensor moment (support moment) were calculated. These data were collected for the trailing limb during the single leg support phase. For statistical analysis, the normality of data was verified using the Shapiro-Wilk test, and either the paired t-test or the Wilcoxon signed-rank test was performed to compare the two conditions. The level of significance was set at $p < 0.05$. RESULTS: Under the DF condition, the maximum ankle dorsiflexion angle ($p < 0.05$) and the ankle plantarflexion moment impulse ($p < 0.01$) were less than that under the F condition. However, the knee extension moment impulse was higher than that under the F condition ($p < 0.01$). The ankle plantarflexion moment impulse was a significantly lower proportion of the support moment impulse than that under the F condition ($p < 0.01$). On the other hand, the knee extension moment impulse was a significantly higher proportion of the support moment impulse than that under the F condition ($p < 0.01$). CONCLUSIONS: These results suggest that under the DF condition, the mechanical stress in the ankle of the trailing limb was lower, but in the knee was higher. Previous studies have shown that the ankle dorsiflexion range of motion and the plantarflexion strength decrease with age. It can be considered that descending stairs with the body facing diagonally forward is an effective method for elderly people with ankle hypofunction.

1-D-18 Influence of foot position on body mechanics during a sit-to-stand task

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BACKGROUND AND AIM: It is documented that individuals affected by degenerative joint diseases develop biomechanical strategies [1] in order to cope with pain and improve their functional capacities. Although compensatory strategies are well documented for walking, those strategies have rarely been reported for more challenging tasks [2]. The aim of this study was to determine the influence of several feet positions on trunk kinematics and lower body kinetics during a sit-to-stand (STS) task. METHODS: The study was conducted on 15 healthy participants. Participants sat on a backless and armless chair with both knees set at 90°. Participants were asked to stand up at their self-selected speed. Seven feet positions were tested: neutral (N); right toe-out angle of 10° (U10), 20° (U20) and 30° (U30); bilateral toe-out angle of 10° (B10); 20° (B10) and 30° (B10). A three-dimensional motion analysis system (VICON Peak, Oxford, UK) was used to capture kinematics at trunk and lower limb levels. An instrumented chair was used to capture forces under each thigh. Two force plates were used to capture the ground reaction forces under each leg. Spatiotemporal parameters (STS time), kinematics (maximal trunk angles in frontal and sagittal planes) and kinetics (vertical ground reaction forces ratio, maximal knee and hip joint moments in frontal and sagittal planes) parameters were analyzed. For each parameter, a comparison between all conditions was performed using repeated measures ANOVA and post hoc tests. RESULTS: Results showed a significant increase in the execution time with a larger toe-out angle (U10: 2.27 sec vs. B30: 2.48 sec; p=0.036). A significant difference between conditions was also obtained for the ground reaction forces ratio (N: 1.05 vs. U20: 1.13; p=0.039). The maximal knee flexion moment was significantly decreased between U10 and U30 (0.89 Nm/kg vs. 0.80 Nm/kg; p=0.007) and significantly increased between U30 and B10 (0.80 Nm/kg vs. 0.89 Nm/kg; p=0.007). Though opposite behavior was observed at hip level (i.e., an increase of flexion moment), no significant differences were noted between conditions (p=0.255). Finally, no significant differences were observed for trunk angles. CONCLUSIONS: Results demonstrated clearly that feet positions have an impact on body mechanics. However, this study is only a first step to better understand the influence of body-mechanical strategies on lower body joint integrity. Further studies are needed to evaluate other functional tasks and strategies on healthy and pathological populations. Indeed, though some strategies may increase the capacity of individuals to realize functional tasks, their long-term effects on joint integrity are still unknown. ACKNOWLEDGEMENTS AND FUNDING : The Natural Sciences and Engineering Research Council of Canada funded this study. REFERENCES: [1] M. A. Hunt, et al., Arthritis Care Res (Hoboken), vol. 62, pp. 1426-32, Oct 2010. [2] M. Guo, et al., Gait Posture, vol. 26, pp. 436-41, Sep 2007.

1-D-19 How to measure foot-placement accuracy during target stepping tasks: centre of pressure or centre of foot?

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Background: Given the importance of the ability to adapt steps in response to the environment for safe independent mobility, target stepping tasks have increasingly been used as a way of measuring and training adaptability of walking. Performance of target stepping is usually captured as accuracy of foot placement; either as the distance of the centre of foot (CoF) or centre of Pressure (CoP) from the centre of target (CoT). CoF may be the most direct measure of stepping accuracy if the instructions are to place the CoF in CoT. CoP may reflect balance control during step alterations, but may or may not coincide with CoF measure of foot-placement accuracy. The aim of this study is to compare CoP and CoF error as measures of target-stepping performance. Methods: Young Healthy adults (YH) (n=9, 4 male, mean ±SD 26±4 years, 3.9±0.5m/s SSWS) and stroke survivors (SS) (n=13, 10 male, 5 right hemi paretic, 67±9 years, 87± 34 months since stroke, 1.7± 0.7m/s SSWS) stepped to targets projected on a force-instrumented treadmill (CMill) while walking at comfortable speed. Targets (8cm deep x40cm wide) were placed on preferred foot-location or to elicit lengthening or shortening of steps (±25% of baseline step lengths) and narrowing (20cm deep x15cm wide on the midline of the treadmill). Three targets of each step condition were presented in semi random order (totalling 60 steps). Target dimensions coincide with the variability in step parameters previously reported in stroke survivors [3] such that targets should only be missed if error in foot-placement exceeds usual variability. Error in foot-placement was measured as distance (AP direction for preferred/short/long/medial steps) from CoT to both CoP and CoF at midstance. Statistical differences where measured with a repeated measures ANOVA, within factors where the different adaptation steps (normal, short, long, and medial steps) and between factor where the different groups (YH, SSp, and SSnP). Results: SS have significantly less AP difference between CoP and CoF at midstance (p= .017) on the paretic side (mean ±SD -2.7± 0.7cm units) than the non-paretic side (-5.6± 0.7cm) and compared to YH (-.7.7± 0.8cm, p<.001). Additionally, for both groups, AP difference between CoP and CoF is greater (p= .008) when shortening steps (-5.9± 0.5cm) compared to preferred steps (-5.2±0.5cm). Conclusion: For pure accuracy, CoF is the appropriate measure to represent foot placement. Owing to differences between CoP and CoF error measures for lengthening vs shortening steps the two measures cannot be used interchangeably and further research is needed to clarify the meaning of CoP error.

1-D-20 Hop Distance Symmetry Does Not Reflect Normalization of Biomechanics in Pediatric Athletes Post-ACL Reconstruction

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BACKGROUND AND AIM: Single-leg hop distance symmetry is commonly used in return-to-sport (RTS) decision making following anterior cruciate ligament reconstruction (ACLR), but little is known about movement biomechanics during the hop landing. This study assessed symmetry and biomechanics of adolescent athletes with recent ACLR during a single-leg hop for distance. METHODS: 39 patients with recent unilateral ACLR (62% female; age 13-18 years; 5-12 months post-surgery) and 29 controls (58% female) performed a single-leg hop for maximal distance. Subjects were classified as asymmetric if hop distance on the operative limb or control limb with the shorter distance was <90% of the contralateral limb. Lower extremity 3D kinematics and kinetics between initial contact and maximum knee flexion were compared among operative, non-operative (contralateral), and control limbs using ANOVA with Bonferroni post hoc tests. RESULTS: Ten of 29 controls (34%) and 12/39 patients (31%) were classified as asymmetric. Asymmetric patients hopped a shorter distance on the operative side compared with both contralateral and control limbs (op: 1.3 leg lengths, non-op and control: 1.6 LL, p≤0.04). Symmetric patients tended to hop a shorter distance on both sides compared with controls (op and non-op: 1.4 LL, p=0.17) with lower peak ground reaction force (op and non-op: 2.8 body weights; control: 3.1 BW, p<0.10). For asymmetric patients, kinematic differences compared with controls included landing more plantarflexed (op: -17.9°, control: -2.2°, p=0.002) with greater pelvic drop (op: -12.9°, control: -9.7°, p=0.055) and less knee varus (op: 0.1°, control: 2.7°, p=0.045). Operative limbs had lower knee flexion moments (p=0.004) and greater power absorption at the ankle (p=0.045), with a trend of higher dorsiflexion moments (p=0.084). Symmetric patients had greater peak hip flexion on both sides compared with controls (op: 70.6°, non-op: 68.3°, control: 55.2°, p≤0.001) and less varus at initial contact on the operative side (op: 0.8°, control: 2.7°, p=0.033). This resulted in higher hip flexion moments (p≤0.002) and power absorption (p≤0.02) and lower knee valgus moments on both sides compared with controls, plus lower knee flexion moments on the operative side (p<0.001). CONCLUSIONS: A similar percentage of patients (31%) and controls (34%) were classified as asymmetric based on single-leg hop distance with a typical 90% threshold. Furthermore, although both symmetric and asymmetric patients demonstrated biomechanical differences compared with controls, they employed different movement strategies. Asymmetric patients offloaded the knee to the ankle, while symmetric patients offloaded the knee to the hip. Symmetric patients achieved symmetry by hopping a shorter distance on the non-operative side. Therefore, symmetric hop distance does not indicate normal biomechanics or RTS readiness.

E Brain imaging/activation during posture and gait

1-E-21 Anticipatory motor control develops through changes in connectivity between higher-order cognitive, somatosensory and cerebellar networks

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Background/aim: The ability of the central nervous system to anticipate or equivalently to generate predictions about the behavior of the motor system and its sensory consequences is a central pillar for achieving appropriately actions. Current opinion holds that these predictions (i) are generated in the posterior parietal cortex and in the cerebellum, and (ii) mature slowly during development. Although there is accumulating evidence that anticipatory control do not result from the functioning of these structures as independent modules but rather from their dynamic interactions with other brain areas operating in a large-scale network, much remains to capture the entire complexity of the network that subtends motor prediction and the way it develops. The present study addressed both objectives. Methods: 20 children (10.1 +/- 0.9 years) and 20 adults (28.2 +/- 4.9 years) participated into the study. Motor prediction was approached using the bimanual unloading task, in which the individual has to predict and anticipate the consequence of a load placed on its postural forearm. Predictive ability was captured through angular displacement of the forearm, the smaller the displacement the more accurate the prediction. Afterwards, we examined the extent to which individual variations in angular displacement relate to individual differences in within-/between-network functional connectivity evaluated at rest. Six resting state networks most likely involved in motor prediction were considered, including the fronto-parietal network (FPN), the cingulo-opercular network (CON), the salience network (SAN), the somatosensory-motor network (SMN), the subcortical network (SN), and the cerebellar network (CN). The association between the angular displacement of the forearm and within-/between-network connectivity was assessed using second-level GLMs (i.e., bivariate regression/correlation models) and network-based statistics. Results: Our results demonstrated that individual differences in forearm angular displacement, hence in anticipatory control, was predicted from the coupling strength between nodes of the FPN, the CON, and the SMN in both adults and infants. The relationship was weaker in children compared to adults. The more important the connectivity, the better the control in both groups. In addition, individual differences in predictive control performance was significantly related to individual differences in the strength of the interaction between the CN and the other networks in children only. Again, the more important the connectivity, the better the control. Conclusions: Interactions between the FPN-CON dual networks and the SMN are critical to the establishment of anticipatory motor control. Such interactions are already in place by late childhood, although not yet adult-like. Interactions between the cerebellum and higher-order cognitive networks are temporally required to set up anticipatory control, possibly until predictions have been consolidated enough in fronto-parietal loops. These results provide background information for understanding the deficit of internal modelling reported in children with learning disorders. Funding: ANR grant (ANR-13-APPR-0010)

1-E-22 EEG spectrum modulation during standing induced by optic flow and light finger touch

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Background and aim Human postural control involves a sensory integration of vestibular, somatosensory, and visual inputs to perceive a state of body in relation to external environments. To approach the multimodal neural processing in the postural control, we examined the modulation of cortical activities during standing induced by optic flow and light finger touch. Methods Fourteen subjects participated in this experiment. The subjects stood in front of a screen (height: 1.08 m and width: 1.58 m), and a virtual 3D corridor with checkerboard textures was displayed on the screen. Three conditions were conducted to examine the effects of visual and somatosensory inputs: 1) standing under optic flow without light finger touch, 2) standing under optic flow with light finger touch, and 3) voluntary postural movement. In the optic flow conditions, the checkerboard texture sinusoidally moved anterior/posterior direction at 0.2 Hz. In the voluntary movement condition, the subjects were instructed to move their postures in anterior and posterior directions to track a target moving at 0.2 Hz. During the experiments, 128ch EEG and 32ch EMG of left ankle muscles were measured by a Biosemi active two system at 2048 Hz. In addition, the postural sway was measured by a force plate (AccuSway) at 200 Hz. Filtered EEG signals were decomposed by an independent component analysis, and the locations of equivalent current dipoles of the independent components were calculated. The differences of behavior (center of pressure and EMG) and power spectrum of the EEG independent components were compared among the conditions. Results The time profiles of the center of pressure and EMG indicate that the postural sway was induced by optic flow. The movement distance of the center of pressure and integrated EMG was significantly reduced in the light finger touch condition. The COP distance in voluntary condition was similar to that in the condition of optic flow without light finger touch. EEG spectrum analysis showed that α band power in visual area was suppressed according to the optic flow. In the light finger touch condition, the α-suppression was weakened, indicating that light finger touch may affect the optic flow process in visual cortex. In comparison between the optic flow condition and the voluntary movement condition, β band power in motor-related area was suppressed in voluntary movement. This results indicates that the postural responses induced by optic flow may skip the process of the motor preparation such as planning and initiation which relate to β band activity in motor related area. Conclusions EEG spectrum analysis showed that (1) light finger touch affected α band power of visual area, and (2) β band suppression for motor preparation was not found in postural sway induced by optic flow. These results might be related to a simplified neural processing for rapid postural response induced by optic flow.

1-E-23 The effects of motor-cognitive training on prefrontal activation in patients with Parkinson?s disease: an fNIRS study

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BACKGROUND AND AIM: Recent studies have shown that deficits in executive function contribute to falls in older adults and patients with Parkinson?s disease (PD). However, most of these studies provided only indirect evidence of this relationship. In a recent randomized control trial (RCT), we showed that a combined treadmill training with virtual reality (TT+VR) that targets motor and cognitive aspects of safe ambulation led to fewer falls, compared to treadmill training alone (TT). Here, we aimed to explore changes in prefrontal activation that may explain differences in fall rates after the intervention and provide insight into the motor-cognitive relationship. METHODS: Sixty-eight patients with PD were randomized into the TT arm (n=36, mean age 72.9±1.1yrs, 64% M) and TT+VR arm (n=32, mean age 69.7±1.3yrs, 71% M). Prefrontal activation during walking was assessed using a functional near-infrared spectroscopy (fNIRS) system consisting of two probes placed on the forehead of the subjects. Participants were instructed to walk under 3 walking conditions (1) comfortable walking, (2) dual task walking, and (3) obstacle negotiation, before and after 6 weeks of training. Gait parameters were collected using an electronic walkway. Linear-mixed model analysis was used to detect changes before and after training, between training arms, and within task conditions. Post-hoc analysis was conducted to better understand the association between changes in prefrontal activation and falls. Subjects were divided into ?responders? (less falls after training than pre-training) and ?non-responders? (the same or more falls after training than before training). RESULTS: Prefrontal HbO2 concentration during walking significantly decreased after training in both training arms, compared to pre-training (p=0.036). This decrease was larger (p=0.05) in the TT+VR arm than in the TT arm. No differences in baseline HbO2 concentrations were observed between the training arms (p=0.513). Training-related reduction in HbO2 concentrations was similar between tasks (p>0.262). Comparison between responders and non-responders revealed significantly lower prefrontal HbO2 concentration after training in the responders group than in the non-responders group (p=0.041). CONCLUSIONS: Our findings demonstrate lower prefrontal activation after intensive motor-cognitive training in patients with PD. The findings are consistent with the idea that training increases automaticity of gait and hence the need to rely on prefrontal, compensatory mechanisms are reduced after training. Moreover, these results suggest that a combined motor-cognitive training leads to a greater reduction in prefrontal activation after training, as compared with training that only focuses on motor function. These findings are in line with evidence from animal models that showed that task specific training affects frontal-striatal related circuits to a greater degree than non-task specific exercise.

1-E-24 Graph theoretical analysis of EEG functional connectivity during reactive and predictive balance control

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BACKGROUND AND AIM: Human bipedal balance control is proposed to involve the activity of distributed neural areas in the cerebral cortex and subcortical structures. The focus of recent work has been directed to advancing understanding of the role of the cerebral cortex in this highly automated behavior. While evidence exists for cortical activity temporally linked to balance control, little is known about the functional interaction of potential cortical regions. In the present study, we used event-related phase coherence (ERPC) and graph theoretical analysis to derive cortical functional networks from event-related potentials (ERPs) recorded during reactive balance control events (perturbation-evoked N1) and predictive/anticipatory postural adjustments (APA-related ERP). METHODS: Subjects (n=14) participated in the reactive balance control experiment where compensatory feet-in place reactions were evoked by temporally unpredictable postural perturbations triggered using a lean and release system. Another 14 subjects participated in the predictive balance control experiment where subjects performed a lateral stepping which was preceded by an APA phase. The perturbation-evoked N1 (identified as the largest negative component between 0 ms and 200 ms post perturbation) and APA-related ERPs (negativity between -800 ms prior to and 200 ms post APA onset) were obtained by averaging the EEG epochs time-locked to the perturbation and APA onset, respectively. Weighted graphs were generated from the functional connectivity matrices containing the ERPC values between all pairs of electrodes. Graph measures were extracted from each thresholded graph and compared between baseline and ERPs. RESULTS: The results revealed evidence of functional connectivity during both reactive and predictive balance control in the theta, alpha, and beta frequency bands. A comparable pattern of connectivity was recorded during baseline (standing) prior to the onset of movement or perturbation. However, there were differences in graph measures between baseline and reactive/predictive control events. Specifically, there was increased connectivity strength, increased transitivity, and decreased modularity during reactive and predictive control events as compared to baseline. CONCLUSIONS: It is proposed that a balance control network may be continuously active during standing (baseline period) and that changes in network connectivity, specifically frequency-specific reorganization, is associated with the change in cortical control of balance. Hence, it is proposed that similar cortical areas are involved in balance control regardless of whether it is of reactive or predictive mode. Collectively, this work supports the model of a complex network of cortical activity that is associated with both voluntarily initiated and externally triggered balance reactions. The work draws parallels to proposed functional networks associated with other fundamental behaviors such as face processing and visual discrimination task. ACKNOWLEDGEMENTS AND FUNDING This work was supported by the Natural Science and Engineering Research Council of Canada.

1-E-25 Cognitive activity measured by functional Near-Infrared Spectroscopy during walking tasks in young adults, older adults and clinical groups: a systematic review

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Background and Aim In addition to motor flexibility, cognitive processes are required during human walking in order to adapt to constantly changing environment and different task demands. The increased availability and use of functional Near-Infrared Spectroscopy (fNIRS) to record brain activation during functional tasks has led to a recent significant rise in the number of studies investigating neural bases of cognitive contributions in gait. However, the evidence remains unclear. Thus, the aim of this systematic review was to summarize knowledge regarding brain activation patterns during simple and complex walking tasks in young adults, older adults and clinical groups, to gain an insight into neural correlates of cognitive processes required for safe ambulation. Methods A protocol was registered with the international Prospective Register of Systematic Reviews. We searched for studies published on the following databases: PubMed, EMBASE, Scopus and PsycINFO. For this purpose, we used the strategy search: (((((near infrared spectroscopy) OR functional near infrared spectroscopy) OR nirs) OR fnirs) AND (((gait) OR walking) OR locomotion) AND (((((young) OR adult) OR older) OR elderly) NOT children)) AND (((Brain) OR cortex) OR cortical). Results Thirty one out of 199 studies retrieved through our search met the inclusion criteria. Of the included studies: 9 involved young adults (simple gait (2), complex gait, e.g. obstacle avoidance (2), dual-task gait, e.g. cognitive and/or motor secondary tasks during gait (5)); 12 involved older people (simple gait (4), dual-task gait (8)); and 10 studies involved various clinical groups (simple gait (2), complex gait (1), dual-task gait (7)). Eight of 9 studies in young adults reported significant increases in activation of cortical cognitive areas, such as the prefrontal cortex, as the walking task increased in complexity (e.g. more difficult secondary cognitive task). A similar pattern of results was observed in clinical groups. While most studies in older people showed increased activation in the prefrontal cortex with gait tasks of increasing difficulty, several studies reported significantly less activation in the prefrontal cortex in older compared to young individuals. Conclusion This systematic review confirms that in healthy young adults, cognitive cortical areas, particularly the prefrontal cortex, tend to be more activated as walking tasks' complexity increases. In clinical groups and older individuals, this increase in cortical cognitive areas activation has been postulated as a compensatory mechanism for their gait deficits. Significant heterogeneity was found among studies involving older adults, most often related to sample size and type of walking task. A major limitation also noted in several studies was the absence of control for head movement and skin blood flow artefacts. Future studies should address these limitations.

1-E-26 Activity in multiple frontal cortical areas during normal, fast and dual task walking: preliminary results of an fNIRS study

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BACKGROUND AND AIM: Most previous studies using functional near-infrared spectroscopy (fNIRS) during walking have assessed the prefrontal cortex only. However, recording of multiple cortical areas allows identification of potential compensatory or other cortical mechanisms related to increased cognitive, sensory and/or motor demands of walking. This study aimed to investigate the activity in multiple frontal cortical areas during normal, fast and dual task walking. METHODS: Ten healthy adults aged from 18 to 31 years performed three 5-minute blocks of alternating tasks (control and experimental) on a treadmill. For each block, tasks were performed for 30 seconds and repeated five times. Tasks included normal walking (at comfortable speed), fast walking (20% faster than normal walking) and dual task walking (walking while performing a memory task). An fNIRS system (OMM-3000, Shimadzu, Kyoto, Japan) with continuous wave laser diodes with wavelengths of 780, 805 and 830 nm recorded cortical activity with a sampling rate of 23.8 Hz. A 40-channel arrangement with 25 optodes (5 x 5), consisting of 13 transmitters and 12 detectors, covered an area 12×12 cm overlying the frontal lobe. Areas assessed included prefrontal cortex, premotor cortex, supplementary motor area and primary motor cortex. Data were pre-processed using Statistical Parametric Mapping (Wellcome Trust Centre for Neuroimaging). Analysis of oxygenated haemoglobin signal was performed using a customized code implemented in MatLab (The MathWorks, Inc). For each task, the period of interest was defined as the middle 20 s (initial and final 5 s were excluded), which were split into early (5-15 s) and late (15-25 s) phases. The averaged normalised difference between control and experimental task was used for statistical analysis (one sample T-tests with Bonferroni correction for multiple comparisons). RESULTS: Relative to standing still, normal walking increased cortical activation in all areas assessed during the early phase. During the subsequent late phase of normal walking, activation decreased and returned to the level of standing still in all areas assessed. No significant differences were observed between normal and fast walking. During dual task walking, the primary motor cortex was the only area that increased activation, which occurred during both early and late phases. CONCLUSIONS: These findings suggest that in healthy young adults increased activity of frontal cortical areas is necessary for walking initiation and adapting to the desired speed but not for steady state walking. No further activation of frontal cortical areas is required for fast walking. Increased activation of the primary motor cortex is required to deal with increased cognitive demand of dual task walking. This novel finding questions the simplistic view of the human primary motor cortex as a purely executive motor structure and suggests an association with cognitive and/or attentional processes during walking.

F Cognitive impairments

1-F-27 Is habitual walking activity different in dementia compared to age-matched older adults?

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BACKGROUND AND AIMS: Regular physical activity (e.g. walking activity) is associated with reduced risk of cognitive decline and development of dementia. Physical activity interventions also show evidence of improved cognition in older adults and may be beneficial for people with dementia. Research has shown individuals with dementia are less physically active compared to cognitively-healthy older adults; however, the majority of studies rely on subjective self-report measures which may not be accurate or reliable. The aim of this study is to quantify differences in free-living walking activity (volumes and patterns of walking) in dementia and compare this to older adults without dementia. METHODS: Nine older adults (age: 77.9±7.1; MMSE: 29.1±1.1) and 13 individuals with dementia (age: 77.5±5.4; MMSE: 23.6±2.0) were recruited. Data was recorded continuously over seven days with a tri-axial accelerometer (Axivity AX3) placed on the lower back. Macro outcomes representing the volume (walking time per day, number of bouts and steps per day, mean bout length), pattern (alpha) and variability of walking were quantified [1]. Mann-Whitney U tests were used to compare walking activity between dementia and older adults. RESULTS: Individuals with dementia spent less time walking ($p=0.018$) than older adults, and walked with shorter ($p=0.015$) and less variable ($p=0.039$) bouts. No significant difference were found for the number of bouts (p=.201) or distribution of bouts (alpha, p=0.155). CONCLUSION: Previous research indicates that individuals with dementia perform lower intensity activities compared to older adults; which may be reflected in our findings. Even in a small cohort, preliminary results show shorter bout lengths and lower variability may indicate individuals with dementia maintain a more stereotyped pattern of daily walking activity compared to older adults. Reduced volume and variability of walking activity are present in individuals with dementia and likely to negatively impact on the health, cognition and quality of life. This further highlights the need for early diagnosis and personalised interventions to prevent or slow dementia-related decline in physical activity. ACKNOWLEDGEMENTS AND FUNDING: Financial support for this study came from the National Institute for Health Research (NIHR) Newcastle Biomedical Research Unit and Alzheimer's Society. [1] Lord S et al, J Neurol., 2013; 260(12):2964-72

G Cognitive, attentional, and emotional influences

1-G-28 Dual-Task Balance Testing In Adolescents With And Without Sports-Related Concussion

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Purpose: Premature return to sports after concussion injury increases the risk of a second more severe concussion. Concurrent balance and cognitive testing has been suggested to provide better assessment of when to safely return to sport. The purpose of this study was to compare sway measured during a dual-task balance test paradigm in adolescents with and without a sports-related concussion (SRC). Methods: Twenty-five adolescents (mean age 15.1 ± 1.9 y) with a SRC within the past 10 days and 22 matched controls (mean age 15.9±2.1 y) participated. The center of pressure (COP) was measured using a force plate while subjects stood feet-apart on firm or foam surfaces. Single-task (20 s) and dual-task (35 s) balance performance was assessed sequentially within the same trial. The dual cognitive-task was a visual reaction time test where adolescents pressed a thumb-switch that either corresponded to the side of the monitor where a rectangle appeared (simple cognitive-task), or corresponded to the direction an arrow was pointing that appeared on either side of the monitor (complex cognitive-task). The dependent variables were the root mean square (RMS) and the normalized path length (NPL) of the COP in the anterior-posterior (AP) and medial-lateral (ML) directions. A linear mixed model was performed to investigate the main effects and interactions of group, single vs. dual-task performance, cognitive-task complexity, and surface on sway. A significance level of 0.05 was used. Results: The main findings were: no significant difference in sway between the SRC and control groups; a significant dual-task effect that produced reduced NPL sway and greater RMS sway compared with the single-task; significantly increased RMS sway during the complex cognitive task compared with the simple cognitive task; and an interaction between groups and surface, such that during the firm surface condition the group with SRC showed greater NPL and RMS sway than the control group, while during the foam surface condition the groups had comparable magnitude of sway measures. Conclusion: Our results showed that type of surface, dual tasking, and complexity of the cognitive task affected the amount of sway in adolescents with and without SRC. On the other hand, no differences in balance performance were observed between groups with and without SRC. The contradiction between our results and the previous research can be explained by that most adolescents with concussion in our study were assessed more than 5 days after their concussive injury whereas the previous research assessed their participants within 24 hours of the injury. Furthermore, our sample may have had milder concussion. In our study 28% of adolescents with SRC reported dizziness compared to 78% reported in previous reports. Therefore the amount of time between the concussion and assessment as well as the severity of symptoms may be critical factors for demonstrating balance deficits in adolescents with SRC.

1-G-29 Postural threat effects on conscious perception of whole body movement during continuous support surface rotations

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BACKGROUND AND AIM: Height induced postural threat leads to reduced amplitudes of sway during quiet stance [1,2] and leaning during maximum voluntary reaching [3]. In contrast, postural threat increases the magnitude of movement related conscious perceptions during quiet standing [4] and perceived body position during voluntary leaning [5]. However, it is unknown how these changes influence perceptions of whole body movement during dynamic phases of stance. Thus, the aim of this study was to examine how postural threat influences both whole body movements and conscious perceptions of these movements during continuous random support surface rotations. METHODS: Seven healthy young adults stood on a moveable platform with their feet 27cm apart, with their eyes closed, for 7 minutes in a low threat (1.2m above ground, away from edge) then high threat (3.2m above ground, near edge) condition. Continuous platform roll displacements evoked large amplitude sway in the medio-lateral (ML) plane with pseudorandom ± 4.5°, 0.05 to 0.15 Hz continuous oscillations. Participants were asked to remain upright and avoid a fall at all times while tracking their ML body movements using a hand held rotary encoder. Kinematic data were recorded at 250 Hz using 3 individual markers placed on the upper trunk. Questions assessed anxiety, fear and confidence, and electrodermal activity (EDA) measured arousal. Body movement and tracked movement root mean square (RMS) amplitude was calculated. Peak cross correlations were calculated to quantify lag of body movements to platform movements and tracked movements to body movements. RESULTS: Height induced threat increased fear, anxiety and EDA, and decreased confidence. Trunk RMS decreased, while tracked movement RMS increased for high compared to low threat. Peak cross correlations times showed no change in lag between threat conditions for body compared to platform movement, or tracked movement compared to body movement. CONCLUSIONS: The observed reduction in actual sway and increase in perceived movement is consistent with previous reports during quiet standing and voluntary leaning [4,5]. Threat related increases in sensitivity of sensory systems related to postural control [6,7] may lead to reduced amplitudes of movements. At the same time the mismatch between the increased amplitude of afferent information received by the central nervous system and efferent copy of motor commands may cause a greater perceived magnitude of movement during postural tasks. Discrepancies between perceived and actual postural performance may be important when examining increased fall risk in those with a fear of falling. REFERENCES: [1] Carpenter et al. (1999) J Vestib Res; [2] Davis et al. (2009) Gait Posture; [3] Hauck et al. (2008) Gait Posture; [4] Cleworth et al. (2016) Neurosci Lett; [5] Cleworth et al. (2016) SfN abstract; [6] Horslen et al. (2013) J Neurophys; [7] Horslen et al. (2014) J Physiol. ACKNOWLEDGEMENTS: Funded by NSERC (MGC).

1-G-30 Cognition and balance control: does processing of contextual cues of impending perturbations affect automatic postural responses?

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Background and aim: Predictive contextual cues are thought to induce adaptive postural responses. Perturbation cueing in previous research has been provided by means of repeated trials with the same perturbation in the context of certainty about perturbation onset time. This experimental strategy, however, confounds predictive cueing with adaptation, and also with non-specific properties of temporal cueing. In the present study, we aimed at evaluating separately the effects of cueing

amplitude or timing of a perturbation, and adaptation to repeated exposures to the same perturbation. Methods: Participants were healthy young individuals (n=25). They were tested on a task consisting of recovering stable stance following unanticipated backward translation of the supporting platform. The platform was moved through a custom-made device in one of three amplitudes: 5, 10 and 15 cm, keeping peak velocity (20 cm/s) and peak acceleration (100 cm/s2) constant across amplitudes. Platform translation was controlled by means of software elaborated in LabVIEW (National Instruments). In Experiment 1, we tested the effect of cueing the characteristics of an impending postural perturbation by means of visual signals, and the effect of adaptation to repeated exposures by comparing blocked versus randomly varied perturbation magnitudes. In Experiment 2, we evaluated separately the effects of cueing the characteristics of an impending balance perturbation and cueing the timing of perturbation onset. Results: Experiment 1 showed that the blocked in comparison with the random sequence of perturbations led to increased stability of automatic postural responses, and modulation of magnitude and onset latency of muscular responses. Results from Experiment 2 showed that only the conditions cueing timing of platform translation onset led to increased balance stability and modulation of onset latency of muscular responses. Conversely, cueing platform displacement amplitude failed to produce any effects on automatic postural responses in both experiments. Conclusions: Findings from both Experiments 1 and 2 converged to show that cueing the amplitude of an impending balance perturbation failed to induce adaptive postural responses. Results from Experiment 1 indicated that the effect of using blocked trials to make perturbation characteristics predictable is due to adaptation to repeated exposure to the same perturbation over trials. In Experiment 2, our results showed that cueing timing of perturbation onset is sufficient to induce adaptive responses, which are not changed by adding perturbation amplitude cueing. These findings support the interpretation of adapted postural responses via optimized sensorimotor processes, at the same time that cast doubt on the notion that processing of contextual cues advancing the characteristics of an impending perturbation can preset tailored postural responses through feedforward control.

1-G-31 Exploring thoughts and attentional focus of older adult fallers under anxiety

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Background and Aim Research indicates that postural threat may impair attentional processing by directing attentional focus internally, with individuals doing so in an attempt to consciously control or monitor movement (Huffman et al., 2009; Zaback et al., 2016). However, as this research was conducted in young adults, the results cannot necessarily be generalised to older adults at risk of falling. For example, research indicates older adult fallers have a greater trait propensity to allocate attention towards both controlling and monitoring their movement (Wong et al., 2008). Therefore, it is possible that these individuals will allocate even greater attention towards controlling or monitoring movement under conditions of anxiety than their non-faller counterparts. As anxiety is related to a 53% increase in older adult fall-risk (Hallford et al., 2016), there is a clear need to identify how anxiety modifies attentional allocation in older adults at risk of falling. This was the aim of the present research. We predicted that while older adults would direct greater attention towards movement processing under conditions of anxiety, this would be most pronounced in fallers. We also predict that older adult fallers would be more likely to allocate attention towards disturbing thoughts/worries related to their previous fall. Methods Older adults reported where they would focus their attention during two scenarios: 1) When they are relaxed and there is no risk of falling, and; 2) When their anxiety is high and there is a risk of falling. Attentional focus was examined using retrospective verbal reports. Participants were classified as "fallers" or "non-fallers" based on the number of falls they had experienced within the past 12 months. The number of falls was then used to explore the relationship between fall-history and attentional focus. Results Preliminary results (from 19 participants) show that when anxious, greater attention was directed towards movement processes and less attention directed towards task-irrelevant thoughts. However, fall-history also appeared to be related to attentional focus. When 'relaxed', number of falls was negatively correlated with the frequency of task-irrelevant thoughts. Fall-history was also positively correlated with the frequency of anxiety-related disturbing thoughts/worries. Examples of anxiety-induced disturbing thoughts/worries included one participant describing the previous fall they had experienced: "I fell outside the main door and spent 3 weeks in hospital and I think about that every time I go out the door." Conclusions The results support previous literature demonstrating that under conditions of postural threat, like young adults, older adults are also less likely to direct attention towards task-irrelevant thoughts, and more likely to focus on movement processes (Zaback et al., 2016). However, the significant correlations observed between fall-history and aspects of attentional focus indicate that thoughts relating to fear of falling are dependent on previous personal experiences. While these attentional processes can be contextualised in frameworks previously described they lead to the conclusion that we cannot generalize work carried out in young adults to make inferences about fall-risk.

1-G-32 Gait and cognition in free-living; the effect of ambulatory bout length

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Background and Aim: Gait impairment is associated with cognitive deficits in Parkinson's disease (PD) [1]. Previous work has identified robust associations between gait and cognition in the laboratory in PD [2]. However, laboratory assessment provides a challenge for widespread clinical use due to the high cost and complex and cumbersome equipment. In addition, laboratory assessment provides a snapshot of participant ability, a limitation in PD due to symptom fluctuations relating to medication. The use of body worn monitors (BWM) allows for comprehensive gait measurement in free-living conditions [3] with the ability to measure gait during different ambulatory bout (AB) lengths e.g. short and long walking periods. Gait and cognition associations are likely to reflect environmental context, therefore gait and cognition associations during different AB lengths need to be understood. The aim of this exploratory analysis was to understand the effect of AB length on the gait-cognition relationship during free-living. Methods: 55 patients with idiopathic PD from the ICICLE-Gait study were assessed three years post diagnosis. Participants completed a comprehensive neuropsychological battery of assessments for domains of global cognition, attention, working memory, fluctuating attention, executive function, visual memory and visual spatial function. Participants wore a BWM (Axivity AX3, UK) on the lower back continuously for seven days. 14 gait characteristics representing domains of pace, variability, rhythm and asymmetry [4] were extracted for short ABs (10-20 seconds) and long ABs (≥120 seconds) in MATLAB® [5]. Partial correlations and multiple regression models were used to identify significant gait and cognition associations for both AB. A stringent p value of ≤.01 determined significance. Results: For longer ABs of steady state walking; increased asymmetry was associated with poorer visual memory (step time asymmetry [$p <.01$]) and worse fluctuating attention (stance time asymmetry [$p <.01$]). For shorter AB: increased rhythm was associated with poorer visual memory (stance time [$p <.01$]); increased asymmetry was associated with poorer attention (step time asymmetry [$p <.01$]) and fluctuating attention (swing time asymmetry [$p <.01$]); and increased variability was associated with worse visual memory (step time SD [$p <.01$]) and poorer fluctuating attention (stance time SD [$p <.01$]). Conclusions: The association between gait and cognition differs according to AB length with shorter ABs demonstrating more evident associations with cognition, most likely reflecting environmental complexity. This work demonstrates the importance of exploring different AB to understand the cognitive functions associated with walking in free-living. [1] Morris R, Neurosci

Biobehav Rev, 2016;64:326-45. [2] Lord S, Front Age Neuro, 2014;6:249. [3] Del Din S, IEEE J Biomed Health Inform, 2016;20:838-47. [4] Morris R, G & P, 2017;52:68-71. [5] Del Din S, J Neuroeng Rehabil, 2016;13:46. Financial support for this study came from the National Institute for Health Research (NIHR) Newcastle Biomedical Research Unit, Parkinson's UK and the NIHR Newcastle CRF Infrastructure funding.

1-G-33 Avoidance strategies in response to phone messaging in healthy individuals walking in a virtual environment

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Background and aim: Obstacle avoidance is an essential ability for activities of daily living. While numbers of accident and death due to the use of mobile communications while walking are on the rise, the impact of phone texting on the ability to safely avoid moving obstacles while walking is poorly understood. This study aims to describe the extent to which reading messages at different stages of the avoidance strategy affects obstacle avoidance behavior in response to pedestrians approaching from different directions. Methods: Healthy adults (n = 4, 50% male, aged 38 5 years (mean ±1SD)) were tested while walking overground and viewing a virtual environment (VE) displayed in a helmet mounted display. The VE simulated a subway station that included a target 11m straight ahead. Three non-reactive female avatars were positioned 7m ahead the participant (±40° right/left and straight ahead (0°)). As participants walked 0.5m, one avatar randomly approached them towards a theoretical point of collision located 3.5m along the midline, while the other avatars walked away. Messages, when present, were randomly delivered as the participants reached 0.5m and 2.5m of forward displacement, for a duration of 2s. The text content was reported at the end of each trial. The ability of the subjects to steer toward the target while avoiding the obstacles was characterized using the 3D position and orientation of the head recorded using a 12 camera Vicon motion capture system. Results: Preliminary results show a trend towards increased obstacle clearance in response to reading phone messages delivered at 0.5m (left: 0.91±0.04; center: 0.90 ± 0.10; right: 0.72±0.10) and at 2.5m (left: 1.0 ± 0.17; center: 0.9 ± 0.96; right: 0.96 ± 0.28) compared to when no messages were displayed (left: 0.83 ± 0.15; center: 0.80 ± 0.08; right: 0.89 ± 0.01). A tendency for earlier onset times of obstacle avoidance was also observed following the introduction of messages at 0.5m (left: 1.74±0.3; center: 1.74 ± 0.5; right: 2.19±0.3) and at 2.5m (left: 1.89±0.2; center: 1.97 ± 0.4; right: 1.92±0.2) compared to when no message was displayed (left: 1.94±0.4; center: 2.0 ± 0.3; right: 2.0±0.4). No consistent adaptions in peak walking velocity were observed in response to reading messages. Conclusions: The implementation of wider clearances and earlier onsets in the presence of text messages indicates that safety may be achieved through more conservative strategies in response to distractions introduced at critical stages of the avoidance strategy, either closer to an anticipated theoretical point of collision or at onset of obstacle displacement. Acknowledgments and funding: Financially supported by CIHR (MOP-77548) and CNPq.

H Coordination of posture and gait

1-H-34 Reduced vestibular function is associated with longer, slower, more variable steps, and slowing of gait speed in healthy older adults

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BACKGROUND AND AIM: Peripheral vestibular signals contribute to control of both balance and forward progression during walking. Gait speed decreases and becomes more variable with age, and when vestibular sensory function is degraded as occurs with age. Gait speed is comprised of both spatial (e.g. step length) and temporal (e.g. stride time, cadence) parameters. It is unclear whether vestibular loss influences gait speed via the spatial and/or temporal aspects of gait. Here we investigated the relationship between vestibular function (including semicircular canal and otolith function) and spatial and temporal gait parameters in a cohort of healthy older adults. METHODS: 71 community dwelling healthy adults (mean age 74.3 (14.2) years, range 24-93 years) participating in the Baltimore Longitudinal Study of Aging were tested. Vestibular semicircular canal (SCC) function was evaluated using quantitative vestibulo-ocular reflex (VOR) gain measurement. Vestibular otolith function was measured with vestibular evoked myogenic potentials. Full body 3-D motion capture (Plug-in-gait, Vicon) was used to quantify gait kinematics during over-ground walking at normal speed. Multiple linear regressions were used to examine the association between spatial and temporal gait parameters and semicircular canal and otolith function separately while controlling for age, gender, gait speed, and height. RESULTS: In multivariate models adjusting for age, gender, height, and gait speed vestibular SCC function was significantly associated with spatial and temporal gait parameters such that every 0.1 increase in SCC function (VOR gain) resulted in faster stride time ($\beta = -236.6$, $p < 0.001$) shorter step length ($\beta = -11.6$, $p = 0.002$), less time in single support ($\beta = -78.4$, $p = 0.002$), and a faster cadence ($\beta = 23.3$, $p = 0.001$). Reduced SCC function (VOR gain < 0.8 unilaterally or bilaterally) was associated with slower gait speed ($\beta = -0.22$, $p = 0.033$), increased step length variability ($\beta = 0.81$, $p < 0.038$), and increased step width variability ($\beta = 0.64$, $p < 0.031$). Otolith function was not significantly associated with any spatial or temporal gait parameters after controlling for age, gender, gait speed, and height. CONCLUSIONS: Reduced semicircular canal function was associated with slower gait speed above and beyond slowing related to aging. Reduced vestibular function was associated with longer, slower steps with more variable foot placement from stride to stride after controlling for gait speed. This suggests more careful control over foot placement, trading normal gait cycle timing for postural control as vestibular function declines. These results suggest that vestibular signals contribute to specific spatial and temporal aspects of the gait cycle. ACKNOWLEDGEMENTS AND FUNDING: Supported in part by NIDCD K23 DC013056 and NIDCD T32 DC000023

1-H-35 Waypoint Selection in Barrier Avoidance

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BACKGROUND AND AIM: How do people circumvent an extended barrier? Gérin-Lajoie & Warren (2008) modeled a barrier as an obstacle with a 'waypoint' at each end, based on Fajen and Warren's (2003) steering dynamics model. However, they did not explain why participants preferred to go around the near end of the barrier. We propose that the two waypoints act like competing goals. In a study of two competing goals, Cohen, Fink & Warren (2007) found that participants preferred the goal with a smaller deviation angle (ß) from the current heading direction, and/or a smaller distance (d). But ß and d were confounded in the barrier experiment, so either could explain the near-end preference. Here we dissociate ß and d to determine their influence on waypoint selection. METHODS: Participants (N=18, 25 ± 7.4 y.o.) were instructed to walk around a barrier to a goal in an immersive virtual environment, in a natural manner. The goal appeared ~11.5 m from the starting point and the barrier ~7.5m. The barrier (3m wide) had an orientation of 45º, 90º, or 135º, and a lateral offset of 0, ± 0.19, or ± 0.30 m, from the start-goal line. The observed initial deviation angle ß and initial distance d to each end of the barrier were recorded on each trial and converted to difference scores (Δß and Δd). The data was analyzed using a mixed-effects logistic regression model with the identity of the participant used for a random intercept, and by-participant random slopes for Δß and Δd. The difference in deviation angle Δß (M = 0.06 degrees, SD = 4.02) and the difference in distance Δd (M = -0.002 meters, SD = 1.71) were fixed-effect predictors. RESULTS: Overall, we observed a rightward bias (57% of trials), with an odds ratio of 1.88 for selecting the right end of the barrier ($p<.01$). When ß for the right end is 1° less than that for the left end, the odds ratio is 1.92 for selecting the right end of the barrier ($p<.001$), adjusting for Δd. When d to the right end is 1m less than that to the left end, the odds ratio is 2.86 for selecting the right end ($p<.001$), adjusting for Δß. Once scaled (standardized units), the odds ratio for Δß is 13.63 and for Δd is 10.31, indicating a similar influence on waypoint selection; the rightward bias remains largely unchanged (intercept, OR = 1.94). The addition of an interaction term (Δß x Δd) did not contribute significantly to the model. CONCLUSIONS: The results indicate that both distance and deviation angle influence waypoint selection in barrier avoidance. When one end of a barrier has both a smaller d and a smaller ß, the participant walks around that end; when ß and d are in conflict, their influence trades off. These findings are similar to those of Cohen, et al. (2008), consistent with the hypothesis that the two ends of a barrier behave like competing goals. We plan to incorporate a non-linear competition term into the barrier avoidance model, which increases the attraction of one waypoint while suppressing the other. ACKNOWLEDGEMENTS AND FUNDING: NSF BCS-1431406

1-H-36 Frontal asymmetry in leaning

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Motivational behavior, like approaching pleasant and avoiding unpleasant situations, are mirrored in postural kinematics and in brain activity. Previous research has shown that approach-like behavior is associated with relatively greater left frontal activity, while avoidance is associated with relatively greater right frontal activity. This frontal asymmetry is often seen as a marker for approach and avoidance motivation within the brain. Research on the coupling between emotion and bodily posture has shown that this frontal asymmetry is associated with both viewing pleasant and unpleasant images but is also present while sitting in a passive forward (approach) position. This suggests that both emotional content (images) and posture can influence our approach and avoidance motivational system. However, being passively tilted in a chair hardly qualifies as approach or avoidance behavior since no regulation of balance is required. Another line of research has consistently found that emotional cues have a clear impact on the regulation of static upright balance. We therefore conducted an experiment to research the effect of self-initiated forward and backward lean, while watching pleasant and unpleasant stimuli, on the frontal asymmetry of participants. In addition to calculation frontal asymmetry, the late positive potential (LPP) will also be investigated, to correlate the effect of the emotional content (generally believed to be reflected in the LPP) to the frontal asymmetry. Participants were asked to stand on a force platform, with 64-channel EEG, and 4 EMG electrodes attached to the head and neck to correct for movement artefacts. For each trial, the Center of Pressure (COP; shown as a black dot) of participants was projected onto a monitor in front of them. When they stood still, a red horizontal bar appeared on the screen, either above (instruction to lean forward) or below (instruction to lean backward) their equilibrium COP position. Participant's task was to displace their COP onto the projected line, by changing the position of the body Center of Mass, which thus involved a lean forward (COP below the toes) or backward (COP below the heel). The COP excursions involved 5 cm anterior, or 2 cm posterior, based on pilot work. Participants were instructed to lean forward using rotation around the ankle joint only, and not their knees or hips. When standing in the instructed position, participants were then shown a series of pleasant or unpleasant images, while EEG was continuously recorded. After seeing the images, participants were asked to rate these images on arousal and valence. The experiment is currently in progress, and we are in the process of analysing the EEG and COP time series. Results will reveal whether frontal asymmetry can also be found while leaning forward and backward, and whether these effects are mediated by the valence (pleasantness or unpleasantness) of visual cues. The result will increase our understanding of how the brain integrates motivational postures (lean) and affective stimuli.

1-H-37 Avoidance strategies in response to moving pedestrians in a physical vs. a virtual environment.

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Background: Virtual reality is increasingly being used in research and in the clinical setting to investigate, assess or train locomotion. One of the main assumptions supporting its use is that behaviours elicited in virtual environments (VEs) are similar to those observed in the physical environment (PE). To date, however, the evidence supporting the presence of similar locomotor behaviours in VE vs. PE is scarce with no studies that have specifically examined complex locomotor tasks such as avoiding moving pedestrians. Aim: To estimate the extent to which obstacle avoidance strategies in response to moving pedestrians differ between the VE and PE in healthy young adults. Methods: Participants (n=5) were assessed while walking and performing an obstacle avoidance task in the PE (physical laboratory) and in a VE (virtual laboratory representation), in a random order. Three female collaborators acted as interferers in the PE. Their gait pattern was recorded using a 12-camera Vicon to create virtual interferers. Both in the PE and VE, participants walked at comfortable speed towards a target located in the far space (8.5m) while avoiding a collision with one of the interferers, as applicable. The interferers were positioned in an arc fashion around a theoretical point of collision located 3.5m ahead of participants' starting position. As the participant walked 0.5m, one of the interferers randomly approached from left (-30°), center (0°) or right (+30°), while the others walked away. In a fourth condition, all interferers walked away. Results: When avoiding the virtual pedestrians in the VE, and compared to their performance in the PE, participants showed delayed onsets of mediolateral trajectory deviation (Range: Mean: ±SD; VE: 2.97±0.47s to 3.20±0.70s; PE: 1.2±1s to 1.8±0.83s), larger maximal deviations from the obstacle (VE: 0.69±0.23m to 0.9±0.2m; PE: 0.53±0.3m to 0.69±0.2m) and slower mean walking speeds (VE: 0.78±0.2m/s to 0.80±0.2m/s; PE: 1.16±0.25m/s to 1.23±0.19m/s). Additionally, on the PE, participants tested so far did not present a clear preferred side of circumvention. In the VE, however, a right-sided circumvention was adopted most of the time (% rightward deviation for left, center and right obstacle= 70%, 82% and 53% respectively). Conclusion: The delayed onsets of avoidance strategy in the VE suggest a divergence in visual perception in the VE vs. PE. The larger maximal ML deviation and slower walking speeds in the VE further suggest the use of more 'cautious' obstacle avoidance strategies. It is yet to be verified, in a larger sample of participants, whether the changes in the side of circumvention are attributed to differences in walking speed between the two environments, and whether alterations observed in the VE attenuate with repeated exposure.

1-H-38 Effect of a concomitant cognitive task on latency in different directions of step adjustment during walking

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BACKGROUND AND AIM. During locomotion in daily activities, we respond to environmental and task changes by adjusting the length and width of our steps. The choice of these adjustments considers several factors, such as the displacement of the foot, the stability, the maintenance of forward progression, and the information obtained from the various sensory systems. Unpredictable changes in the environment or in the task require corrections on the trajectory of the foot. In this context, it has been shown that the task of stepping on a moving target has low latency (100-120 ms) when a person is standing and needs to step on the target, which suggests the involvement of subcortical pathways. Thus, the inclusion of a concomitant cognitive task may not affect the latency of this adjustment. The aim of the present study was to investigate the effect of a concomitant cognitive task on latency in different directions of step adjustment while walking. METHODS. Fifteen young adults (23.7±3.8 yrs) performed 60 trials on a 7 m walkway, with a target (30 cm long x 15 cm wide) projected on the ground and located 3 steps from the starting point. Participants were instructed to step on the target, but the target could change its location at heel-contact of the contralateral foot on the forceplate in the step immediately before. The rectangle could be moved from the spot of normal foot landing (adjusted for each participant) to the anterior (long step), posterior (short step), lateral and medial locations. Participants performed ten trials with target change for each side, while control trials were performed twenty times. Trials were completely randomized. In half of the trials of each condition, participants performed a concomitant cognitive task (monitoring digit test). In this test, they counted how many times a target number was spoken in the audio recording that they listen to while walking. Twelve passive retroreflective markers were positioned bilaterally in the 1st metatarsus, 2nd metatarsus, 5th metatarsus, lateral malleolus and calcaneus (lateral and medial sides). These markers were tracked by 8 cameras (Vicon motion capture system). For latency calculation, only the 2nd metatarsus marker was used. Two-way ANOVA (4 sides x 2 cognitive tasks) with repeated measures in both factors was run to analyze the latency variance ($p<0.05$). RESULTS. We identified a main effect of side ($p<0.001$), with the long step (291.9±27.1 ms) presenting a higher latency than the posterior (178.5±19.6 ms; $p=0.031$), lateral (120.7±8.7 ms; $p<0.001$) and medial (139.8±10.5 ms; $p<0.001$) steps (Figure 1). There was no main effect of cognitive tasks or interactions between sides and cognitive tasks. CONCLUSIONS. The long step adjustment was the only condition that presented latency higher than the other directions. Yet, the addition of a concomitant cognitive task did not influence the latency for step adjustments in any direction. ACKNOWLEDGEMENTS AND FUNDING. FAPESP/Brazil (Grant # 2016/02202-8) and CAPES/Brazil.

1-H-39 Obstacle Avoidance Strategies of Soccer Players in Various Forms of Locomotion in Different Environmental Conditions

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INTRODUCTION: Gibson's Affordance theory states that the environmental possibilities for each individual depends on both particular features of that individual and the relation of those features to the characteristics of the environment. Previous research demonstrated that when passing through narrow apertures, magnitude of shoulder rotation increased once the aperture decreased to ≤1.3x one's shoulder width (critical point) (Warren & Whang, 1987). More recently, individuals chose to walk around apertures ≤ 1.4x their shoulder width in a non-constrained environment (Hackney et al., 2011). Aperture crossing behaviours can also be affected by training, such that football players demonstrate better intrinsic representation when running than control athletes (Higuchi et al., 2011). The purpose of the current study was to determine the effects of changes to locomotion and goal position on the behaviours of varsity soccer players during an obstacle avoidance/aperture crossing task. A closer goal position at the sport specific dribbling locomotion were predicted to have smaller critical point aperture sizes than the other conditions. METHODS: Five male varsity soccer players performed an obstacle avoidance task while walking, running, and dribbling towards a goal (7m or 10m from start) while avoiding two poles located 5m from the start perpendicular to their path. The gap size between the poles was based on each participants' shoulder width (0.8-1.6x SW, increasing by 0.2). Participants were outfitted with Optotrack IRED markers to record kinematics of the head, trunk, and feet at 120Hz.

Kinematic measures include medial-lateral COM position at time of crossing, AP and ML safety margin, speed of approach and crossing, and shoulder rotation onset and magnitude. Preliminary data includes observations of path selection to examine the critical point- the smallest aperture size participants chose to penetrate through rather than go around, in at least fifty percent of trials- of the three locomotive conditions. RESULTS: The preliminary results show that critical points differ between the three locomotive conditions, such that critical point increased from 1.0 to 1.2 to 1.4, for walking, running, and dribbling conditions respective, which was not affected by goal location. CONCLUSIONS: The preliminary data suggests that attractiveness of the goal is more affected by form of locomotion than goal location as the locomotion condition became closer to training-like behaviours, participants became more cautious. These findings are contradictory to previous findings and our expectations. It appears that for this population during this task, soccer players choose a more direct pathway with greater risk of obstacle collision to the goal in walking conditions in comparison to other forms of locomotion. Further analysis of kinematic data will determine the specific effects of locomotion style and goal distance on the behaviour of these and future participants.

1-H-40 A follow-up study on the Influence of obesity on the postural sway of patients with type 2 diabetes mellitus.

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Aim: In patients with type 2 diabetes mellitus, to assess the influence of obesity on postural sway on a follow-up of 38.9 ±6.3 months. Methods. 66 patients gave their informed consent to participate in the study. They were aged 55.9 ±9.1 years and they had no history of otology, neurology, orthopedic or balance disorders. According to their body mass index (BMI), they were classified in 2 groups: BMI<30 (n=39) and BMI≥30 (n=27). At baseline and at the end of follow-up, all participants replied to a self-administered questionnaire of symptoms related to balance, then peripheral neuropathy and neurotological evaluations were performed and body sway was recorded during quiet upright stance on hard/soft surface, with eyes open/closed. A preliminary repeatability assessment at 3 months showed repeatability of all measurements between 94% and 98.5%. Results were analyzed using "t" test and analysis of covariance. Results. At baseline, the general characteristics were similar in the 2 groups, but systemic high blood pressure and peripheral neuropathy were more frequent in the BMI≥30 group, in which unsteadiness in the dark and while looking at moving objects were also more frequent than in the BMI<30 group, as well as a smaller area of sway when standing on soft surface with the eyes open ($p<0.05$). At both baseline and at follow-up, covariance analysis showed a consistent influence of the BMI group on the length/average speed of sway when the eyes were closed, with a significant interaction with peripheral neuropathy and gender; while the total score of the questionnaire of symptoms was consistently related to the area of sway, for all the sensory conditions. At the end of the follow-up, the frequency of symptoms related to balance was similar in the two groups, and the percentage of patients with a total score of symptoms ≥4 was higher in the BMI<30 group than in the BMI≥30 group ($p=0.01$). Comparisons between recordings showed an increase of the length/average speed of sway just in the BMI<30 group, but not in the BMI ≥30group; recordings at follow-up in the BMI <30 group were very similar to those observed on the BMI ≥30 group at both baseline and follow-up. The combined influence of BMI group, neuropathy, gender, total score of the questionnaire and age at diagnosis of diabetes on sway differences from baseline gave a significant whole model R from 0.52 to 0.63 ($p<0.05$) for the area of all sensory conditions and the length/average speed of sway of the conditions on hard surface, eyes open & closed. Conclusions. Patients with diabetes mellitus and BMI≥30 may develop diabetes complications including balance decline earlier than patients with BMI<30. The interactions among BMI group, peripheral neuropathy and gender may be related to the length/average speed of sway mainly when vision is not available, while the report of unsteadiness may be related to the area of sway, with/without vision.

1-H-41 The Effect of Walking on Inclined Surfaces (Uphill and Downhill) on Gait Parameters using Self-Paced Treadmill in Virtual Environments

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BACKGROUND AND AIM: It was shown that gait parameters change in relation to the surface's slope when walking uphill (UH) or downhill (DH) [1, 2]. Thus far, inclined gait analyses have been subject to technical limitations: using treadmills (TMs) with fixed speed or, alternatively, sampling only a few gait cycles on inclined surfaces set up in gait laboratories [3, 4]. Here we examine the feasibility of using a self-paced TM (SPTM) which facilitates more natural walking implemented in ecologically-enhanced virtual reality (VR) settings. This study aims to investigate effects of slope on gait parameters, with a focus on upper body kinematics. METHODS: Gait of 11 young healthy participants (age: 31.8± 4.3 y, 7 women) was sampled during two minutes of walking (after reaching steady state gait speed) using a SPTM-VR setup. Measurements were made at slopes of +10º, 0º and -10º. Force plates and a motion capture system (Vicon, Oxford, UK) were used to reconstructed spatiotemporal gait parameters. Twenty parameters were analysed. Previously described parameters were compared with the literature to validate this novel approach. Upper body kinematics and bilateral gait coordination parameters, i.e., gait asymmetry (GA) and phase coordination index (PCI; quantifies the anti-phase stepping generation [5]), were studied. RESULTS: In the UH condition gait speed decreased (from 1.47±0.13 m/s to1.19±0.12 m/s; p=0.003). Interestingly, in DH walking, gait speed increased in about half of the participants (n=5; 1.6±0.12 m/s; p=0.018), but decreased in the others (n=6; 1.29±0.12 m/s, p=0.018). Changes in step length and cadence accompanied the gait speed changes. Most of the lower and upper body parameters, as well as gait speed were found to be affected by the walking slope angle (see Table 1for representative examples). For example, elbow flexion range was significantly decreased in the UH condition. GA and PCI were not affected by walking slope angle. In the DH condition, the effect was also influenced by the increase or decrease in the gait speed (data not shown). CONCLUSIONS: This work validates the study of UH and DH walking using SPTM within VR environments, as earlier described effects were reproduced here. Further, we found that upper limb kinematics is affected while walking on inclined surfaces. GA and left- right coordination are, however, robust characteristics of walking and are not affected by slopes. The results from the DH, suggest that gait speed is a covariate that interacts with the slope effect. Future work needs to address whether the differential speed effect during DH also impact differentially gait kinematics. References: [1] Leroux et al, Gait & posture 2002; 15: 64-74. [2] Whittle, Human Movement Science 1996; 15: 369-387. [3] McIntosh et al, Journal of biomechanics 2006; 39: 2491-2502 [4] Werner et al, Neurorehabilitation and neural repair 2007; 21: 76-80. [5] Plotnik et al, Experimental brain research 2007; 181: 561-570.

1-H-42 Differential Lower Limb Control Supports Interlimb Coordination during Normal and Forced Asymmetrical Walking

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Background and Aims: Goal equivalent manifold (GEM) analysis examines motor fluctuations that do and do not affect task performance. During treadmill walking, humans exploit redundancy to regulate variability, adjusting stride speed (Sn) by covarying stride time (Tn) and length (Ln) (Dingwell et al., 2010). Lower limb behavior is assumed to be symmetrical even though asymmetries are observed in posture and gait (Haddad et al., 2006; Sadeghi et al., 1997). These asymmetries are believed to be functional and can change based on task demands. Forced asymmetric walking is a common paradigm for examining locomotor adaptations (Choi & Bastian, 2007). Initially, an asymmetrical 'limping' gait is observed. After a brief period, the phase of the lower limbs returns to 180°. During asymmetric walking, the lower limbs could be controlled similarly based on the speed of each belt, but may not be because 1:1 coordination is maintained between the limbs despite different oscillation frequencies. To investigate these possibilities, we examined the regulation of Sn based on limb dominance during normal and asymmetrical treadmill walking. Methods: Fifteen young adults (28.9 ± 5.6 years; 9 female) performed three walking trials: preferred walking speed (PWS), 50% of PWS (Half-PWS), and asymmetric walking (AW) where the dominant limb was driven at PWS and the non-dominant limb at Half-PWS on a splitbelt treadmill. Kinematic data were collected at 120 Hz and low-pass filtered at 7 Hz. Tn, Ln, and Sn were computed bilaterally. GEM analysis was conducted separately on each limb. The GEM is defined by all combinations of Tn and Ln satisfying $v = Ln/Tn$, where v is the belt speed. Variance along (VGEM) and orthogonal (VORT) to the GEM and a synergy index, ΔVz, were computed. ΔVz represents the Fisher-transformed difference between VGEM and VORT. $\Delta Vz > 0$ measures the extent to which Tn and Ln stabilize Sn. Two-way task (3) × limb (2) repeated-measures ANOVAs were conducted for all outcomes. Results: Significant task x limb interactions were observed for Vgem ($F_{5,89}=4.02$, $p=0.02$), Vort ($F_{5,89}=4.09$, $p=0.02$), and ΔVz($F_{5,89}=15.76$, $p<0.01$). Vgem increased for the dominant limb in the AW condition. Vort decreased for the dominant limb in the AW condition. ΔVz increased for the dominant limb in the AW condition. No changes were observed in the non-dominant limb. Conclusion: During normal treadmill walking, the lower limbs appear to be controlled symmetrically. During asymmetrical walking, Sn is stabilized more in the dominant limb. Consistent with the functional asymmetry hypothesis, we infer that Sn of the dominant is further stabilized while the non-dominant limb is used to correct deviations from the preferred 180° phasing. The magnitude of the observed asymmetry may scale with the difference in belt speeds. However, it remains unclear whether changes to the stability of Sn are driven by limb dominance or gait velocity. Further research is needed to clarify these issues.

1-H-43 Qualitative Assessment of Postural Dynamics: Evidence for a Chaotic Attractor

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BACKGROUND: Models of postural control implicitly assume mechanisms that would result in specific dynamic regimes. For instance, one could easily derive fixed-attractor dynamics from inverted pendulum and closed-loop control models. Nevertheless, hardly any study provided support for such a regime. The main result observed, so far, is that the postural sway lives in a dimension higher than one; which would imply at least a limit cycle attractor. Also, some also speculated on the possibility that the attractor could be chaotic: a pattern that is sensitive to initial conditions being divergent over time. Here, we qualitative assessed the dynamics of posture in quiet standing in order to assess the current models of postural control. METHODS: Twelve participants performed the quiet stance paradigm under eight conditions. These conditions were derived from three manipulations: visual availability (open/closed eyes), tactile information availability (finger touch/ no touch) and surface compliance (foam/ no foam). To assess the attractor dynamics, we used two measures: correlation dimension and the largest Lyapunov exponent. Additionally, we reconstructed the geometric shape of the attractor and observed the Poincaré section for a qualitative assessment. RESULTS: The correlation dimension ranged from 2.31 to 4.76 with the manipulation with the lowest value being foam/with-vision (2.82 ± 0.30) and the highest rigid surface/with-touch (3.26 ± 0.48). The largest Lyapunov exponent ranged from 0.23 to 1.15 with manipulation with the lowest value being foam/no-vision (0.73 ± 0.17) and the highest rigid surface/no-touch (0.87 ± 0.15). From the Poincaré sections and attractor reconstruction, we observed

that the system lived in a restricted space - providing evidence that the system is not a pure random system. CONCLUSION: The system lives in a space around three dimensions and show a divergent pattern that is not a result of purely random variation. This contrasts with current models of postural control that assume smaller dimensions. It is not clear, however, whether the system is chaotic provided that not all conditions show three or more dimensions (a requirement for a chaotic system).
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1-H-44 Classification of trunk muscle coordination impairment in individuals with thoracic spinal cord injury

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BACKGROUND AND AIM: A spinal cord injury (SCI) at the thoracic-level could result in paresis or paralysis of the trunk muscles which can impair sitting balance. Trunk is a complex neuromuscular system with numerous neuromuscular elements contributing to maintenance of upright sitting. Moreover, SCI can significantly affect muscle coordination. However, there is still no clear understanding of how trunk muscle coordination changes following thoracic SCI. Therefore, the aim of this study was to analyze trunk muscle coordination during multi-directional seated reaching in individuals with thoracic SCI and compare it to able-body individuals. METHODS: A total of 27 individuals were recruited and subdivided into: (a) high thoracic SCI (n=8; injury level T1-T7); (b) low thoracic SCI (n=11; injury level T8-T12); and (c) able-body (n=8) groups. Participants were seated on a chair without back support with their feet on the ground and asked to lean their trunk in eight specified directions. Trunk muscle activity was recorded bilaterally on the: lumbar erector spinae (L3), low thoracic erector spinae (T9), trapezius (Tr), and latissimus dorsi (LD). Muscle coordination was assessed using the non-negative matrix factorization (NMF) method to extract muscle modules and their directional activation patterns for each participant. Muscle modules are the synergistic trunk muscle activation patterns which characterize the neuromuscular complexity and were used to assess co-contraction levels. Directional activation patterns were used to assess directional specificity of muscle modules. Finally, correlations between neuromuscular and clinical measures were computed. RESULTS: Individuals with thoracic SCI used less muscle modules, more co-contractions, and less directional tuning, compared to able-bodied people. Moreover, it seems that individuals with high thoracic SCI solicited non-postural muscles (i.e., Tr and LD) more than able-bodied individuals. These results suggest impaired and simplified muscle coordination, which was predominantly observed among individuals with high thoracic SCI. Moreover, variability in muscle coordination within SCI individuals and weak correlations between neuromuscular and clinical measures were shown, suggesting that clinical measures alone may not fully characterize potential neuromuscular impairment. CONCLUSIONS: Overall, we demonstrated that impaired trunk muscle coordination is typically characterized with more co-contractions and lower directional tuning in individuals with thoracic SCI compared to able-bodied individuals during seated reaching. Muscle coordination deficits revealed impaired neuromuscular strategies which provide implications for assessment and training of sitting balance in individuals with thoracic SCI.

1-H-45 Effect of vision and dynamic stability margin on avoidance behaviours of older adults with double planar obstacles

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Background Preferential foot placement when avoiding a single planar obstacle found the emergence of three selection strategies: 1) placing foot in plane of progression; 2) choosing a longer step over shorter; and 3) selecting a medial over lateral step. All choices coincide with a minimal foot displacement from natural footfall to maintain forward progression. Successfully adapting locomotion relies on both the amount and timing of vision. The purpose of the current study was to determine if dynamic stability affected foot placement strategies of older adults (OA) during a ground level double planar obstacle avoidance task and whether strategies were affected by the amount of vision available prior to avoidance. OA have age-related vision and balance control deficits, so it was predicted they would favor stability over momentum. The second purpose was to examine what factors of the first avoidance influenced the behavior chosen during the second avoidance. It was hypothesized that lower stability during the first avoidance would predict a lateral step for the second obstacle; to regain stability while sacrificing forward momentum. Methods 10 OA (7F, x̄age=74.5) were outfitted with Optatrak (NDI) markers to track their head, torso, and ankles, sampled at 60Hz. OA walked along a 10m path towards a goal and 6m from the start two planar obstacles (0.72m x .15m) were projected onto the ground either when the participants were in steady state locomotion (DS) or at two steps prior to the location of the first/left obstacle (DD). The obstacles appeared where the natural footfalls of the participants would have been when no obstacles appeared. Kinematic data was used to determine foot location during avoidance trails as well as Dynamic Stability Margin (i.e. minimum separation between ML COM and BOS during single support) for 2 steps before the obstacles and the two avoidance steps. Results The dominant first footfall during double avoidance was a medial step during both DD (78%) and DS (78.6%). DSM for step prior to first avoidance was significantly lower compared to the other steps ($F=6.76, p<.01$). DSM of any step during the progression did not vary based on the amount of visual information provided ($F=.104, p=.76$). The dominant behavior for avoiding both obstacles during DD was a double crossover (62%), however during DS it was a steering method (58%). No relationship existed between DSM during first avoidance and location of second avoidance, DS (ñ=.037) or DD (ñ=-.0002). Conclusions For both visual conditions, the first avoidance kept momentum moving forward; this is consistent with previous literature. During DD, the OA maintained forward progression while sacrificing stability. During DS, the OA performed the opposite. The step before the avoidance had the smallest DSM (OA became unstable to keep forward momentum). The second obstacle avoidance was not impacted by the stability of the first avoidance, only by the amount of visual information available.

1-H-46 Navigation through apertures by individuals with stroke

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BACKGROUND AND AIM: Safely walking through a narrow aperture requires fine-tuning the walking direction toward the center of the aperture and adjusting the posture to avoid contact with the frame of the aperture. The risk of falling in individuals with stroke might increase during walking through a narrow space, because the body rotation for avoidance of the contact is required. The present study was designed to test the ability of stroke individuals to safely walk through apertures. Our particular interests were to understand the side of the body for penetrating into an aperture and whether the selection of the body side for penetration was related to safe walking through apertures without making contacts. METHODS: Twenty three individuals with stroke and moderate lower-limb impairments volunteered to participate (Ten stroke fallers and 13 stroke non-fallers). Twenty three healthy controls also participated. In the main task, they walked for 4 m and passed through an aperture of various widths (0.9, 1.0, 1.1, 1.2, and 1.3 times the participant?s shoulder width) without making any contact with the frame of an aperture. Participants performed this task for a total of 15 trials (three trials for each of the five aperture sizes). Whole-body kinematics were measured with a three-dimensional motion analysis system. Three dependent measures were used: the percentage of contacts with the frame of an aperture, the absolute body rotation angle at the time of passage, the absolute deviation of the upper-body midpoint from the center of the doorway, and the body side to penetrate an aperture and the side of the body where contact occurred. They also performed a perceptual judgment task to test how accurately they perceived their aperture passability. RESULTS: The results of the main task showed that stroke fallers, but not stroke non-fallers, showed frequent contacts with the frame of an aperture at the moment of aperture crossing. The failures to avoid contacts were likely to be due to insufficient body rotation, rather than the failure to finely tune the walking path toward the center of an aperture. Because the perception of aperture passability was not significantly different among three groups of participants, the insufficient body rotation observed in stroke fallers did not simply result from inaccurate perceptual judgement made from a remote place. The contacts with the frame of an aperture occurred more frequently on the paretic side only in stroke fallers; however, when they penetrated into an aperture from the paretic side, contacts on the paretic side did not occur frequently. CONCLUSIONS: Stroke fallers showed frequent contacts with the frame of an aperture because of insufficient body rotation. Contact with the frame of an aperture occurred more frequently on the paretic side in stroke fallers. However, when they penetrated an aperture from the paretic side, contact on the paretic side did not occur frequently. Two possibilities explain this result, i.e., the availability of vision and/or the availability of spatial attention to represent the paretic side of the body.

1-H-47 Improvement of pelvic stability by neurosensory insoles

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Background and aim In podiatric practice, pelvic instability and its consequences are one of the most common reasons for consultations. Low back pain (Nadler et al, 2000), knee injuries (Ireland et al, 2003) and ankle instability (Friel et al, 2006) have all been reported to be related to pelvic instability. The aim of this study is to confirm the presence of pelvic-foot neuromuscular synergy and to demonstrate that postural treatment with neurosensory insoles improves pelvic stability, increases the duration of unipodale stance and changes spinal kinematics. Method 26 participants with unilateral pelvic instability and an ankle strategy were evaluated after 8 weeks of treatment. 12 additional participants served as a control group. Results were recorded from three randomized tests: The single leg stance test evaluates stability. The test timed and stopped after 45 consecutive seconds. It was repeated up to three times in the event of a fail test. The clinical posturodynamic test evaluates the quality of postural response to a lateral spinal lateral flexion. Four spinal segments were controlled (cervical, thoracic, lumbar, and pelvis) for the right and left sides of the body. The test was repeated on foam to assess the role of the plantar exteroception. The unipodal test of pelvic stability is a monopodal stance used to test for functional disorder of the hip abductors. The location of the plantar inserts on the insoles was determined by the practicing podiatrist following clinical examination of the patient. The inserts did not exceed 3 millimeters in thickness. Results Degrees of pelvic instability varied following treatment with Khi^2 test results of $p < 0.001$. After treatment, there was a significant increase of the time of the monopodal task ($p=0.001$), on both limbs. Results of the clinical posturodynamic test also showed changes after use of neurosensory insoles ($p=0.008$). Conclusions The results indicate that neurosensory insoles contribute to increased unipodal stability, improve pelvic stability and a change in spinal kinematics in the frontal plane. This study suggests that neurosensory soles affect not only the foot-ankle complex but also, due to this pelvis-foot neuromuscular synergy, the stability of the pelvis and spinal kinematics. This is supportive of the presence of a neuromuscular synergy between the pelvis and foot. Further prospective studies should evaluate the impact of the single leg stance test and the unipodal test of pelvic stability in the development of limb injury and low back pain in athletes.

1-H-48 Wavelet decomposition of sway reveals automaticity components in cognitive task conditions

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BACKGROUND AND AIM: Recent investigations attribute improvements in postural control in cognitive task conditions to an automatic postural control brought on when the participant is distracted from active control of posture [1,2]. This has recently been supported by the finding that cognitive tasks lead to more irregular sway, indicative of a more efficient postural control [2]. However, this hypothesis needs to be reinforced by examining other dynamic measures of sway. Hence, the present study used the Wavelet transformation to analyse the frequency components of sway in different dual-task conditions. METHODS: Twenty-two young adults (20.8 ± 2.82 years; 9 males) were asked to stand quietly on a force platform while performing the following tasks: single-task standing, internal focus (focus on movement production), external focus (focus on movement effects on an apparatus) and a cognitive task (counting the occurrence of two single digits in an auditory three-digit number sequence). One-dimension discrete Wavelet transformation and multisignal analysis was used to separate the anterior-posterior center of pressure signal in four frequency bands: 1) moderate (1.56-6.25 Hz), 2) low (0.39-1.56 Hz), 3) very-low (0.10-0.39 Hz), and 4) ultralow (<0.10 Hz) [3]. It is believed that these frequency bands capture postural movements associated with muscular proprioception (moderate), cerebellar (low), vestibular (very-low), and visual systems (ultralow) [3]. RESULTS: Results reveal no condition effect in the moderate band ($p > 0.05$). However, a greater percentage of the signal was present in the low band in the cognitive task condition (15.8%) as opposed to the single-task standing (12.5%), internal focus (12.7%) and external focus (12.8%; ps < 0.01). Moreover, a greater percentage of the signal was present in the very-low band in the cognitive task condition (27.4%) as opposed to the internal focus condition (21.1%; $p < 0.01$). Finally, a lower percentage of the signal was present in the ultralow band for the cognitive task condition (55.1%) as opposed to the single-task standing (61.1%), internal focus (64.5%) and external focus (62.2%; ps < 0.01). CONCLUSIONS: Results suggest the use of a different postural strategy in the cognitive task condition as opposed to single-task standing and attentional focus conditions. A higher reliance on the cerebellar and vestibular systems instead of on the visual system could indeed be indicative of automaticity of sway. [1] Polskaia et al., Gait Posture 41 (2015) 454-458. [2] Potvin-Desrochers et al., (2017) Submitted for publication. [3] Quek et al., Gait Posture 39 (2014) 1069-1073.

1-H-49 MARGIN OF DYNAMIC STABILITY IS INCREASED DURING WALKING COMBINED WITH GRASPING IN AN UNPREDICTABLE ENVIRONMENT

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BACKGROUND AND AIM: In our prior studies, participants walked and grasped a dowel using an anticipatory mode of control. They adopted a conservative strategy to ensure stability as shown by increased margin of dynamic stability (MDS). However, it is unknown how the MDS changes during walking and grasping in an unpredictable environment. The aim in this study was to investigate the MDS in both anterior-posterior (AP) and medio-lateral (ML) directions during the combined task of walking and grasping using visual cues that indicated grasping direction at different time points in the approach phase. METHODS: 15 young adults participated in this study and performed the combined task in four visual cue conditions all indicating the direction of the grasping task (left or right): 1) pre-cued: visual cue available before starting walking; and 3 visual cue conditions available at different moments during the approach phase: (2) at the moment of grasping (step N), (3) two (N-2), and (4) one (N-1) step before grasping. For all cue conditions the side to grasp the dowel was manipulated, such that participants grasped the dowel using different coordination patterns: ipsilateral (right foot + right hand (RR); left foot + left hand (LL)) and contralateral (right foot + left hand (RL), left foot + right hand (LR)). The dowel was positioned laterally with a distance corresponding to 50% of the participant´s right upper limb length and adjusted to greater trochanter height. We used 11 infrared cameras to track passive reflective markers to build a 3D full body model. The extrapolated center of mass was computed to obtain the MDS at heel contact for the step corresponding to dowel contact. Metatarsal and heel markers on both feet were used to define the extremities of the foot and to compute MDS in the AP and ML directions. RESULTS: MANOVA revealed an interaction effect between visual cue timing and coordination patterns for both AP and ML directions ($p<0.001$). MDS AP was less negative for RL and LR than for RR for the visual cue at step N-1. MDS ML was more positive when the visual cue was presented in step N than in the pre-cue condition for RR and LL. For LR, MDS ML was negative for the visual cue at step N compared to the pre-cue condition. MDS ML decreased for the visual cue at step N compared to visual cue at step N-1 for both RL and LR. However, it increased for LL. CONCLUSIONS: When the visual cue appeared at the moment of grasping, MDS was negative, indicating an unstable system where the uncertainty associated with the direction of the grasping task acts as a perturbation to the walking task These adjustments at the moment of grasping were done based on an online control, different of the other visual conditions, where participants could use an anticipatory control to modulate the MDS. Finally, the ipsilateral coordination pattern during the walk and grasp was more stable than the contralateral pattern when cues were provided late in the approach phase.

1-H-50 Attentional demands of curved- vs straight-path walking in older adults

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BACKGROUND AND AIM: Straight-path walking is not a fully automated motor activity but requires attentional resources, as shown in various dual-task experiments. The dual-task paradigm (i.e., walking while talking) is the gold standard for measuring attentional demand during walking. Walking in an everyday environment does not only require straight walking, but also curved walking. Curved walking may require higher attentional resources, as compared to straight walking, potentially resulting in an increased fall risk. The aim of this study was to measure the attentional demand of curved vs. straight walking using a dual task protocol and objective instrumented gait analysis. METHODS: Twenty-four community dwelling older adults aged 65 years and older were included in the study. Subjects underwent a gait assessment under single task and dual-task conditions (i.e., counting backwards -3 from a random number between 70 and 100) during straight walking (distance 7 meters) and curved walking (circle with a diameter of 2.40m). Spatio-temporal gait parameters including velocity, cadence, stride length, single support, and base of support were measured during straight walking using a GAITRite walkway system. The same spatio-temporal parameters were measured during curved walking using a GAITRite CIRFace system (rectangle of 2.5 x 3 meters). Decrease of performance under dual-task conditions (compared to single task) defined as dual-task cost (DTC) was computed for each gait parameter for both straight and curved walking by the following formula: ([dual task - single task]/single task x 100). DTC represented a measure of attentional demand of the walking task. Paired t-test were used for comparing DTC between curved-and straight walking. RESULTS: When compared to straight walking, DTC during curved walking where significantly increased for temporal gait variables including cadence (DTC: curved walking -13.1±13.7%; straight walking: -8.6±13.9%, $p=.05$) and single support (DTC: curved walking -6.3±10.4%; straight walking: -1.5±6.5%, $p=.025$). Descriptive results showed increased DTC during curved walking also for other gait parameters, although differences were non-significant in the small sample (p=. 0.067-.429). CONCLUSIONS: Performing a simultaneous cognitive task during walking resulted in higher DTC during curved walking as compared to straight walking. Results suggest that curved walking requires increased attentional demand, potentially enabling a more realistic estimation of fall risk in older adults. Results may help to design tailored gait assessment protocols for fall risk estimation. Also, curved walking should be included into dual-task training protocols for reducing fall risk in older adults.

1-H-51 Spectral measures of centre of pressure: a marker of altered balance control after concussion in the general population.

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BACKGROUND AND AIM: Although much sport-related concussion research exists, research involving individuals with acute concussion among the general public is lacking. One of the most impactful consequences of concussion is balance impairment and can be quantified using features of the center-of-pressure (COP). Spectral analysis of the COP signal during quiet stance can characterize reactive control strategies (>0.4 Hz)[1]. The purpose of this study was to characterize balance impairments and recovery using spectral analysis of the COP. It was hypothesized that high-frequency power of the COP signal will be elevated after concussion and will decrease over the course of recovery. METHODS: Participants were referred to the study within 1 week of concussion diagnosis at Emergency Room visit. Balance was recorded on force plates for 50 s in quiet standing with eyes open (EO) and eyes closed (EC). Participants with balance assessments at Weeks 1, 2, 4 and 8 after injury were included. The COP was processed by fast Fourier transform and power spectrum density (PSD) was estimated using Welch method. The integral of the PSD was computed and the mean power in the high frequency band (0.4-3 Hz) was used to describe central tendencies and compared to age-matched healthy controls (HC). RESULTS: Twenty participants with clinically confirmed concussion (CON) were included in the analysis (34.6 ±12.4 years). Twenty-two HC (36.6 ±13.8 years) were assessed for comparison. In the anteroposterior (AP) and mediolateral (ML) directions, there was greater power of the COP in EC than EO in CON participants ($p<0.01$). No change over time was observed. When compared to HC, mean power of the COP in CON was significantly reduced at Weeks 1, 2, and 8 in EO, and Week 8 in EC for the AP direction ($p \leq 0.045$). No significant differences were found between HC and CON in the ML direction. DISCUSSION: Postural instability, as indicated by increased high frequency power, is associated with an greater risk of falls post stroke[1]. With EO, the CON group does not show a significantly higher power spectrum than HC. However, in EC, the CON group shows a trend towards HC values across time points. The elevation of power in high frequencies in the absence of vision suggests an increased reliance on vision for balance immediately after concussion and a persistent impairment in processing vestibular and somatosensory information for maintaining stability. Although this trend in EC is only significant from HC at Week 8 in the AP direction, this differs from existing knowledge related to recovery trajectories after sport-related concussion, where recovery of balance impairment occurs within 1-2 weeks[2]. The data also reflect heterogeneity in balance impairment following concussion in the general population. Data collection and analyses are ongoing. REFERENCES: 1. Schinkel-Ivy A, et al. 2016. Clin Neurophys, 127, 2463-71. 2. Ruhe A, et al. 2014. Sports Health, 6(5), 426-33.

1-H-52 THE IMPORTANCE OF SPECIFIC SPATIOTEMPORAL PARAMETERS IN THE ASSESSMENT OF BALANCE CONTROL IN PRESCHOOLERS

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BACKGROUND AND AIM: To assess balance control in preschoolers, a combination of the Timed Up and Go test (TUG) and Pediatric Balance Scale (PBS) has been proposed previously in literature.(1) However, to assess balance control during gait, spatiotemporal parameters (STP) can be used as well. Previous analyses of STP in preschoolers revealed a model of gait that consisted of three principal components: rhythm and pace, variability and postural control. Rhythm and pace comprised walking speed, age, mean step length, leg length and step time variability. Variability consisted of step length and -width variability. Postural control comprised BMI, mean step time and -width. The purpose of this study was to validate the obtained model of gait by correlating the identified components to results of the TUG and PBS. METHODS: Thirty-three preschoolers with typical development (58.9 ± 15.6 months old) performed gait on treadmill at three age-specific walking speeds (range 2 - 4.5 km/hr) as well as the PBS and a modified version of the TUG.(2,3) Based on the available normative data, raw scores of PBS and TUG were converted to z-scores.(3,4) Pearson correlation coefficients between the identified principal components and z-scores of the PBS and TUG were calculated. RESULTS: A significant weak correlation was found between variability and the z-scores of the TUG ($r=0.153$, $p=0.043$) and between postural control and the z-scores of the PBS ($r=0.221$, $p=0.003$). Their relationships are shown in Figure 1. CONCLUSIONS: The weak but significant correlations between these measures suggest their complementarity in the assessment of balance control in children who are preschoolers. Therefore, to fully address the concept of balance control in this specific population, step width and its variability and step length variability should be implemented in the protocol for the assessment of balance control. ACKNOWLEDGEMENTS AND FUNDING: none to declare REFERENCES: (1) Verbecque E, Lobo Da Costa PH, Vereeck L, Hallemans A. Psychometric properties of functional balance tests in children: a literature review. Dev Med Child Neurol. 2015 Jun;57(6):521-9. doi: 10.1111/dmcn.12657. (2) Franjoine MR, Gunther JS, Taylor MJ. Pediatric balance scale: a modified version of the berg balance scale for the school-age child with mild to moderate motor impairment. Pediatr Phys Ther. 2003 Summer;15(2):114-28. (3) Verbecque E, Vereeck L, Boudewyns A, Van de Heyning P, Hallemans A. A Modified Version of the Timed Up and Go Test for Children Who Are Preschoolers. Pediatr Phys Ther. 2016 Winter;28(4):409-15. doi: 10.1097/PEP.0000000000000293. (4) Franjoine MR, Darr N, Held SL, Kott K, Young BL. The performance of children developing typically on the pediatric balance scale. Pediatr Phys Ther. 2010 Winter;22(4):350-9. doi: 10.1097/PEP.0b013e3181f9d5eb.

J Devices to improve posture and gait

1-J-53 Assessment of stand-up and sit-down posture transition support by standing mobility Qolo for patients with paretic lower limbs

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[Objectives] Qolo is a personal mobility vehicle which assists sit-to-stand and stand-to-sit postural transitions as well as navigation in standing posture for those with motor disability in the lower limbs. Qolo has two characteristics. First, its mechanism to assist the postural transition is composed of passive gas-springs and a rigid link structure without electric actuators or controllers, contributing to keep it small, lightweight and low-cost. Second, it assists the postural transition in total coherence with natural postural transition movement in humans. In this study, to evaluate the motion assist by Qolo for sit-to-stand and stand-to-sit postural transitions, we report on experiments (1) with healthy subjects to compare the necessary muscle activity in postural transitions with and without Qolo and (2) with patients with paretic lower limbs to assess the plausibility of Qolo's motion assist. [Methods] (1) Eight healthy subjects (mean: age 29.1 y, height 174.5 cm, weight 65.1 kg) performed sit-to-stand and stand-to-sit postural transitions with using Qolo (Figure) and then without using Qolo. During the experiments, the participants were equipped with wireless EMG sensors (Delsys Trigno Lab) on the bilateral extensor muscles. EMG data were band-pass filtered, rectified and evaluated according to maximum value of local integration by a moving window of 100ms width. (2) Five patients with paretic lower limbs after neurological disorder (3: Spinal Cord Injury, 1: Cervical Compressive Myelopathy, 1: Right Lumbar Plexus Injury) performed sit-to-stand and stand-to-sit postural transitions with using Qolo. Possibility and safety of the device, and the time for them to perform the motions was assessed. [Results] (1) In postural transitions using Qolo in comparison with those without using Qolo, maximum activation of quadriceps and gluteus maximus muscles were respectively smaller by 74% ($p<0.01$) and 48% ($p<0.01$) in sit-to-stand transition and by 53% ($p<0.05$) and 30% ($p<0.01$) in stand-to-sit transition. Erector spinae muscles did not show significant difference. (2) After several trials for familiarization, all of the participants safely performed sit-to-stand transfer (median: 12 seconds) and stand-to-sit transfer (median: 14 seconds). One participant (SCI) needed to use the upper limbs for additional support. They, except one with cervical myelopathy, could keep standing posture safely without effort for more than 30 seconds. [Discussion/Conclusion] In the first experiment, significant reduction in the knee and hip extensor muscles during postural transitions using Qolo was observed. As it indicated, in the second experiment, the patients with reduction in the lower limb muscle control were able to perform the postural transitions. For the SCI patients, improvement of pelvis and hip attachment was considered for future work. The device might be useful for patients with paretic lower limbs to enhance their independence and daily activities.

1-J-54 Retention of safer obstacle crossing behavior after virtual reality training

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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 was transferred to a real-world obstacle crossing task. The purpose of this study was to replicate our previous work and to determine if this newly adopted, safer obstacle crossing strategy was retained 48 hours later. It was hypothesized that learning to cross virtual obstacles would transfer to the real-world obstacle crossing task and that retention of the safer obstacle crossing behavior would be observed 48 hours later. METHODS: Fifteen young, healthy adults (20.7±2.4 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). Participants returned 48 hours later to cross 10 more real environment obstacles (48hr retention). Full body kinematic data were recorded at 100 Hz. The obstacle crossing variables examined were radial clearance (closest distance) to the obstacle and peak elevation during crossing for both lead and trail limbs?both measured in meters. A repeated-measures MANOVA was used with pairwise comparisons (á=.05). RESULTS: In concurrence with our previous study, participants significantly increased radical clearance (RC) and peak elevation (PE) for both the lead and trail feet from pre-training to post-training ($p<0.05$). Data are presented as mean ± one standard deviation. Lead RC increased from 0.116±0.02 to 0.130±0.02, Trail RC from 0.092±0.02 to 0.104±0.03, Lead PE from 0.386±0.04 to 0.402±0.05, and Trail PE from 0.473±0.08 to 0.497±0.09. After 48 hours, only Lead RC remained significantly elevated (0.130±0.02, $p<0.05$). Trail RC and Lead PE after 48 hours (0.099±0.03; 0.398±0.05, respectively) remained elevated relative to pre-training, but did decline from the post-training performance, suggesting some retention occurred. CONCLUSIONS: This study indicates virtual reality training may influence the retention of an increased lead foot clearance, which may be argued to be the more important foot to reduce fall-risk. After lead foot crossing, the lead foot becomes the stance limb to accept the center of mass weight during trail foot crossing. From a fall risk-perspective, clearance with the lead foot is needed to ensure a stable placement of the weight accepting limb. In addition, a partially retained trail foot clearance may reduce the risk of falling as the trail foot has previously been found to be the more frequent obstacle contactor. Future studies will need to examine the training principles of duration and frequency to optimize retention of safer obstacle crossing behavior.

1-J-55 Fighting Freezing of Gait in Parkinson's disease: open-loop versus closed-loop cueing

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BACKGROUND AND AIM: Accumulating evidence suggests that inadequate integration of sensory information and defective proprioceptive internal maps may underlie abnormal motor control in Parkinson's disease (PD). In fact, freezing of gait (FoG) most frequently occurs during tasks that require control of asymmetric motor tasks that depend heavily on integration of proprioceptive information, such as turning. For these reasons, augmenting somatosensory information with biofeedback during appropriate phases of the gait cycle may improve gait disturbances. Here, we compare the effects of open-loop external cues (metronome) and closed-loop tactile biofeedback on FoG in PD. METHODS: Forty-one subjects with idiopathic PD participated in the study (age:70±6). Twenty-three subjects had FoG (FoG+, MDS-UPDRS III:47±10) according to the New Freezing of Gait questionnaire and eighteen subjects did not have FoG (FoG-, MDS-UPDRS III:43±11). Subjects turned in place for one minute (changing turning direction after each 360 degree turn) while off levodopa medication with 3 inertial sensors mounted on the posterior trunk and on each shin. Turning was compared across 3 randomized conditions: i) baseline (no cues); ii) turning to the beat of a metronome (open-loop), and iii) turning with phase-dependent tactile biofeedback via light vibration to the wrists every time the ipsilateral foot was in stance phase (closed-loop). Each condition was performed twice under single- and dual-task (counting backward by threes). A Freezing Ratio was calculated as the power spectral density ratio between high and low frequencies of shins accelerations and the percentage of time spent freezing during the tasks were measured. A 3x2 repeated measures ANOVA was carried out to investigate the effect of condition, task, and interaction. RESULTS: At baseline, the Freezing Ratio was 2.2±0.4, and it significantly reduced with the metronome to 0.8±0.2, and tactile-biofeedback to 0.8±0.1 for the single- and dual-task (condition: $F=19$, $p<0.0001$; task: $F=0.5$, $p=0.4$; interaction: $F=1.1$, $p=0.3$). Similarly, the % time spent freezing in the turning task significantly decreased from 45±5% at baseline to 18±4% with the metronome and to 19±4% with the tactile biofeedback for the single- and dual-task (condition: $F=41$, $p<0.0001$; task: $F=0.4$, $p=0.5$; interaction: $F=1.4$, $p=0.2$). Surprisingly, the dual task did not increase FoG severity or percentage time spent FoG in any condition (see task effects above). Instead, the average turn peak velocity was affected by the dual task only in FoG+ (conditions: $F=12.9$, $p=0.01$; task: $F=3.8$, $p=0.05$; interaction: $F=5$, $p=0.02$) and not in FoG- (conditions: $F=40$, $p<0.0001$; task: $F=1.6$, $p=0.2$; interaction: $F=0.1$, $p=0.6$). CONCLUSIONS: We observed a significant decrease in freezing of gait while turning in both a biofeedback (closed-loop) and externally-cued condition (metronome, open-loop). In the laboratory, neither metronome nor biofeedback seems to compromise the ability to carry out a concurrent cognitive task while turning. These preliminary observations suggest that augmenting somatosensory information with a phase-dependent biofeedback system relying on an unobtrusive modality, might be an effective tool in reducing FoG in everyday life.

L Ergonomics

1-L-56 Time dependency of bilateral weight distribution during prolonged standing

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BACKGROUND AND AIM: Approximately 57% of the United States work force spends the majority of their workday standing. Those who stand experience discomfort due to lower extremity blood pooling, muscle fatigue, and cartilage compression. Repeated exposure to prolonged standing has been shown to lead to long term injuries such as degenerative joint damage, muscle injury, venous disorders, increased risk of stroke, and carotid atherosclerosis. Center of pressure weight shifts may alleviate discomfort by reducing pressure on joints and engaging venous return to allow oxygenated blood to reach the lower extremities. While multiple studies have investigated blood pooling and muscle fatigue during standing, very little is known about cartilage compression. In order to better understand the impact of prolonged standing on cartilage compression, it must first be known how much weight is placed on the legs during standing, and how weight distribution changes over time. The goal of this study is to determine how much body weight is placed on each leg during prolonged standing and how weight distribution changes over time, in order to better examine its effects on cartilage compression in the future. METHODS: To achieve this goal, nine healthy subjects (4 female and five male, aged 23.3 ± 2.9 years, 1.8 ± 0.1 meters tall, 76.9 ± 14.3 kg in weight) stood with constant foot-ground contact for one hour while performing a computer task. Two force plates collected postural movements at a sampling rate of 1000 Hz, and data was down-sampled to 20 Hz for analysis. Frequency and duration of weight distribution were segmented into bins at 20% intervals and compared to total standing time. RESULTS: Our data indicates that each leg may endure upwards of 80% body weight during prolonged standing. Additionally, the frequency of weight shifts increases over time while the duration of each shift decreases as time standing increases. The weight on each leg is distributed less equally over time. CONCLUSIONS: This suggests that cartilage in the knee joint must withstand much greater than 50% body weight at varying loading patterns over time. Therefore, an assumption of equal body weight when modeling knee joint cartilage compression is not necessarily correct or constant. ACKNOWLEDGEMENTS AND FUNDING: Research supported by NIOSH K01 OH010759.

M Exercise and physical activity

1-M-57 Effect of muscle fatigue on gait balance control during dual-task walking

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BACKGROUND AND AIM: Walking and simultaneously performing an attention demanding task may occur concurrently with increasing muscle fatigue toward the end of some daily activities or job performance. Although previous studies have demonstrated independent effect of these factors, their interactions are rarely taken into consideration. Therefore, the purpose of this study was to examine changes in gait balance and working memory performance in healthy college-age adults after lower extremity muscle fatigue. METHODS: Ten healthy adults (5 females, 20.6±1.0 yrs) performed the following three tasks before and after a muscle fatigue protocol: 1) Walking with a self-selected pace, 2) Sitting and performing a 3-back test, in which participants listened a series of digits over a loudspeaker and were instructed to verbally respond "yes" whenever a digit is heard that is the same as presented three positions back in the series, and 3) Walking and performing a 3-back test simultaneously. Sit-to-stand task at a pace of 0.5 Hz was performed to induce muscle fatigue. Maximal voluntary isometric strength of knee extensors was assessed using Biodex before and after the fatigue protocol and at the end of study. Whole body motion data were collected from a set of 29 retro-reflective markers placed

on bony landmarks with a 10-camera motion system. Gait balance control was examined using the total medial-lateral CoM displacement (M-LCoM). Two-way ANOVA with repeated measures were used to detect differences between single and dual-task conditions. RESULTS: An average of 21% knee extensor strength reduction was observed immediately after the completion of fatigue protocol, and it was recovered to approximately 10% by the end of study. In both gait conditions, M-LCoM was found to increase significantly after fatigue (3.1±0.2 vs. 3.7±0.3 cm, p = .01). Accuracy of the 3-back test was not significantly affected by the fatigue or gait condition. CONCLUSIONS: Our preliminary findings indicated that gait balance control, as measured by the CoM sway, during a dual-task gait task might be more sensitively affected by the acute muscle fatigue induced in the current study.

1-M-58 Gait parameters change according to physical exercise features in Parkinson's disease.

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BACKGROUND AND AIM: Different types of training with physical exercise have demonstrated major effects in gait parameters over even terrain in people with Parkinson's disease (PD), such as strength, aerobic, dance, and multimode. Related to training characteristics, duration varies between short (6 weeks to 3 months) and medium term (6 months); the intensity between moderate and high; and frequency from 2 to 4 times a week. Based on that we ask: Which changes in gait parameters of people with PD can be observed in long term interventions with physical exercise? The aim of this study was to verify gait changes of people with PD enrolled in long term interventions (8 months, twice a week) with different types of training with exercise. METHODS: Ninety eight individuals with idiopathic DP, from mild to moderate disease severity, were randomly assigned in three groups: multimode (M; exercises for the functional capacity components); locomotor (L; to improve walking and balance control); and cognition (C; to work with cognitive parameters such as attention and memory). Participants in "ON" medication status were invited to walk in their self selected velocity over an 8m long walkway, in 3 intervention moments (pre-test, post1 after 4 months and post2 after 8 months). To assess the kinematic gait parameters (stride length, duration and velocity), two IREDs were attached to the participant right foot (fifth metatarsal and calcaneus) and their trajectories were captured by means of the OPTOTRAK Certus (3D Motion Measurement System, NDI). Gait data were treated and calculated in a specific algorithm written in Matlab (Versão 7.0 - Math Works, Inc.). After the intervention, the sample size decreased (M=25, L=22, and C=22 individuals and the analyses includes 88 attempts in M, 74 attempts in L and 63 attempts in C. RESULTS: A two-way ANOVA revealed interactions between group and moment for stride duration ($F_{3, 222}=3.54$; $p<0.012$) and stride velocity ($F_{3, 222}=12.97$; $p<0.001$). Stride duration was not affected by multimode training while locomotor training impacts stride duration only in the first 4 months of intervention. Mostly in the first 4 months of intervention, multimode and locomotor trainings have similar effects in increasing stride velocity while cognitive training decreased it. Stride length did change neither the intervention types nor the moments. CONCLUSION: Medium term physical exercise interventions (4 months) positively change gait parameters in people with PD maybe due by both the improvement in functional capacity components and the walking and balance control.
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1-M-59 Cycling as an exercise intervention for participants with Parkinson's Disease

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Background and Aim: Parkinson's Disease (PD) is characterized as a progressive neurodegenerative condition that results following selective degeneration of basal ganglia neurons in the brain. The disease is characterized by motor and non-motor symptoms including tremor, rigidity and postural instability [Penko et al,Clin Biomech 2014,29:1089-1094]. Improved motor function, balance and mobility of individuals with PD has been shown following participation in a regular aerobic exercise program. Specifically, intermittent bursts of cycling on a stationary bike (interval training) has shown positive health gains including improved cognition, metabolism, cardiovascular fitness and increased energy [Alberts et al,Exercise Sport Sci R 2011,177-186]. In a partnership with YMCA-Guelph we set out to assess the efficacy of their cycling classes for individuals with PD living in the community. Methods: Two intakes of the protocol occurred. The first included 8 participants (age: 40-75 years; 2 female) and the second is currently underway (n=5, 1 female). At baseline, we took anthropometric measures (e.g. waist circumference, height, weight) and the Mini-Best Test (MBT) was performed. Participants then stood quietly (3 trials; 1 minute; 100 Hz) on a force plate (AMTI-AccuGait) while visually fixating on a target. Five walking trials were completed while an instrumented carpet (GAITrite 12m; 60 Hz) recorded components of gait (e.g. step length, velocity). Finally, a VO2 max test was completed in order to individualize the exercise intervention (i.e. to ensure participant safety). Participants where randomly assigned to either the interval (10x high intensity, 1 min@88% peak power; 1 min@10% peak power) or continuous (55-65% peak power: Wks 1-4: 30 mins; Wks 5-7: 40 mins; Wks 8-10: 50 min) and all measurements were completed again the week following a 10-week intervention. ANOVAs were conducted (group; time point) and Pearson correlations were conducted between MBT and measures of gait/ posture. Results: The first intake group demonstrated no difference in VO2 measures (group; interval 29.1±5.9ml?kg-1?min-1 vs. continuous 25.9±4.4 ml?kg-1?min-1;p=0.26), however all subjects improved their aerobic capacity regardless of cycling group (time point; pre:24.1±4.5ml/kg/min; post:31.5±3.2ml?kg-1?min-1;p=0.03). Overall improvements in postural measures post-exercise were observed between time points (i.e. COP path length, pre:0.96±0.2m; post:0.61±0.2m; p=0.02). A general improvement in Mini-BESTest scores (pre:20±8; post:23±5;p=0.46) and gait velocity (pre:1.52±0.2m/s; post:1.9±0.3m/s;p=0.06) were also detected for both groups following the intervention, however, these values were not statistically significant. Conclusion: Results suggest that in individuals with PD, interval and continuous cycling programs elicit similar improvements in balance, gait and cardiovascular fitness, critical elements for independent living and sustaining a high quality of life.

N Falls and fall prevention

1-N-60 Reactions evoked by sudden loss of balance: Are arm reactions that protect the body during impact with the ground strategies of last resort?

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BACKGROUND AND AIM: Arm reactions evoked by sudden loss of balance can play an important role in preventing falls and protecting against serious injury. Effective arm reactions require the brain to rapidly make several critical decisions which are dependent on situational factors such as the direction and speed of the fall and the proximity of objects that can be touched or grasped. A fundamental decision is whether to use the arms to aid in recovering balance or to prepare to protect the head and torso during a pending impact with the ground. This study aimed to probe the capacity to select and execute effective arm reactions based on fall speed and direction and availability of handholds. Large perturbations were included to force falling in some trials. METHODS: Unpredictable platform motion was used to evoke arm reactions. Participants were exposed to small, medium and large, forward and backward platform translations that allowed balance recovery or resulted in a ?fall? (safety harness load

> 10% body weight). To counter adaptation, analyses were limited to the initial trials (n=6) experienced by each subject. To heighten reliance on arm reactions, stepping movements were prevented by barriers. Thirteen healthy young adults were tested (20-28 yrs; 6 women; 7 had a handrail present). EMG onset latency was measured for bilateral tibialis anterior, gastrocnemius, medial deltoid and biceps. Motion-capture markers on the third metacarpal and acromion were used to calculate hand kinematics and timing. Repeated-measures ANOVA was used to test effects of perturbation direction/magnitude and handrail presence/absence on the features of the arm reactions. RESULTS: The majority of trials (> 97%) exhibited rapid arm reactions (biceps and/or deltoid latencies < 200 ms). Preliminary analyses indicate that these reactions were significantly modulated according to perturbation direction/magnitude and handrail presence/absence. In all cases, the direction of the early arm movement was consistent with balance recovery, i.e. gravito-inertial 'counter-balancing' or reaching to touch or grasp a handhold. There was no clear evidence of early-onset impact-protection reactions, even though 64% of trials resulted in a ?fall?. CONCLUSIONS: The results of this study support the remarkable ability of the CNS to modulate early-onset arm reactions in such a way as to aid in balance recovery. However, we saw no clear evidence of early-onset reactions that served impact protection. These initial results suggest that impact-protection reactions are indeed "strategies of last resort" that are invoked when initial balance-recovery reactions fail to restore equilibrium. Further investigation is needed, using protocols that allow the body to fall to a larger extent than allowed in the present study.
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1-N-61 Effectiveness of using a Kinect-based Rapid Movement Therapy (RMT) for fall prevention in chronic stroke survivors

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INTRODUCTION: Community-dwelling stroke patients have higher fall prevalence than healthy older adults, possibly due to their impaired capacity to perform rapid balance-recovery reactions [1]. These reactions involve ballistic limb movements to rapidly expand the base of support to prevent falls. Stroke-induced instability often lead to fear of falling, reduced physical activity, and further impairment in limb functions. Traditional stroke rehabilitation programs often focus on improving the paretic limbs' range-of-motion (ROM) and muscle strength, which neglected the importance of movement speed in preventing falls. Furthermore, these services often require the presence of clinical personnel, which place enormous financial burden on the healthcare system [2]. Moreover, it would be difficult for the training staffs to track the progress of all of their patients objectively and continuously. Therefore, the objective of this study is to develop a 3D interactive Kinect-based Rapid Movement Therapy (RMT) programme to train rapid limb movements in chronic stroke patients for fall prevention. Such system is capable of automatically tracking and providing real-time feedback on the ROM and movement speed of its users. Effectiveness of the system will be evaluated using a randomized controlled trial study. It is hypothesized that Kinect-based RMT can match/exceed the benefits of conventional training in restoring upper/lower limb motor performance and balance/gait control, leading to improved balance confidence and fewer falls. METHODS: Community-dwelling chronic stroke patients with some limb and balance impairment are randomly assigned to receive twenty 1-hour sessions of either RMT or conventional balance training (control) in seven weeks. Subjects in the RMT group are required to stand in front of a Microsoft Kinect motion sensor and respond as quickly as possible by reaching/stepping in various directions as prompted by a display screen in front of them. Real-time feedback on their performance on their ROM and response time will be given as a motivator to promote motor relearning. All subjects will be evaluated before and after the training period. RESULTS: Post-assessments of only three subjects have been completed; results from ~20-30 subjects will be presented in June. Preliminary results suggest that Kinect-based RMT may be effective in improving the participant's upper/lower limb functions (FMA-UE: 20→25 vs. 29→30.5; FMA-LE: 11→13 vs. 20.5→17.5), balance (BBS: 49→52 vs. 51→51.5) and balance confidence (ABC: 81%→88% vs. 76%→83%) in comparison to the two control subjects. CONCLUSIONS: If proven effective, this affordable and automated training system can be put into routine rehabilitation program in home/clinical settings to reduce fall risk among stroke patients. ACKNOWLEDGEMENTS: Health and Medical Research Fund (grant #12131911) REFERENCES 1. Mansfield A, et al. Phys Ther. 91:958-969, 2011. 2. Godwin KM, et al. Top Stroke Rehabil. 18:676-684, 2011.

1-N-62 Can visual fixation on an obstacle prevent trips?

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BACKGROUND AND AIM: Tripping is a major cause of falls, and insights can be gained by examining the inadvertent trips that occur in the laboratory with a stationary, visible obstacle. During 150 obstacle crossing trials, subjects who never tripped visually fixated more on the obstacle than subjects who tripped more than once (Pontecorvo et al, 2015). Similarly, in a foot targeting task, people who focused on the target longer had more accurate foot placement than those who looked away earlier (Young & Hollands, 2010). The purpose of this study was to determine if instructing subjects to fixate on the obstacle during approach would reduce inadvertent contacts. METHODS: Twenty-five young adults (23.8±3.9 yrs) walked over an obstacle placed in the middle of an 8-m walkway for 150 trials; obstacle height was 25% of leg length. Fifteen subjects received no gaze instruction (control group), and ten were instructed ?Please look at the obstacle all the time? each trial (gaze instruction group). Foot clearance (FC) of the trail limb and the number of contacts were measured. The change in FC for each subject was quantified with a linear regression, as a drift in FC with repeated trials has been observed previously (Heijnen et al., 2012), which could reflect decreased attention to the task. RESULTS: With gaze instruction, the percent of subjects who inadvertently contacted the obstacle decreased from 73 to 30%. With gaze instruction, the percent of trials with obstacle contacts decreased 57%, from 0.7 to 0.3% (p=0.03). These findings support the contention that modifying gaze behavior with instruction may lead to reduced trips and falls. Qualitatively, the following patterns were observed in trail FC: linear decrease until obstacle contact (Fig 1A), asymptotic (Fig 1B), and stable (Fig 1C). The control group had 67, 13, and 20% of linear decrease, asymptotic, and stable, respectively. The gaze group had 30, 30, and 40% of linear decrease, asymptotic, and stable, respectively. Thus, with gaze instruction, the percent of subjects with a linear decrease reduced from 67 to 30%. The average slopes in trail FC were not different for the two groups: -1.0 and -0.8 mm/trial for control and gaze groups (p=0.68). The trail limb is not visible during crossing, and the drift in trail FC is similar to the drift observed in other motor tasks that do not have visual feedback (Ambike et al., 2016). Since the instruction reduced obstacle contacts, but did not prevent trail FC drift, it is unlikely that decreased attention to the obstacle is the cause of the drift in trail FC. CONCLUSION: Participants instructed to visually fixate on the obstacle were less likely to contact the obstacle than those without instruction. This was evident in the percent of subjects who contacted the obstacle, the percent of trials with a contact, and the pattern of foot clearance. Thus, a visual fixation strategy in everyday life may lead to reduced risk of trips and/or falls.

1-N-63 The Challenge of Virtual Reality Balance Games to the Balance Control System in Healthy Elderly: Exploring Muscle Activity

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Introduction: Muscle weakness is an important risk factor for falls in elderly. Fortunately, muscle strength and balance performance can be increased with sufficiently challenging exercise. The number of repetitions, sets and intensity of exercises are important determinants of the exercise effectiveness. The aim of this paper is to assess the intensity in Virtual Reality (VR)-balance games by means of assessing muscle load. Whereas for resistance exercises it is common to quantify the intensity by expressing the weight used as a proportion of the maximum weight a subject can move once, this method cannot be applied for body-weight exercises, which are typically seen in VR games. We therefore propose a novel method to analyze Electromyography (EMG) that takes into account the amplitude of the EMG signal and the distribution of bouts of muscle activity over the time of a game. Methods: Fifteen young and fifteen healthy elderly played eight different VR-balance games, during which muscle activity of the m.Vastus Lateralis, m.Vastus Medialis, m.Soleus and m.Gluteus Medius was assessed with an 8-channel wireless EMG system (Aurion, Zero-wire). The EMG signals were filtered, rectified and normalized to those obtained during maximal voluntary contractions (MVC). We divided each trial in blocks of 200ms, with each block being categorized by its average normalized EMG activity i.e. > 80%, 60-80%, 40-60% or lower than 40% MVC (figure 1; left). For each trial, we calculated the total number of blocks in each category to score intensity, Furthermore the maximal number of Consecutive Blocks (MCB) > 60% MVC, that were not separated by more than 3 seconds was determined, to identify interval length at specific intensities. Results: Data from 15 young and 15 elderly show that muscle activity during game-play is mostly below 40% MVC and games lack prolonged activation above 60% MVC. Games that included slow lunges, squats or other slow to nearly static movements such as Kinyoga, Wiiyoga, Sky, and Cityride, resulted in very low number of activation blocks. Games that included more dynamic movements showed activation blocks in the higher zones (figure 1; right) and also resulted in a higher number of MCB > 60% MVC. Conclusion: Muscle activity during VR-balance games that are used in intervention studies was quantified using EMG recordings. Our method allowed us to analyze the overall muscle activity and the distribution of activity over a trial. Although in general the activation levels during these VR-balance games were low, we managed to identify games with certain aspects that could potentially provide a sufficient training stimulus. However, the numbers of repetitions and sets and the intensity achieved in gaming, need to be optimized to achieve sufficiently challenging VR-balance training for lower limb muscles.

1-N-64 Feasibility of detecting falls with wearable sensors at the lower back and thighs for possible integration into older adults' undergarments

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Background and aim: One-half of older adults who fall are unable to independently rise and are at risk of experiencing a 'long lie'. With growing recognition of the problem, fall detection systems have emerged to automatically alert care providers of the occurrence of a fall. System accuracy and user compliance are important barriers, and one possible solution is to integrate sensors into everyday clothes such as undergarments. Therefore, we investigated the accuracy of wearable sensors for fall detection placed at the lower back and thighs, for future integration into older adults' undergarments (or hip protectors in frailer populations). Methods: Fifteen young adults (aged 19-33) were asked to mimic in the laboratory a range of fall scenarios that are common for older adults (Robinovitch et al., 2013). These included falls due to tripping, missteps, incorrect weight transfer while rising from sitting to standing, and while descending from standing to sitting, hit/ bump, unintentional rolling out of bed and loss of consciousness/ collapse. In addition, data were collected during near falls (for each of the above scenarios) and activities of daily living (ADL). Three wearable sensor units (Xsens Technologies), including a tri-axial accelerometer (range 16g) and barometer (range 300-1100hPa), were placed at the lower back, and right and left thighs. The acquired data were split into training and test sets of similar size. A continuous wavelet transform (CWT) was used to detect fall patterns in the accelerometer and barometer signals based on custom mother wavelets generated from the training data set. The maximum coefficient values of the CWT (estimates for the similarity of a pattern with the mother wavelet) were then used as the input to a machine learning classifier (Random Forest). Results: In total, 566 trials (191 falls, 104 near falls and 271 ADLs) were included into our analysis. With a single sensor, the lower back site achieved the highest classification accuracy of 97.5% (sensitivity: 94.1%, specificity: 99.4%) compared to 84.2% (sensitivity: 72.9%, specificity: 90.4%) for the right thigh and 91.7% (sensitivity: 81.2%, specificity: 97.4%) for the left thigh. Without the barometer, the accuracy of the lower back sensor declined to 87.1% (sensitivity: 74.1%, specificity 94.2%). Combining the sensor data of all three sites, falls were detected with an accuracy of 98.3% (sensitivity: 96.4%, specificity: 99.4). Conclusions: Our algorithm distinguished falls from near falls and ADLs with over 98% accuracy based on wearable sensor data from the lower back and thighs. In particular, the inclusion of the lower back site and the combination of accelerometer and barometer led to promising results, which compare well to previous fall detection studies. In future, our findings can be applied to the design and development of sensor-based undergarments, enabling automatic detection of falls in older adults.

1-N-65 Gait balance classification of young adults, elderly non-fallers and fallers using center of mass velocity and acceleration

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BACKGROUND AND AIM: Falls most frequently occur during walking. A better understanding of dynamic balance control during walking would facilitate early identification of older individuals at a high risk of falling. Dynamic balance control has been quantified based on the position and velocity of the whole-body center of mass (COM) with respect to the base of support. Given that acceleration induces changes in velocity, examining COM acceleration could enhance our understanding on how momentum is controlled during gait, which would allow us to better differentiate individuals with different balance control abilities. The objective of this study was to classify individuals with different balance control abilities with the use of velocity- and acceleration-related COM and stability parameters. METHODS: Control of the COM in the antero-posterior direction during walking was examined in healthy young adults, elderly non-fallers and elderly fallers (n = 15/group). Average COM velocity and peak COM acceleration during a gait cycle were calculated as COM parameters. Using a single-link-plus-foot inverted pendulum model, forward boundaries of the region of stability (ROS) were determined based on the COM position at toe-off and its instantaneous velocity (ROSv) or peak acceleration (ROSa). Stability margins to the respective stability boundaries were calculated as stability measures. A discriminant analysis was then performed with velocity- and acceleration-related COM and stability parameters to assess classification accuracy of each subject group. RESULTS: Although no significant difference was detected in the average COM velocity between healthy young and elderly non-fallers (p=.173), the peak COM acceleration differed significantly (p=.011), suggesting age-related differences in momentum control during walking. Elderly fallers demonstrated the largest stability margins, followed by elderly non-fallers and young adults. Classification accuracy of elderly non-fallers was relatively low (26.7%) when velocity-related parameters were used as independent variables, which was much improved when acceleration-related parameters were added (73.3%) (Table 1). Accordingly, 82.2% of the overall subjects were correctly classified when both velocity- and acceleration-related parameters were used as independent variables, which was better than the result of using velocity-related parameters only (68.9%). CONCLUSIONS: COM accelerations differed significantly even when there were no detectable differences in COM velocities, which allowed us to correctly classify our subjects with

more than 80% of accuracy. Significantly smaller COM acceleration observed in our older subjects could be indicative of their poor momentum control possibly due to reduced muscular functions and/or a protective strategy for potential falls. The use of COM acceleration in addition to its velocity would enhance fall risk assessment, providing a further understanding of a person's momentum control.
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1-N-66 Evidence that small inconsistencies in step rise is neither perceived nor accommodated during stair ascent
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BACKGROUND AND AIM: Stair use is a daily activity associated with fall risk and associated serious injury. Non-uniformity in step going is common within homes and the community and has been identified as a leading cause of falls, especially during stair descent. However, the effect of a variation in step rise is unclear. In stair ascent, an unexpected increase in rise could result in the foot catching the step-edge, increasing the risk of a miss step, trip or fall. Therefore, the aim was to identify the strategy young adults adopt in the approach to a step of unexpected inconsistent rise during stair ascent. This information can help develop guidelines for improving stair safety. METHODS: Twenty-seven young adults (age: 24.5±3.3years) negotiated an instrumented seven step custom-built staircase (force plates embedded in the first four steps) with step dimensions set to either NORMAL, a uniform staircase (rise 200mm; going 250mm); or RISE, a non-uniform staircase where the 3rd step only was elevated by 10mm. Kinetic and kinematic characteristics of approach to the changed step were captured bilaterally, and foot clearance of the leading limb (that landing on step 3) and foot contact area were determined. The average values of 5 NORMAL trials were compared to the first RISE trial. A paired T-test and vector field analysis were used to identify differences between the conditions with the significance level set at P=0.05. RESULTS: No significant differences in peak joint angles, joint moments, ground reaction forces, CoM accelerations and CoM-CoP distance and angle were found between conditions in the approach to the elevated step. Vector field analysis in vertical and anterior-posterior direction showed no significant differences in the trajectory of the foot in the approach to the elevated step (Figure 1). At the elevated step, foot clearance of the leading limb and foot contact area were significantly reduced in the RISE when compared to the NORMAL condition (RISE: 25.78±8.70mm vs. NORMAL: 30.26±8.69mm; 64.51±11.65% vs. 67.07±10.19%) while no differences were detected between conditions on the unchanged steps. CONCLUSIONS: There were no significant differences between how participants approached the uniform step and the raised elevated step. The lack of any biomechanical adjustments when negotiating the higher rise step suggests that the difference in step height was not detected. As a consequence, the foot touched down on the elevated step earlier in the unaltered gait cycle, and foot clearance and foot contact area were reduced. Variability in step rise by 10mm during stair ascent was undetected by young adults resulting in no adjustments in the approach towards an elevated step. The resulting decrease in toe clearance and foot contact area suggest that variability in step rise increases the risk of tripping.

1-N-67 The dynamics of daily-life walking in older adult fallers and non-fallers: Is loss of complexity a reflection of loss of dynamic stability?
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Background: In the last two decades, two competing theories have been proposed to explain the changes in gait dynamics associated with aging and disease: loss of complexity and loss of stability. However, no study has directly assessed the relationship between these two constructs for daily-life walking of older adults. The aims of the present paper were, therefore, to assess the association between complexity and local dynamic stability (LDS) of daily-life walking in older adult fallers and non-fallers, and to investigate the influence of different numerical definitions of stability and complexity. Method: The study re-analysed inertial sensor data of 3-day daily-life activity originally described by Weiss et al (2013). The data set contains inertial sensor data from 39 older persons who reported less than 2 falls (i.e., non-fallers) and 32 older persons who reported two or more falls (i.e., fallers) during one year. Complexity and LDS were estimated using sample entropy and maximum finite size Lyapunov exponents, respectively, for 50 sec walking epochs. Both phase-dependent and phase-independent versions of the numerical definitions were used to investigate the consistency of the relationship between gait complexity and stability during the step cycle. Median values were computed across all walking epochs of each person. Significant differences between fallers and non-fallers were assessed by independent samples t-tests and the relationship between complexity and LDS was assessed by Pearson cross-correlations. Results: Compared to the non-fallers, the elderly fallers had significantly lower complexity ($p < 0.001$) and significantly higher LDS ($p < 0.01$) during daily life walking (see Figure 1A). A high, positive correlation between complexity and LDS was found for different phases of the step cycle ($R = 0.85$ to 0.95, $p < 0.00001$) and overall (see Figures 1B and 1C, respectively) in both fallers and non-fallers. Conclusion: Measures of complexity and stability of the dynamics of daily-life walking are closely related, where loss of complexity is associated with a gain in dynamic stability. Thus, the present study indicates that loss of complexity and loss of stability apparently do not co-exist and confirm the loss of complexity in the daily-life walking of elderly fallers. Further work is needed to assess the role of gait stability and complexity measures as predictors for future falls in community-dwelling older persons. References: Weiss, A., Brozgol, M., Dorfman, M., Herman, T., Shema, S., Giladi, N., Hausdorff, J.M., 2013. Neurorehabilitation and Neural Repair 27(8), 742-752.

1-N-68 Fear of falling in dizzy patients depends on external conditions

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Background and aim: Fear of falling is a disabling symptom, often leading to a decline in quality of life and social isolation. In a recent study, we found that fear of falling is high in central balance disorders and moderate in vestibular and functional disorders. Clinical experience suggests that it occurs differently in daily activities. Therefore, we aimed at determining external conditions that evoke fear of falling in these patients. Methods: This work is part of a controlled cross-sectional study at our tertiary care outpatient clinic. Fear of falling was assessed using the 16-item Falls Efficacy Scale-International (FES-I). We report on the proportion of participants being at least somewhat concerned about falling. Individual items of the FES-I were evaluated. Results: Patients were categorized into four groups: central balance disorders (n=107), peripheral vestibular disorders (n=48), peripheral neuropathy (n=35) and functional dizziness (n=173). In general, patients were concerned about falling on slippery ground. About 40% with functional dizziness were concerned in social situations (events, crowds, shopping). In about 80% of the patients with vestibular hypofunction and peripheral neuropathy fear of falling was triggered by demanding gait conditions (uneven surface, stairs, slopes). Patients with central balance disorders showed the highest proportions of concerned patients in all FES-I items. Conclusion: External conditions, such as specific situations or tasks, evoke fear of falling in patients with functional dizziness and peripheral sensory deficits. A social context, like going to an event, seems to be a prominent fear-provoking factor in functional dizziness. Situational factors may help to design targeted interventions to reduce fall-related anxiety.

1-N-69 Postural control, Trips and Slips in Community Dwelling Older Adults: MOBILIZE Boston Study

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BACKGROUND Trips and slips during gait are well described biomechanically, but their epidemiology in older adults is not. As different fall locations have different medical and postural risk factors, we determined the rate of trips and slips and their relationship to fall location. We tested how postural sway amplitude, stiffness and damping predict the prospective rate of trips, slips, and other falls in a representative sample of community-dwelling older adults. METHODS The MOBILIZE Boston Study is a prospective study examining risk factors for falls. The study includes a representative population sample of 765 elderly volunteers, who were 77.9±5.3 years old, with height of 1.63±0.10 m and weight of 73.9±15.5 kg. 65% were female. Center of pressure (COP) and falls data with ≥6 months of follow-up were used. Subjects stood barefoot with eyes open on a force platform. The COP data were sampled at 240 Hz. Subjects performed two sets of five quiet standing trials, 30 seconds each. One set included a serial subtractions task. Postural stiffness was calculated as previously, where the postural system is modeled as an inverted pendulum with stiffness and damping. Movement of center of mass (COM) was estimated (Sway). Fourier transform of the difference between COP and COM was fit to a damped oscillator model to determine Ke (stiffness) and B (damping). Sway, Ke, and B were determined for each trial, then scaled to body size and log-transformed. Falls were reported using a monthly mail-in postcard calendar, with mean follow-up of 17 months (range 6-32 months) after the COP measurement. Based on the reports, falls were classified into slips, trips, and others. The association between sway, Ke, and B values with prospective falls were determined with a negative binomial regression. Covariates were also considered: age, sex, race, education, daily alcohol use, gait speed, executive function, depression, disability, peripheral neuropathy, Berg balance scale, urinary incontinence, and history of falls. RESULTS Of 1425 verified falls, 581 (41%) were trips, 315 (22%) slips, and 529 (37%) neither. 49% of trips occurred outdoors and 51% indoors. 70% of slips occurred outdoors, and 30% indoors. 39% of other falls occurred outdoors and 60% indoors. Lower stiffness ($p=0.05$) and damping ($p=0.004$) predicted trips. Lower damping ($p=0.05$) predicted slips. Increased sway predicted other falls ($p<0.004$). DISCUSSION Over double of the slips occur outdoors than indoors. Trips occur with similar frequency outdoors and indoors. 37% of falls were neither slip or trip. Such categories may be insufficient to accurately describe falls in older adults. Better classification may improve identification of postural deficits and targeting of interventions. Our result is not explained by our previous work where outdoor falls are associated with stiffness and damping, and indoor falls with sway. Motor control training to respond to perturbations may prevent trips and slips.

1-N-70 Cognitive-motor gaming for reducing fall risk in chronic stroke survivors

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Cognitive-motor gaming for reducing fall risk in chronic stroke survivors Lakshmi Kannan, Jinal P Vora, Tanvi Bhatt. University of Illinois at Chicago, Chicago, IL 60612 Background: Dual-tasking (performing a motor task with a cognitive task) has been associated with increasing fall risk 1-3, especially in ambulatory stroke individuals4. Although conventional methods and alternate therapies like virtual reality are known to improve balance control5 their effects in reducing fall-risk under attention-demanding, real-life like situations, is debatable. Thus, the purpose of this study was to examine effect of an emerging cognitive-motor gaming (dual-task training) paradigm on different balance domains in chronic stroke survivors. Based on results of a feasibility pilot study6, we hypothesized that such a paradigm that simulated both at attentional and functional demands of the real world would result in significantly improved balance performance under dual-task conditions resulting in lowering of fall-risk in chronic hemiparetic stroke survivors. Methods: Ten chronic stroke survivors completed balance assessment using Limits of Stability (LOS, Equitest® Neurocom) for intentional balance, Slip-Perturbation (SP) Test (Motorized treadmill, ActiveStep) for reactive balance under single (ST) and dual-task (DT) conditions (along with a working memory task). They then underwent high-intensity cognitive motor training using the Nintendo Wii Fit program performed in conjunction with different cognitive gaming tasks for 6 weeks (20 sessions; 90mins/ session). Subjects played 4 balance board games in a randomized order: table tilt, tight rope walking, soccer heading and bubble balance. Two slightly challenging games (light run and basic step) were added at session 11 and session 6 respectively, which focused on stepping and endurance. Cognitive tasks included category fluency, word list generation, analogies, digit recall, arithmetic, repeated letter. All balance and cognitive tests were examined post six weeks of training. Stability during reactive balance, end point excursion during intentional balance control and cognitive responses were analyzed by comparing the pre-post scores. Results: Post-training there was a significant improvement in stability on the SP Test for single and dual task conditions ($p<0.05$ for ST & DT) and in end point excursion on the LOS test ($p<0.05$ for ST & DT) for both conditions as well. The fall incidence decreased from 30 to 20% for both single and dual task condition for SP test. Significant decrease in total completion time for incongruent visual stoop ($p=0.007$) and spatial working memory task ($p=0.01$) was observed. Conclusion: The results demonstrate that cognitive motor training has a compound effect on improving dual task performance which is reflected in the improved performance of both motor and cognitive task alone as well as both tasks performed simultaneously. A combined training protocol reducing cognitive-motor interference for both domains of balance control could have a significant impact in reducing fall-risk.

1-N-71 Age-associated factors contributing to obstacle negotiation abilities: Not all is as expected

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Background and aim: Tripping over an obstacle is one of the most common causes of falls among older adults. A paucity of studies have explored the different strategies used to overcome anticipated and unanticipated obstacles as a function of subject characteristics (e.g., executive function), obstacle height and available response time (ART) during over ground walking. Using a computer controlled obstacle course, we aimed to investigate the role of age, subject characteristics, and obstacle characteristics (i.e., obstacle height and warning time). Methods: In this cross sectional study, we included 20 healthy older adults (mean age: 77.7±3.4 years; 50% women) and 20 healthy young adults (mean age: 29.3±3.8 years; 50% women) who underwent cognitive, gait and balance testing (e.g., MOCA, TMT, FSST, mini BEST) before negotiating the computer controlled obstacle course. This unique system enables us to examine the effects of the obstacle height and ART on obstacles negotiation. The height varied from 25mm-150mm for the anticipated obstacles. The unanticipated obstacle ART varied from 225msec-625msec and was tested at two obstacle heights (25mm/75mm). The primary outcome measure was the ability to successfully negotiate the obstacles (without touching); independent variables included the age-group, obstacle height and ART. RM-ANOVA was used to assess the role of age, obstacle height and ART on the ability to successfully negotiate the obstacles. Results: As hypothesized, the success rate (SR) for all subjects was higher when the obstacle was expected (99.0±2.8%, as compared to unexpected

66.0±20.2%; p<0.001). With an obstacle height of 25mm and an ART of 225msec, the SR was lower (p<0.001) among older adults (50.0±40.4%), as compared to young adults (100±0.0%). For all subjects, the effect of unexpected obstacle height on SR was opposite to our hypothesis. Surprisingly, the SR was lower when the obstacle height was higher (p<0.001). For young adults, the SR was related to ART (p=0.02), however, for the older adults, the SR was not related to ART. Among the older adults, SR tended to be related to stride length (rs=0.42, p=0.039) and executive function, as measured using Trail Making Test B (rs=-0.38, p=0.055). Conclusions: These findings provide new insights into the ability of older adults to successfully negotiate obstacles and help to better understand the mechanisms that underlie this everyday skill. The results suggest that impact of height on successful obstacle negotiation depends on how much time the subject has to plan ahead and that also differs in young and older adults. Future work should examine these factors and their contribution to fall risk among elderly fallers.

1-N-72 Effects Of A Novel Two-Phase Rehabilitation Program On Fall Recovery Kinematics In Older Adults

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BACKGROUND AND AIM: Falls are a major source of morbidity and disability in the aging population. Twenty to thirty percent of older adults who fall suffer moderate to severe injuries such as lacerations, hip fractures, and head traumas. A serious component of falling often overlooked in rehabilitation interventions is the fear of falling. The fear of falling is part of a debilitating spiral that leads to decreased activity, loss of independence and muscle weakness. The goal of this investigation was to determine if a novel two-phase rehabilitation program designed to reduce the fear of falling and increase lower-extremity muscle strength could improve postural control during simulated falls in older adults. METHODS: Phase I: Older adults participated in 8 A Matter of Balance (AMOB) workshops, 2hours/week, total of 16 hours, designed to provide cognitive restructuring to reduce the fear of falling. Within 1-2 weeks of completion, participants enrolled in Phase II: a standardized 10 week lower-extremity strengthening program. Participants performed high-intensity concentric resistance exercise on a modified seated ergometer (Eccentron, BTE Technologies) 2x/week for up to 20 minutes per session. Temporal and spatial kinematic measures were gathered on 2 healthy older adults during reproducible falls at three time-points: baseline (T0), after Phase I AMOB (T1), and after Phase II strengthening (T2). Falls were induced by treadmill perturbations (VGait system, MotekForce Link) occurring at slow (2m/s2) and fast (5m/s2) belt accelerations while standing in a static position. RESULTS: Step length and step width of the recovery limb increased from baseline after the 18 weeks of training in both slow (31.8mm; 32.7mm) and fast (72.4mm; 1.81mm) perturbations. Reaction time was also improved compared to baseline in slow (-0.76s) and fast (-0.49s) perturbations following the two-phase intervention. The number of compensatory steps required to maintain upright was decreased in both slow (-1.2steps) and fast (-0.5steps) perturbations across both phases of the program. The greatest improvement in each individual phase of the program was seen in step length (Phase I), and reaction time (Phase II). CONCLUSIONS: These data suggest that a two-phase rehabilitation program focused on cognitive restructuring and strength training can improve specific components of postural control during recovery from falls. Individual phases showed slight improvement, but the greatest effects occurred in the combined analysis. Rehabilitation interventions aimed at reducing falls in older adults should consider adding a component of cognitive restructuring to reduce the fear of falling in conjunction with standard of care resistance training. ACKNOWLEDGEMENTS: Research reported in this publication was supported by the National Center for Advancing Translational Sciences of the National Institutes of Health under award number KL2TR001103, and the Texas Physical Therapy Association under award number RP0204.

1-N-73 Fall-risk during opposing stance perturbations among healthy adults and chronic stroke survivors.

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Background and aim: Studies examining recovery from SLIPS and TRIPS indicate higher incidence of falls during SLIPS than TRIPS however, the differences in the recovery mechanisms during these opposing perturbations have not been examined. The aim of this study was to examine fall risk during forward and backward large magnitude perturbations at same intensity within chronic stroke survivors as compared with healthy adults. We hypothesized that stroke survivors would demonstrate higher fall risk during SLIPS than TRIPS resulting from lower stability change from liftoff to touchdown during SLIPS compared with TRIPS (higher change indicating better ability to re-establish balance at compensatory step touchdown). Further, during SLIPS and TRIPS, the stability change in stroke survivors would be lower than healthy controls due to inefficient compensatory step and trunk control. Methods: Younger adults (N=11, 23.63 ± 3.9 years), age-matched adults (N=11, 58.08 ± 5.80 years) and chronic stroke survivors (N=12, 60.75 ± 5.78 years) were exposed to a single SLIP and TRIP through a motorized treadmill (16.75 m/s2, 0.20m). Stability was measured as the shortest distance of the instantaneous center of mass state (position and velocity relative to base of support) from a theoretical threshold for forward and backward loss of balance. The stability change from step liftoff (LO) to touchdown (TD), compensatory step length, trunk angle change from LO to TD and peak trunk velocity were recorded. Results: During SLIPS incidence of falls among stroke survivors was greater than both control groups (53.83% vs. 0%, $p < 0.05$) however not for TRIPS ($p > 0.05$). Stability change during TRIPS was higher than during SLIPS for all the groups (main effect of perturbation type, $p < 0.01$). Among healthy young and age-matched adults, higher stability during TRIPS was achieved by the ability to control trunk flexion at TD and lower peak trunk velocity as compared with SLIPS (main effect of perturbation type $p < 0.05$), with no difference in compensatory step length between the perturbations ($p > 0.05$). Chronic stroke survivors increased compensatory step length during TRIPS vs. SLIPS ($p < 0.05$), contributing to greater stability change during TRIPS than SLIPS. They were unable to control trunk excursion and peak trunk velocity as compared with healthy adults leading to lower stability change than both control groups during SLIPS and lower stability change than younger adults during TRIPS (main effect of group, $p < 0.01$). Conclusion: These findings suggest that reactive balance control to large perturbations varies with regards to the perturbation direction. Difficulty in trunk control during SLIPS among all individuals and compensatory stepping response among stroke survivors emphasizes higher fall risk for SLIPS than TRIPS among these populations. Although aging and presence of neurological impairments predispose individuals to falls during sudden disturbances, the likelihood of backward falls seems higher than forward falls, particularly in chronic stroke survivors. Acknowledgments and funding: This study was supported by the American Heart Association, Scientific Development grant (12SDG12170022).

1-N-74 Motor prediction modulates protective balance and startle responses to sudden drop perturbations in standing humans

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Background and aim. Sudden external disturbances of standing posture during 'first-trial reactions' (FTRs) evoke rapid and exaggerated neuromuscular reactions resembling startle-like responses that diminish with repeated exposure from habituation. Studies examining FTRs have focused mainly on body responses in forward-backward or sideways directions. Less is known about FTRs to sudden downward motion of the body under gravity and their potential to be modulated. Sudden lowering of standing support surface during FTRs show large electromyographic (EMG) responses and increased muscle co-activation and joint stiffness causing greater peak vertical ground reaction forces (vGRFs) upon landing. Compared with externally-triggered trials (EXT), use of motor prediction via self-activated drop perturbations (SLF) can reduce FTR peak EMG amplitude and landing impact forces. However, whether or not changes in peak EMG amplitude and vGRF following SLF trials are retainable has yet to be determined. The aim of this study was to determine whether the effects of repeated SLF drop perturbations on vGRF and peak EMG amplitude are retainable. Methods. Eight healthy participants (25.6±1.6 yrs. 3M/5F) stood atop a moveable platform secured to a fixed rigid frame using 10 electromagnets which released via computer for EXT reactive trials, or by manual remote during SLF predictive trials into a 20cm drop onto a force platform. Drop acceleration was controlled using a counterbalancing apparatus attached to the platform. Muscle activity was recorded bilaterally over the sternocleidomastoid (SCM), middle deltoid (DLT), biceps brachii (BIC), vastus lateralis (VL), biceps femoris (BF), gastrocnemius (MG), and tibalis anterior (TA). Blocks of 12 EXT trials were followed by 12 SLF trials spaced 20 minutes apart to minimize habituation carryover between conditions. After the last SLF trial, participants received two EXT trials spaced 20 minutes apart to assess retention (RTN) of any modulation effects. Differences in peak EMG amplitude and vGRF between FTRs and RTN trials were compared using paired sample t-tests. Results. Mean SCM onset latencies for FTR EXT trials occurred within 100ms after perturbation which is typical of startle responses. Reductions ($p<.05$) in peak EMG amplitude between EXT FTR and SLF trials were retained in subsequent RTN trials for SCM (47%), DLT (56%), and BIC (34%). Peak vGRF was reduced by 20% between EXT FTR and RTN trials. No significant differences in peak EMG amplitude were observed in lower extremity muscles. Conclusions. Reductions in EXT peak EMG amplitude and vGRF are retainable following repeated SLF drop perturbations in upper extremity muscles indicating acute modulation of FTRs through motor prediction. Although the lower extremity muscles did not show reductions in EMG amplitude, other mechanisms such as reduced co-contraction may have contributed to reduced vGRF. [Supported by NIH R21AG049615]

1-N-75 Balance Training with Augmented Feedback in Adults with Stroke

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BACKGROUND AND AIM: Following a stroke there is risk of postural instability and falls due to hemiparesis, decreased sensation, and biomechanical changes. Somatosensory and visual demands produce coactivation of lower limb muscle responses, but this strategy limits the ability to respond to changes in the environment. The goal of this study was to determine if training in the dark on an unstable support surface while receiving sub-threshold vibration feedback to the plantar surface would produce more effective postural behaviors in adults with stroke. METHODS: Postural responses of three adults at least 1 year post-stroke (39-67 yrs) were assessed in a virtual environment before, after, and two weeks after training. Training consisted of 45 min of standing in the dark on a platform sway-referenced (SR) in both the anterior-posterior (AP) and lateral (ML) directions over 10 consecutive days. Sensitivity of the platform was gradually increased over training sessions with the criterion of maintaining double-leg stance. Sub-threshold white noise vibration was delivered for each 60 sec trial via actuators embedded in flip-flops at the distal end of first and fourth metatarsals and the heel. Assessment trials included measures of AP and ML center of pressure (COP) while standing on a SR platform and viewing continuous pitch upward or downward rotations of the visual field at 30 deg/sec. Root-mean- square (RMS) and power spectral density of the COP were calculated across 60 sec periods in the AP and ML planes. Response to the visual field was normalized to 5 sec of quiet stance in the dark for each subject, and compared across trials with paired t-tests ($p<.05$). RESULTS: RMS and maximum power of COP measures in the AP direction were significantly larger prior to training compared to directly post training ($p<.01$, $p<.02$ respectively) and two weeks after training ($p<.05$, $p<.01$). In the lateral direction, RMS of COP significantly increased in a dynamic visual field for all assessment periods Pitch up of the visual scene produced a significantly higher maximum power compared to stance in the dark ($p<.05$) and to pitch down of the visual scene ($p<.01$). CONCLUSIONS: Training in the dark on an unstable support surface with vibratory feedback to the soles of the feet produced decreased amplitudes and reduced noise in sway responses that were sustained over time. These changes would support improved stabilization in a disturbing visual environment. We are, as yet, unable to distinguish the effects of training on the dynamic platform versus the addition of the vibration feedback. Further analyses of sway density and complexity are planned to provide a window toward understanding the mechanisms underlying these changes. ACKNOWLEDGEMENTS: Supported by NIDRR grant H133F100010.

1-N-76 Evaluating ease of use, enjoyment and exercise adherence to 'Standing Tall' - a home-based exercise programme delivered through iPad technology for reducing fall risk in community-dwelling older people.

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Background and aim: With population ageing, falls in older people pose a significant health care burden. Considerable research has elucidated the benefits of exercise for fall prevention in older people. There is now a need to develop programs that maximise exercise adherence for effective fall prevention. 'Standing Tall' is an innovative home-based exercise program that was developed together with older people, and uses iPad technology to deliver tailored balance training exercises coupled with behaviour change techniques to prevent falls and maximise long-term exercise adherence. Methods: We report on the 6-month follow-up findings related to ease of use, enjoyment and exercise adherence to the 'Standing Tall' 2-year randomised control trial (RCT). Intervention group participants (N=101; age 77.1±5.4) were asked to perform 2 hours per week of unsupervised home-based balance training using 'Standing Tall'. Average weekly and total training duration were automatically recorded by the iPad and used as outcome measures of exercise adherence. A user experience questionnaire was used to collect information on the level of enjoyment (PACES-8), program usability (SUS) and user experience (open ended questionnaire) in the intervention group participants. Results: The average adherence rate over the first 6 months of intervention was 65% (mean 29.5 hours±17.0). A mean score of 30.1 (SD 9.8) on the PACES-8 and 80.7 (SD 15.3) on the SUS indicated a high level of enjoyment and good program usability. 'Standing Tall' was rated as being very good or good by most participants (n=94%), and 78% of participants indicated they saw themselves continuing to use 'Standing Tall'. 80% of participants reported benefiting from using 'Standing Tall'. Of these, 71% reported perceived improvements in their physical abilities, including balance (n=41%); mobility (n=15%); and general fitness and strength (n=29%). Health problems and lack of time were the two most common reasons for non-adherence. The program characteristics participants liked the most were the progress track feature, which participants reported motivated them to exercise regularly (n=38%); the convenience of home-based delivery (28%); the ease of use of the program (22%), and the inclusion of simple yet challenging exercises (20%). No adverse events occurred during the intervention. Conclusions: These first results from a 2-year RCT provide evidence that it is safe and feasible for community-dwelling older people to perform balance training exercises unsupervised in their home using the 'Standing Tall' program. Older people found the program to be enjoyable, easy-to-use, and it motivated them to be more active. Future study results will provide information on the optimal exercise dose that is necessary to reduce risk factors for falls when exercising using the 'Standing Tall' program, and whether the program can reduce falls in older people.

O Habilitation & rehabilitation

1-O-77 Development of a clinical assessment tool for walking adaptability post-stroke: Preliminary results

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BACKGROUND AND AIM: Walking adaptability (WA), the ability to modify walking to meet task goals and environmental demands, is crucial to community ambulation. While WA is often severely compromised post-stroke, its assessment has received relatively little attention in the clinical setting. Lack of a targeted clinical assessment limits quantification of adaptability deficits and design of rehabilitative strategies. The overall goal of this study is to develop a clinical assessment for WA. Our approach to assessment development is based on contemporary testing approaches of Item Response Theory (IRT). A necessary requirement for this approach is the determination of a hierarchy of assessment items (item hierarchy) from less challenging to more challenging. The purpose of this study was to investigate an item hierarchy within selected assessment items, based on behavioral, physiological, and biomechanical data. Here we report preliminary results from the behavioral data, with the hypothesis that these data will demonstrate face validity in establishing an item hierarchy. METHODS: Thirty-three individuals with stroke (60±13 years) performed an 'item bank' of 19 walking tasks, 18 of which necessitated adaptability. Selected items represented 8/9 domains of WA contributing to comprehensive assessment of WA. Task performance was graded by a physical therapist on a 4-point ordinal scale. Grading was based on success in adaptability, safety and the ability to maintain balance while task performance. Statistical analyses were conducted using a Rasch Partial Credit Model. Rasch analysis is a common statistical tool used in IRT-based testing that places person's ability level and the item-difficulty level on the same continuous scale enabling analysis at an individual item-level as opposed to the assessment as a whole. RESULTS: Results from the Rasch item-fit statistics showed that all assessment items, except 'walk fast' (InfitMNSQ=1.56, OutfitMNSQ=3.32) fell within published item fit guidelines (indices ranging from 0.6 to 1.4). The mean item-difficulty ranged from -1.11 to 1.23 logits. Preliminary item hierarchy was revealed in the Rasch-generated item-person map, with the item 'walk and bend to pick an object' (1.23 ± 0.34 logits) being the most challenging item. Other items of high difficulty level were 'walk to step up a stool' (1.17 ± 0.33 logits), 'walk and answer questions' (1.05 ± 0.33 logits) and 'walking on grass' (0.93 ± 0.27 logits). 'Walking at a self-selected pace and no adaptability was the least challenging (-1.11 ± 0.38 logits). CONCLUSIONS: Results from the Rasch item-person map revealed preliminary item hierarchy. While our results need to be confirmed with larger samples, these pilot data demonstrate face validity of the behavioral data to establish an item hierarchy. Item-fit statistics showed that all assessment items (except 'walk fast') fit the construct of WA, additionally validating the item bank. Our future work will use physiological and biomechanical outcome measures collected in our study to further investigate and confirm item hierarchy. Ultimately, a clinical assessment tool developed based on contemporary testing approaches and guided by qualitative and quantitative data will contribute to targeted assessment of WA.

1-O-78 Amazing effects of neurosensory insoles on plantar pressure in people with chronic ankle instability

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Background and purpose : The practice of podiatry reveals that ankle sprains are the most common injuries of the lower extremity area, more than nine million each years in the United States (ACSM). Some authors suggests that feed-back control may not be sufficient to prevent them (Pop & al, 1979; Forestier & al, 2014; Kiers & Al, 2012). In stable conditions, the gait analysis is known to reveal the feed-forward control mechanism (Zhang et al, 2013). This study was conducted to determine whether neurosensory insoles can improve feed-forward motor control for people suffering from chronic single-ankle instability by analyzing plantar pressure under both feet. Methodologies : 7 participants: 6 females, 1 male, Average age 44 years, Average height 168 cm, with unilateral ankle instability are evaluated in the aftermaths of 8 weeks of treatment. 2 tests were used: Plantar pressure were measured by selecting an area of interest under the six areas of the foot: toes, medial, central and lateral forefoot, midfoot and heel. In order to study the modifications of the motor control, plantar pressures were recorded barefoot. The foot lift test: It is a single leg stance (30 seconds trial) where each foot wobbles is recorded as an error. But individuals are required to touch their non-weight-bearing foot to the weight-bearing leg at calf level, with the arms relaxed at the sides. A foot wobble is defined as lifting of the anterior, posterior, medial, or lateral portion of the foot. A point is added when the non-weight-bearing foot touches the ground, and an additional point is recorded for every second that the non-weight-bearing foot remains on the floor. The location of the plantar inserts on the insoles was determined by the practicing podiatrist following clinical examination of the patient. The inserts did not exceed 3 millimeters in thickness. Results : The relative time of pressure under the central forefoot and toes is extended under both feet after treatment ($p<0.015$). Under the healthy lower limb, the relative time of pressure under the lateral forefoot is increased ($p=0.029$) In addition, there is a statistically significant increase in relative pressure under the medial forefoot and the toes of the unstable foot after 8 weeks of wearing insoles ($p<0.02$). The foot lift test is enhanced after treatment on the pathological side ($p=0.004$) and shows statistical trend on the healthy side ($p=0.051$). Conclusion : The novelty of this study is that neurosensory insoles contribute to modify the feed-forward motor control in participants suffering from chronic ankle instability on both the pathological and healthy sides. It would be interesting to compare those neurosensory insoles with the physiotherapy treatment in terms of efficiency but also cost for the health system.

1-O-79 Visual feedback to improve temporal gait asymmetry in people with stroke

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Background and aim: Temporal gait asymmetry (TGA) affects 55% of people with stroke1. TGA is characterized as unequal timing of gait cycle phases between the affected and unaffected legs. TGA is resistant to conventional therapy2, therefore new approaches are required. One approach may be visual feedback (FB) during gait training. FB improves motor skill acquisition in healthy adults, with an optimal frequency of FB following ~50% of attempts3. However, the optimal FB frequency for motor learning in people with stroke may differ from neurologically-intact individuals. This study aimed to determine the optimal amount of visual FB during practice to improve TGA post-stroke. Methods: Demographics (age, months since onset) were collected and participants were characterized by with clinical measures of motor impairment and cognition. An acquisition-retention paradigm was used. Visual FB about TGA was provided on a tablet during an acquisition session of 25 walking trials (30sec each) at 1 of 3 frequencies (randomly assigned): after every trial (100% FB) after every 2nd trial (50%FB) and never (No FB). TGA for each 30 sec trial was recorded with a pressure sensitive mat. After 24 hours, TGA of over-ground walking was measured over 10 trials without FB. The acquisition session was divided into 5 blocks (5 trials each). TGA was averaged over each block for each participant (A1-A5) and over the 10 retention trials (R) and then plotted as mean motor learning curves for each FB group. Change scores for TGA (=A1 - R) were calculated for each participant. One-way ANOVA (No FB, 50%FB, 100%FB) was performed on change scores to determine differences between groups. Results: To date, 7 people with stroke (mean (SD) 53.1 (37.5) months post-stroke; 64.3(15.8) years old) have been recruited. Demographics, motor impairment, cognition and TGA at the beginning of acquisition (A1) were similar across FB groups (all $p > .05$). TGA change scores from A1 to R were No FB = 0.02 (0.05); 50% FB = 0.03 (0.05) and 100% FB = -0.02 (0.08); however, there was no significant effect of FB group (Figure 1, $F = 0.39$, $p > .05$). Conclusions: Thus far, there is no significant effect of feedback frequency on change in TGA. However data collection is ongoing and target sample size is n=30. Additional results will be presented at the conference. References: 1) Patterson et al. Arch Phys Med Rehabil 2008;89(2):304-10; 2) Patterson SL J Rehabil Res Dev. 2008;45(2):221-8; 3) Vander Linden et al. Phys Ther. 1993; 73:79-87.

1-O-80 Music enjoyment has no influence on spatiotemporal gait parameters in healthy young adults

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BACKGROUND AND AIMS: Rhythmic Auditory Stimulation (RAS), a therapeutic technique used to rehabilitate disordered gait, involves synchronizing footsteps to auditory stimuli (i.e., metronome or musical rhythms). Among patients with Parkinson's Disease (PD) gait improvements in stride velocity, stride length, cadence (steps/min) and stability have been found, however the approach and outcome of RAS lacks consistency. Individual differences in beat perception ability and music enjoyment may influence our gait parameters. METHODS: In the present study, gait parameter changes to enjoyed music, unenjoyed music, and a metronome were investigated with comparisons between beat perception ability (good vs poor) and instruction type given (walk freely vs synchronize to the beat). After obtaining one's preferred walking pace (or cadence), the participant rated 32 song clips- played at a tempo 15% faster than the initial cadence. Based on the participant's ratings of familiarity, groove (the desire to move to music), enjoyment, and beat salience, 16 songs were walked to (eight high enjoyment and eight low enjoyment) as well as two metronome clips. The individuals' score on the Beat Alignment Test determined the level of beat perception ability. RESULTS: We found no influence of enjoyment on gait parameters, however the musical rhythms had significantly longer and faster strides then the metronome tones; the instruction to synchronize significantly increased cadence, stride velocity and decreased double support time compared to the instruction to freely walk; and poor beat perceivers showed significantly shorter strides compared to good beat perceivers. CONCLUSIONS: It was concluded that poor beat perceivers do not show improvements in gait performance to the same extent compared to the good beat perceivers when told to synchronize footsteps to the beat, indicating that beat perception ability may influence outcomes of RAS. Further research is needed on the contribution that beat perception ability has on long-term gait improvements; especially since rehabilitation programs are more effective when tailored to individual differences. Since enjoyment did not influence gait, this implies that a therapist can choose any song that elicits a desire to move for the individual to show benefits in gait rather than the music having to be self-selected.

1-O-81 A longitudinal evaluation of gait recovery trajectory following Traumatic Brain Injury

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Background: Gait deficits after traumatic brain injury (TBI) are associated with limited community integration. Gait deficits include reduced gait speed and increased step time and step length variability compared to healthy adults. However, changes in spatiotemporal gait parameters during the first year of recovery are not well researched yet. A better understanding of characteristics of the gait recovery trajectory will better inform the development of gait interventions for people with TBI to improve outcomes including community integration. Methods: A secondary analysis of a research database was conducted. The database contained results from over-ground gait assessment with a pressure sensitive mat of people admitted to an inpatient rehabilitation program. Spatiotemporal parameters of preferred pace gait were recorded at 2, 5 and 12 months post admission. Variables of interest were speed (cm/s), cadence (steps/min), stride length (cm), cycle time (sec), double support (% of gait cycle), and single support (% of gait cycle). Other variables extracted were gender, age and length of post traumatic amnesia (LPTA) as a measure of severity. People were classified by LPTA as follows: short: 1-7 days, moderate: 1-4 weeks, long: >4weeks. A two-way mixed model analysis of variance (ANOVA) was conducted to examine the effect of LPTA group and time on the gait variables of interest. Post hoc Tukey's test was used to examine pairwise differences in the case of significance. Results: A total of 79 people with TBI were included in the analysis. Mean age(sd) for the group was 38.6 (17.0) yrs (20 female, 59 male). There were 12, 47 and 20 people classified as short, moderate and long LPTA. Mixed model ANOVA revealed a significant main effect of time on speed ($p<.001$), cadence ($p<.01$), stride length ($p<.001$) and cycle time ($p=.02$). Post hoc Tukey revealed significant differences between 1st and 2nd time point and the 1st and 3rd time point for speed (increased), cadence (increased) and cycle time (decreased) (all $p<.05$). Stride length significantly increased across all 3 time points (all $p<0.05$). There was no main effect of LPTA on any variable. There was a significant interaction between time and LPTA for speed ($p<.01$) and stride length ($p<.01$). Discussion: This study showed significant improvements in speed with corresponding changes in cycle time, step length and cadence over 12 months post admission to TBI rehabilitation. In most cases the significant change occurred between 2 and 5 months post admission. Severity of TBI (LPTA) appears to influence recovery of speed and step length. Compared to healthy adults double support was prolonged and single support was and did not change over 12 months. These altered phases may indicate impaired postural control during gait in people with TBI. These findings help characterize the spatiotemporal characteristics of gait recovery post-TBI. Ongoing analysis will further examine the interaction of time and LPTA.

P Modeling

1-P-82 Modelling obstacle avoidance during locomotion with predictive and emergent processes

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BACKGROUND AND AIM: A mathematical model comprising of predictive and emergent processes was used to analyze circumvention behaviours along the continuum of normal to altered gait as observed in individuals with stroke. The predictive process enables the estimation of distances from the obstacle at all times, especially when moving in close proximity to the obstacle. The emergent process relies on the differential games approach to express the dynamic interaction between an individual walking towards a central target while avoiding collision with an intersecting obstacle. The obstacle influence was modelled by a time varying Gaussian 2D distribution with elliptical horizontal cross-sections. Assuming that the locomotor strategy is optimal in each avoidance task, the inverse problem for the reconstruction of the shape of the obstacle influence can be solved, giving the exact shape parameters. The objective of this study was to investigate if outputs from the predictive and emergent models were associated with observed experimental outcomes. METHODS: Five healthy and five post-stroke participants were assessed while walking towards a central target and avoiding virtual obstacles that randomly approached from either head-on, or 30° to the left or right, or remained stationary. The association between the predicted distance from the obstacle at the point of passing and the observed predicted distance at passing was investigated, using separate linear regression models for each obstacle approach. The association between maximum change in the elliptical obstacle influence (ratio of the long and short axis length) and the observed dynamic clearance (average weighted distance from the obstacle throughout the avoidance strategy centred at the minimum distance) were investigated. RESULTS:Linear regression analyses revealed that the predicted distance from the obstacle at passing was directly related to the observed distance at passing. The predicted minimum distance explained ≥95% of the variance in the observed distance across obstacle conditions in all participants. The obstacle influence ratio also showed an association with dynamic clearance, but only in avoiding moving obstacles. For diagonally approaching obstacles, both the differential games model output and the dynamic clearance corresponded with variations in avoidance strategies observed in stroke participants. CONCLUSIONS:The mathematical model was supported by experimental data to suggest that both predictive and emergent processes shape obstacle circumvention behaviours along the continuum of normal to altered gait.

Q Neurological diseases

1-Q-83 BALANCE AND PLANTAR PRESSURE OF INDIVIDUALS WITH DIABETES DURING STAIR GAIT

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BACKGROUND AND AIM: Diabetic peripheral neuropathy (DPN) is a dysfunction of the peripheral nerves that restricts sensation from the limbs constraining mobility and quality of life. Furthermore, the foot sensation of DPN individuals is reduced, compromising their balance. To compensate, they generate greater foot pressures while walking - often leading to tissue ulcerations, and lower-extremity amputations. As well, foot pressures during stair gait are greater than level gait. Currently, there are market-available diabetic insoles that claim to offload foot pressure, and limit ulcer formation; however, these insoles have not been examined. The aim of this study is to investigate balance and plantar pressures of individuals with diabetes during stair gait, while wearing three diabetic insoles (and one normal insole). METHODS: Individuals with diabetes (n=7) and reduced plantar sensation were instructed to traverse a seven-step staircase at 'Stair Lab' within the Toronto Rehabilitation Institute, while wearing the four insoles. Balance - center of pressure (COP) range and standard deviation (SD), and foot pressures (peak) were recorded using Medilogic (Germany) pressure insoles placed inside standardized footwear. RESULTS: Overall peak pressures across insoles were not significantly different. Regional pressure analysis of the toe and medial metatarsal displayed no significant difference, expressed as percentage of total foot pressure, between insoles. Prothotics insole displayed significantly less COP (medial/lateral (M/L)) range and SD, and COP (anterior/posterior (A/P)) range versus other insoles. The COP (M/L) SD and range of Prothotics insole (mean SD = 24.3 mm; mean Range =87.2 mm) was significantly less than normal insole (mean SD =30.5 mm, p=0.008; mean Range =106.9 mm, p =0.011, respectively). Further, Prothotics insole displayed significantly less COP (A/P) range (346.9 mm) versus normal insole (442.2 mm, p=0.004). Prothotics insole, only during descent, displayed significantly less COP (A/P) SD (mean = 86.1 mm) versus normal insole (mean = 131.0 mm, p=0.001). CONCLUSIONS: Diabetic insoles worn by individuals with diabetes displayed the same foot pressures as normal insoles. While analyzing regional foot pressures during stair gait (toe and medial metatarsal), all insoles provided similar pressure patterns especially at foot regions most impacted during stair gait. Therefore, these

insoles may not reduce the pressures during stair gait. The relationship of the COP and an individual's center of mass (COM) are important for balance. When the COP range is large the individual may have trouble controlling the COM motion over the step, and an increase in SD influences the fine control of the COM during the stance time of stair gait. Therefore, the Prothotics insole may provide better balance vs. the other insoles. However, analysis of the COM movement will have to be investigated to confirm this conclusion.

1-Q-84 Postural Control Over Multiple Trials of Wii Play in Individuals with Parkinson's Disease

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Aim and Background: Interactive gaming systems, such as the Nintendo WiiFit (Nintendo, Kyoto, Japan) with balance board (WBB) are increasingly used as a postural control rehabilitation tool in Parkinson?s disease (PD). The WBB is an appealing tool because it is compact, lightweight and relatively inexpensive. In addition, its game features allow tracking of progress. These features make the WBB ideal for home-based balance programs where improvement in static and dynamic balance as well as mobility and functional abilities are observed in individuals with PD (Esculier et al., 2012). However, one gap in this research is the consideration of the human-machine interaction of the WiiFit device that could substantially alter interpretation of balance performance. Therefore, the purpose of this study was to assess changes in postural control using the Nintendo WiiFit gaming system during a series of first-time trials among individuals with PD. Methods: Twelve participants (ages 37-70) with PD (Hoehn and Yahr stages 1-3) were included in the study. A Wii Balance Board (Nintendo, Kyoto, Japan) was mounted on top of a force platform (TrueImpulse, Northern Digital Inc., Waterloo). Participants played four trials (70 seconds each) of the WiiFit Soccer Heading Game while kinetic data was recorded at 120Hz. Calculations of range, standard deviation (SD), and velocity of center of pressure (COP) were completed separately in the Anterior-Posterior (AP) and Medial-Lateral (ML) directions. Repeated measures ANOVA compared COP measures over the four trials. Results: No significant differences were found in range or SD of COP throughout the four trials ($p > 0.05$). COP velocity (ML and AP) significantly increased over the trials ($p = 0.043$ and $p = 0.021$), particularly between trials 3- 4 ($p = 0.040$). Conclusions: Magnitude of COP within the first four trials of the WiiFit game play did not alter significantly in individuals with Parkinson?s disease. Rather COP magnitude gradually increased over four trials, indicating that participants gradually deviate further from the center of the platform over multiple trials. COP velocity did significantly increase likely because of increased magnitudes constrained within a set time. These findings contrast with data in healthy young adults who significantly alter COP patterns after one trial of play and then plateau COP excursions (Reed-Jones et al., 2017). The practical implications of this study are that increases in COP movements observed in PD may be due to motor learning of the human-computer interaction and not necessarily improvements in postural control itself. This is an important consideration for researchers and clinicians examining postural control with interactive gaming systems. In addition, these data provide evidence that the benefits of interactive gaming may be that they facilitate exploration of the outer limits of balance capabilities through this interaction process, providing an opportunity to build confidence all while under immediate supervision.

1-Q-85 Effects of side to obstacle circumvention during walking in people with Parkinson's disease

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BACKGROUND AND AIM: Gait is considered a symmetrical task in young healthy individuals. However, increases in walking complexity, such as obstacle circumvention, evidenced asymmetric behavior with increased personal space for the non-dominant side. One of the main characteristics of people with Parkinson's disease (PD) is that symptoms manifest more severely on one side of the body, which could exacerbate gait asymmetry during obstacle circumvention. Therefore, the aim of this study was to investigate the effects of obstacle circumvention of the least and most affected side on personal space and gaze behavior in people with PD and a control group. METHODS: Fifteen people with PD and 15 matched-neurologically healthy individuals (control group) were instructed to walk along a pathway, at a self-selected velocity, and to circumvent an obstacle (0.35 m diameter and 1.30 m height), avoiding contact with it. Each participant performed 5 trials for each side (10 trials in total). The kinematic parameters were recorded by an 8 cameras Vicon Motion System® with a sample rate of 100 samples/s. We calculated the personal space, horizontal distance when participants started to circumvent the obstacle, and strategy to circumvent the obstacle. Gaze behavior was recorded by a mobile eye tracker (ASL) and the following parameters were analyzed: number of fixations, mean duration of fixations, and total time of fixations. In addition, gaze fixations were classified into four different areas of interest: ground, obstacle, wall, and random. The parameters were grouped according to the side that the obstacle was circumvented during the task: people with PD - most and least affected side; control group - dominant and non-dominant side. Personal space and horizontal distance when participants started to circumvent the obstacle were compared by two-way ANOVAs (group X side to obstacle circumvention) with side as repeated measure. For areas of interest, the data were analyzed by three-way ANOVAs (group X side to obstacle circumvention X area of interest), with side and area of interest as repeated measures ($p<0.05$). RESULTS: People with PD presented shorter horizontal distance to the obstacle ($p<0.001$) and smaller personal space ($p<0.004$) when the obstacle was circumvented to the most affected side (Figure 1). In addition, they used a "lead-in" strategy and increased the number ($p<0.001$) and time ($p<0.001$) of fixations on the ground, while these parameters decreased ($p<0.001$) on the obstacle when the obstacle was circumvented to the most affected side. The control group also presented asymmetric behavior, although lesser than people with PD, in the obstacle circumvention strategy, personal space ($p<0.001$), and gaze behavior ($p<0.05$) between sides. CONCLUSIONS: Both people with PD and neurologically healthy individuals presented asymmetric behavior between sides to obstacle circumvention, but this asymmetry was exacerbated in the former. People with PD presented worse motor and perceptual strategies during obstacle circumvention to most affected side compared to the least affected side. Therefore, obstacle circumvention to the most affected side is risky for people with PD. ACKNOWLEDGEMENTS AND FUNDING: FAPESP (#2014/20549-0).

1-Q-86 The use of clinical balance scales to detect balance differences between freezers and non-freezers

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BACKGROUND AND AIM: Postural instability and freezing of gait (FoG) are key features of Parkinson's disease (PD) which are closely related to falls. Although postural instability and FoG often co-occur, it is still unclear whether and how both symptoms overlap. To tackle this question, studies have investigated balance differences between PD patients with and without FoG using two different approaches, i.e. clinical balance scales and posturography. The results from studies using posturography techniques are so far inconclusive. The effectiveness of clinical balance scales to distinguish between both groups has not yet been closely examined. Therefore, the current literature was reviewed to investigate whether clinical balance scales have sufficient discriminative power to detect balance differences between freezers (FR) and non-freezers (NF). METHODS: PubMed was used to search for literature, based on the following search terms mentioned in the title and/or abstract: 'freezing of gait' or 'freezers' in combination with 'posture', 'postural', 'balance', 'stability'. Relevant articles were identified based on screening of titles, abstracts and full-texts. The search strategy was independently performed by two authors and ended on November 15th 2016. A meta-analysis on balance scores of different clinical balance scales was conducted. RESULTS: Nine studies including 570 PD patients (247 FR, 223 NF) reported outcomes of clinical balance scales. A moderate amount of heterogeneity existed (I^2=37%) between studies. Overall clinical balance scores were significantly lower in FR compared to NF (standardized mean difference (SMD) = 0.68; 95% confidence interval (CI): 0.45-0.90, p<0.00001). The Berg Balance Scale was found to be most effective to discriminate between FR and NF (SMD=0.53, 95% CI: 0.31-0.75, p<0.00001) and showed the least amount of heterogeneity (I^2=0%). The Mini-BESTest also significantly discriminated between groups (SMD=1.07; 95% CI: 0.44-1.70, p=0.0008) as well as the BESTest (SMD=1.22; 95% CI: 0.73-1.71, p<0.0001) and the Fullerton Advanced Balance Scale (SMD=0.69; 95% CI: 0.16-1.22, p=0.01). Medication had some influence on the discriminative power. Heterogeneity between studies ON-medication was lower, but both ON- (SMD=0.57; 95% CI: 0.38-0.76, p<0.00001) as OFF-medication (SMD=1.08; 95% CI: 0.31-1.84, p=0.006) balance performance differed between FR and NF. CONCLUSIONS: This review illustrates that clinical balance scales are sufficiently sensitive to detect balance differences between PD patients with and without FoG, regardless of medication state. Due to the substantial heterogeneity and the rather small sample sizes, results should be interpreted with caution. Nevertheless, we provide important evidence for more pronounced postural instability in patients with FoG, which is partially alleviated by medication indicating an involvement of both dopaminergic and nondopaminergic mechanisms.

1-Q-87 Frequency-dependent cortical excitability in rhythmic movement with auditory cues in Parkinson's disease

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BACKGROUND AND AIM: Impaired internal rhythm is noted in patients with Parkinson's disease (PD) and this may interfere with rhythmic movements such as walking and finger tapping. To improve the rhythmic movement problem, auditory cues are often used in clinical setting. However, it is still unknown which frequencies are suitable for patients with PD. Thus the aim of this study was to investigate the effects of applying different frequencies of auditory cues on rhythmic movements and to explore possible electrophysiological change using transcranial magnetic stimulation (TMS). METHODS: This study was a crossover study. Patients were randomly assigned to 1Hz, 2Hz and 3Hz groups. Each patient did rhythmic finger motor practice under both externally-triggered (ET, with rhythmic auditory cues) condition and self-initiated (SI, without auditory cues) condition in random orders. There was one week wash-out period between two conditions. Behavioral assessments included fast tapping task (FTT), synchronization-continuation task (SCT). TMS recording included resting motor threshold (RMT), motor evoked potential (MEP), short intracortical inhibition (SICI) and intracortical facilitation (ICF). Assessments were done before and after motor practice. RESULTS: In behavioral assessments, there was no significant difference before and after motor practice in SI conditions over three frequencies. The coefficient of variance (CV) of SCT decreased significantly in ET condition of 3Hz group. Significant decreased CV of FTT was also noted in ET condition of 2Hz group. In TMS recording, significant increase of SICI was found in ET condition comparing with SI condition over 1Hz, 2Hz and 3 Hz groups. Also, ICF decreased significantly in ET condition of 1 Hz and 3Hz groups. CONCLUSIONS: 2Hz and 3Hz auditory cues could reduce the variation of rhythmic movements. All 1Hz, 2Hz and 3 Hz auditory cues could modulate the inhibitory and excitatory circuits of the motor cortex. We concluded that auditory cues could improve rhythmic movement performance and modulate cortical excitability. Different frequencies in auditory cues may cause frequency-dependent cortical excitability and motor performance.

1-Q-88 Instrumented gait analysis with wearable technology identifies potential markers for Parkinson's disease converters.

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BACKGROUND AND AIM: Parkinson's disease (PD) is a progressive disorder including a prodromal period during which the disease has started but definitive motor and non-motor symptoms to permit a diagnosis have not yet appeared. In people with PD motor/gait impairments are typical and are associated with increased fall risk, loss of independence and poor quality of life. Quantification of gait with wearable technology (WT) may serve as a powerful tool to accurately identify surrogate markers of incipient disease manifestation [1]. Recently arm swing and selective gait characteristics measured with WT have been shown to be potential prodromal markers for people at risk for PD [2]; however these data were obtained from a cross-sectional assessment and the potential of these markers in a longitudinal cohort with persons who eventually convert to PD has not been investigated yet. The aim of this longitudinal prospective observation study was to investigate if a comprehensive set of gait characteristics can predict PD conversion. METHODS: 13 participants (age: 68±5 years) who were diagnosed with PD on average 4 years after baseline assessment (converters (PDC)) and 39 age-matched old healthy adults (HA) recruited in the TREND study were assessed [3]. Data was collected longitudinally at 2-year intervals between 2009 and 2016. For the purpose of this analysis we considered baseline (T1) and first follow-up assessments (T2). Participants were asked to walk at their preferred speed, performing 2 straight-line walking trials over 20m with a WT sensor placed on the lower back. Data were segmented into individual walking trials and 14 validated clinically relevant gait characteristics were evaluated [4]. General linear models were used to examine main effects of group (PDC vs HA) and time (T1 vs T2), and time x group interactions on gait characteristics. RESULTS: Main group effect showed that during preferred walking speed PDC walked with significantly higher variability and asymmetry and shorter step length than HA ($p \leq .037$). There was a significant time effect for step length, step velocity and step length asymmetry which decreased over time ($p \leq .048$) for both groups. Significant time x group interactions were found for step time, swing time variability and step length asymmetry which decreased for PDC and increased for HA ($p \leq .047$). CONCLUSIONS: Our pilot results from a longitudinal prospective observation study with a reasonable number of PD converters suggest that step time, swing time variability and step length asymmetry represent sensitive predictive markers of prodromal PD close to conversion to clinical PD. We see this as a useful basis for further analyses with the existing dataset and for validation purposes in independent cohort studies. ACKNOWLEDGMENTS: We want to thank the TREND study group. REFERENCES: [1]Hobert et al, Acta Neurol Scand, 2014; 130: 139-147 [2]Mirelman et al, Mov Disord, 2016; 31(10):1527-1534 [3]Metzger et al, Front Aging Neurosci, 2016; 8:235 [4]Del Din et al, JBHI, 2016; 20(3):838-847

1-Q-89 Fragile X-associated tremor/ataxia syndrome, Parkinson disease, and essential tremor subjects demonstrate distinct gait and balance deficits under normal, environmentally challenging, and dual-task conditions

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BACKGROUND AND AIMS: Fragile X-associated tremor/ataxia syndrome (FXTAS), a progressive neurodegenerative disease that affects carriers of a ?premutation? size (55-200) CGG repeat expansion in the fragile X mental retardation 1 (FMR1) gene, is often initially diagnosed as Parkinson disease (PD) or essential tremor (ET) due to overlapping motor symptoms. It is critical to characterize the distinct phenotypes in FXTAS compared to PD and ET to improve diagnostic accuracy. Environmentally challenging and dual-task paradigms have the capacity to reveal subtle motor impairments. Therefore, we examined gait and balance performance in FXTAS, PD, ET and controls using these paradigms. METHODS: Subjects with FXTAS (n = 10; mean age 69.70 ± 6.81 years), PD (n = 15; mean age 70.87 ± 7.97 years) and ET (n = 9; mean age 69.56 ± 7.35 years) and controls (n = 12; mean age 64.42 ± 7.12 years) underwent quantitative gait and balance testing using an inertial sensor system (APDM; Oregon). Gait testing included an instrumented Timed Up and Go test (i-TUG) and 2-minute walk test (i-WALK) under self-selected and fast as possible speed and dual-task cognitive interference conditions. Balance testing included the i-SWAY test where stance (feet apart/together), vision (eyes open/closed), surface stability (firm/foam), and cognitive demand (single or dual-task) were manipulated to create increasingly challenging conditions. Dual-task conditions for both gait and balance consisted of performing a concurrent verbal fluency task. RESULTS: During the i-TUG, FXTAS subjects demonstrated significantly increased sit-to- stand peak velocity compared to PD subjects (p = 0.04). During the self-selected speed and dual-task i-WALKs, they showed increased stride length compared to PD subjects (p = 0.03 and 0.04, respectively), and during the self-selected and fast i-WALKS they showed reduced cadence compared to PD subjects (p = 0.03 and 0.04, respectively). On the i-SWAY, both FXTAS and ET subjects demonstrated increased jerk (m2/s5; smoothness of path sway) compared to PD subjects during the foam, feet apart, and eyes closed condition (p = 0.01 and 0.04, respectively). CONCLUSIONS: This pilot data demonstrates that subjects with FXTAS, PD, and ET exhibit distinct deficits in gait and balance under normal, environmentally challenging and dual-task conditions. This suggests that these quantitative measures of gait and balance may be sensitive to distinguish FXTAS from PD. ACKNOWLEDGEMENTS AND FUNDING: This work was supported by the awards from Rush Translational Science Consortium (JO), NFXF Research Fellowship award (ER), and NINDS [R01 NS082416], Shapiro Foundation, National Parkinson Disease Foundation, Pfizer, and Neurocrine (DAH).

1-Q-90 Influence of Osteoarthritis on Disease Characteristics, Mobility and Function in Patients with Parkinson?s Disease

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Both Parkinson's disease (PD) and osteoarthritis (OA) demonstrate deficits in gait brought about by similar symptoms; stiff joints, slowness, inflexibility, weakness, and a need for assistive devices. Although these functional similarities exist, little is known about the impact of OA on gait impairment in persons with PD. This assessment is critical to determine the extra burden that OA may contribute to gait impairment in persons with PD and thus the medical management of these patients. We sought to understand to what extent i) OA severity impacts characteristics of PD and ii) severity of OA influences mobility and function across time. We included 4,428 patients with PD from the National Parkinson's Foundation QII database with available timed up and go (TUG) and OA information at baseline and 1-2 years follow-up (9 months to 27 months after baseline) in this analysis. At baseline 2,538 (57.3%) patients reported no symptoms of OA, 1,047 (23.6%) reported asymptomatic/minimal OA, and 843 (19.1%) reported symptomatic OA (moderate to very severe). Patients with symptomatic OA were older, had higher body mass index, and were more disabled (higher Hoehn and Yahr disease severity, reduced cognition, required assistive help at home and to stand) (all p-values <0.0001). Also, patients with symptomatic OA were more likely to fall and had higher number of symptomatic comorbidities. Patients with symptomatic OA had worse TUG time and functional mobility total scores than patients in the other two groups at both baseline and 1-2 year follow-up (all p-values <0.0001). Both TUG time and functional mobility total scores became worse within each group at the follow-up compared to the baseline (all p-values <0.001). However, the changes were not statistically significant across the three groups (p-values= of 0.243 and 0.077, respectively). Patients with symptomatic OA were less likely to perform the TUG without pushing off than patients in the other two groups at both time points (p-values <0.0001). In all three groups, more patients either pushed off or required the use of an assistive device in order to perform the TUG at the 1-2 years follow-up compared to baseline. Furthermore, when comparing changes in how the TUG was performed (no push-off, push-off, or used walking aide) across the groups, more patients with symptomatic OA got worse than those in the other two groups (19.8% vs 13.3% and 15.3%). Interestingly, more patients with symptomatic OA got better than those in the other two groups (8.2% vs 5.7% and 6.7%) over time (p< 0.0001). These results highlight the impact of concurrent OA may have on disability and mobility performance in persons with PD. Future work must attempt to determine the singular and concurrent contributions of OA and PD to declines in mobility impairment observed in this patient population.

1-Q-91 Lower limb muscle activity underlying temporal gait asymmetry post-stroke

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BACKGROUND AND AIM Improving hemiparetic gait, which is characterized by asymmetry [1], is a major focus of stroke rehabilitation [2]. Spatiotemporal parameters, such as step length and swing/stance times, are used to calculate a symmetry index that describes the quality of gait control [3]. Even when walking speed is normal, significant asymmetry can persist [1]. Temporal gait asymmetry (TGA) is significantly correlated with lower limb motor function as well as ankle spasticity and strength [4]. However, these findings are limited by the use of gross clinical scales or static conditions that do not fully reflect the complex and dynamic nature of gait. A greater understanding of asymmetric gait is required to develop targeted interventions that address the underlying mechanisms and associated negative consequences. Therefore, this study aimed to determine how lower limb muscle activity during overground walking relates to symmetry after stroke. METHODS Individuals post-stroke with and without TGA (based on a swing time ratio cutoff of 1.06 [3]), as well as age- and sex-matched healthy participants, performed multiple self-paced overground gait trials. Electromyography (EMG), motion capture and force plate data were collected. A battery of clinical tests for neurological impairment was administered. The duration of leg muscle activity ("on" time) was obtained from the filtered EMG recording by a single threshold method (>2 SD above baseline). Values are expressed as a percentage of gait phase ± SE. Additional analyses (i.e. temporal organization with respect to gait events, co-contraction, force generation) will be presented at the conference. RESULTS Two individuals with chronic stroke (>1 year post), one with TGA (Participant A) and one without (Participant B) have been analyzed to date; a larger dataset (target n=20) will be presented at the conference. Participant A and B were similar in terms of lower limb motor impairment (Chedoke McMaster Stroke Assessment leg 5, foot 3 and 4, respectively) and self-selected walking speed (0.68 m/s and 0.49 m/s, respectively). In Participant A, "on" time during swing phase was lower in tibialis anterior and medial gastrocnemius on the affected (28±4% and 35±4%, respectively) versus unaffected (91±4% and 71±5%, respectively) side. The inter-limb difference in swing phase EMG activity of tibialis anterior was greater in Participant A

(63±3%) when compared to Participant B (13±3%). CONCLUSIONS This preliminary analysis of two cases suggests that inter-limb differences in the duration of ankle muscle activity during the swing phase of gait are present and may be related to TGA post-stroke. Further analyses and comparison with healthy controls will reveal other effects of stroke on EMG characteristics and elucidate the relationship between muscle activity and gait symmetry. FUNDING: CIHR & NSERC REFERENCES [1] Patterson et al 2008 APMR 89:304 [2] Latham et al 2005 APMR 86:S41 [3] Patterson et al 2010 G&P 31:241 [4] Lauziere et al 2014 Int J Phys Med Rehabil 2:201

1-Q-92 Speeding up Gait in Parkinson's disease

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Background and Aims: Gait speed is the most common outcome measure of clinical trials evaluating interventions to improve mobility in Parkinson's disease (PD). Gait speed is a relatively simple, objective parameter of gait with robust clinimetric properties. However, increasing gait speed does not necessarily reflect improved quality of gait. The aim of this study is to evaluate how changing gait speed influences other gait parameters and whether matching gait speed in people with PD and age-matched controls also matches gait quality. We hypothesized that people with PD can increase their gait speed but faster walking does not normalize all of their gait metrics. Methods: Sixty-seven subjects with PD (H&Y 2-4, age 70±8) and 40 healthy elderly subjects (age 70±8) walked for 2 minutes back and forth over a 7-meter straight path with 180° turns. Two conditions were compared: Self-selected, comfortable speed and as fast as they could (without running). Six inertial sensors placed at the feet, trunk, and arms were used to calculate spatiotemporal gait variables, including cadence, stride length, double support time, stride time variability, arm range of motion (RoM) turning velocity and steps, and trunk range. We also compared gait quality between PD and HC subjects that were matched on gait speed by using the fast walk condition for PD and comfortable walk for HC. This resulted in two groups of 39 subjects each. Results: In the fast walk, subjects with PD walked 0.22 m/s faster (from 0.99 to 1.21 m/s) than in the comfortable walk. Healthy subjects were able to speed up their gait more than PD subjects (0.30 m/s; from 1.20 to 1.50 m/s, $p<.05$). Changes in gait speed from comfortable to fast were strongly correlated with changes in stride length, swing time and double support time ($r>0.7$, $p<.001$), and moderately with arm RoM changes in all subjects ($r = .43$, $p<.001$). In contrast to HC who increased stride length to walk faster, subjects with PD also increased cadence in order to speed up. Stride time variability and trunk motion changes were not associated with changes in gait speed in either group. Turn velocity increased with increased gait speed, but steps to turn did not change. When we matched PD and HC subjects based on gait speed, cadence, stride length, arm RoM, heel angle at foot contact, turn velocity and steps to turn were still significantly impaired in PD, compared to healthy subjects (all p's<.001). Conclusions: Although asking people with PD to walk fast improved several gait measures, the results support our hypothesis that walking at a faster speed does not result in normal gait quality in people with PD. In fact, number of steps to turn, stride time variability and trunk motion parameters showed little modulation by gait speed. These findings have important implications for clinical research. First, it would be good practice to include gait speed as a co-variate when comparing spatial-temporal gait metrics between groups. Second, gait assessment should be extended to include turning and postural measures, which may be independent of gait speed, yet critical for safe mobility. Acknowledgements and Funding: MRF Early Clinical Investigator Award (KS), NIH K99 (MM), NIH R01, VA Merit award (FBH)

1-Q-93 Differentiation of Parkinson's Disease and Atypical Parkinsonian Syndromes through Spatiotemporal Gait Analysis

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BACKGROUND AND AIM: Extensive literature exists on the gait features of Parkinson's disease (PD), however, there is a relative paucity of gait research on the less common atypical parkinsonian syndromes (APD) including Multiple System Atrophy (MSA), Progressive Supranuclear Palsy (PSP), Lewy Body Dementia (LBD), and Corticobasal Degeneration (CBD). Gait disturbance is a debilitating feature of these disorders, and is often refractory to treatment. In addition, different parkinsonian disorders overlap early in their course and differentiation by clinicians can be challenging. The aim of this project was to combine quantitative gait features to aid in the differentiation of Parkinsonian syndromes. METHODS: In a retrospective patient cohort, 66 APD patients (27 MSA, 17 PSP, 15 LBD, and 7 CBD) were identified, with an additional 66 age and gender matched PD controls. Gait parameters were collected in the on-medication state for all participants using a 14-foot GAITRite instrumented walkway as part of routine clinic visits. Clinical measures including the Unified Parkinson's Disease Rating Scale part III (UPDRS-III), Hoehn and Yahr (H&Y), Parkinson's Disease Questionnaire (PDQ-39), Beck Depression Index (BDI), Apathy Scale (AS), and Mini Mental Status Exam (MMSE) were also collected. Continuous variables were presented as means and compared using Analysis of Variance (ANOVA), assuming $p<0.05$ for statistical significance. RESULTS: APD and PD groups included 43 males and 23 females each, 69 ± 10 y.o., of similar stature. The APD group walked significantly slower (86.4 ± 26.1 cm/s vs. 104.7 ± 19.2 cm/s), at a decreased cadence (100.9 ± 10.9 steps/min vs. 106.3 ± 8.6 steps/min), with shorter steps (50.7 ± 11.9 cm vs. 59.2 ± 10.6 cm) ($p<0.01$). Swing, stance, single support, and double support time differences were also statistically significant along with within-subject variability for each gait parameter above ($p<0.05$). For clinical measures, no significant differences in UPDRS III or H&Y were found, however symptom duration was significantly less in APD (9.4 ± 7.6 years vs. 16.3 ± 8.7 years). BDI, AS, MMSE, and six out of eight PDQ-39 scales were all significantly worse in APD ($p<0.05$). Each specific APD (MSA, PSP, LBD, and CBD) was associated with unique combinations of significantly different gait and clinical measures when compared to PD controls. CONCLUSIONS: Our results demonstrate multiple significant gait differences between APD and PD groups of similar motor symptom and stage severities. APD (MSA, PSP, LBD, and CBD) show unique combinations of significantly different measures relative to controls. These findings suggest that detailed gait analysis can be a potential tool to assist in diagnosing different Parkinsonian syndromes and should be further explored in future studies.

R Orthopedic diseases and injuries

1-R-94 Between-leg differences in challenging single-limb balance performance one year following anterior cruciate ligament reconstruction

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BACKGROUND AND AIM: Following anterior cruciate ligament (ACL) rupture, reconstructive surgery (ACLR) is often performed to mechanically stabilise the knee, however functional deficits often persist long after surgery. Impaired single-limb standing balance has been observed in the ACLR limb compared to healthy individuals. However, it remains inconclusive as to whether these same balance deficits exist between the injured and contralateral uninjured limb, during challenging balance tasks, and at a time when patients are permitted to return to sport. Further, concomitant injuries identified at the time of

ACLR can increase the risk of post-traumatic osteoarthritis: one mechanism for this may be altered neuromuscular control which could manifest as balance deficits. This study investigated between-leg differences in static single-limb balance performance with eyes closed, in patients 12 months post-unilateral ACLR. We also explored any associations between concomitant injuries at the time of ACLR and balance performance one year later. METHODS: 100 adults who had undergone a primary hamstring-tendon ACLR 12 months previously (68 male; median [IQR] age: 28.1 [14.1] years) performed tests of single-limb standing balance with the knee in a functional position of 20-30 degrees flexion, with their eyes closed, over 20 seconds (Nintendo Wii Balance Board). Two repetitions were performed on both the ACLR and contralateral uninjured limb. Measures of postural control included centre of pressure (CoP) total path velocity, anterior-posterior and mediolateral range and standard deviation, and were averaged across the two trials. Wilcoxon signed-rank tests for two related samples were used to identify any between-leg (ACLR versus uninjured [control] limb) differences in CoP measures. Multiple linear regression analyses (enter method) were performed to determine whether concomitant injuries or surgery at the time of ACLR were associated with CoP measures (normalised to participants' height) on the surgical limb only. The alpha was set at 0.05. RESULTS: Wilcoxon signed-rank tests showed no significant between-leg differences in single-limb standing balance for any of the CoP measures of interest (all P values >0.686). Further, multiple linear regression analyses showed no significant associations between concomitant meniscectomy or chondral lesions noted at the time of ACLR and measures of single-limb balance on the ACLR limb 12 months post-surgery (all P values >0.213). CONCLUSIONS: Static standing balance on the ACLR limb does not differ to that of the uninjured limb one year post-surgery. In the context of prior research, these findings suggest bilateral balance deficits may exist prior to ACL injury, or appear post-ACL injury or ACLR. Therefore, clinical assessments of balance, and interventions targeting balance performance, should consider both the injured and uninjured limbs during post-ACL injury or post-ACLR rehabilitation programs. ACKNOWLEDGEMENTS AND FUNDING: None to declare.

1-R-95 After Total Knee Replacement Younger Patients are More Physically Active Compared to Older Patients

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After Total Knee Replacement Younger Patients are More Physically Active Compared to Older Patients Brian D. Street California State University, Bakersfield, CA, USA BACKGROUND: Recent national joint replacement registries have reported a significant increase in the frequency of younger patients (<64 years old) undergoing total knee replacement (TKR). Currently, the indication of TKR surgery for younger patients is not universally accepted, as concerns over the longevity of the implanted prosthesis and revision surgery remain. It has been hypothesized that an elevated patient bodyweight, a younger age at surgery, and increased physical activity levels may negatively affect prosthesis longevity. However, continued pain and dysfunction that can accompanying the delay in surgery may increase patient sedentarism and the risk of developing associated chronic illnesses. The physical activity levels of TKR patients is understudied, in particular, for younger patients. AIM: The goal of this project was to objectively measure the activity levels of the younger TKR patient and compare their levels to the typical, older (>65 years old) TKR patient. METHODS: A convenience sample of 44 unilateral TKR patients (six months post-surgery) made up the two experimental groups: 1) younger patient (YP; n=21, 57.2 ± 6.2 years) and 2) older patient (OP; n=23, 75.8 ± 5.5 years). Each participant had an ambulant tri-axial accelerometer (wGT3X-BT, ActiGraph, Pensacola, FL) that was placed around their waist and worn for seven consecutive days. Activity cut points were based on measured counts per minute (cpm); sedentary < 100 cpm; light 100 to 1951 cpm; moderate 1952 to 5724 cpm; vigorous 5725 to 9498 cpm.

RESULTS: The YP group spent a significantly less percentage of time sedentary (84.6 ± 3.0 v. 89.3 ± 5.0%, p = 0.010), significantly more percentage in light physical activity (14.32 ± 2.9 v. 9.44 ± 4.5 %, p = 0.004), and produced significantly more steps each day (4838.1 ± 1989.3 v. 2759.0 ± 1653.5 steps/day, p = 0.008) than the OP group. However, the percentage of time spent in moderate to vigorous physical activity between the YP and OP groups did not differ significantly (1.31 ± 1.0 v. 1.04 ± 1.1 %, p = 0.530). CONCLUSION: The YP group is significantly more active than the OP group, however, the observed age-related differences seem to be associated more with the magnitude rather than the measured intensity of the physical activity. Importantly, neither of the groups met the American Physical Activity Guidelines and would be at an increased risk of developing additional chronic illnesses associated with low physical activity. Future research should seek to create and improve interventions aimed to increase the amount of physical activity engaged in by TKR patients.

S Proprioceptive function and disorders

1-S-96 Is somatosensory function altered in people with Parkinson's disease and Freezing of Gait?

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BACKGROUND AND AIM: Somatosensory dysfunction has been suggested as an underlying mechanism of motor blocks, as freezing of gait (FOG) and upper limb freezing in individuals with Parkinson's disease (PD). However, the number of studies assessing tactile and kinesthetic functions in individuals with motor blocks is close to zero. Hence, the aim of this study was to assess tactile and kinesthetic functions in the upper limb of PD participants with (FOG+) and without FOG (NFOG). Since motor blocks of the upper and lower limbs share very similar mechanisms, we assessed the somatosensory function in the upper limbs to minimize the influence of motor output difficulties usually observed in FOG+. METHODS: Forty-two participants (FOG+, NFOG and healthy elderly: HC; n=14 per group) participated. The tactile function was assessed by the Perceptual Threshold of Touch (PTT) test, using participants' right hand. For that, a pair of electrodes was fixed on the tenar region (cathode) and on the bulb of the index finger (anode). A constant current of 40 Hz with single square pulses with 80 µs of duration was used and the current amplitude was increased in steps of 0.5 mA per second. The PTT was considered as the minimal stimulus level of touch that could be detected. The participants' proprioceptive function was assessed using an elbow Joint Position Sense test (JPS: active-active method). For this test, six reflective markers were positioned on participants' upper limbs and their positions were captured by seven MX-T20 optoelectronic cameras (Vicon, Oxford Metrics, UK). For this test, participants were requested to actively reproduce random degrees of elbow flexion without visual feedback. The wrist 3D spatial error was considered for analyses. RESULTS: Both PD groups showed similar motor disease impairments. No differences between groups were found on the PTT test ($F[2,39]=0.07$; $p=0.93$) showing no tactile dysfunction in both NFOG and FOG+. In contrast, the JPS test showed an impaired kinesthetic function in FOG+: a main effect of group was found for 3D spatial error (FOG+: 23.96+11.93 mm; NFOG: 14.93+4.90 mm; HC: 14.35+6.43 mm; $F[2,39]=5.86$; $p=0.005$). The post-hoc analyses showed that the FOG+ group performed worse than both NFOG and HC ($p<0.02$). No difference between NFOG and HC was found ($p=0.98$). CONCLUSION: Tactile function is preserved in PD, regardless of the presence of FOG. However, people with PD that experience FOG have a markedly kinesthetic dysfunction that is exclusive for this group. These results highlight the importance of the assessment and treatment of kinesthetic deficits in rehabilitative programs for people with FOG.

U Sensorimotor control

1-U-97 Sensory modulation process is associated with gait in ecological conditions but not in a laboratory setting

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Background and Aim: Gait abnormalities increase with the rapidly growing older population. The effect of different sensory systems (i.e., vision, hearing, tactile, and proprioception) on the development of gait abnormalities has been widely explored. However, the effect of an integrated sensory modulation profile on gait is yet to be determined. Moreover, most studies exploring the associations between sensory systems and gait were population-based studies that relied on self-report for walking abilities or were conducted in a laboratory setting with limited ecological characteristics. The aim of this study was to explore the effect of sensory modulation on gait with dual-task in ecological conditions in community-dwelling older adults. Method: Twenty-four community-dwelling older adults (mean age 69.9, SD 4.9) performed a 1-minute walking task, both with and without performing a cognitive arithmetic task (i.e., dual-task paradigm), on a flat surface under laboratory conditions and also outside the laboratory in a crowded area. Gait speed and gait variability were evaluated using the APDM mobility lab system. Sensory processing was evaluated with the Sensory Responsiveness Questionnaire-Intensity Scale (SRQ-IS). The Activities-specific Balance Confidence (ABC) Scale was also administered. Findings: Higher sensory responsiveness was associated with decreased gait speed under both single- and dual-task in ecological conditions outside the laboratory ($r=-.51$, $p=0.01$; $r=-.43$, $p=0.03$, respectively) but not in the laboratory setting after controlling for age. In addition, the sensory modulation profile was associated with balance confidence ($r=-.046$, $p=0.02$). Conclusion: Sensory modulation may shed light on gait abnormalities that lead to an increased risk of falls during daily activities of older adults and should be incorporated into fall examination and treatment.

1-U-98 Added postural sensorimotor training versus added sham exercise in physiotherapy of patients with chronic non-specific low back pain: A randomised controlled pilot trial

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Background and Aim: Sensorimotor training (SMT) is popularly applied as exercise in rehabilitation settings. There is only low quality evidence on its effect on pain and function. This study investigated the effects of SMT in rehabilitation of patients with chronic non-specific low back pain (CNLBP). Methods: In this parallel, single-blinded, randomised controlled trial, two arms received 9x30 minutes physiotherapy (PT). The experimental arm received added 15 minutes of postural SMT on a labile platform. The comparator arm performed 15 minutes of added sub-effective low-intensity training (SLIT). A treatment blinded tester assessed outcomes at baseline (BL) 2-4 days prior to intervention, pre- and post-intervention (T0, T1), and at four-week follow-up (FU). Main outcomes were pain (VAS) and functional status (Oswestry Disability Index, ODI). Postural control variables were analysed using a video-based tracking system and a pressure plate during perturbed stance on a labile platform (sagittal joint-angle variability and centre of pressure derived data). Robust, nonparametric multivariate hypothesis testing was performed. Results: 22 patients (11 females, mean age=55 years (32-75), mean (95%CI) pain at BL=22.5% (17.4-27.6%), ODI at BL=18.1% (13.8-22.5%)) were included for analysis (11 per arm). Mean (95%CI) VAS decreased from 24.8% (17.2-32.3%) at BL to 15.6% (3.3-27.9%) at FU in the SMT group, and from 19.9% (12.1-27.7%) to 15.5% (8.8-22.2%) in the control group ($p=0.94$). Mean (95%CI) ODI decreased from 19.7% (14.4-25.0%) at BL to 8.2% (2.3-14.2%) at FU in the SMT group ($p < 0.01$), and from 16.0% (4.8-27.2%) to 12.3% (7.1-17.5%) in the control group (Pwithin=0.39, Pbetween < 0.001). However, group-by-time interaction effects were non-significant (Q=3.3, p=0.07). Secondary kinematic outcomes did not change over time in either of the groups. Conclusions: Despite significant improvement of ODI after SMT, overall findings of this pilot study suggest that, in patients with moderate CNLBP, 9x15 minutes of added SMT as part of prescribed physiotherapy provides no added benefit for pain reduction or functional improvement. Higher doses may be more effective and results may not apply to patients with higher pain levels. Trial registration: ClinicalTrials.gov: NCT02304120. Please see related study protocol, DOI: 10.1186/1471-2474-15-382

1-U-99 Interaction between proprioception and vision during quiet standing in young healthy adults

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Background and aim: The contribution of proprioception, vision and vestibular information in maintaining standing balance is well documented. It can be examined by altering the information from different sensory modalities and measuring the influence on postural sway. For example, when proprioception is stimulated through muscle vibration it produces postural reactions specific to the vibrated muscles: forward lean during posterior neck muscle vibration, and backward lean during Achilles tendon vibration. Segmental responses to vibrations are known to be affected by vision, however the interaction between proprioceptive and visual information during quiet stance remains to be elucidated. The objective of the present study was to determine how changes to proprioceptive and visual stimulation influence balance during standing in young healthy adults. Methods: Sixteen healthy young participants (9 females, 30±6 years old, average height and weight: 1.72±0.09m, 74±12 kg) stood unrestrained atop two force-platforms (AMTI, MA, USA). Motion analysis (NDI Certus, ON, Canada) captured segmental 3D displacements of the feet, pelvis and head. In total, nine experimental conditions were tested in a pseudo-random order between participants, and evaluated as a combination of 3 visual (normal light, dim light, and eyes closed) and 3 proprioceptive (no vibration, posterior neck muscle vibration, and Achilles vibration) conditions. Vibration started 15 seconds after recording began and lasted for 15 seconds. Relative anteroposterior position of the head, pelvis, feet and centre of pressure (COP) were compared between visual and vibration conditions, before and after the vibration started, using 3-way ANOVAs (vision (3) x vibration (3) x OFF/ON period (2)) and a priori contrasts. Results: Neck vibration produced a significant shift of the COP (p<0.001) and pelvis (p<0.001) anteriorly while Achilles tendon vibration generated a posterior shift of the COP (p<0.001) and pelvis (p<0.001). In addition, the position of the head relative to the pelvis was more anterior during neck vibration for all vision conditions (p<0.023), but was more posterior only under dim light conditions (p=0.009, eyes open: p=0.42, or closed: p=0.25) when Achilles tendon vibration was applied. Conclusion: No interaction appeared between proprioception and vision when comparing the postural reactions to neck and ankle muscle vibrations at the pelvis or COP. However, the effects of Achilles vibration on the trunk under dim lighting conditions highlights that vibration site may play an important role in understanding proprioceptive-vision interactions.

1-U-100 Leg dominance influences the balance response mechanism to a visual perturbation

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BACKGROUND: We are interested in identifying the neural control mechanisms underlying balance during locomotion by investigating the properties of the balance response to a visual perturbation. Previous analyses show a systematic balance response consisting of: 1) a shift of the stance foot center of pressure (CoP) towards the direction of the fall; and 2) a subsequent shift of the swing foot placement in the same direction. Here, we investigate the coordination of these balance mechanisms and the role of leg dominance during a visual perturbation. METHODS: Subjects walked on a self-paced, split-belt instrumented treadmill surrounded by a 220° circular visual screen with a visual display of 3D cubes moving in the sagittal plane that matched the speed of the treadmill and the position of the subject. The perturbation consisted of a right or left rotation of the visual scene around the ankles in the frontal plane initiated at heel strike every 10-13 steps, with a constant acceleration of 60°/sec². Full body kinematics and center of pressure (CoP) under each foot were recorded at 250 Hz and 1000 Hz, respectively. Leg dominance was determined by asking "Which foot do you use to kick a ball?". RESULTS: CoP modulation in the medial/lateral direction under the stance foot of the dominant leg began in the first stance phase ~400ms after the perturbation. The dominant leg created a larger amplitude CoP shift than the non-dominant leg during the first stance phase following perturbation. The dominant leg also created a larger step response than the non-dominant leg. DISCUSSION: Upon close examination of the onset of the balance response there appears to be a systematic asymmetry favoring the dominant leg in generating an effective step response. When the non-dominant leg triggers the stimulus, CoP modulation is minimal, and the dominant leg compensates with a large step response. When the dominant leg triggers the perturbation, a relatively large CoP modulation occurs, leading to a smaller step response of the non-dominant leg. Such results suggest a highly coordinated response between the legs to achieve balance while walking. Neurological trauma that affects the dominant leg may lead to far more severe mobility impairment than trauma affecting the non-dominant side.

1-U-101 Locomotion though apertures as the person-plus-object system:when the body is off the center

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Background and aim Walking on to a subway train while carrying a suitcase or driving a car through a tunnel are examples of locomotion through an aperture as a person-plus-object system. In both cases, the midpoint of the body and the midpoint of the person-plus-object system are not coincident. The impact of this on locomotion through apertures is unknown. We conducted two experiments to investigate this issue. Methods Participants walked while holding a long, horizontal bar (in Experiment 1) or while using a walker (a locomotor-assistance device (Experiment 2) and passed through a narrow aperture. We measured the kinematics of locomotor patterns and spatio-temporal patterns of eye movements both when the body midpoint was at the center (center condition) and when the body midpoint was off the center (always deviated to the right; off-center condition). Results Compared to the center condition, the off-center condition showed: (a) more frequent collisions on the left side (i.e., the far side), (b) no increase in the total number of collision (i.e., task difficulty did not increase), (c) more frequent fixations toward the right side (i.e., the near side), and (d) relatively less impact on kinematics, such as movement speed or head movement. Furthermore, more frequent collisions on the right side were observed during the center condition when participants initially performed this task during the off-center condition and then performed during the center condition, indicating the adaptation to the off-center condition. Conclusion Participants were generally able to adapt to altered action capabilities even when the midpoints of the body and the person-plus-object system are not coincident.

1-U-102 Different Influence of Vision and Touch on Postural Dynamics

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BACKGROUND: There is a general assumption that visual and tactile information have similar roles in postural control. Studies that manipulated the availability of either visual or tactile information showed that, when these are available, the postural sway is decreased. The interpretation is that these sources of information provide a reference in which the postural system rely on. However, the directional trend of cause and effect can be questioned (i.e., does the system vary less to maintain visual input constant or the visual input help the postural system to decrease variability?). From a dynamical systems approach to motor behavior, the answer for such a question is possible when the dynamics of the system is considered. This would provide how the system acts regarding the present constraints, and if vision and tact are similar, the dynamics should be equally influenced. METHODS: We compared the effect of vision and touch in quiet standing in 12 individuals manipulating three variables surface compliance (foam/no foam), vision availability (open/closed eyes) and tactile information availability (finger touch/no finger touch) resulting in 8 conditions performed by all individuals. To compare the postural dynamics, we used correlation dimension - a measure that reconstructs and measures the dimension of the attractor (how the system behaves); and standard deviation as a measure of postural sway. We run a repeated ANOVA to compare all conditions. Here we focus on the differences between vision and touch manipulation. RESULTS: Standard deviation followed previous literature in which both vision and touch decreased the postural sway (vison: $F(1, 11) = 66.193$, $p < .05$; touch: $F(1, 11) = 41.533$, $p < .05$). Correlation dimension showed vision manipulation had no main effect ($F(1,11)=1.638$, $p=.227$) and an interaction between Surface and Vision ($F(1,11) = 6.724$, $p=0.025$). The interaction occurred because vision decreased the dimension in the foam surface compared to no foam condition. Touch manipulation, however, showed a main effect ($F(1,11)=5.788$, $p=0.035$, $\eta p=.345$) in which touch increased the dimension of the attractor. Additionally, there was also an interaction touch and surface (F and p values) in which touch increased the dimension in the rigid surface. CONCLUSIONS: In the light of the present results, we can conclude that vision and tactile information do not constrain the behavior in the same way, contradicting previous interpretations. Although both manipulations decreased the postural sway (replicating previous literature), the touch manipulation introduced more active degrees-of-freedom (in accordance to a reference interpretation) while vision afforded a lower dimensional space. This contradictory result follows from an interpretation that when surface is unstable, and no vision is provided, the individual might increase stiffness to avoid falling (increasing the dimension). Vision might provide general information of body orientation decreasing the constraints (stiffness).
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1-U-103 Circuits for contextually dependent vestibulo-motor reflexes in the mouse

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BACKGROUND AND AIM: Maintaining balance following an external postural perturbation requires the modification of ongoing motor plans in favour of contextually appropriate muscle activations. These motor responses must take in to account body and limb position, strength and direction of the perturbation as well as the environmental surroundings. Little is known regarding the neural circuits that process these different streams of sensory information and ultimately generate motor commands. Our aim is to understand the neural circuits that impart contextual information on the motor centres of the brainstem and spinal cord to generate appropriate motor commands in different environments.

METHODS: We have used a combination of mouse behavioural tests such as balance beam walking with perturbation and traversing unstable platforms of various widths in order to generate varying degrees of postural threat. We have used EMG recordings to record muscle activations to perturbations, optogenetic stimulation of neurons in the lateral vestibular nucleus, and immediate early gene expression to assay the neural circuits involved in behaviour. RESULTS: In recent studies, we have shown that the lateral vestibular nucleus (LVN) contains anatomically and functionally distinct cell types that can generate different modules of a motor program in response to a postural perturbation. Using mouse genetics and transsynaptic tracing we have demonstrated that effective activation of muscle groups by LVN neurons is context-dependent. Optical stimulation of LVN neurons during treadmill locomotion does not elicit muscle activation, whereas the same stimulation during balance beam walking results in a clear motor response. This suggests to us that vestibulo-motor reflexes initiated in the LVN can be gated or modified according to the perceived threat to balance. We have now developed a series of behavioural tasks where mice are trained to walk across elevated platforms which can be perturbed in such a way as to generate a corrective motor response. By varying the width of the elevated walkways or the heights of side barriers, we can adjust the perceived threat without whilst maintaining body posture and level of motor response needed to correct for the perturbation. Using a combination of EMG recordings and immediate early gene expression we have studied the activity of neural circuits that feed in to the LVN and are recruited in these different environments. CONCLUSIONS: Probing the activity of these circuits will help us understand how vestibular sensory information is filtered and gated during different behavioural contexts.

1-U-104 Effect of visual tasks on the coupling between visual information and body oscillation of older adults with and without falling history

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BACKGROUND AND AIM: Eye movements modify the postural stability of older adults compared to fixation and it is associated with visual and postural task challenges. Particularly, older adults with falling history have showed altered gaze and postural control and stronger responses to visual manipulations. However, it is unknown whether the gaze behavior affects the relationship between visual information and body sway of this population. The aim of the study was to investigate the effect of eye movements on coupling between visual information and body sway of older adults with and without falling history. METHODS: Ten older adult fallers (70.4 ± 6.1 years) who fell at least once last year and 10 older adult non-fallers (69.3 ± 3.7 years) stood upright, inside of a "moving room", on a force platform, using an eye tracker device. The room was stationary in the first eight trials and oscillated backward and forward at 0.2 Hz and amplitude of 0.65 cm in the following eight trials. Four visual tasks were performed: free-gaze with absent target (AT); gaze directed to stationary target (ST); and moving target with certain (CT) and uncertain (UT) locations. The target was a filled circle with 3 cm of diameter displayed in the room's frontal wall. In the latter two conditions, the task required horizontal saccades towards the target moved to right or left at 1.1 Hz. Target eccentricity was 11.5 degrees of visual angle. Dependent variables were: mean latency and its variability between horizontal saccades and visual target, number and mean duration of fixations, mean sway amplitude at anterior posterior direction, gain and phase between room's movement and body sway. MANOVAs and ANOVAs were used to compared groups and visual tasks conditions (α=0.05). RESULTS: At stationary room trials, mean amplitude of older fallers was higher than non-fallers and lower at UT compared to ST task. At moving room trials, only older fallers showed lower amplitude at both CT and UT compared with ST and AT tasks and AT task compared to ST one. Older fallers swayed similarly to non-fallers only at UT task condition. For both groups, gain values were lower at UT compared with ST task and phase values indicate body sway slightly ahead to room's movement across conditions. The results showed lower number of fixations and higher mean fixation duration at ST task for both groups. However, higher number of fixations and lower mean fixation duration at CT compared with UT task was observed only at moving room trials. Negative mean latency revealed saccadic anticipation to the target at CT compared to UT task with higher variability at stationary room trials. CONCLUSIONS: These results suggest that gaze behavior associated with the visual task challenge modifies the coupling between visual information and body sway of older adults with and without falling history. However, increased body instability of older fallers, mainly at moving room trials, seems to indicate larger deterioration in the relationship between gaze and postural control which might lead to falls incidence. ACKNOWLEDGEMENTS AND FUNDING: FAPESP #2014/23963-1, #2015/12856-2.

1-U-105 Intra-Modality Re-Weighting in Dyslexic Children's Postural Control

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BACKGROUND AND AIM: Living in an environment with sensory changes requires us to continuously modify the coupling strength between the available sensory stimuli and our body orientation. Such mechanism may differ in children with literacy difficulties. Thus, the aim of this study was to investigate the dynamics of intra-modality re-weighting process by examining dyslexic children's postural control responses to manipulation of visual and somatosensory modalities separately. METHODS: Participated of these study twenty dyslexic and 18 non-dyslexic children. All participants performed one trial standing upright inside of a moving room and another trial lightly touching a moving bar. Both trails lasted 240 seconds, with three different stimulus characteristics: low amplitude (pre transition), high amplitude (transition) and low amplitude (post transition). In the first 60 seconds, the room/bar was moved continuously velocity of 0.6 cm/s and amplitude of 0.6 cm (pre transition). In the 60 seconds subsequent, the room/bar was moved with velocity of 1.75 cm/s and amplitude of 2.9 cm (transition). In the last 120 seconds, the room/bar was moved again with velocity of 0.6 cm/s and amplitude of 0.6 cm (post transition). The movement of the room/bar position and body sway were obtained through Optotrak IREDs, at a sampling rate of 100 Hz, placed on the room/bar and the participant's back, respectively. Body sway magnitude and the relationship between the movement of the room/bar surface and body sway were examined. RESULTS: Visual and somatosensory manipulation induced body sway in all children. Dyslexic children oscillated more than non-dyslexic children in the transition condition when the visual modality was manipulated. However, dyslexic children were less coherent to the visual stimulus manipulation in all condition compared to non-dyslexic children. Furthermore, dyslexic children were more influenced by visual manipulation in the transition and post transition condition compared to non-dyslexic children. Finally, dyslexic children used higher applied force levels in the somatosensory modality in all conditions compared to non-dyslexic children. CONCLUSION: Dyslexic children were not able to re-weighting of the visual sensorial channel in detriment to other sensorial channels. Interestingly, when the manipulation of the visual modality returned to the initial parameter (low amplitude), dyslexic children were not efficient in down-weighting to the presented stimulus, remaining strongly influenced by the visual stimulus. However, the same was not observed in the condition in which there was manipulation of the somatosensory modality. Thus, we can infer that in this condition dyslexic children used additional information from fingertip contact on the moving surface to reduce the influence of the somatosensory movement in all conditions.

1-U-106 Investigating the effect of specific athletic training on performance during a reaction time task

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BACKGROUND AND AIM: Balance control during single support has revealed that soccer players possess more refined maintenance of static balance. However, single leg static balance control is not trained in isolation, therefore measuring balance control while challenging individuals cognitively should further emphasize benefits to soccer training. Cognitive demand during a balance task can be challenged using a Go/No-Go paradigm to elicit variations in balance control among different populations. The purpose of this study was to determine whether there was a difference in single leg balance control of soccer players and non-athletes when completing a reaction time task. It was hypothesized that as the balance task became more cognitively demanding, the difference in balance control between the groups will be greater. METHODS: The study included 10 varsity soccer players (5 females), and 10 gender and age-matched non-athletes. Participants stood in stable single support on a Nintendo Wii Balance board sampled at 100Hz while the Fitlight Trainer system administered a concurrent reaction time task. Five Fitlights were arranged on the floor anterior to the participant in a semicircle at 60°, 30°, and 0° about the midline. Each light illuminated 6 times in random order either all GREEN (Go trials) or mix of GREEN and RED (30%) (Go/No-Go). Participants were instructed to hover over the GREEN lights with their non-stance leg and withhold movements for RED lights. Participants completed a total of 12 trials (2 feet x 2 trial types (Go or Go/NoGo) x 3 trials of each condition). Balance control was quantified by analyzing participants? COP total path length through a two-way mixed ANOVA. RESULTS: COP length showed an interaction between participants and trial type ($F= 4.38$, $P= 0.05$) such that during all Go trials, non-athletes reported longer COP length compared to soccer players ($\bar{x}$Non-Athletes= 121.10m vs. $\bar{x}$Soccer = 106.63m), but there was no difference during the Go/No-Go trials ($\bar{x}$Soccer= 114.98m vs. $\bar{x}$Non-Athletes = 109.10m). CONCLUSION: Responding to GREEN lights with the non-stance foot served as a perturbation to the participants? balance. The shorter COP lengths of the soccer players suggests that their training helps them maintain and control balance during single support better while performing a continuous task, similar to the Go trials. However, this difference disappeared during the more cognitively demanding Go/No-Go trials, which was opposite to our hypothesis. The most likely reason for this finding was that the No-Go trials allowed individuals (all) to recover balance errors accumulated during the hovering movements. ACKNOWLEDGEMENTS: The authors would like to thank and acknowledge Wilfrid Laurier University, the LPMB lab, and NSERC.

1-U-107 Steadiness constraint set by a manual task modulates dynamic balance control

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BACKGROUND AND AIM: Requirement of integration between the control of body balance and manual actions is a challenge particularly evident in sports' skills, like throwing a ball, but it is also present in everyday actions like carrying a glass full of beverage while walking. Anecdotal evidence suggests a bidirectional interaction, so that while performance on the manual component of the task is affected by balance stability, abstract constraints set by the manual action might be thought to modulate body balance control. In this investigation we aimed at evaluating the effect of steadiness requirement imposed by a manual task on dynamic balance control. METHODS: Volunteered for this experiment 20 young healthy university students. The experimental task consisted of keeping upright stance on an oscillatory base of support while holding a cylinder stably on a tray. The manual action imposed different steadiness requirements, with the cylinder lying either on its flat (low constraint) or round (high constraint) side. Oscillation of the support base was produced by a custom-made movable forceplate, with cyclic translations (10 cm amplitude) in the anteroposterior direction during 1 minute.

Evaluation was made with the supporting platform oscillating at 0.4 or 1 Hz. An optoelectronic motion analysis system was used to track passive markers attached to the head, joints of interest and to the tray. Sequence of conditions combining manual task constraint and oscillation frequency was counterbalanced across participants. RESULTS: Analysis revealed that performing the high constraint manual task in the low oscillation frequency led to increased tray steadiness, in association with decreased variability of the head and center of mass sway, and increased amplitude of center of pressure displacement. The high manual task constraint induced also increased amplitudes of shoulder rotation and distinct modes of interjoint coordination, with increased values of relative phase between the hip and shoulder rotations for both low and high oscillation frequencies. CONCLUSIONS: Our results showed that requirement of increased manual steadiness by a voluntary task led to increased stability of dynamic body balance. Modulation of hip-shoulder coordination as a function of manual task constraint seems to represent one of the main loci of the interplay between body balance control and voluntary movements of the upper limbs to stabilize the tray position.

V Tools and methods for posture and gait analysis

1-V-108 Understanding the relationship between postural response latencies and their relationship to visual induced instabilities

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BACKGROUND AND AIM: Limit cycle oscillations (LCOs) are self-sustained periodic fluctuations that indicate dynamic instability in nonlinear, time-delayed systems such that are found in the control of upright human balance. Recent mathematical models predict that LCOs emerge in postural sway when neuromuscular feedback time-delay and gain are high (Chagdes et al. 2016a; Chagdes et al. 2016b). This postural instability has been observed in the standing posture of several populations known to have longer time-delays including concussed young adults and adults with neuromuscular impairment (Chagdes et al. 2016a; Chagdes et al. 2016b). However, the relationship between feedback gain and time-delay that lead to LCOs have yet to be explored experimentally. In this study we examined the neuromuscular time-delay of participants standing quietly under altered visual feedback to examine the relationship between these two parameters as it relates to the onset of LCOs. METHODS: Thirty healthy, young adults free of neurological disorders, impacting balance, or significant visual deficits were recruited. Neuromuscular time-delay was assessed via support surface translations since this paradigm is highly correlated with somatosensory evoked potentials (Cameron et al. 2008). Participants then stood in a moving surround (Neurocom Equitest) that was anti-phase coupled to their center-of-pressure (COP) movements. Feedback was manipulated by altering the magnitude of the visual surround movement ($\theta_{room}/\theta_{sway}$, range 0-2) to amplify perceived sway (effectively increasing feedback gain). COP trajectories were analyzed using a novel wavelet-based technique to identify LCOs (Chagdes et al. 2016a; Chagdes et al. 2016b). RESULTS: Postural response latencies ranged from 109-152 ms (mean = 124.8 ± 8.6 ms). The protocol induced LCOs in 26 of 30 participants. A weak, negative relationship (r = -0.31) between time-delay and the lowest visual gain that produced LCOs was observed. Thus, postural instabilities were induced in healthy, young adults by increasing perceived sway. Furthermore, there was a positive correlation between the numbers of participants experiencing LCOs and the magnitude of visual gain. At the lowest level of visual gain only 4 of 30 individuals experienced LCOs whereas LCOs were induced in 15 of 30 individuals at the largest visual gain. CONCLUSIONS: The negative relationship between time-delay and LCO onset is in agreement with the predictions of the mathematical models and suggests that the emergence of postural instabilities may be related to increases in time-delay and

further exacerbated by high feedback gain. This finding has implications for the assessment and diagnosis of neuromuscular related balance issues through a simple and invasive protocol similar to that used in this study. Further studies will examine this relationship over a wider range of neuromuscular time-delays by recruiting older individuals and individuals with neurological impairment. REFERENCES:
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1-V-109Differences in the instrumented Timed Up and Go during single and dual task conditions among older adults

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INTRODUCTION: Walking while performing a concurrent cognitive task is associated with increased fall risk in older adults. We tested whether an instrumented version of the traditional Timed Up and Go test (iTUG) has added value in unmasking additional impairments compared to single task conditions and whether performance on the dual task iTUG is associated with fall risk. METHODS: 20 older adults (mean age: 77.70 yrs ± 3.46, 50% males) performed the iTUG while wearing a body-fixed sensor on the lower back during single task (ST) and dual task (DT) (i.e., serial subtractions) conditions. iTUG sub-components including walking, transitions, and turning were evaluated. Clinical and subject characteristics included the number of falls in the past year, the Falls Efficacy Scale (FES-I) used to assess fear of falling, and the Four Square Step Test (FSST) used to assess balance and obstacle negotiation abilities. RESULTS: Significant differences were found between conditions in iTUG duration (ST: 10.2±1.8 sec vs. DT: 13.0±3.8 sec, p=0.016). None of the participants had a high fall-risk based on TUG duration. Subjects had a higher number of steps (ST: 10.4±2.3; DT: 12.0±4.0; p=0.003) and longer step duration (ST: 0.56±0.05 sec; DT: 0.64±0.10 sec; p=0.002) in DT as compared to ST. Duration of sit-to-stand tended to be longer in DT (p=0.056) with higher (worse) jerk, representing a less controlled movement (ST: 0.51±0.40 g/sec vs. DT: 0.63±0.49 g/sec, p=0.018). Turn duration increased (ST: 1.54±0.27 sec vs. DT: 1.80±0.42 sec, p=0.023) and correspondingly, axial angular velocity (yaw) decreased (ST: 180.03±40.8 deg/sec vs. DT: 149.50±37.1 deg/sec, p=0.027). The amplitude of pitch movement during stand-to-sit increased during DT, reflecting an increased lean during this phase (ST: 118.5±46.4 deg/sec vs. DT: 129.01±44.5 deg/sec, p=0.019). Changes in transition measures during DT but not ST were related to age and history of falls (r=-0.488, p=0.034 and r=0.495, p=0.031, respectively) while angular velocity during turns in DT was negatively associated with balance measures (FSST) (r=-0.49, p=0.041) and fear of falling (r=-0.43, p=0.029). CONCLUSIONS: Older adults tended to perform worse on multiple aspects of the DT iTUG. Measures of turn and transitions during DT are associated with age, balance, history of falls and fear of falling, while these associations are not seen during the ST iTUG. The findings suggest that performing the iTUG with a cognitive load can unmask additional impairments and can be valuable in quantifying mobility and identifying fall risk in older adults.

1-V-110Assessing the association between sensory perception and mobility performance using inertial sensors

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BACKGROUND and AIM: Sensory deficits of the visual, somatosensory and vestibular system may affect everyday mobility performances such as rising from a chair, walking, or turning, and in turn increase the fall risk. Currently used traditional mobility assessments such as the Timed Up and Go Test (TUG) do not allow a specific assessment of underlying balance deficits and performance of sensory subsystem. New sensor-based versions of the TUG may enable specific assessment of the mechanisms causing functional deficits. The aim of this study was to explore the association between sensory subsystems and functional performance (TUG) measured by inertial sensors. METHODS: Forty-one community dwelling older adults (Ø 73 years, 58-89 years) were included in this study. Mobility was measured with an instrumented TUG (iTUG) using a smartphone mounted on the lower back. The time of the total TUG and the time of the TUG subphases including sit-to-walk, walk, turn, turn-to-sit and sit-down was extracted. Additionally, subjects underwent sensor-based posturography in a stance position with feet hip width apart (20 seconds) under four conditions: a) eyes open, b) eyes closed on firm surface, c) eyes open on foam, d) eyes closed on foam. Based on posturography, the performance of each sensory subsystem was calculated as visual, somatosensory and vestibular ratio using validated algorithms (Horlings et al. 2008). Participants were subdivided into high and low functional performers based on total TUG time and based on time of each TUG subphases. High and low functional performers were compared using Student's t-tests in order to explore potential differences in sensory subsystems. Cohen's d effect sizes were calculated to express the discriminative power. RESULTS: For the total duration of the iTUG significantly higher values for the somatosensory ratio (p=0.01, ES=1.02) and lower values for the vestibular ratio (p=0.01, ES=-1.15) were found in low performers as compared to high performers. Likewise, for the iTUG walking subphase significantly higher somatosensory ratios (p=0.00, ES=0.96) and lower vestibular ratios (p=0.01, ES=-0.86) were found in low performers compared to high performers. For the turning subphase significantly lower vestibular ratios (p=0.03, ES=-0.69) were found in low performers compared to high performers. No significant between groups differences in sensory subsystems were found for the iTUG subphases sit-to-walk, turn-to-sit and sit-down (p=0.08-0.59, ES=0.17-0.57). CONCLUSION: High functional performers showed a higher vestibular ratio than the low performers. In contrast, for the somatosensory ratio low performers had higher values. Our results may indicate that age-related decline in the vestibular system adversely affects everyday functional performances. Specifically, the iTUG subphases of walking and turning are sensitive to detect a decline in sensory subsystems. Our results may help to inform a specific sensor-based assessment

1-V-111Proposal of the Multiple Objective Optimal Design Example concerning the Structure of Mobile Force Plate Based on Biomechanical Evidence during Gait

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The importance of rehabilitation in the treatment for walking disorders due to such illnesses as strokes continues to increase. When physical therapists instruct a patient during rehabilitation, information about joint moment of lower limb is very useful. In the past, joint moment of lower limb has been calculated by inverse dynamics applied to data obtained from a force plate and three-dimensional motion analysis system, including high-speed infrared cameras. However, because these analysis devices must be installed in experimental facilities at a purpose-built structure, their use conditions and measurable amount of steps are limited. If multiple force plates are installed, a large space and great expense are necessary, and the possibility is very low. In addition, the locations of the force plates cannot match the steps of all people. A method to resolve those problems can be converting force plates and the three-dimensional motion analysis system into wearable devices. Therefore, the wearable gait motion analysis system using mobile force plate and attitude sensor has been developed for the unrestrained gait measurement. As a result of the experiments, the behaviors of each load component along a gait cycle are understood and the effectiveness of the developed gait motion analysis system including the mobile force plate to analyze human biomechanics and kinematics during gait and refine the rehabilitation program was validated. However, structural optimization of the mobile force plate based on the ground reaction force patterns during normal gait as the experimental evidence consistent with biomechanics has not been investigated yet. In this paper, we showed a new optimum design example of the mobile force plate through the numerical simulation by applying proposed the structural optimization technique for multiple objective optimization using finite element analysis, response surface method, desirability function, design of experiments and mathematical programming. As a result of inputting each load condition by using ground reaction forces for stamping as biomechanical evidence when walking forward, we could optimize the structure of the mobile force plate as the minimization of several dimensions based on the maximization of strains to each axis direction of the elements and nodes of maximum principle stresses on the force plate. Finally, we performed characteristics evaluation by applying optimum design variables to the simulation model of finite element analysis and validated the effectiveness of the proposed multiple objective optimum design of the mobile force plate by obtaining sufficiently improved evaluation indices concerning each contact condition to the floor.

1-V-112Simplification of a whole-body anthropometric model to quantify postural stability in response to a surface perturbation

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BACKGROUND AND AIM: Destabilizing events (e.g. support-surface perturbations) require the central nervous system to elicit postural responses to maintain upright balance (i.e. stability). Hof et al. (2005, J Biomech, 38(1):1-8) proposed a spatial measure to quantify the state of dynamic stability (margin of stability; MoS) based on the inverted pendulum model. This stability model specifically accounts for velocity and displacement of the whole-body centre of mass (CoM), which must be maintained within the base of support (BoS). To quantify CoM via kinematic analyses, researchers use anthropometric models often simplifying them (i.e. excluding body segments) due to certain constraints (Winter et al. 1998, J Neurophysiol, 3(4):193-214; Kubo et al. 2006, Gait Posture, 23(4):512-18; Worden et al. 2016, J Motor Behav, 48(5):455-67). Thus, the purpose of this study was to examine how altering the number of body segments included in the CoM model will influence dynamic margin of stability metrics during a support-surface perturbation task. METHODS: Ten healthy young adults (5 males) completed thirty-two trials that required them to respond to one of eight support-surface perturbations (four directions × two magnitudes). Within each trial, kinematic data was collected to quantify the position of the whole-body CoM using four variations of the Winter et al. (1998) model: WFM = full model; WNA = Winter model excl. arms; WNL = Winter model excl. legs; WHTP = Winter excl. legs and arms. For small perturbation conditions (postural response using fixed BoS), minimum sagittal and frontal MoS were quantified using (and compared between) each of these CoM models. For large perturbation conditions (postural response using step), sagittal and frontal MoS at step contact were examined similarly. RESULTS: Comparisons of MoS made between simplified CoM models (WNA, WNL, and WHTP) and WFM revealed significant CoM model effects. For small perturbation conditions, WNL had a significant effect on sagittal MoS for backwards ($p < 0.001$) and frontal MoS for right perturbations ($p = 0.046$). WHTP had a significant effect on sagittal MoS for backwards ($p < 0.001$), left ($p = 0.036$), and right ($p = 0.014$) perturbations. For large perturbation conditions, WNL had a significant effect on sagittal MoS for backwards perturbations ($p = 0.028$); WHTP had an effect on backwards ($p = 0.011$) and right ($p = 0.020$). CONCLUSIONS: All model effects manifested as underestimation of the MoS relative to WFM (i.e. CoM was closer to/beyond boundaries of BoS). Though simplification of the CoM model had an effect on quantifications of MoS, use of this method remains viable; though this should be limited to examinations of frontal MoS following support-surface perturbations. Examination of sagittal MoS necessitates inclusion of all body segments with the exception of the upper limbs. Future work will examine how these simplified models represent dynamic stability for other tasks (e.g. gait).

1-V-113Measuring the Subjective Postural Vertical: Evaluation of the Test Procedure

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Background and aim: The internal estimate of verticality can be assessed through the subjective visual, haptic, or postural vertical (SPV) using the method of adjustment, also called the method of average error. It?s a classical psychological procedure in which a person is asked to control and alter a test stimulus until it is the same as a reference stimulus. In SPV assessment subjects are asked to adjust their body position to what they consider to be upright. The adjustments are performed starting from a set of varying tilted test stimuli (i.e., tilted body positions) resulting in an average error value. This value, however, could possibly be biased by the tilt offset from vertical of the test stimuli or the sequence in which these stimuli are presented. The aim of this study is to investigate the influence of these factors (tilt offset and sequence) on the estimation of verticality. Methods: The SPV was assessed during standing using a device (Spacecurl, Physio Boerse, Germany) that allows rotation of the subject around each body axis separately. The subjects were tilted passively and had to verbally identify the position that they felt to be upright. The SPV was first assessed in the sagittal plane and afterwards in the frontal plane. One sequence of six stimuli (12°, 15°, and 18°; each in either direction) was conducted per subject and plane, chosen out of the 36 possible permutations. In order to have n=5 data per permutation, a total of 180 healthy subjects (HS) is intended to enroll into this study. Absolute error was calculated as the main outcome parameter. Results: This interim analysis was performed after inclusion of n=112 HS. The 2-way repeated measurement ANOVA for the sagittal plane showed significant main effects for tilt and sequence, and a significant interaction ($p<.00$). Tukey-HSD tests for pair wise comparisons revealed that the tilt offset produced significantly ($p<.023$) different values (12°: 1.7; 15°: 2.1; 18°: 2.5), and that the first 2 values of a sequence were significantly different compared to the following 4 values. Results for the frontal plane showed significant main effects for tilt and sequence ($p<.033$). Although showing a significant main effect for sequence, Tukey-HSD identified only one homogeneous subset. Regarding the tilt the 18° offset was significantly different compared to the other offsets (12°: 1.2; 15°: 1.3; 18°: 1.6). Conclusions: Keeping in mind that these data are not fully balanced yet, they might indicate that the first two stimuli should be tested a second time within a sequence, while the first two stimuli should be excluded from calculating the SPV in the pitch plane. Tilt offset seems to be an influencing factor as significant different values were found. Further studies should therefore report the applied tilt offset angles used to measure the SPV. Results for the dataset of n=180 HS will be presented at the conference.

1-V-114The design of an obstacle device for treadmill gait studies

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BACKGROUND AND AIM: The ability to navigate through complex environments is crucial for safe mobility. We frequently negotiate obstacles during locomotion in daily life, which requires adjustments to the regular gait pattern. Obstacle avoidance tasks are also commonly used in experiments probing the mechanisms controlling adaptive locomotion. Laboratory settings allow accurate and comprehensive assessment of locomotor behavior, however physical space constraints often restrict the number of successive gait cycles that could be recorded and analyzed. To overcome issues of space and gait continuity, treadmills are conveniently used in gait studies. However, in order to study adaptive locomotion, devices should be customized to deliver perturbations or release obstacles while the participant is walking on the treadmill. Previous studies have successfully used an obstacle attached to a magnetic that is unexpectedly released on the treadmill (Schillings et al, J Neurosci Methods, 1996; 67:11-17). In such setup, the obstacle is released very close to the feet, constraining the time available for preparation to negotiate the incoming obstacle. To overcome this challenge we designed a new obstacle device with lengthened approach phase prior to obstacle negotiation and independent speed control to study adaptive locomotion. METHODS: Two metal rails, one on each side of the treadmill run from 2m-long beyond the front of the treadmill to the end of the treadmill (Figure 1a). Each rail has a belt where a vertical pole (15cm height, adjustable) is attached. A paper ribbon running between the poles served as an obstacle because it can be easily broken in the event of a collision with the lower limbs. The vertical poles move symmetrically along the rail via a motor that can be controlled programmatically or manually, with settings for speed, acceleration, movement onset, start and end position. We asked a participant to walk on the treadmill at a constant speed of 1.12m/s and step over the obstacle. The obstacle approached the treadmill at either 0.82, 1.12 and 1.23m/s. Subject's feet and obstacle were tracked by a motion capture system. RESULTS: The preset obstacle speeds were confirmed by the motion capture data and the speeds tested allowed between 3-5 steps prior to obstacle negotiation. Foot movement over the obstacle followed expected trajectories (Figure 1b). Average foot clearance was 21.8±2.4cm (23.9±2.1cm, 20.5±3.7cm, 20.9±3.0cm, respectively for obstacle speeds of 0.82, 1.12 and 1.23m/s). CONCLUSIONS: The device allowed the independent control of an approaching obstacle during treadmill walking, which can be a useful tool for the investigation of adaptive locomotion in restricted laboratory space. Additionally, the extended 2m-long obstacle approach in front of the treadmill is an important feature for the study of vision-mediated anticipatory gait adjustments.

1-V-115Can foot placement errors accurately be derived from center of pressure data?

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BACKGROUND AND AIM: The ability to flexibly adjust foot placements in response to environmental demands, i.e. step adjustment, is essential for safe ambulation in daily life[1]. Step adjustment can be tested by stepping towards a target that suddenly changes position during the step, with the foot placement error (FPE) relative to the new target position as the primary outcome measure. The use of this so-called step adjustment test has yet been confined to laboratory settings, because a 3D motion capture system is needed for measuring the FPEs. The aim of this study was to determine the validity of force-plate derived measures for assessing FPEs compared to a motion capture system as the gold standard. METHODS: Fourteen healthy participants (24.5±8.3 years, 1 male) performed the step adjustment test on a dual-belt treadmill (Motekforce Link BV, Amsterdam, NL) with two embedded force-plates. They stood barefoot with their feet in two rectangles (20 cm apart) projected on the belt´s surface. In each trial, an initial target was displayed 14 cm in front of the stepping leg. Participants were instructed to step as fast and accurate as possible to the target and subsequently place the other foot alongside. In 20 of the 50 trials the initial target randomly ´jumped´ 14 cm in forward (FW), backward (BW), medial (MED) or lateral (LAT) direction (5 trials in each direction) at foot off. FPEs were calculated at foot contact of the trailing leg as the anteroposterior (FW and BW jumps) or mediolateral (MED and LAT jumps) distance between the target center and 1) the leading foot center (i.e. mean of the markers placed on the calcaneus and 2nd metatarsal) as recorded by motion capture (Vicon Motion Systems,

Oxford, UK), 2) the position of the Center of Pressure (CoP) as derived from the force-plate data. The agreement between Vicon and force-plate derived FPEs for individual jump trials was determined from Bland Altman plots. RESULTS: The foot center undershot the target center with FPEs ranging from 30.3±20.7 to 43.4±29.9 mm as measured with Vicon. For CoP-derived FPEs, these values ranged from 27.3±21.0 to 60.9±34.8 mm. The agreement in FPEs between systems was higher for jumps in ML direction (systematic error ± random error: -3.7±11.3 mm (MED, Fig 1A); -3.0±12.9 mm (LAT, Fig 1B)) than in AP direction (1.5±38.7 mm (FW, Fig 1C); 23.3±69.3 mm (BW, Fig 1D)). CONCLUSIONS: FPEs in anteroposterior direction could not accurately be derived from CoP data, as indicated by the large random errors (BW: 69.3 mm which is 49.5% of target displacement). FPEs in mediolateral direction were more accurately estimated (random error: 8.1% (MED) and 9.2% (LAT) of target displacement) from the CoP position, and may be sufficiently accurate for identifying persons with pronounced impairments in step adaptability[2]. Yet, for this purpose it may not add much to the naked clinical eye.
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1-V-116The effect of walking speed on quality of gait in older adults
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BACKGROUND AND AIM: Gait quality characteristics estimated from daily-life trunk accelerometry can contribute to the identification of individuals at high risk of falls (Rispens et al., JNER 2016; van Schooten et al., PLoS one 2016). Since older adults with high fall risk tend to walk slower than older adults with a lower fall risk, walking speed may explain the differences in characteristics of stability, smoothness and regularity found between these groups. Therefore, the aim of this study was to study the effect of walking speed on these gait quality characteristics estimated from trunk accelerometry in older adults. METHODS: We invited 11 older people (aged 70 ± 4 yrs) to walk on a treadmill for 5 minutes per speed at 0.5, 0.8, 1.1 and 1.4 m/s. Participants wore a tri-axial accelerometer on their lower back, which recorded trunk accelerations in vertical (VT), mediolateral (ML), anteroposterior (AP) direction at 100 samples per second. From these trunk accelerations, we determined the step frequency, root mean square, harmonic ratio, index of harmonicity, sample entropy and logarithmic divergence rate per stride. RESULTS: All gait characteristics were significantly affected by walking speed, except for sample entropy in AP direction. An increase in gait speed resulted in a higher stride frequency, root mean square, harmonic ratio and lower logarithmic divergence rate per stride. For the index of harmonicity and sample entropy, we observed direction dependent effects. With increasing walking speed, index of harmonicity in VT direction increased, while in ML and AP directions it decreased. Sample entropy decreased slightly in VT and increased higher in ML direction with higher walking speeds. CONCLUSIONS: An increase in walking speed in older adults resulted in higher gait intensity, more symmetry, and stability, reflecting qualitatively better gait. Increased walking speed further led to higher gait smoothness and regularity in VT, lower smoothness in ML and lower smoothness and regularity in AP direction, all indicative of qualitatively better gait. Our results suggest that differences in walking speed between people at high or low risk for falls might partially explain differences in gait quality between these groups. Future studies are required to determine whether a slower habitual walking speed among people with a high risk for falls is due to impaired neuromuscular capacities or a compensation to maintain balance.

1-V-117Effect of ageing on the misalignment of the desired and measured center of pressure during straight walking
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BACKGROUND AND AIM: The dynamic postural instability of human gait due to ageing, impairment and disease has been attracting a lot of attention. As a measure of the dynamic postural instability, we have proposed a use of the desired center of pressure (dCOP), defined as a virtual point on the ground where the moment around the body center of mass (COM) becomes zero when dCOP and the measured COP (mCOP) coincide [1]. The misalignment of dCOP and mCOP (dCOP-mCOP) is proportional to the moment around the body COM, and hence can relate to the dynamic postural instability. Therefore, we hypothesized that the dynamic postural instability of the human gait due to ageing may be caused by the increased misalignment of dCOP-mCOP. This study aimed to examine the age effect on the dCOP-mCOP values during straight walking. METHODS: Kinetic and kinematic data for 215 subjects (20-77 yrs.) published in National Institute of Advanced Industrial Science and Technology, Gait Database 2015 [2] were used for the analysis. Six force plates and a three-dimensional motion capture system were used to measure body kinetics and kinematics. The whole body COM position was estimated from kinematic data. The global center of pressure of the whole body, i.e., mCOP, was calculated using the force plate data. Subjects were instructed to walk straight on a level floor at their normal walking speed five times. The dCOP-mCOP time courses in the mediolateral (ML) and anteroposterior (AP) directions were compared among age groups (20-24, 25-44, 45-64, and 65-77 yrs.). As a comparison, COM-COP values in the ML and AP directions were also evaluated. RESULTS: The dynamic postural instability at heel contact was assessed, since we assume that the foot location at each foot contact may be affected by ageing. A one-way ANOVA revealed that there was a significant difference in the dCOP-mCOP in the ML direction among age groups ($p < 0.01$). A post-hoc analysis revealed that the dCOP-mCOP in the ML direction was significantly larger in older adults (65-77 yrs.) (0.012±0.007 m) than younger age groups (0.008±0.005 m for 20-24 yrs., $p < 0.001$; 0.008±0.006 m for 25-44 yrs., $p < 0.05$). On the other hand, the dCOP-mCOP in the AP directions and the COM-COP values in both directions were not significantly different among age groups ($p > 0.05$). CONCLUSIONS: These results suggest that the age related change in the COP control at each foot location, particularly in the ML direction, increase the misalignment of dCOP and mCOP, inducing a large moment and resulting in gait instability of older adults. The results also suggest the feasibility of dCOP concept in assessing the dynamic postural instability compared to COM-COP. ACKNOWLEDGEMENTS AND FUNDING: This work was partially supported by JSPS KAKENHI Grant Number 16K06038. REFERENCES: [1] Takeshi Yamaguchi, et al. Misalignment of the Desired and Measured Center of Pressure Describes Falls Caused by Slip during Turning, PLoS ONE 11(5): e0155418. [2] Yoshiyuki Kobayashi, Hiroaki Hobara, Masaaki Mochimaru, 2015: AIST Gait Database 2015. http://www.dh.aist.go.jp/database/gait2015/

W Vestibular function and disorders

1-W-118 Updated norms in balance testing for screening vestibular functionUpdated norms in balance testing for screening vestibular function

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Background and Aim: For several years we have worked on developing new screening tests of balance. We have modified the battery, reduced the number of balance tests and modified the procedure for some test. The goal of the study was to determine if ROC values, sensitivity and specificity high enough for tests to be clinically useful. Methods: Subjects were 2i2 controls and 92 patients with vestibular disorders. They were tested on tandem walking with eyes closed, three trials, with socks but no shoes; and they were tested on the Romberg on medium density complaint foam (Sunmate; Dynamic Systems), with feet adjacent and head still, head moving at 0.3 Hz in yaw and head moving at 0.3 Hz in pitch. Inertial motion units were used to collect kinematic data and trial duration. Results: ROC values for Tandem Walking with eyes closed were between 0.7 and 0.80, for percent of correct steps out of 10 and were approximately 0.5 for duration. These values were too low for both good sensitivity and specificity. The test identified control subjects well but not patients. Kinematic measures provided no value for screening due to low ROC values. Therefore, tandem walking is not recommended for clinical use in screening patients for vestibular disorders. Romberg on foam with eyes closed, either head still or head moving in pitch or yaw at 0.3 Hz had ROC values from 0.68 to 0.88. ROC values were better in age groups older than 50 years and even better in seniors. Sensitivity and specificity were better for head movement trials than with head still, ranging from 0.65 to 0.88. Age-related differences were found in all three conditions. Scores decrease around late middle age, mid-50?s and again around late 70?s. Therefore, when using this test for screening patients for vestibular disorders, age-based norms should be used, either by decade or age group. Conclusions: We recommend against use of tandem walking with eyes closed for screening patients for vestibular disorders because the ROC values are too low. ROC values, sensitivity and specificity are better for Romberg on foam, especially with head moving. Therefore we can recommend this test for screening, Supported by NIH grant 2R01DC009031 (HSC), grants from the National Space Biomedical Research Institute through NASA NCC 9-58 (APM, JB) and a fellowship from the Austria Marshall Plan Foundation (JS).

1-W-119 Sound determines the gait pattern of hearing impaired adults: results from a pilot study

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Background and Aim: Given their common location in the inner ear, an impairment of the cochlea can also affect the vestibular sense organs, and thereby contribute to impaired balance and poorer physical functioning. In this preliminary study, we aim to explore how auditory information influences gait parameters in adults wearing a cochlear implant (CI) and presenting with bilateral vestibular loss. Methods: Eight adults (7 males, 1 female, mean age 61 ± 14 years) fitting the inclusion criteria were instructed to walk barefoot overground at self-selected speed in three different conditions: with CI turned on, while listening to music and with CI turned off. Variables of interest were spatiotemporal and kinematic parameters of gait calculated according to the Plug-In Gait model. Results: Removing auditory feedback by turning off the CI decreased stride time (Δ = 0.03s ± 0.13s), decreased hip flexion (Δ = 2° ± 8°) and increased knee flexion (Δ = 2° ± 7°) compared to the control condition with the CI on. Walking while playing music positively affected gait compared to walking with the CI on but without augmented feedback. By increasing the range of motion in the hip (Δ = 2° ± 5°), stride length increased (Δ = 0.07m ± 0.2m), while stride time decreased (Δ = 0.06s ± 0.10s). Conclusion: The results confirm the hypothesis that addition of auditory cues can improve gait in patients with hearing loss and vestibular loss. Music as a means of providing auditory cues to improve mobility should be further explored. Acknowledgements and Funding: This study is made possible by means of a Hercules Grant type 2 for medium sized research infrastructure from the Flemish Research Council (AUHA/09/006).

1-W-120 Postural responses to galvanic vestibular stimulation in adolescents with idiopathic scoliosis

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BACKGROUND AND AIM: One of the most appealing hypotheses about the origin of Adolescents Idiopathic Scoliosis (AIS) attributes the asymmetric action of the paraspinal muscles to an abnormal vestibulospinal drive resulting in a differential mechanical pull on the spine(1). Galvanic Vestibular Stimulation (GVS) employed to elicit postural reflexes of vestibular origin revealed larger in amplitude but not asymmetric responses in AIS suggesting an impairment in the sensorimotor networks processing vestibular information rather than a deficit of peripheral vestibular origin (2). In the present study, we examined the asymmetry and timing of the postural and muscle reflexes elicited by GVS in an effort to shed additional light into the above hypothesis. METHODS: Participants of two groups (AIS adolescents, n=9, age: 14.34±1.54,height: 1.62±.05, weight:49.17±7.98, Cobb angle: 26.33±11.08o and healthy age and gender matched controls, n=8, age:13.99±.96,height:1.64±.04,weight:51.31±4.95) stood for 100s with eyes closed on two adjacent force platforms while 10 binaural, bipolar GVS pulses (2s, square-wave, 1.2±.42 mA) were randomly delivered (8 trials). Current polarity was randomly alternated between successive stimuli. Postural responses to a total of 40 stimuli on each side were aggregated before calculating response onset, peak vertical force and integrated EMG activity of peroneus longus (PER), gluteus medius (GL) and lumbar erector spinae (ES) during and 1s after GVS. Parameters were compared between groups and body sides using non-parametric statistics. RESULTS: Postural responses to GVS were delayed in AIS compared to control group participants (right side: U=1, p=. 000, left side: U=12, p=. 021). This was accompanied by greater response amplitude (Fig 1) that was not statistically confirmed (U=21, p=. 167). AIS participants had marginally greater right ES (U=17, p=. 05) and GL (U=18, p=. 05) IEMG activity than controls after GVS offset. No significant right-left asymmetries were found in any of the postural and EMG parameters. CONCLUSIONS: Results confirm previous studies (2) showing greater but not asymmetric GVS responses in AIS. The observed delayed response onset in AIS participants provides new evidence in support of a peripheral deficit affecting the vestibulomotor response pathway in addition to sensorimotor integration limitations. More research is necessary to validate the observed findings. ACKNOWLEDGEMENTS: Research received funding from the Spine Society of Europe (EUROSPINE) REFERENCES 1. Lambert FM, et al J Neurosci. 2013;33(16):6845?56. 2. Pialasse J, et al. 2015; PLOS ONE DOI:10.1371/journal.pone.01431241?12.

1-W-121 A multifaceted tailored randomised-controlled trial to improve quality of life, balance and gait in older people with dizziness

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BACKGROUND AND AIM: Dizziness is a frequent complaint, increasing with age and affecting up to 30% of community-dwelling older adults. Its multifactorial etiology makes it difficult to investigate and if untreated, dizziness can lead to reduced quality of life, functional disability, depression, restricted participation in social activities and falls. The study aims were to: (i) Improve the diagnosis for dizziness in older people with a multidisciplinary assessment; and (ii) assess the effectiveness of a tailored multifaceted dizziness intervention in a randomised controlled trial. METHODS: 308 community-dwelling people (mean (SD) age 68 (8) years, 63% females) who reported a significant episode of dizziness in the 12months prior, completed the dizziness handicap inventory (DHI) (physical, functional and emotional burden) and questionnaires regarding medical history and falls in the past 12 months. They also underwent assessments of vestibular function (Dix-Hallpike, head shaking and head impulse tests), anxiety and depression, strength, balance and gait. Participants were then randomised to intervention or control groups, and based on their test performances, intervention participants were allocated to one or more interventions: vestibular rehabilitation, cognitive behavioural therapy, medical/medication management by a general practitioner or at a falls clinic and strength and balance exercises using the Otago exercise program. RESULTS: At the completion of the six month trial and compared with baseline, median (IQR) DHI scores in the intervention group were significantly reduced compared with the control group - (baseline: 20(26) vs. 22(20.5); re-assessment: 14(19) vs. 18(22) respectively, p=0.004). There were also indications for fewer dizziness episodes (incidence rate ratio=0.86, 95%CI 0.64-1.14) in the intervention group, and intervention-specific improvements in those allocated to the four intervention types. CONCLUSIONS: The findings indicate that a multifactorial approach for treating dizziness is effective in reducing dizziness handicap in older people. ACKNOWLEDGEMENTS AND FUNDING: NHMRC project grant funding: 1026726; ANZ Clinical trial registry: 12612000379819

X Visual function and disorders

1-X-122 Visualization of gaze shifting performance of healthy subjects and patients with neurodegenerative diseases

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BACKGROUND AND AIM: Rapid eye-head movements are an essential part of, and prerequisite for successful mobility and daily activity. They are needed in particular during walking situations. This function is obviously affected by aging and neurodegenerative diseases, and the investigation as well as visualization of the movement is considered difficult. This study aimed at visualizing disease-specific movement patterns of rapid eye-head movements ("gaze shifting") by applying an innovative visualization technique: time-continuous scatter plots. METHODS: Patients with Progressive Supranuclear Palsy (PSP) and Parkinson's disease (PD), age- and sex-matched healthy older and young adults were recruited. Subjects were asked to fixate a light emitting diode (LED) at 0° while walking on a treadmill. Throughout the experiment, short visual stimuli were repetitively applied by a set of six LEDs at different horizontal positions in front of the patient (-60°; -45°; -30°; 30°; 45°; 60°) in a random order with varying inter-stimulus intervals. Subjects were asked to perform gaze shifts towards these eccentric LEDs as fast as possible. An eye-head tracker (EyeSeeCam®) was used to quantify parameters related to eye-head coordination. Time-continuous scatter plots of horizontal eye versus head position were used for data analysis and visualization. In contrast to "traditional" scatter plots were data points are considered independently, here their time correlation is specifically preserved. The advantage of this technique is that it gives a more comprehensive picture of overall performance, i.e., it illustrates how movements correlate (e.g. eye and head movement) while additionally having a notion of how fast these movements were executed. RESULTS: As expected, young healthy subjects showed precise fixation of the central LED at 0° and precise eye-head movements to the eccentric LEDs while gaze shifting. Healthy older subjects exhibited a similar pattern of fixation and gaze shifting but a slightly slower eye-head movement close to the target. In contrast, patients with neurodegenerative diseases showed a much more heterogeneous patterns on an individual as well as on a group level. Specifically, PD and PSP patients exhibited a substantially reduced gaze shifting performance in terms of precision and velocity of eye-head movements. CONCLUSION: Visualization of eye-head coordination with time-continuous scatter plots, seems to be useful to present the complex function and dysfunction of gaze shifting movements. These plots may be used for presentation of individual and group differences of

distinct cohorts, and for individual counselling. The poster will present visualized as well as statistical details about the above-mentioned groups.

Tuesday, June 27, 2017

A Activity monitoring

2-A-1 Monitoring changes in physical activity levels and intensity in preschool aged children; efficacy of a home based intervention

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BACKGROUND AND AIM: Past research has examined physical activity (PA) levels in older children and adults, however few studies examine these levels in preschool aged children. Although it is well known that PA reduces risk of childhood obesity, the rate of obesity among children continues to grow with the underlying causes remaining unknown [Guinhouya et al.Int. J Pediatr Obes 2011 5(6):361-368]. Higher PA levels in young children have been shown to reduce risk of chronic disease [Janssen et al. Int. J. Behav. Nutr. Phys. Act. 2010,7:40] and as development of exercise habits start during early childhood [Malina. Res Q Exerc Sport 1996 67:S48-S57] it is essential to investigate current quantities of PA in children and explore interventions to increase these levels. In addition to observing the amount of PA, the intensity of PA must also be analyzed; the Canadian Physical Activity Guidelines state that children should participate in a combination of light physical activity (LPA) and moderato-to-vigorous physical activity (MVPA) each day. The current study monitored amount and intensity of PA of preschool aged children before and after an intervention based on motivational interviewing. The aim of the study was to accurately quantify the amount and intensity of physical activity in preschool aged children during their day, over several days and to observe whether this can be affected by the intervention. We hypothesized that the intervention groups would have increased daily levels of LPA and MVPA, and would increase more in MVPA levels post-intervention. METHODS: Healthy preschool aged children (n=29) aged 18 months to 6 years involved in the Guelph Family Health Study were divided into either the control group, 2 home visit (2HV) or 4 home visit group (4HV). The intervention groups received motivational interviews on either 2 or 4 occasions as well as tailored emails and mailed incentives over a 6-month period. All children were instructed to wear an Actigraph GT3X accelerometer (Pensacola, FL) on their non-dominant wrist for a period of several days for baseline and post intervention testing (6-month follow-up). Three paired sample T-tests (control, 2HV, 4HV) were conducted to compare percentage change of LPA and MVPA baseline to post-intervention. RESULTS: Both baseline and post intervention LPA and MVPA levels were expressed as a mean percentage of total wear time for each child in the study. The was no significant difference found between baseline and post intervention for all groups however, there was a trend for an increase in MVPA in the 4HV group; $t(10)=-2.067$, $p=0.066$. Table 1 contains all mean percentage values of LPA and MVPA for all groups for baseline and post intervention testing. CONCLUSIONS: Although no major differences were observed between baseline and post intervention testing, further investigation will examine day-to-day variance in the amount and type of PA to better understand PA in preschool aged children.

B Adaptation, learning, plasticity and compensation

2-B-3 Evaluation of the accuracy and agreement in matching gait complexity to several complex auditory metronomes

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Background and aim: A growing body of literature is demonstrating the utility of complexity measures to understand the control of gait (Hausdorff, 1995). Complexity measures reveal patterns within time-series data of traditional gait parameters (e.g., stride time), during normal unperturbed walking. Recent findings have demonstrated the potential for auditory cueing with a complex metronome to prescribe the complexity of stride time (Hunt et al., 2014). The prospect of "prescribing" gait complexity by use of a complex metronome can open a framework to reveal important aspects of locomotor adaptation to the environment. However, an assessment across repeated measurements is warranted to examine the level of agreement (deviation of repeated measurements) of such complex metronomic cueing tasks. This project assessed the level of agreement in fractal index of stride time across multiple sessions, when cueing to various complex metronomes. Methods: 7 healthy young participants (1 female, mean age = 27 4 years; height = 1.74 0.84 m) participated; recruitment is on going. All participants attended three sessions (SES: S1, S2, S3) separated by a minimum of three days (7 5 days). Participants walked on a motorized treadmill (Bodyguard Fitness, Quebec, CA) at a comfortable walking speed (CWS: 1.05 0.09 m/s). White (WN), pink (PN) and red (RN) noise metronomes (MET) were generated based on the participant's mean and standard deviation of stride time when walking at CWS; participants were asked to cue their right heel strike to the beep sequence. Each MET condition was performed twice, for a total of 6 trials per session. The accuracy of participants' ability to match their stride time fractality to the metronome fractality was estimated as root-mean square error (RMSE). The level of agreement across MET type and and SES was assessed by the standard deviation (SD) of RMSE. Results: No interaction between MET and SES ($p = 0.974$) and no main effect of SES ($p = 0.229$) was revealed for RMSE data. A main effect of MET was found [$F(2,12) = 39.02$, $p < 0.0001$] for RMSE. Tukey-Kramer post-hoc analysis revealed that all MET levels RMSE values were significantly different from each. No interaction between MET and SES ($p = 0.152$), no main effect of SES ($p = 0.606$) and no main effect of MET ($p = 0.747$) were found for SD. Conclusions: Preliminary results suggest that the ability to match fractality of stride time to the fractality of several complex auditory metronomes is a challenging task; participants demonstrated the greatest accuracy in the WN condition. The level of agreement among the different complex metronome types was similar (Figure 1A). The level of agreement of matching to complex metronomes was similar across sessions (Figure 2A) demonstrating that agreement in fractality did not differ across sessions. References Hausdorff, J. M., Peng, C. K., Ladin, Z., Wei, J. Y., & Goldberger, L. (1995). Is walking a random walk? Evidence for long-range correlations in stride interval of human gait. Journal of Applied Physiology, 78(1), 349-358. Hunt, N., McGrath, D., & Stergiou, N. (2014). The influence of auditory-motor coupling on fractal dynamics in human gait, Nature Science Reports, 4(5879), 1-8.

2-B-4 Spatial and Temporal Aspects of Gait Are Controlled Separately: Evidence from Split-Belt Treadmill Adaptation

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BACKGROUND AND AIM: Gait adaptation to the split-belt (SB) treadmill requires alteration of spatial (i.e. step length) and temporal (i.e. phasing) aspects of locomotion. Upon return to tied-belt treadmill walking, aftereffects are present, indicating the motor system has stored changes to the locomotor plan. Previous SB literature hypothesizes distinct neural pathways for the control of spatial and temporal aspects of gait, however it is not yet understood whether a simultaneous auditory distraction affects either aspect of gait. This project first aimed to understand how the presence and duration of an auditory dual task affects overall gait adaptation to the SB treadmill in healthy young individuals. The secondary aim was to further explore individual patterns in spatial and temporal gait parameter adaptation with a specific emphasis on "non-responders". METHODS: After a Baseline period at typical walking speed, healthy adults (n=49, 23.3 years) walked with treadmill belts at different speeds for 14 minutes (Adaptation Phase) followed by tied-belt walking (De-Adaptation Phase). During the Adaptation Phase, participants completed an auditory distraction task requiring verbal responses for 0, 8 or 14 mins. Spatiotemporal parameters of gait were assessed using inertial sensors (APDM, Portland OR). In order to differentiate spatial and temporal gait adaptation, Step Length Symmetry (SLS; spatial parameter) and Dual Support Symmetry (DSS; temporal parameter) were analyzed during Baseline, Adaptation and De-Adaptation phases. RESULTS: SLS and DSS changes during Adaptation or De-Adaptation phases relative to Baseline were not related to a particular distraction group (0, 8, 14 minutes). All participants increased spatial and temporal asymmetry with the onset of Adaptation ($p<0.05$), however two distinct adaptation patterns were evident (Figure 1). 57% of participants followed the expected SB adaptation pattern with a significant negative SLS AND DSS that returned to Baseline values by the end of Adaptation and displayed positive aftereffects ($p<0.05$, dark grey curve). However, 27% of participants only followed the expected adaptation pattern (dark grey curve) for EITHER SLS OR DSS. In these participants, a positive adaptation curve was shown at the beginning of Adaptation in one outcome (SLS or DSS) that did not return to Baseline and did not show Aftereffects in the De-Adaptation period indicating no alterations to the internal locomotor plan were made (light grey curve). Finally, 16% of participants did not adapt spatial nor temporal aspects of gait, indicating a "non-responder" group for SB adaptation. The ability to adapt spatial and/or temporal aspects were not related to a particular SB distraction group. CONCLUSIONS: Results provide further evidence of distinct neural pathways for spatial and temporal aspects of gait. There were healthy young participants unable to adapt to the SB treadmill that is currently unreported in the literature. ACKNOWLEDGEMENTS AND FUNDING: NSERC (DCH, CP), FRQS (DC), CFI (CP)

2-B-5 Effects of speed of walking on the accuracy of foot placement control in Stroke Survivors compared to age-matched control

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Background: Time constraints are known to deleteriously affect a person's ability to adjust footfall location (such as when trying to avoid obstacles) in both healthy and clinical populations due to the speed-accuracy trade-off. However, this phenomenon has only been examined in healthy participants performing discrete single steps during standing rather than during walking in participants that are prone to falling (i.e. Stroke survivors). Aim: To measure the effect of gait speed on foot-placement accuracy in stroke survivors (SS) and age-matched (AM) healthy older adults. Method: SS (N=9 age=687.8 mean SD SSWS=1.5 0.3m/s) and AM (N=8 age=979.7 SSWS=3.30.7km/h) stepped to targets while walking at three speeds (self-selected (SSWS), fast (SSWS%+20%) and slow (SSWS-20%)) on a force instrumented treadmill (C-Mill). Targets were projected onto the treadmill at participants' step length and width at each walking speed. Target sizes were: large (60cm deep x40cm wide; no accuracy constraint) or small (length and width of the individual's shoe; accuracy constrained). Targets were presented in semi-randomised order at a ratio of 3:1 (large to small targets) with equal amount of left and right small targets. Small targets were presented at locations 10% shorter or longer than normal step length (counterbalanced) to challenge participants to actively control foot placement to the target. Two blocks of 64 steps (16 small) were performed at each walking speed in random order. Targets were visible two steps in advance. Error in footfall location was measured as distance in anterioposterior (AP) direction from centre of foot (COF), measured using motion capture synchronously with CMill, to the centre of the target at mid-stance. Results: A mixed design ANOVA showed significantly higher stepping error was evident for the paretic (95%CI=-6.3cm to-4.2cm, p>0.001) and non-paretic leg (95%CI=-5.2cm to -3cm, p=0.023) than AM (95%CI=-3cm to-0.4cm). There was also an effect of step length showing significantly lower errors for shortening (ICC=-3.5cm to -2.1) than lengthening steps (-5.3 to -3.9) for both groups(p=0.018). An interaction effect showing short steps at a slow speed have higher error (p=0.05) than short steps at SSWS or Fast speed was also found (see fig1). Conclusions: Overall, SS make greater errors than AM when stepping to accuracy constrained targets at all walking speeds. Lengthening steps is most difficult for both SS and AM and error of shortening steps increases, surprisingly, when walking slowly.

C Aging

2-C-6 Concurrent Validity of APDM Opal Sensors and GAITRite Walkway in Older Adults

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BACKGROUND AND AIM: Spatiotemporal parameters have been commonly used to identify older adults with mobility deficits. For example, previous studies have shown that older adults at high fall-risk walk slower, take shorter and wider steps and have greater step variability compared to their healthy counterparts. Several portable systems are gaining attention to measure gait for both clinical and research use. The APDM system is one such system that uses body-worn OPAL (inertial) sensors, is highly portable and has a variety of plugins for gait and balance evaluation. Studies evaluating the clinimetric properties of the APDM system have mostly focused on the balance plugins but not the validity of gait plugins. Therefore, the aim of this study was to investigated the concurrent validity of the spatiotemporal parameters measured by the APDM system with the gold standard pressure sensors-based GAITRite walkway system. METHODS: Thirty healthy older adults (75±6 years) and 17 older adults (81±8 years) at high fall-risk (as defined by American Geriatrics Society guidelines) participated. They walked 5 times each at self-selected comfortable speed (SS) and fast speed (FS) across 14' GAITRite Walkway while wearing the OPAL sensors. A mean of 5 trials was used to determine the intraclass coefficient ICC (2,5) for gait parameters that were common to both the systems: gait speed, cadence, single, double support, stance and swing %, step time, stride length, and gait cycle duration. RESULTS: For the healthy older adults at their SS, the ICC values were high (>0.881) for all the gait parameters, except for gait cycle duration (0.034). For those at high fall risk at their SS, the ICC values ranged between moderate (0.675) to high (0.973) for all the parameters except gait cycle duration (0.068). For the FS condition, data from the APDM system could only be obtained from 20 healthy older adults and 14 older adults at high fall risk due to limited step count. For the healthy older adults at their FS, ICC values for most of the gait parameters ranged from moderate (0.676) to high (0.907), except gait cycle duration (0.049). For older adults at high fall-risk at their FS, ICC was high (>0.823) for gait speed, cadence, step time and stride length, and low for gait cycle duration (0.038). ICC values for rest of the variables could not be determined. CONCLUSIONS: Our results suggest that for the measured 14' walking distance, the APDM system and GAITRite walkway seemed to generate similar results for walking at SS but not at FS among older adults. Differences in the technology could have contributed to the results observed. While both the systems have advantages for measurement of spatiotemporal parameters, the APDM system has the advantage of allowing measurement in the patient's own environment. The results of the current study provide useful data for clinicians and researchers to compare and contrast the utility of two different kinds of gait measurement systems.

2-C-7 The impact of visual attention on sensory integration during standing in the elderly

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BACKGROUND AND AIMS: The incidence and severity of falls in the elderly make them a strong target of prevention. Aging has been shown to impact attentional processes, sensory integration, and postural control. Recent literature suggests that attention is involved in sensory integration of visual and auditory stimuli along with standing balance. Additionally, when multiple senses are in conflict additional attention is required to maintain balance. Increased reaction time and postural sway with aging indicate that attentional challenges to the somatosensory system may impact the elderly to a greater degree. The goal of this study is to better understand the influence of attention in the visual stream on sensory integration during sensory conflict and destabilizing moving visual environments while standing in the elderly. METHODS: Twenty-four young (mean age 23.5 ± 2.9, 12M) and thirty-one elderly (mean age 76.0 ± 4.0, 13M) healthy adults with no history of vestibular or neurological disorders participated in this study. Elderly participants were screened into good balance or poor balance groups (n=20 and n=11, respectively) using a functional gait assessment score of less than 24. Postural sway was collected using a dynamic posturography platform (Equitest, Neurocom Inc., Clackamas, OR). Data was collected for 180 seconds of standing while changes in the support surface or visual scene movement were provided with and without a concurrent information processing task, presented in randomized blocks. Platform conditions included fixed floor (FIX) or sway-referenced floor (SRF). Visual conditions were eyes open with a fixed scene (EO) or sway-referenced visual scene (VSR). A visual choice reaction time (VCRT) task was used. Postural sway was evaluated using the RMS of the center of pressure (COP) in the anteroposterior direction. RESULTS: As the difficulty of the task increased, postural sway increased in all groups. In the elderly poor balance group, the visual scene had a bigger impact on postural sway than it did in young and elderly good balance groups. This was true for both FIX VSR and SRF VSR conditions. VCRT times were significantly longer and more impacted by VSR in the elderly compared to young. While reaction times were correlated with postural sway during FIX EO in elderly adults, reaction times were highly correlated with postural sway during SRF VSR in the elderly poor balance group only. CONCLUSIONS: Sensory integration, especially visual integration, is important in balance control in the elderly. Our results demonstrate that if the postural task and information processing task have congruent sensory requirements, both on the visual stream (VSR and VCRT), but the sensory information is unreliable (ie, VSR), the dual-task cost is higher and sway is increased. This is especially true in the elderly with poor balance. This implies that sensory requirements of real-world tasks performed while maintaining balance or walking can have an impact on postural control. ACKNOWLEDGEMENTS AND FUNDING: We thank Susan Strelinski and Anita Lieb for their help. This was supported by the NIA (R01AG014116) and Pittsburgh Claude D. Pepper Older Americans Independence Center (P30 AG024827).

2-C-8 Age-associated changes in obstacle negotiation strategies

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INTRODUCTION: Tripping over an obstacle is one of the most common causes of falls among older adults. Compared to young adults, older adults approach and step over obstacles more slowly and with smaller steps, landing dangerously close to the obstacle with their lead limb. These reported findings were attributed to obstacles placed in advance to allow for a long preparation time ("anticipated" obstacles). However, we often encounter obstacles in different sizes that appear just as one approaches them, providing a shorter preparation time ("unanticipated" obstacles).Changes in strategies used to negotiate different type of obstacles have not been tested systematically yet. Here, we aimed to use an innovative, computer controlled, obstacle course to evaluate age-associated changes in negotiating obstacles in different height and preparation time. METHODS: Twenty older adults (ages: 77.7±3.4 years; 50% women) and twenty young adults (age: 29.3±3.8 years; 50% women) walked along obstacle course while negotiating AO and UO at heights of 25mm and 75mm. Kinect cameras captured the movement of the subject's feet while they stepped over the obstacles and provided depth images that were analyzed to characterize the negotiation strategy based on four measurements: (1) distance of foot before the obstacle, (2) distance of foot after the obstacle, (3) height of leading foot above the obstacle (clearance), and (4) trailing foot clearance. Linear-mix models evaluated changes between groups and within obstacle types. RESULTS: The distance of the foot was lower before higher obstacles ($p<0.001$) and unanticipated obstacles ($p=0.002$) in both groups. In contrast, the distance of the foot after higher obstacles decreased in older adults (95±10 at 25mm to 87±910 at 75mm) and increased in young adults (148±11 at 25mm to 183±10 at 75mm; interaction: $p=0.007$). In addition, both groups increased the clearance of the leading and trailing feet at higher obstacles ($p<0.001$) and unanticipated obstacles ($p<0.001$). However, young adults had significantly higher clearance of trailing foot than older adults in higher obstacles (young: 167±7 at 75mm; older adults: 127±7 at 75mm; interaction: $p<0.001$) and unanticipated obstacles (young: 155±8mm; older adults: 128±8; interaction: $p=0.026$). CONCLUSIONS: Older and young adults utilized different strategies to negotiate anticipated and unanticipated obstacles and obstacles at different heights. As compared to older adults, young adults increased: 1) distance of foot after higher obstacles and 2) clearance of trailing foot in higher and unanticipated obstacles. These changes observed in young adults may enhance safety by reducing the chances of hitting and tripping over obstacles. Therefore, we suggest that training programs to reduce fall risk in older adults should target obstacle negotiation strategies by increasing the distance of foot after the obstacle and increasing the clearance of trailing foot.

2-C-9 Perturbation training Improves Pelvic and Trunk Motion in Older Adults ? A Randomized Control Trial

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Perturbation training Improves Pelvic and Trunk Motion in Older Adults ? A Randomized Control Trial Background and aim: Most falls among older adults occur during locomotion especially while walking. Horizontal pelvic and trunk range of motion are required to maintain stability during walking. It was found previously that pelvic and trunk motions are impaired in older adults compare with young's and in old fallers compared with non-fallers older adults. We aimed to explore whether perturbation training that incorporates unexpected loss of balance during treadmill walking that evokes balance recovery reactions will improve pelvic, thorax, and trunk kinematics at different walking speeds. In addition we aimed to explore whether flexibility of gait was changed as a results of the perturbation training. Flexibility was defined as the ability to make kinematic adaptations in the different walking speeds. Methods: Fifty-three independent older adults (age 80.1±5.6 years) were randomly allocated to an intervention group (n=27) or a control group (n=26). Both groups received 24 training sessions over 3 months, twice a week, 30 minutes each session. The intervention group received unexpected left-right and forward-backward perturbation balance exercises during treadmill walking, while the control group received treadmill walking only. Gait kinematics and flexibility of gait was measures in different walking velocities that was systematically increased from 0.5 to 0.9m/s with increments of 0.1m/s, and then similarly decreased. The primary outcome measures were the horizontal pelvic, thorax, and trunk range of motion (i.e., trunk motion is the subtraction of pelvic and thorax angles of range of motion). The secondary outcome measures were stride times, stride length, and stride width. Baseline characteristics were compared between groups, in addition 2×2×5 General Linear Model for repeated measures (2 groups, 2 tests, 5 different walking speeds) was performed. The significance level was set to 0.05. Results: During treadmill walking in their preferred walking speed a significant group-by-time increase in pelvic and trunk transverse tROM with large effect size with benefit to the intervention compared with the control group (p=0.009, [ES]=0.5; p=0.017, [ES]=0.75, respectively) (see table 1). It should be noted that both groups significantly improved the thorax tROM after training. No improvement where found in other gait variables. Conclusions: The results show carryover improvement in pelvic and trunk range of motion while walking following perturbations treadmill training that drives balance recovery responses. This may lead to improved gait stability and a decreased risk of falls in their everyday living.

2-C-10 Compensatory rapid leg movement during unexpected loss of balance while walking - Age related differences

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BACKGROUND AND AIM: Falls are a serious threat to the lives, health, and independence of older adults. Lateral falls are those that are likely to result in hip fracture. Deterioration of balance control, as a consequence of disease or simply increasing age, increase the occurrence of clinical balance impairments, as well as the risk of balance loss and falls. The key factor that ultimately determines whether or not a balance perturbation leads to a fall is our ability, or inability, to recover balance loss, which is the ability to step rapidly and effectively following postural perturbation. Most studies measured balance recovery reactions during standing, very little however has been studied during walking. Thus, we aimed to investigate age-related changes in balance recovery responses to unexpected lateral balance loss METHODS: A convenience sample of 35 older adults (70 years old and over) and 19 healthy young adults (20-30 years old) participated in the study. Subjects were instructed to walk comfortably on an instrumented treadmill without handrails (BaMPer System) and were exposed to unexpected lateral perturbations in order to trigger a compensatory stepping response. We used an Ariel Performance Analysis System (APAS) to perform kinematic analysis. Compensatory step parameters (step initiation time, step time, step length and step velocity), were measured along with arm reaction and center of mass (COM) displacement. Stepping threshold i.e., the perturbation magnitude to initiate stepping response, were also measured. RESULTS: Significant differences were found in COM displacement, step length, and step velocity between age groups. No differences were found in step reaction time and step times. Step reaction times were faster than arm reaction times. No stepping threshold was found in older adults, they tended to step in the lowest perturbation magnitude. Moreover, older adults were found to have low flexibility i.e., defined as the ability to adapt a different stepping behavior following different perturbation magnitudes and high variability within a specific perturbations (operationalized as mean standard deviation) in compensatory balance reactions while exposed to different perturbation magnitudes. CONCLUSIONS: In a sudden loss of balance, older adults will initiate stepping in a smaller COM displacement compare with young's and less effectively (i.e., a smaller step length).

2-C-11 Stability control during walking and obstacle crossing at fast speeds and its relationship to a clinical test battery in older adults

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Daily activities like crossing the street require walking and negotiating obstacles at fast speeds. This type of task may be more challenging with age, but performance during fast obstacle crossing in older adults has yet to be reported in the literature. The purpose of this experiment was to test the effects of increased speed on the changes in stability from walking to obstacle crossing in older adults. Additionally, cognitive faculties like executive function (EF) are related to gait speed and fall-risk. Therefore we also evaluated the relationships between the magnitude of the observed change in stability and a cognitive performance across a clinical cognitive test battery. Twenty- seven participants (73±5 yrs, 10 males) consented to a University approved Institutional Review Board approved protocol and 27 participants (73±5 yrs, 10 males) were observed in a range cognitive and gait tasks. Gait kinematics were recorded in four4 conditions: overground walking and obstacle crossing at both self-selected (SS) and fast speeds. Margin of stability (MOS) in the anterior and posterior direction were calculated using the extrapolated center of mass technique. Lower MOS values indicate an unstable position requiring additional action to maintain balance in each phase of gait and obstacle crossing. Lead and trail limbs were matched across conditions and minimum MOS in one stride was calculated. The percent change in MOS was represented calculated as ((percent change in MOS from single walk- to single obstacle)/walk)*100 and fast walk to fast obstacle for both speed conditions was compared using. Paired t-tests evaluated differences between conditions with change scores. Partial Pearson bivariate correlations controlling for age and education determined associations between locomotion MOS and clinical tests. Results show the percent change in minimum MOS was greater for SS versus fast speeds in lead limb double support phase (p=.029). When compared to SS, There were no differences in average horizontal heel speed and toe clearance while crossing the obstacle quickly . However, distance to the obstacle in lead and trail limb foot placement limbs were significantly different, stepping further from the obstacle at fast speeds (p<.001). EF was related to the magnitude of change in MOS in lead double support; better EF scores led to less changes in stability from fast walk to fast obstacle (Montreal Cognitive Assessment (MoCA) r=-.554, p=.005) and worse EF scores were related to greater stability changes from walk to obstacle crossing (Delta TMT= Trails B - Trails A) in both fast r=.41, p=.046 and SS speeds r=.75, p=<.001. Overall, dynamic stability control is altered in lead limb double support when an obstacle is in the walkway and speed is increased. The same measure is correlated with aspects of cognition, specifically EF. At fast speeds older adults with compromised EF may exhibit more conservative stepping strategies when negotiating an obstacle in the environment. Further research is needed to determine if EF is related to other complex walking tasks in older age.

2-C-12 Mediolateral and anteroposterior components of required coefficient of friction during turning gait for young and older adults

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BACKGROUND AND AIM: Older adults often have difficulty in maintaining lateral postural stability and lateral falls do cause life-threatening hip-fracture injuries in older people. Slips are one of the most frequent events leading falls. When slip occurs during turning, falls are likely to occur in the mediolateral (ML) direction and the balance recovery in the ML direction is necessary. Thus, slip during turning is challenging for older adults to step lateral direction and maintain their postural balance. However, there are few studies investigating slip and fall during turning for older adults. The peak value of the traction coefficient (the ratio of the shear force component (fh) to the vertical force component (fz) applied to the floor) obtained shortly after a heel contact is termed the required coefficient of friction (RCOF). RCOF is considered as the minimum static coefficient of friction to prevent slip during stance phase when walking. This study investigated mediolateral and anteroposterior components of the required coefficient of friction (RCOF) during turning gait for young and older adults. METHODS: Sixteen healthy young adults (8 males and 8 females) and sixteen older adults (8 males and 8 females) participated. The participants were instructed to conduct trials of straight walking and 90° step and spin turns to the right at each of three self-selected normal speed. The mediolateral (ML) and anteroposterior (AP) directions during turning were defined using the orientation of the pelvis to construct a body-fixed reference frame. RESULTS: There was no significant difference in traction coefficient in the ML and AP directions during the whole stance phase for young and older adults when walking straight ($p > 0.05$). During turning (both spin and step turns), the traction coefficient in AP direction for older adults was significantly smaller than that of young adults mainly at propulsion phase ($p < 0.05$). On the other hand, the traction coefficient in the ML direction for older adults was significantly smaller than that for young adults at 12-87% stance phase during step turn and 5-76% stance phase during spin turns ($p < 0.05$). The mean values of AP RCOF component were not significantly different among age groups for straight and turning ($p > 0.05$). However, the mean values of ML RCOF component for older adults were significantly lower than those for young adults ($p < 0.05$ during step turn; $p < 0.001$ during spin turn). Older adults turned with a shorter turning radius and slower turning speed ($p < 0.01$), and the centripetal force during turning gait for older adults was lower than that for young adults ($p < 0.01$) due to their slower turning speeds ($p < 0.001$). CONCLUSIONS: This study demonstrated that older adults turn with the lower ML component values of RCOF compared to young adults because of lower turning speed. The results may ultimately be used to develop new interventions to prevent slip and fall during turning for older adults. ACKNOWLEDGEMENTS AND FUNDING: This work was partially supported by JSPS KAKENHI Grant Number 16K06038.

D Biomechanics

2-D-13 The Effects Of Imposing Temporal & Spatial Gait Asymmetry On Knee Joint Kinetic

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A key impairment of gait after unilateral conditions (e.g. amputation, knee osteoarthritis (OA) and stroke) is spatiotemporal asymmetry [1-3]. It is widely thought that gait asymmetry (GA) increases stance time on the unaffected limb and consequently loading known to be risk factor for development of OA [2,3]. However, this implicit assumption that spatiotemporal asymmetry leads to knee loading patterns indicative of development of knee OA has not previously been tested. Therefore, this study sought to establish causality of effect of spatial and temporal asymmetry on healthy participants? knee loading. Magnitudes of GA following stroke were used to impose temporal and spatial asymmetry via auditory and visual cues. Methods: By using 3-D motion analysis, Spatiotemporal, Kinematic and kinetic data were obtained from healthy participants (n=6, all men, 55.4±4.8 years) while walking over 6 meters (contact with the force platforms) in three different conditions; Natural gait (NG), Spatial Asymmetrical Gait (SAG) (imposing step length asymmetry via stepping to footprint targets), and Temporal Asymmetrical Gait (TAG) (imposing swing time asymmetry via metronome). Because loading at the knee is related to gait speed [4], in each gait condition, participants? walking speed was controlled (via metronome) at two different slow speeds (0.4 m/s and 0.8 m/s corresponding with different extents of stroke severity [5]) in addition to their self-selected speed. The extent of temporal and spatial asymmetry imposed were to give a swing time ratio of 1.25 and step length ratio of 1.13 corresponding with the median swing time and step length asymmetry observed in stroke survivors [6]. Results: 10 healthy young adults (age 54.9 ± 3.8 years) took part. Data from 6 have been analysed and no significant effects on knee joint loading (peak external Knee Flexion Moment (KFM) and Knee Adduction Moment (KAM)) of imposed spatial or temporal asymmetry were found. Peak KAM was significantly lower on the shortened (swing duration or step length) side in slower walking speeds compared to self-selected walking speed (Figure 1). Discussion: To our knowledge, this is the first study that exploring the immediate effect of altering spatiotemporal symmetry in healthy participant on knee joints? load. Preliminary results of the six-healthy participants suggested that spatiotemporal asymmetry might not be the main reason for increase knee joint load leading to development of OA in unilateral pathologies [1-3]. Data from all 15 participants will be presented at the time of the conference.

2-D-14 Mechanical economy during walking on gradients

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1) BACKGROUND AND AIM: When walking on a slope, potential energy must be added/subtracted each step, which will modify the pendulum-like mechanism of walking. The aim of this study is to analyze the effectiveness of this mechanism across slope and speed. In 2002, Cavagna et al. [1] introduced the ?recovery within the step? (r), which evaluates the transduction between potential (Ep) and kinetic (Ek) energy at each instant t of the step. A faultless r of 100% indicates that the changes in Ep mirror the changes in Ek, however it doesn?t give any information about the amount of energy economized. Therefore, we introduce a new variable: the mechanical economy Eint, which represents the amount of energy saved through the pendular mechanism. 2) METHODS: Ten subjects walked on an instrumented treadmill at different slopes (0, ±3, ±6 and ±9°), and seven speeds (from 2 to 8 km/h). From the ground reaction forces, we evaluated the instantaneous power saved e(t), computed from the difference between the theoretical maximum work that should be performed if no Ep-Ek transduction took place and the work actually done when the Ep-Ek transduction occurs: $e(t) = (|\Delta Ek|+|\Delta Ep|-|\Delta(Ek+Ep|)/\Delta t$, where ΔE is the difference in energy between the instants t and $t-\Delta t$. The mechanical economy (Eint) is the time-integral of e(t) over given periods of the step: T1 occurs during the first part of contact when Ep increases while Ek decreases and T3 occurs during the second part when Ep decreases while Ek increases. During T2 (i.e. between T1 & T3) and during T4 (i.e. between T3 & T1), e(t)= 0 since Ep and Ek are in phase. 3) RESULTS: When walking uphill, Eint during T1 is greater than on the level whereas it is smaller during T3. When walking downhill, Eint during T1 is smaller than on the level whereas it is greater during T3. At first approximation, the trajectory of the COM during walking can be described by a ?compass gait? model: the COM moves on an arc in the sagittal plane on two rigid limbs [2]. On a flat terrain, this arc is more or less symmetric with respect to the vertical (Fig. 1). On a positive slope, the arc of the compass is tilted backwards and the lower-limb reaches its vertical position later during contact. As speed and slope increases, (1) the duration of T1 becomes longer and T3 becomes shorter than at 0° and (2) the vertical movement of the COM increases during T1 and decreases during T3. Consequently, Eint increases during T1 and tends to zero during T3. On a negative slope, the arc of the compass is tilted forwards and the lower-limb reaches its vertical position earlier during contact. As speed and slope increases, (1) the duration of T1 is shorter and the duration of T3 is longer and (2) the vertical movement of the COM decreases during T1 and increases during T3. Consequently, Eint tends to zero during T1 and increases during T3. 4) CONCLUSION: Mechanical economy Eint seems a pertinent variable to understand in which phase of the walking step the pendulum-like mechanism is optimized to minimise work. 5) REFERENCES: [1] Cavagna, G. A., Willems, P. A., Legramandi, M. A. & Heglund, N. C. (2002). J Exp Biol 205: 3413-3422 [2] Saunders, J. B., Inman, V. T. and Eberhart, H. D. (1953). JBJS 35 A: 543-558

2-D-15 Foot postures have different influences on hallucal loading, with the arch height in individuals with hallux valgus being a determining factor.

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BACKGROUND AND AIM: Hallux valgus (HV) is one of most common foot deformities in women. HV has commonly been associated with increased plantar pressure under the hallux. Previous studies often cite low arch foot structure (LA) resulting in increased plantar pressure under the hallux. However, even individuals having a normal arch (NA) suffer from HV because the plantar pressure under the hallux is affected by the static posture and dynamic motion of the foot. The aim of this study was to investigate how static foot posture and dynamic foot motion relate to the center of pressure (COP) movement toward the hallux in individuals with HV, who, depending on their foot arch height, were classified into groups having NA and LA. METHODS: Fifteen female participants with HV angle > 20¡Æ were recruited and static foot evaluations were conducted. For all subjects, normalized navicular height truncated (NNHt), rearfoot angle (RFA), navicular drop test and transverse arch length were measured. NA and LA were defined as NNHt ¡Ã 0.24 and NNHt < 0.24, respectively. Motion analysis was performed during walking using a three-dimensional motion analysis system and eight force plates. The rearfoot, midfoot and forefoot angles during stance phase were calculated using a five-segment foot model, while the COP was calculated using data obtained from the force plates. The distance between the COP and the first metatarsal head (MTH) was calculated when the COP passed the line joining the first and fifth MTH. This distance was then divided by the distance between the first and fifth MTH (COP-MTH). The normality of the data distribution was assessed using the Shapiro-Wilk test, whereas Pearson¢¥s correlation analysis was performed to investigate how static foot posture and foot motion during walking relate to COP-MTH in NA and LA groups. RESULTS: A total of 8 and 7 participants were classified into NA and LA groups, respectively. For the NA group, no significant correlations were found between COP-MTH and static foot measurements. However, a significant correlation between maximum rearfoot eversion angle during walking and COP-MTH was observed. In the case of LA group, RFA and maximum rearfoot eversion angle during walking were significantly correlated with COP-MTH. CONCLUSIONS: Previous studies have reported that rearfoot deformity and LA may predispose to HV. This study shows that depending on the arch height, static foot posture and dynamic foot motion had different effects on COP movement towards the hallux. In participants with HV and LA, there was a significant correlation between COP movement toward the hallux and static rearfoot alignment and rearfoot eversion angle during walking. These results suggest, that static rearfoot alignment may allow for an increased plantar pressure estimation under the hallux in individuals with HV and LA. However, in individuals with HV and NA, whether static rearfoot alignment allows for that estimation remains unknown.

2-D-16 Kinematic analysis during virtual-reality dance-based gaming in aging and stroke: A Cross-Sectional Study

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Background: Stroke is the common cause of disability in adults, which affects activities of daily living. Stroke survivors experience severely reduced physical activity levels that increases their risk of secondary cardiovascular accident. Virtual reality (VR) dance program has been reported to have a positive effect on the physical function of people with stroke. However, there are inadequate or no feasibility studies on the effect of VR dance exercises on the movement and balance in this population. Furthermore, there is no objective means of quantifying improvements in dance-therapy induced performance improvements. Aim: The goal of this study was to characterize and provide ?normative? joint kinematics from healthy young adults during a virtual-reality dance protocol and document changes occurring due to healthy aging and stroke. Method: This is a preliminary cross-sectional study design. Ten individuals with stroke, 10 age-matched controls (AC) and 10 young controls (YC) were exposed to dance movements using the commercially available Microsoft Kinect game ?Just Dance 3?.

Three songs with slow (SP), medium (MP) and fast (FP) pace were selected for the study. An 8-camera motion capture system recording at 120 Hz was used to record full-body kinematics and compute the center of mass (COM). Postural stability was examined via COM position excursions in the anterior-posterior (AP) and medio-lateral (ML) directions for each dance. Results: The Anteroposterior (AP) COM excursion of the FP song and mediolateral COM excursion (ML) for the SP song was a significantly lower among the stroke than young ($p < 0.05$) and the age-matched ($p < 0.05$) healthy groups. For the MP song, there was no significant difference between the groups ($p > 0.05$). Conclusion: This study was able to evaluate the kinematic analyses of the COM during a virtual reality-based dance across the three groups. Additionally, the results of this study have provided normative data that could be used to determine improvements in dance-therapy based movement and balance performance in stroke patients. Clinical Significance: The diagnostic method, thus obtained during the study may be used in the development of dance as a rehabilitation therapy for both aging and stroke. It can be inferred from this study that, SP songs could be used to train COM stability and balance control in ML direction, whereas FP songs could be used to increase mobility in AP direction such as walking. MP songs could be used to target improvements in impairments.

2-D-17 Reliability of Daily Motor Activity variability recorded over 7 days

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Reliability of Daily Motor Activity variability recorded over 7 days Nicholas Reynolds & Vivien Marmelat Background and aim: Human daily motor activity (DMA) is characterized by complex temporal fluctuations presenting scale invariance, e.g. the properties of fluctuations remains similar over a wide range of time scales, from minutes to hours. DMA is estimated from a time series composed of consecutive bouts of activity recorded per-epoch from an activity monitor. Scale invariance from DMA variability has been proposed to be a marker of progression of neurological disease. The aim of this study was to compare the complex temporal fluctuations of groups of healthy young and healthy elderly subjects. The second aim of this study was to assess the consistency of this measure across a multiple days recording period. Future collections will include patients with Parkinson's disease, as well as 6-month and 1-year follow up collections for all subjects. Methods: In this study, 23 healthy young (mean age 24.39 ± 3.59 y.o.) and 19 healthy elderly (mean age 64.16 ± 8.85 y.o.) individuals wore an Actigraph GT9X activity monitor on their non-dominant wrist for 7 consecutive days. Accelerometer data from the activity monitor was sampled at 100 Hz and the vector magnitude was extracted at epoch lengths of 15 seconds. VM refers to the magnitude of the resulting vector that forms when combining the sampled acceleration from all three axes on the device, and is defined as: VM=√(〖(Axis 1)〗^2+ 〖(Axis 2)〗^2+ 〖(Axis 3)〗^2) Detrended fluctuation analysis (DFA) was used to estimate scale invariance of the 'active' periods (9am to 9pm), thus providing a scaling exponent αDFA for each days. Intra-class correlations were run to test the between-day reliability of the scaling exponent αDFA for each group. Two-Sample t-test was run between the mean αDFA values from each individual in each group. Results: The average αDFA_HY and αDFA_HE were respectively 0.92 (SD=0.07) and 0.91 (SD=0.09). Student t-tests revealed no significant differences between groups ($p=0.72$). Cronbach alpha value from the ICC comparison of the αHY and αHE was respectively αICC_HY=0.701 ($p<0.05$) and αICC_HE=0.866 ($p<0.05$). Conclusions: Our results were consistent with previous literature investigating the scale invariant properties of DMA. We did not found any statistical significant differences between groups for the average DFA values. The DFA values close to one confirmed the presence of scale invariance in VM time series. Further, we evidenced that the DFA results are consistent between consecutive days for a given individual. This result suggest that future studies could use DMA recorded only over a shorter period a time (1-2 days). Further work is in progress to determine if neurological disorder such as Parkinson's disease affects DMA variability, and if disease status and progression is correlated to DMA variability.

2-D-18 Biomechanical influences of gait termination with holding of baggage in one hand

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BACKGROUND AND AIM: In daily life, people often use a handbag to carry objects, such as during shopping. The mechanism of steady walking while holding baggage has been revealed in recent studies. It is known that the holding of baggage in one hand during steady walking enhances lower extremity muscle activation. It is important to consider not only steady walking, but also termination of gait as essential components of the movements required in daily life. However, the gait termination (GT) while holding of baggage has received less attention. Therefore, the purpose of this study was to analyze the biomechanical changes of the lower extremities during GT with the holding of baggage in one hand. METHODS: This study was conducted with the participation of 10 healthy young subjects who aged 23.5 ± 3.1. The subjects walked on a walkway and stopped on force plates in two steps: the right leg was the leading limb and the left leg was the trailing limb. The GT was examined under the following two conditions: walking without a bag and walking with a 4 [kg] bag. To induce natural motions, all subjects were asked to practice the tasks sufficiently on the walkway before the test. The tests were conducted at the speed preferred by the subjects. We recorded the coordinates of 45 retro-reflective markers pasted on anatomical landmarks using a three-dimensional motion analysis system. Ground reaction force (GRF) were recorded by four force plates. The coordinates of the center of gravity (CoG) and center of pressure (CoP), the joint moments, and the negative work at each joint were calculated. A paired t-test were executed using SPSS ver. 22.0. RESULTS: The anterior displacements of the CoG and CoP were not statistically significant. The differences in the posterior GRF impulses in the leading limb were also not statistically significant. However, the integrated values of the knee extension and ankle planter flexion moments in the leading limb were significantly larger while holding baggage. In addition, the negative work at the knee and ankle joints in the leading limb was significantly larger while holding baggage. CONCLUSIONS: Because of the holding of baggage, it was found that the subjects received a larger impact at the initial contact in the leading limb. Thus, it is necessary to exert a greater eccentric knee extension moment while flexing the knee after the initial contact to absorb the impact of the initial contact in the leading limb. Moreover, the ankle joint planter flexion moment in the leading limb was required to control the bending forward of the shank. Therefore, these results would seem to indicate that holding baggage in one hand during GT increases the biomechanical requirements of the leading limb to stabilize the motion of gait termination motion.

E Brain imaging/activation during posture and gait

2-E-19 The role of the prefrontal cortex during walking over ground and walking on treadmill in patients with Parkinson's Disease

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BACKGROUND AND AIM: Among patients with Parkinson's disease (PD), gait is disturbed and less automatic. These gait changes are associated with impaired rhythmicity and increased prefrontal activation, an ineffective attempt to compensate for reduced automaticity. Indeed, we recently showed that the prefrontal cortex is recruited to a larger extent in patients with PD, as compared to controls during over ground walking (Maidan et al., 2016). Previous work also showed that treadmill walking and other forms of external cueing enhance automaticity and improve gait in patients with PD, putatively bypassing the impaired neural circuitry. Based on these findings, we tested the hypothesis that during treadmill walking, when the pace is determined and fixed: a) prefrontal activation will be reduced, as compared to over-ground walking, and b) the walking pattern will become more stable, compared to over-ground walking, in patients with PD. METHODS: Ten patients with PD, as defined by the UK Brain Bank criteria, (mean age 72.01 ± 5.28 years; mean disease duration: 8.60 ± 4.59 years, 60% men) performed two walking tasks: (1) Over ground walking, and (2) treadmill walking. Gait was evaluated using a 3D-accelerometer attached to the lower back and ankles (Opal?, APDM). Prefrontal activation during the walking was assessed using an fNIRS (Artinis?, The Netherlands) system consisting of two probes placed on the forehead of the subjects. Measures were estimated with the subjects walking at their self-selected comfortable walking speed. The maximum Lyapunov exponent was used to estimate the "stability" of the walking pattern. Values smaller than 0 indicate a deterministic system (where trajectories move closer to each other) while values larger than 0 indicate a chaotic system (trajectories move apart of each other). Previous work suggests that lower values indicate a more stable and less chaotic gait patterns. RESULTS: Hb02 decreased from 0.50±0.07 µM/L during over-ground walking to 0.37±0.09 µM/L during treadmill walking ($p=0.034$). Average gait speed was 1.09 ± 0.14 m/sec over-ground and 0.85±0.14 m/sec on the treadmill ($p=0.007$). The Lyapunov exponent in the anteroposterior axis decreased by 0.2±0.2 ($p= 0.028$) during treadmill walking, as compared to over-ground walking. CONCLUSIONS: These findings support the idea that during over-ground walking, patients with PD activate the prefrontal lobe to compensate for diminished automaticity and that external pacing reduces this dependence and hence lowers prefrontal activation. This interpretation is supported by the lower Lyapunov exponent during treadmill walking. Future studies are needed to more fully assess the mechanisms at play here, to examine the effects of treadmill walking on gait during more complex tasks, and to evaluate the possibility that treadmill walking may help to improve and rehabilitate gait by restoring automaticity and reducing prefrontal activation during walking.

2-E-20 The Energy Cost of Walking While Thinking

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Background: In clinical research, there has been emerging interest in the 'work of walking', or the energy expended to walk. The energy cost of walking is derived from indirect calorimetry and analysis of expired gases and is defined as the mean rate of oxygen consumption divided by walking speed at usual pace. This energy cost of walking is influenced by biomechanical and neuromuscular factors, and possibly brain function. The primary objective of this study was to determine if the measure of the energy cost of walking is sensitive to the added energy demands of various cognitive loads, or walking while thinking. Methods: Eight young adults participated (mean age 23 yrs ± 1.6, 2 men). For each of six conditions, participants walked for 4 minutes (walking alone, WA) followed by 2 minutes of engagement in a cognitive task (WWT); treadmill speed was held constant at each participant's usual pace throughout. The cognitive tasks varied by complexity and domain: easy and hard versions of a math updating task, a word recall task, and a listening/phenome monitoring task. Indirect calorimetry was used to derive the energy cost of walking (mean oxygen consumption/ treadmill speed, ml/kg m) and respiratory exchange ratio (RER) for each condition during WA and WWT. For a subset of participants ($n=3$), VO_2 and RER were determined during sitting alone (SA) and sitting while thinking (SWT). Repeated measures ANOVAs were used to compare energy cost and RER during WA across conditions. Paired sample t-tests were used to compare energy costs and RER of WA vs. WWT. Results: There were no differences in mean energy costs and RER of WA across conditions, (energy cost range 0.11 - 0.12

ml/kg m, p=0.25; RER range 0.79-0.83, p = 0.25). There were no differences between mean energy costs of WA vs. WWT for any of the cognitive tasks (mean difference in energy cost, range -0.001 - 0.003). There were increases in mean RER during WWT compared to WA for four of the six conditions (update easy, WA=0.79, WWT=0.85, p=0.017; recall easy WA=0.79, WWT=0.85, p =.001; recall hard, WA=0.81, WWT=0.88, p=0.016, listening easy WA=0.81, WWT=0.84, p=0.08). Both VO2 and RER increased from SA to SWT for all 3 subjects (mean VO2 increase 0.387ml/kg/min; mean RER increase 0.04). Discussion: Fatigue was not a confound, as energy costs of WA remained stable across conditions. While the energy cost of walking did not increase with the added cognitive task, the increases in RER may indicate a shift toward an anaerobic metabolism contribution to the energy used with the added cognitive task. The increase in the energy expended for added cognition in sitting, but not while walking, remains to be explained. These energy cost differences for thinking in walking compared to sitting may be important in understanding the impact of aerobic exercise on cognitive functioning. These young adult data will serve as the basis for examining age-and disease-related differences in the energy cost of walking while thinking.

2-E-21 The effect of changing visual information on brain activity during sensory integration in young adults- a functional NIRS study

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BACKGROUND and AIM: Increased activity in the vestibular cortex, as estimated using functional near-infrared spectroscopy (fNIRS), has been associated with sensory integration processes during static balance control tasks. While increases in brain activation have been found during eye closure, it is not known if the vestibular cortex is also active when misleading or optokinetic visual stimuli are viewed. The purpose of this study was to examine if the vestibular cortex is activated when sway-referenced surrounding (false visual input) or optokinetic stimulation is provided in young adults during sensory integration balance tasks. METHODS: Fourteen healthy young adults (mean age: 25 ± 3y) participated in this study. A Smart EquitestTM platform (Natus, Clackmas, OR) was used to display visual sway-referenced surrounding or optokinetic stimulation test conditions. A 16-channel continuous wave fNIRS instrument (NIRSport, NIRx, Berlin Germany) was used to record hemodynamic changes on left hemisphere over the dorsolateral frontal cortex and temporo-parietal cortex. An A-B-A-B-A-B-A block design (baseline-test-baseline) was used to elicit changes while subjects maintained balance during eight test conditions: 1) Fixed-visual surround (FS) - Sway-referenced visual surround (SS) - FS on Fixed platform; 2) SS-FS-SS on Fixed platform; 3) FS-SS-FS on sway-referenced (SR) platform; 4) SS-FS-SS on SR platform; 5) no optokinetic stimulation (NOS)- OS - NOS on Fixed platform; 6) OS - NOS - OS on Fixed platform; 7) FS, no OS-OS- no OS on SR platform; and 8) FS, OS-no OS- OS on SR platform. Each block lasted 20 seconds (i.e. 140 seconds trial time), and the eight test conditions were randomly presented. The fNIRS data were analyzed based on a spatial-temporal version of a general linear model. Group-level analysis across the subjects was performed using a random-effects model of brain activity . The level of significance is set at $p < 0.05$. RESULTS: When the visual input changed from FS to SS during the fixed platform conditions (1 & 2), the supratemporal gyrus was activated . When the visual input changed from FS to SS during the sway-referenced platform conditions (3 & 4), the dorsolateral frontal cortex and supratemporal gyrus were activated. During the optokinetic stimulation with fixed platform condition, the supramarginal gyrus was activated. During the optokinetic stimulation with sway-referenced platform condition, the dorsolateral frontal cortex and supratemporal gyrus was activated. CONCLUSION: Young adults had changes in activation patterns according to the different visual information conditions. When a misleading visual information was provided, the supratemporal gyrus was activated. When the optokinetic stimulation was provided, the supramarginal gyrus was activated.

The dorsolateral frontal cortex was activated when the balance tasks became more difficult (sway-referenced platform). Our results suggest that the vestibular cortex was involved with integration of visual information.

2-E-22 Influence of STN stimulation in intra stride cortical dynamics in Parkinson's disease

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BACKGROUND AND AIM: Impairment in the execution of automatic movements in Parkinson's disease (PD), such as walking. Furthermore, it is unknown how deep brain stimulation of the subthalamic nucleus (STN-DBS) aids in performing automatic movements. Therefore, we study the cortical dynamics during walking in healthy controls and PD patients with STN-DBS. We hypothesize that the cortical modulation of the gait cycle is less pronounced in the off state of PD patients as compared to healthy controls. Furthermore, we hypothesize that STN-DBS will increase the cortical modulation of the gait cycle. 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 of nine meters. Patients were measured in two conditions: with stimulation of the STN (STN), and without stimulation (off). Gait was recorded by three sensors attached on both left and right ankle and lumbar, measuring acceleration and angular velocity three directions. This allowed us to extract the main gait cycle events, heelstrike, midswing and toe-off. Synchronized to the kinematic measurements, we recorded a 48-channel EEG during straight walking. In offline analysis, we computed the time-warped cortical activity of the gait cycle in different frequency bands. RESULTS: Preliminary analysis showed that cortical activity is modulated with respect to the gait cycle. Cortical activity increases at heel strike and toe-off in both the alpha (8-12 Hz) and beta band (13-30 Hz) primarily over the central motor cortex. This was observed in both healthy controls and PD patients during Off. However, the modulation of cortical activity was attenuated during Off compared to healthy controls. STN-DBS could increase this modulation towards the level of healthy controls. CONCLUSIONS: We found that the physiological cortical modulation of the gait cycle (Gwin et al., 2011) is still present in PD. However, we found an influence of STN-DBS on the cortical modulation of the gait cycle in PD. Further analysis have to show the exact origin of the electro-cortical modulation using source localization. ACKNOWLEDGEMENTS AND FUNDING: Gwin JT, Gramann K, Makeig S, Ferris DP. Electrocortical activity is coupled to gait cycle phase during treadmill walking. Neuroimage. 2011;54:1289-96.

2-E-23 Functional near infra-red spectroscopy during walking in young, old and Parkinson's disease: a structured review

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BACKGROUND AND AIM: The use of functional near infra-red spectroscopy (fNIRS) to investigate cortical activity during walking is emerging and may provide information regarding the neural correlates of mobility impairments caused by ageing and Parkinson's disease (PD). However, there is a need for standardizing methodological procedures. This structured review aimed to (i) review fNIRS study design and protocols; (ii) assess the signal processing techniques used with fNIRS data to reduce artefacts and physiological noise; and (iii) synthesise key findings relating to fNIRS during both normal and complex walking tasks in young adults, older adults and people with PD. METHODS: Four electronic databases were searched (Embase, Psych-Info, Scopus and Pubmed). Search request consisted of four search fields; 1) measurement technique of interest to evaluate cortical activity, 2) synonyms for populations of interest (i.e. only studies that tested healthy young adults, healthy old adults or people with PD were included), 3) synonyms for walking tasks, and 4) synonyms for dual (cognitive and/or motor) tasks. Data was extracted by three reviewers (RV, SS, LA) and synthesised into table format and data entry was confirmed by another reviewer (AP). Data reviewed included: study design and protocol; dual task protocol; fNIRS devices; data outcomes; signal processing; and key findings. RESULTS: The search strategy yielded 73 articles from publication databases and seven additional articles were identified by screening reference lists. Twenty-one studies satisfied the criteria for inclusion. The frequency of published papers in this research area has increased considerably in the last four years. Protocols and methods for removing noise and artefacts varied; for example, many different filtering techniques and thresholds were reported. The studies reviewed reported increased activity in several cortical areas during walking relative to a rest condition. Differences in activation patterns were observed in treadmill vs. overground walking, normal vs. complex walking, easy vs. difficult tasks, acceleration vs. steady state phase during gait, young vs. old individuals and healthy vs. people with PD. CONCLUSIONS: Although recently great advances have been made in the field, further work is needed to establish robust methodologies. This review highlighted many inconsistencies in study design and protocols, signal processing techniques, as well as the description of age- and PD-related changes in cortical activity during walking. Changes in cortical activity are sensitive to task characteristics (i.e. complexity, difficulty, preparation, speed etc.) and phase (i.e. acceleration and steady state periods). The limited existing evidence suggests critical alterations in cortical activity during walking related to ageing and PD.

F Cognitive impairments

2-F-24 Gait in dementia subtypes: A step in the right direction?

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BACKGROUND AND AIM: Distinguishing dementia subtypes is difficult due to similarities in clinical presentation. Safe and effective gait requires complex cognitive processes, highlighted when observing gait deficits in people with cognitive impairment. There is increasing interest in the role of discrete gait characteristics as markers to aid diagnostic algorithms in dementia. This structured review aimed to explore the similarities and differences of gait across four dementia subtypes: Alzheimer's disease (AD), dementia with Lewy bodies (DLB), vascular dementia (VaD) and Parkinson's disease with dementia (PDD). METHODS: Key terms were identified to create a search strategy for the literature. Six databases produced 5,211 articles after removing duplicates on 10th June 2016. Other eligible papers brought to the reviewer's attention were also considered. 43 articles were selected after title and abstract screening adhering to inclusion and exclusion criteria. Findings were grouped into the domains of gait (pace, rhythm, variability, asymmetry, postural control) proposed by Lord et al. (2013)'s model of gait to aid interpretation. RESULTS: The majority of literature discusses AD, showing a gap regarding gait deficits in non-AD dementia. Individuals with dementia were reported to have slower pace, increased rhythm and increased variability compared to controls. People with AD display less impairment in the pace, rhythm and variability domains of gait compared to non-AD dementias. However the evidence is limited and non-specific within the non-AD dementias. There is some evidence that gait performance (pace, rhythm and variability domains) deteriorates in AD with increasing disease severity and disease duration. Limited direct comparisons between the subtypes, modest subject numbers, discrepancies in diagnostic criteria and methodology used, and limited reporting of gait outcomes (many studies reported solely on gait speed) highlight gaps in the literature. Asymmetry and postural control are not well characterised within the literature. CONCLUSIONS: In conclusion, individuals with dementia have impaired gait compared to controls. Non-AD dementias have more gait impairments compared to AD;

however, the current literature is limited and conclusive signatures of gait cannot be drawn. Different presentations of gait across subtypes could help differentiate them and strengthen current diagnostic criteria and could provide clinicians with an easily accessible, low-cost diagnostic tool.
ACKNOWLEDGEMENTS AND FUNDING: Financial support for this study came from the National Institute for Health Research (NIHR) Newcastle Biomedical Research Unit and Alzheimer's Society. Lord et al., Move Disorder, 2013 28(11): 1534-1543

2-F-25 Vestibular Contributions to Cognitive Function: An Investigation of Prevalence and Potential Mechanisms.

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Abstract: Vestibular Contributions to Cognitive Function: An Investigation of Prevalence and Potential Mechanisms. Themes: Cognitive, attentional, and emotional influences; Cognitive impairments. Authors: S. Surenthiran, L. Smith, D. Wilkinson, R. Bicknell & M. Bodani BACKGROUND AND AIMS: An emerging body of evidence suggests that the vestibular system contributes to cognition. However, vestibular-cognitive effects remain poorly understood and the optimal procedures for screening and treating these distressing symptoms is still unknown. This study aimed to determine the prevalence and nature of vestibular-cognitive effects by examining which cognitive operations are particularly affected by vestibular dysfunction and which mechanisms underlie these effects. More specifically, are cognitive impairments linked to vestibular dysfunction via a direct mechanism (e.g. damage to areas within the cortical vestibular network such as the hippocampus), or are they related indirectly through other comorbid disturbances (e.g. psychiatric, fatigue/ sleep, age-related, auditory)? METHODS: 100 patients (predominantly vestibular migraine) diagnosed with primary vestibular disorder at their initial neuro-otology appointment completed validated neuropsychological assessments of depression, anxiety, depersonalisation, fatigue, sleep, memory, attention and executive function. Balance function testing was also completed to quantify vestibular pathology. Analyses first calculated the prevalence of comorbid impairments. A series of structural equation models then tested whether vestibular function exerted a direct influence on cognition, or influenced performance indirectly via psychiatric, fatigue/ sleep, or age-related mechanisms. RESULTS: All participants showed evidence of clinical impairment on at least one neuropsychological measure, the majority experienced a combination of symptoms. Anxiety, fatigue, working memory impairments and problems sustaining attention were especially common (over 50% fell outside the normative cut-off). Balance function (assessed using a balance platform) also had a significance direct influence on cognitive performance that was independent of any age, psychiatric or fatigue/ sleep-related effects. CONCLUSIONS: Previous studies indicate that vestibular loss impacts cognitive function, however, these have been relatively limited in scope. The present findings identify new clusters of impairment and highlight the importance of vestibular function to cognition and well-being. Clinical services should consider the reach of vestibular dysfunction beyond balance symptoms and may benefit from adopting a multidisciplinary approach to diagnosis and treatment. ACKNOWLEDGEMENTS AND FUNDING: University of Kent, School of Psychology

G Cognitive, attentional, and emotional influences

2-G-26 Effect of visual dependence and task loads on the TUG sub-components in old and young adults

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BACKGROUNG AND AIM: Older adults are more visually dependent than younger adults (Lord & Webster, 1990) and are more at risk for falls with visual distraction. The Timed Up & Go (TUG) test is a clinical measure to assess the probability of an individual having a fall (Kenny et al., 2011). One limitation of the test is that it is validated only for gait in a quiet environment. We aim to examine the kinematic properties of young and old adults performing a TUG test during additional attention demanding conditions. We will concentrate on the functional tasks that are part of the TUG test: sit to stand (SiTSt), turn, walk, and stand to sit (StTSi). METHODS: A motor task of holding a half full glass of water and a visual task of viewing a scene of snowflakes moving in the pitch up or pitch down directions overlaid on the view of the room was added to the TUG test. Eight conditions were presented to 7 young (25.7±3.3 yrs) and 2 older healthy adults (69.5±6.2 yrs). These included: TUG, TUG with motor task (TUGmotor), TUG while wearing the Oculus Rift without additional tasks (TUGOculus_Rift), TUG while wearing the Oculus Rift with motor task (TUGmotor_Oculus_Rift), TUG with visual task in pitch up (TUGvisual(PitchUp)) and pitch down (TUGvisual(PitchDown)) directions, TUG with motor and visual tasks (TUGmotor_visual(PitchUp)) and (TUGmotor_visual(PitchDown)). Time to complete the task was recorded as were acceleration range SiTSt and StTSi, turning angular velocity and cadence, gait speed, arm swing and trunk peak velocities were recorded with Trigno? wireless IMU sensors (Delsys Inc.). RESULTS: All participants took a longer time to complete the TUGOculus_Rift compared to TUG (p=0.05). In SiTSt, they exhibited higher trunk pitch peak velocity in TUGOculus_Rift compared to TUGmotor (p=0.008), TUGmotor_visual(PitchUp) (p=0.003) and TUGmotor_visual(PitchDown) (p=0.001). Participants took higher trunk yaw peak velocity in TUGvisual(PitchUp) compared to TUGmotor_visual(PitchUp) (p=0.04) in SiTSt. CONCLUSION: Preliminary data show that SiTSt element of the TUG when combined with visual and motor tasks provide more information than the standard TUG test score, which is only time-based. However, the small sample size is a limitation in the current report to make a general conclusion. REFRENCES: Lord, S. R., & Webster, I. W. (1990). Visual field dependence in elderly fallers and non-fallers. The International Journal of Aging and Human Development, 31(4), 267-277; Kenny, R. A., Rubenstein, L. Z., Tinetti, M. E., Brewer, K., Cameron, K. A., Capezuti, L., ... & Suther, M. (2011). Summary of the updated American Geriatrics Society/British Geriatrics Society clinical practice guideline for prevention of falls in older persons. Journal of the American Geriatrics Society, 59(1), 148-157. Funding Source: Saudi Arabia Ministry of Higher Education.

2-G-27 The Effects of Task Prioritization on Postural-suprapostural Task in Parkinson's Disease Patients with Different Balance Ability

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BACKGROUND AND AIM: Postural-suprapostural task is prevalent in our daily life, defined as achievement of a concurrent motor or cognitive task performed simultaneously with successful postural control. Most previous studies suggested that prioritizing postural over suprapostural task is a safer strategy for avoiding a loss of balance for patients with Parkinson's disease (PD). However, overemphasize on postural balance itself may result in postural instability due to interfere with the body's natural control processes. The aim of this study was to investigate the effects of task-priority strategies on postural-suprapostural performance in PD patients with different balance ability. METHODS: Fifteen PD patients were recruited in this study. Patients were classified as BBS > 52 (n = 8) or BBS ≤ 52 (n = 7) group by Berg Balance Scale (BBS) based on previous researches, which shows that PD patients with a score of 52 or less on BBS is prone to fall. All participants were requested to perform a force-matching precision grip task (suprapostural task) while maintaining balance on a stabilometer (postural task) with their major attention focusing on the postural or suprapostural task (posture focus (PF) vs. supraposture focus (SF)). Behavioral data included dual-task effect (DTE: % change in dual-task

condition; positive value: dual-task benefit, negative value: dual-task cost) of posture error and force error. RESULTS: In the group with BBS ≤ 52, less posture error DTE ($p < 0.05$) was found of the PF condition, but the force error DTE was not different between the PF and SF conditions. In contrast, the group with BBS > 52 showed higher DTE values of posture error and force error in the SF condition. CONCLUSIONS: This preliminary study suggests that appropriate task-priority strategy may vary with balance ability of PD patients. For PD patients without severe balance impairment (BBS > 52), focusing on the suprapostural task could increase dual-task benefit for postural stability and decrease dual-task cost for force accuracy during performing a postural-suprapostural dual task. On the other hand, for PD patients with severe balance impairment (BBS ≤ 52), focusing on the posture itself may be a safer way to keep balance and prevent falling. Future investigations are necessary to further explore these preliminary findings, considering that this is the first time to investigate the different task-priority strategies in PD patients with different balance ability on postural-suprapostural task.
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2-G-28 Obstacle height, one's location and dual-tasking influence obstacle clearance parameters in older adults

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Background and aims: Increasing the height of an obstacle likely increases the challenge to control body stability. This study investigated obstacle clearance parameters during the negotiation of a series of unequal obstacles under single and dual-task conditions in older adults. In addition, it explored whether the location of the participant during the negotiation of an obstacle series influences obstacle clearance parameters. It examined whether the level of reaction time (RT) difficulty affects obstacle clearance parameters during obstacle crossing, as dual-tasking while walking is known to be a risk factor for falls in older adults. The overarching purpose was to compare the effect of obstacle height and participant location on foot clearance in older adults. Methods: 10 healthy older adults (5 males, 5 females; age: 67.0 ± 6.9 years) walked onto and over a series of 6 obstacles of varying heights (i.e., small: 460 mm, medium: 690 mm; large: 920 mm) while completing no RT, simple reaction time (SRT), and choice reaction time (CRT) tasks. A foot-switch was placed onto each of the obstacles, and was used to trigger the auditory stimuli. The time to completion of stepping onto and over the 6 obstacles was recorded. The Vicon512TM System (Oxford Metrics, Oxford, UK) was used to perform kinematic analyses in order to calculate minimum foot clearance and an estimate of the center of mass (COM) displacement in the medial-lateral (ML) direction by averaging the medial-lateral displacement of the anterior and posterior superior iliac spine on the left and right sides. Results: The large obstacles elicited the lowest toe clearance. The first 3 obstacles revealed smaller heel clearance compared to the last 3 obstacles. The No RT condition revealed greater heel clearance compared to SRT and CRT dual task conditions. Longer time to completion was shown for the CRT trials compared to no RT and SRT. Greater estimated COM displacement in the ML direction was shown for no RT compared to SRT and CRT. Conclusions: The findings indicate that the large obstacles resulted in less toe clearance compared to the smaller obstacles, which may be due to greater biomechanical constraints. The smaller heel clearance observed for the first 3 obstacles may be suggestive of greater information processing demands due to the planning of subsequent obstacle crossings. Dual-tasking provoked significant modulations in obstacle clearance parameters, probably due to differences in attention demand. The reduced estimated COM displacement in the ML direction observed during the SRT and CRT conditions may be suggestive of a stiffening strategy employed during dual-tasking in order to reduce the degrees of freedom of the COM to facilitate successful obstacle clearance compared to the single-task condition. These data suggest that

the height and location of the participant in the series of obstacles, as well as dual-tasking pose alterations to obstacle crossing in older adults.

2-G-29 Executive function predicts gait velocity in pre-rehabilitation Traumatic Brain Injury

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Background and Aim: Originally assumed to be an automatic process, emerging evidence suggests that gait engages higher order (frontal) brain regions. Dual task gait experiments consistently show that measures of gait pattern are altered when a cognitive task is performed during walking. More recently, executive function has been linked to single-task gait performance in healthy adults, seniors, and people with dementia. Miyake's Model of Executive Function describes three subdomains: information updating and monitoring, mental shifting, and cognitive function. It has been shown that the information updating and monitoring subdomain is linked directly to gait variability in adults across the lifespan, and dementia. This study aimed to describe the relationship between executive function and gait variability following traumatic brain injury (TBI). Methods: Adults with TBI (n=93) completed cognitive tests and an assessment of spatiotemporal gait parameters with a pressure sensitive mat at 2 months, 5 months and 12 months post-admission to inpatient rehabilitation. We used the digit span test (forward) as a measure of attention, and the trail making task (part B) to measure two sub-domains of executive function, namely, mental shifting and information updating and monitoring. Gait variables of interest were velocity (to measure overall gait function) and step length differential (to measure stride variability). Self-paced (SP) and maximum paced (MP) gait data was reported, therefore all analyses were stratified by walking pace. Results: The TBI group was 41(17) years old and 25 were women. The mean gait speed was 149.48(50.99)m/s and mean step length differential was 3.64(7.74)cm. The mean trail B score and digit span score was 46.82(14.20) and 4.66(1.17), respectively. Spearman's Correlation Coefficients were calculated at 2 months and 12 months for velocity & trail B score, velocity & digit span score, step length differential & trail B score, and step length differential & digit span score. Significant correlations existed for velocity & trail B scores in both self-paced and maximum paced measures at 2 months ($r(SP) = 0.28$, $p < 0.05$; $r(MP) = 0.28$, $p < 0.05$), but not at 12 months. Velocity & digit span score at baseline were significantly correlated for maximum pace, but not self-pace ($r(SP) = 0.16$, $p > 0.05$; $r(MP) = 0.26$, $p < 0.05$). No significant correlations existed between step length differential and digit span score or trail B score. Conclusions: The results of this analysis show that cognitive measures of executive function and attention are associated with gait velocity but not variability post-TBI before completion of inpatient rehabilitation. The results suggest that the gait rehabilitation process may promote alternative cognitive mechanisms of gait control that may be more complex than that of healthy and older adults with mild cognitive impairments. Future investigations should examine the effect of gait rehabilitation on attention and executive function in order to determine the impact of functional rehabilitation on cognition.

2-G-30 Does cognitive-motor interference differ with postural demands of balance tasks in individuals aging with and without a stroke?

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Background: In older stroke survivors, whether deficits in dual-task function are compounded by brain injury, natural aging, or the type of motor task remains unclear. This study aimed to examine the influence of a higher cognitive task while concurrently performing three different dynamic postural tasks - limits of stability (intentional balance), compensatory stepping to large backward perturbations (reactive balance) and walking, across healthy young adults, older adults and older chronic stroke survivors. Based on attentional demands incurred by the postural tasks we hypothesized that the cognitive-motor interference (CMI) pattern will differ across the three balance tasks. CMI of performing the balance tasks would be greater among stroke survivors than the healthy adults. CMI was defined as decline in motor (motor interference), cognitive (cognitive interference) or both (mutual interference) tasks in dual-task (DT) condition. Methods: Young adults (n=36), healthy older adults (n=36, 62.5±4.7) and older community dwelling chronic stroke survivors (n=36, 58.6±6.4). Subjects performed either of the three motor tasks - forward limits of stability(LOS), forward reactive stepping(RB) and gait with (DT) and without (single-task) performing a serial subtraction (SS) task. The SS task was also performed in isolation. Maximum center of pressure excursion (MXE) for LOS, center of mass position relative to base of support at step touchdown for RB, gait velocity and number of correct responses for SS task were measured. Motor and cognitive costs were calculated by ST-DT)/ST*100. Results: Young and older adults showed higher motor cost for the RB and gait tasks than the LOS task (main effect of tasks $p<0.05$). Within the stroke group, motor cost did not differ between the postural tasks. The motor cost for older adults and stroke groups were more than for young adults for all postural tasks ($p<0.05$ for all comparisons). However, motor cost was significantly greater in stroke group than healthy older adults only for the LOS task. A comparison of motor and cognitive costs within each group showed lower motor and higher cognitive cost for RB and LOS tasks for young group, with similar motor and cognitive costs for gait task. Unlike young adults, other two groups showed prioritization of motor task for the LOS task alone. Conclusion: In healthy (young & old) adults, higher motor cost was associated with RB and gait tasks suggesting greater attentional demands for postural task that are biomechanically more unstable. In chronic stroke survivors, all dynamic balance tasks incurred equal attentional resources regardless of the postural challenge. It is possible that the ability to flexibly allocate attention to postural task remains affected in chronic phases of stroke. Reduced central capacity due to aging or in chronic phase of stroke may affect prioritization of tasks while dual-tasking. It is likely that in chronic phase, stroke survivors may regain some DT function displaying similar strategies as healthy counterparts. Balance training interventions for elderly with or without a stroke should explore use of dual-task interventions to enhance allocation of attentional resources while dual-tasking, improving balance control in challenging situations.

2-G-31 Clinical efficiencies of stabilometry and visual feedback test for differentiating the patients with psychogenic vertigo from healthy subjects.

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[BACKGROUND AND AIM] The psychogenic vertigo has been diagnosed based on subjective dizzy symptom without abnormal findings of oculomotor tests and vestibular tests. We investigated the characteristics of the postural control system in patients with psychogenic vertigo using stabilometry and Body Tracking Tests with a visual feedback test?iFig1?j to assess the dynamic body balance. [METHODS] This study consisted of 14 patients with psychogenic vertigo and 92 aged-match healthy subjects. Healthy subjects did not have vertigo or a history of balance disorders. They did stabilometry and Body Tracking Tests with a visual feedback test. The BTT equipment was composed of a stabilometer (Anima-G620, Anima Co., Tokyo, Japan) and a visual stimulus display. During the tests, the subjects stood with their feet closed together and parallel and maintained an upright posture. Examinations were performed for 60 s on each subject. They were instructed to keep the center of pressure constantly in the target circle displayed on the screen in front of the subjects. In accordance with the Declaration of Helsinki, the experimental procedures were explained to the participants (volunteers), and each of the subjects provided written informed consent before participation in the study. The authors have no conflicts of interest to declare. We conducted investigation during the analysis using the total distance (cm), area (cm2), locus length per unit area (cm/s), spectral analysis with the maximum entropy method (MEM) in Stabilometry and the total distance (cm), area (cm2), locus length per unit area (cm/s), and the proportion of the center of pressure (COP) that enters a circle (%) during the BTT. [RESULTS] <Stabilometry> The psychogenic vertigo group showed a larger area and a smaller locus length per unit area in comparison with the healthy subject group ($p < 0.01$). In spectral analysis with the maximum entropy method (MEM), the power of the medio-lateral and antero-posterior positional power spectrum under eyes open condition were significantly largest at around 0.125 Hz in the psychogenic vertigo group. <BTT> No significant difference in the result of Body Tracking Tests with a visual feedback test was found between both groups. Our results suggest that the patients with psychogenic vertigo maintain body balance with extremely slowly and large movements for quiet stance during eyes open condition. [CONCLUSIONS] The results of Body Tracking Tests with a visual feedback test may indicate that the spontaneous postural control itself in patients with psychogenic vertigo does not differ from that in healthy individuals. We believe that this test could be useful as one of the significant diagnostic tests for psychogenic vertigo.

H Coordination of posture and gait

2-H-32 Segmental Evaluation of the Spinal Movement in Gait by Rasterstereography

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BACKGROUND AND AIM Rasterstereography is a high precision technique for the quantitative analysis of the shape of surfaces based on Moirée topography. The human body surface reflects to a certain degree the spatial arrangement of immediately underlying skeletal structures. Based on back shape data and orientated on visible anatomical landmarks a suitable algorithm can be used for the estimation of the segmental spine posture. For standing postures such algorithms could be validated easily by comparisons with corresponding X-rays. In the control of scoliosis therapy, for instance, validated rasterstereography is used in order to reduce the number of spinal X-rays. Due to increasing computer power, it has been possible to further develop this method for the analysis of segmental spine analysis in motion. We have applied rasterstereography for the analysis of the segmental spine movement in the gait of 130 healthy subjects in order to assess its clinical potential. METHODS The DIERS Formetric III 4D analyzing system has been used for our study. A pattern of horizontal lines is projected onto the naked back of a subject walking on a treadmill. The deformation of this line pattern as induced by the walk is recorded at a frequency of 60 Hz by a camera unit placed in a defined position and analyzed by a dedicated computer program using triangulation algorithms. In addition 3 reflecting markers are fixed on the subject's back enabling the computer program to determine the coordinates of the C7 spinal process and of both SIPS as points of reference. A geometrical relationship with the spine structure can be established by the computer program this way. The three-dimensional intersegmental movement patterns can then be calculated from the recorded back surface data. The system is supplemented by a foot pressure measuring platform and a device for the recording of the leg axis in the sagittal and in the frontal plane. The spine motion data can thus be assigned to the corresponding gait phases. We have examined with this system a total of 130 pain free and healthy male and female subjects in an age range from 18 to 70 years. The geometry of the vertebral column in the standing position as well as its segmental movements during level gait on a treadmill at a speed of 2, 3, 4, and 5 km/h were determined. The study was approved by the local ethics committee. RESULTS The complete set of data is currently subject to a comprehensive statistical evaluation process. First results seem to confirm in general the impressions that have been reported in the past in context with clinical gait monitoring. In individual cases, however, our results differ strongly from these general findings. The complete data analysis will be concluded shortly. Its results will be presented and discussed in full at the conference. CONCLUSIONS Up to the present a reliable analysis of the segmental motion of the vertebral column in gait by a mere observation of the back surface has not been possible. To improve this situation, suitable measuring and data processing procedures have to be developed and validated by comprehensive series of examinations. We consider our study a viable contribution to this endeavour.

2-H-33 Variability of the center of mass and base of support during gait altered in persons with multiple sclerosis

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BACKGROUND AND AIM: Multiple sclerosis alters sensorimotor feedback loops between the trunk and the feet, leading to gait and balance deficits and decreased stability during walking. Previous studies examined movement patterns at these segments individually, but maintaining stability requires a controlled interaction between trunk (center of mass) and feet (base of support). The purpose of this study was to measure variability of acceleration at the trunk relative to variability of acceleration at the feet during walking to determine if persons with multiple sclerosis (PwMS) exhibit altered relationships between the trunk and foot segments during walking. METHODS: Forty PwMS (age 21-57) and forty age-matched HC walked on a treadmill at self-selected pace for a single 3-minute trial while wearing two tri-axial accelerometers; one sensor on their sternum, and one sensor on their right ankle. Accelerations were recorded at 128 Hz for the full trial, and transformed into resultant frontal and sagittal plane acceleration. Linear and nonlinear variability measures were calculated for the resultant trunk and foot acceleration time series. Linear measures included root mean square (RMS), range, and standard deviation (SD). Nonlinear measures included approximate entropy (ApEn), sample entropy (SaEn), and Lyapunov exponents (LyE). The ratio of trunk acceleration variability to foot acceleration variability was calculated individually for each variability measure with larger values denoting higher variability of the trunk relative to the foot. Independent samples t-tests were used to test for differences between groups for each ratio measure. RESULTS: Gait speed was similar between groups. In the frontal plane, PwMS have a significantly lower trunk to foot acceleration ratio compared to HC for RMS, range, SD, and LyE, but a significantly higher trunk to foot acceleration ratio compared to HC for ApEn and SaEn ($p<0.05$ for all). In the sagittal plane, PwMS have a significantly lower trunk to foot acceleration ratio compared to HC for RMS and LyE only ($p<0.05$). CONCLUSIONS: The present study shows that PwMS have an altered relationship between trunk and foot motion compared to HC, particularly in the frontal plane. During gait, motion in the frontal plane is largely controlled by active sensorimotor mechanisms. These mechanisms may be altered in PwMS due to slowed neural conduction velocities, leading to the altered relationship between the trunk and feet, and subsequently affecting balance control. Examining the ratio between acceleration variability at the trunk and at the feet can quantify this segmental relationship providing a more comprehensive description of whole body motion during gait, which can be further developed for fall risk assessment in clinical and real-world settings. ACKNOWLEDGEMENTS AND FUNDING: This work was supported by the National Multiple Sclerosis Society RG 4914A1/2, the NIH National Center for Advancing Translational Science 1KL2TR00011, and the NIH Ruth L. Kirschstein National Research Service Award T32 HD057850 from the National Institute of Child Health and Human Development.

2-H-34 Differential Changes to Gait Parameter Fractality During Asymmetric Walking

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BACKGROUND AND AIM: Previous research indicates that gait parameter variability is associated with gait stability. Beyond analysis of the magnitude of variability, more recent analyses of the structure of variability (i.e., fractality) have provided insights into the potential adaptability of gait. Specifically, fluctuations in the gait parameter signal at small temporal scales are statistically correlated to larger fluctuations at larger scales. When the fluctuations at varying scales are logarithmically graphed, a linear relationship indicates scale invariance. The slope (i.e., α) of best fit specifies if the signal is persistent (i.e., the signal is likely to continue in the direction it currently is in; $0.5<\alpha<1.0$), approaching optimal fractality (i.e., $\alpha = 1.0$), or anti-persistent (i.e., the signal tends to change direction from stride to stride; $\alpha < 0.5$), potentially reflective of greater control effort. Recent research within our lab demonstrates that greater persistence (i.e., higher α) in stride time dynamics emerges in response to asymmetric walking constraints. However, it is unclear whether changes to the temporal structure of other gait parameters manifest during asymmetric walking. METHODS: Fourteen young (age = 29.4 ± 5.5 years), active (mean self-reported moderate-to-vigorous physical activity = 287.2 ± 111 min/week) adults (9F, 5M) voluntarily participated in this study. Three walking conditions were performed while on a split-belt treadmill: preferred speed, half of preferred speed, and asymmetric. Asymmetric walking consisted of the dominant leg moving at preferred speed and the non-dominant leg at half of preferred speed. Fractality (α) of stride time, stride length, step length, step width, stance time, and swing time was assessed via detrended fluctuation analysis. RESULTS: Stride time fractality did not increase in the asymmetric condition compared to the symmetric walking in either leg. This result contrasts earlier findings. However, the dominant leg's step length and swing time fractality increased from $\alpha = .58\pm.14$ to $.69\pm.11$ ($p=.016$) and from $\alpha = .70\pm.08$ to $.79\pm.11$ ($p=.046$), respectively, indicating increased persistence. Moreover, stride length variability in both legs became more anti-persistent in response to the asymmetric constraints, from $\alpha = .46\pm.06$ to $.30\pm.04$ ($p<.001$) and from $\alpha = .44\pm.07$ to $.32\pm.04$ ($p<.001$) for the non-dominant and dominant legs, respectively. CONCLUSIONS: Active, young adults appear to regulate their stride length in an anti-persistent, possibly error correcting manner. That is, a short stride length is likely followed by a subsequent longer stride, and vice versa. The functional adaptation to this treadmill-imposed constraint appears to be a strengthening of fractality (i.e., increase persistence) of step length and swing time dynamics of the dominant leg. This change may be functional in that it may increase adaptive capacity, though this notion requires empirical investigation.

2-H-35 Characterizing slips during gait using an entire support surface perturbation: Comparisons to previously established slip methods

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BACKGROUND AND AIM: While many slip paradigms to date involve low friction surfaces or non-motorized platforms [1], the repeatability of the slip itself across participants can be influenced by changes in surface friction, gait speed, and contact surface area (foot size). A motorized platform provides an alternative to these methods as motion of the slip perturbation can be kept consistent across participants. While a motorized platform has been used extensively during quiet standing [2,3], only one study to date has examined slips during gait [4]. This may be due to the limited understanding of whether a motorized platform mimics a 'real world' slip, as the perturbation is applied to both feet. Therefore, the purpose of the current study was to characterize how slips evoked via a motorized platform change gait and postural stability. METHODS: 14 young adults (27.3 ± 4.1 yrs) performed 3 gait trials followed by an unexpected slip perturbation trial across a 6x3m platform; participants were told that the platform would not move during these trials. The slip perturbation (Acc: 1.5m/s², Vel: 0.45m/s, Dis: 0.135m, [2,3]) was evoked at heel contact (embedded force plate, 50N threshold). Whole-body kinematics (Vicon, UK) and ground reaction forces (AMTI, USA) were collected. Gait events were determined kinetically. The current abstract focuses on descriptive characteristics of the slipping foot during the acceleration phase (peak velocity, peak shear force, coefficient of friction) in the anteroposterior (AP) direction; additional data (i.e. gait characteristics, postural stability during phases of the slip perturbation) will be presented at the conference. RESULTS: 10 participants have been analyzed to date. Peak AP velocity of the slip foot was 0.43 ± 0.01 m/s, slower than reported non-motorized platform (1.81 ± 0.49 m/s) and low friction surface (1.38 ± 0.43 m/s) slip velocities [1]. Additionally, peak AP shear force during the acceleration phase of the motorized slip was greater (-0.14 ± 0.04 N/bw) compared to a non-motorized platform (-0.07 ± 0.02 N/bw) and low friction surface (-0.06 ± 0.03 N/bw) [1]. Lastly, a greater coefficient of friction occurred (0.16 ± 0.03) compared to a non-motorized platform (0.04 ± 0.01) and low friction surface (0.04 ± 0.01) [1]. CONCLUSIONS: Preliminary results demonstrate a lesser magnitude slip event occurs when using a medium level perturbation, previously established for quiet standing perturbations [2,3], than when using a non-motorized platform or low friction surface. Analyses of gait and postural stability changes (prior to the slip, at contralateral limb liftoff following slip onset, and at recovery step touchdown) will aid in determining the effect this slip perturbation has on postural control and balance reactions. FUNDING: Canadian Partnership for Stroke Recovery & CIHR. REFERENCES [1] Bhatt et al (2009) J Neurophysiol 101:948-57 [2] Maki et al (1999) IEEE Trans Rehabil Eng 7(1):80-90 [3] Pai et al (2000) J Biomech 33(3):387-92 [4] McIntosh et al (2016) Oct 10:1-11

2-H-36 How does stepping-over behavior change depending on the obstacle height?

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BACKGROUND AND AIM: This study aims to describe the dynamics of the human adaptive behavior, i.e., stepping-over an obstacle to avoid a contact or collision in various environments. Our preliminary study aims to investigate how stepping-over behavior changes depending on the height of the obstacle. Our study is based on the theoretical background of affordance theory in ecological psychology and the dynamical systems approach (DSA) based on the self-organization theory. According to affordance theory, to act safely and adequately in the environment, animals must accurately perceive the relation between environmental properties and their own body properties. In other words, environmental properties are scaled by individual animals' body properties and animals perceive them based on the relation between each individual and its environment. For example, in a stair-climbing behavior, the height of a displayed stair (an environmental property) is perceived relative to the individual's leg length (an animal's body property), and when the ratio of each property (stair height/leg length) reaches specific values, qualitative changes occur in the animal's behavioral pattern. In contrast, within the DSA framework, an animal's behavioral pattern at the macro-level of the complex system can be modeled as a motion equation using a control parameter and an order parameter. The order parameter describes the low-dimensional behavior (the system's macroscopic pattern) that emerges from the high-dimensional neuromuscular system (the micro components of the system). The model predicts the behavior of a system comprising numerous mutually interacting components (degrees of freedom) at the micro-level, as the dynamics of a few order parameters. Empirical studies from the viewpoint of DSA, however, have mainly described behaviors with variables defined by elements of an animal system but not by elements of an animal-environment system. METHODS: We apply the variables defined by elements of an animal-environment system to the DSA framework. In this presentation, we propose an integrative approach using ecological and dynamical approaches and an empirical framework to examine the validity of our approach. In particular, in our pilot study, we manipulated the height of a horizontal bar (0, 10, 20, 30, 40, 50, 60, 70 cm). Five participants were asked to walk and step-over it five

times for each height. A 3D motion capture system captured stepping-over behavior. We analyzed the toe clearance at the moment of stepping-over it and calculated its standard deviation as an index of the behavioral stability. RESULTS: As a result of the analysis of the standard deviation of the toe clearance at the moment of stepping-over the horizontal bar, we could not find any particular change in stepping-over behavior stability or pattern across participants. We suppose that the normalization of the bar heights by participants' leg length should be done, and other indexes of the behavioral stability should be considered. CONCLUSIONS: This study is still in progress. However, if we can reveal the dynamics of stepping-over behavior and the critical point at which this behavior destabilizes, then this knowledge may lead to a better understanding of safe obstacle avoidance.

2-H-37 Does holding an object benefit the performance of a standing precision manual task?

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Background and Aims: Standing postural sway is reduced when a finger contacts a surface at force levels that provide minimal mechanical support (Jeka & Lackner, 1994). This light touch effect is strongest for, but not limited to, fixed surfaces (Albertsen et al., 2010). Reduced postural sway has been observed in infants and young adults while quietly standing and grasping lightweight objects (Claxon et al., 2013; Ustinova & Langenderfer, 2013). However, people routinely stand to perform other goal-directed actions. It is unclear whether postural changes associated with holding an object accommodate or interfere with goal-directed performance. To determine whether holding an object has functional consequences for goal-directed action, we examined postural sway and performance errors while individuals stood and performed manual tasks with varying precision demands. Methods: Five healthy, young adults (age = 20.4 ± 0.5 years; height = 175.7 ± 11.2; mass = 74.0 ± 12.7 kg; 3 female) performed a manual precision task while standing. Participants transported a 100 mm x 100 mm blocked to an opening with their dominant hand and maintained the block in the opening for 20 s. The opening was located at shoulder height, 125 % of arm's length, and horizontally aligned with the dominant shoulder. Precision demands were manipulated using two opening sizes: large (140 mm x 140 mm) and small (110 mm x 110 mm). Participants were instructed to fit the block as accurately as possible. Two holding conditions were performed: no object and holding an object scaled to 1 % of body weight in the non-dominant hand. Control conditions consisted of quiet standing with and without the object. Raw forces and moments were collected at 1000 Hz and low-pass filtered at 20 Hz before estimating the center-of-pressure (CoP). Sway area was computed by fitting a 95 % best-fit ellipse to the CoP trace. Fitting performance was measured as the number of times the block contacted the opening perimeter. Results: Fitting errors occurred in 0.01 % and 44 % of trials for the large and small opening, respectively. A one-way ANOVA revealed no significant differences in errors between the no-hold and hold conditions for the small opening. Sway area was compared using a task (3) x hold (2) ANOVA. No significant effects were observed, which was expected given the small sample size. However, trends for reduced sway area were observed for the hold condition during quiet standing and fitting to the large, but not the small, opening. Conclusion: This study confirms the observation of reduced postural sway when holding an object while standing. When holding an object, no improvements were observed in fitting performance, as measured by the error rate. Based on these preliminary results, we demonstrate that holding an object reduces postural sway in less challenging balance conditions, but these effects saturate as task difficulty increases and do not benefit task performance.

2-H-38 Does geometry of feet positioning on the ground affect muscular responses in the lower limbs? Comparison between the gastrocnemius and soleus muscles

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BACKGROUND AND AIM: In anteroposterior perturbations of stance, part of body balance recovery is achieved through torques applied at the ankle by means of the triceps surae (TS) activation. Previous investigation has shown that the medial gastrocnemius (MG) muscle has an activation profile distinct from the lateral gastrocnemius (LG) and soleus (SOL) muscles in situations requiring fast and vigorous responses at the ankle. In the current investigation, we aimed at evaluating activation patterns of those three muscles in response to mechanical balance perturbation as a function of feet orientation angle on the ground. METHODS: Twenty-two young (M = 23.81 years, SD = 5.53) healthy participants were tested on a perturbed-balance task. Balance perturbation was produced by unanticipatedly releasing a load attached to the participant's trunk, leading to a fast-forward body sway. Feet-in-place responses were allowed only. We compared muscular activation patterns to loads corresponding to 5% (low) and 10% (high) of the participant's body weight while standing on the following symmetric feet orientation: parallel, preferred (M = 8.19°), 15° and 30° for each foot regarding the body midline. Muscular activation was recorded through wireless electrodes. Sequences of loads and feet orientations were counterbalanced across participants. RESULTS: Results showed that feet orientation at 30° led to stronger muscular responses than in the other feet orientations in the primary epoch (0-150 ms following activation onset) for both low and high loads, and in the secondary epoch (150-300 ms) for the high load. The MG muscle had a differential activation pattern, as indicated by (a) shorter latency of activation onset, (b) higher magnitude of activation in the primary and secondary epochs, and (c) increased gain following activation onset in comparison with the LG and SOL muscles. CONCLUSIONS: Increased magnitude of muscular activation with the feet oriented outwards suggests that feedback-based muscular responses to perturbation are sensitive to biomechanical constraints affecting the capacity to exert force on the ground at the ankles to recover balance stability. The differential pattern of activation of the MG muscle can be explained by its architectural and contractile properties leading to faster and stronger responses than the LG and SOL muscles when a vigorous muscular activation is required. Our results, then, indicate a functional specialization of the MG muscle to respond to unanticipated perturbations leading to forward body sway.

2-H-39 Neuromuscular control of stepping in response to uneven terrain.

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BACKGROUND AND AIM: Walking is a fundamental mode of transportation for humans. Each step taken is one in a series of controlled falls. The goal of which is to commute between two locations while maintaining the upright posture of the head, arms and trunk (HAT). Complicating this endeavour is that the surface upon which these steps are taken may not always be flat. As such, certain neuromuscular control mechanisms are employed to ensure that these controlled falls are arrested. Feedforward and feedback pathways integrate sensory information from before and after foot contact with the uneven terrain and facilitate adaptations safely towards a goal. Unfortunately, the timing and relative contributions of these control mechanisms have not yet been fully investigated. It is the purpose of this study to examine the neuromuscular control mechanism involved in stepping over uneven terrain. METHODS: Twelve university-aged participants (4 female, 18-33 y/o) were recruited to perform a series stepping trials. The experimental condition involved stepping onto a 15° wedge (30 cm square) that faced either the mid-line of the body (medial inclination) or away (lateral inclination). The remaining trials were a control condition where the participant walked on a flat surface without the wedge. Motion capture of these stepping trials was conducted using infrared light-emitting diodes (IREDs)

placed on the HAT, pelvis, legs, shank and feet of the participants. The kinematics of these IREDs was achieved using six Optotrak sensors (NDI, Waterloo, Canada). Kinetics were calculated from the ground reaction forces measured by four forceplates (AMTI, Watertown, USA). Electromyography (EMG) of two trunk stabilizer muscles, four hip stabilizers as well as three shank muscles were recorded. Custom MATLAB scripts were created to process the kinematic, kinetic, and EMG data and to aggregate the trials to examine the timing, direction and magnitude of adjustments to the gait pattern and stability of the trunk. RESULTS: In anticipation of stepping onto a wedge, there was increased minimum clearance between the foot and the ground. This was achieved by increased in hip flexion, knee flexion and to a lesser extent ankle dorsiflexion. Activation of the erector spinae muscles decreased for wedge trials at the time of foot contact as compared to control. Wedge trials further exhibited a delay in activation of these muscles. CONCLUSION: Both feedforward and feedback control strategies were employed to ensure safe stepping on complex terrain. Increased ground clearance in anticipation of stepping onto a wedge is suggestive of a feedforward control mechanism. Activation of trunk stabilizer muscles following foot contact indicate involvement of a reactionary feedback mechanism. Continued analysis of this and future experiments will elucidate the contribution of these postural control mechanisms accompanying steps over uneven terrain.

2-H-40 Postural and stepping strategies on turning while walking.

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BACKGROUND AND AIM: Though turning has a high risk of falling among stroke patients, previously there has been little research on turning undertaken using visual cues. The aims of this study are to correctly analyze the strategy for the onset of turning while walking, and to detect a preference for types of turn in young, elderly, and hemiparetic people after stroke. METHODS: Ten healthy young people (24.5 ± 4.5 years), 10 healthy elderly people (67.6 ± 1.7 years) and 10 stroke patients (66.1 ± 10.3 years, independence without walking cane) participated in this study. After walking 4-5m, participants were visually cued to turn 90° to the left or right. Visual cues were activated in the left or right foot landing (stance) by using a foot switch. The timing of the cues and the directions of the turns were random. With the stance and the direction, the turning tasks were classified as the ipsilateral turning or the contralateral turning. The movement of Head and Pelvis in response to the turning cue were examined by using inertial sensors. And, the types of turning strategy were recorded by a video camera and a web camera. RESULTS: All participants started Head movement to turn before Pelvis movement ($p<0.05$). Young had an earlier onset reaction time of Head than other groups. And Stroke patients had a slower onset reaction time of Pelvis than healthy individuals ($p<0.05$). Regarding the turning strategies, all participants showed a preference for step turn on the ipsilateral turning. On the other hands, the preference for types of turn were different in each group on the contralateral turning. Young preferred the spin turn. Elderly and Stroke showed the variegated strategies. CONCLUSIONS: This is the first study analyzed more clearly the timing of the onset of turning by using the foot switch. In response to the visual cue, Head movement started to turn before Pelvis movement. And these results suggest that the turning strategies are affected by the turning direction, aging and the hemiparesis. The contralateral turning is a difficult task to construct a constant strategy for the stroke survivors. ACKNOWLEDGEMENTS AND FUNDING Grants-in Aid for Scientific Research in Japan.

2-H-41 Effects of cognitive tasks on postural control mode in young and older adults

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BACKGROUND AND AIM: Studies looking at the effects of performing of a concurrent cognitive task on postural control in young and older adults using spatial center-of-pressure measures and dynamical measures produced discordant results. Some found increased postural stability, while others found decreased stability. Improvements of postural stability have been suggested to be due to an automatization of postural control or to the use of an ankle stiffening strategy. It has been suggested that an automatic mode can be identified by an increase in entropy (i.e. more complex sway) and an increase in postural stability. Thus, the aim of this study was to compare the effects of cognitive tasks on postural control in healthy young adults and healthy older adults in order to confirm the postural control mode privileged in a dual-task paradigm using sample entropy. METHODS: Twenty-one young adults and twenty-five older adults were asked to stand on a force platform while performing a cognitive task. Participants performed control standing as well as four cognitive tasks: two discrete and two continuous. The two discrete cognitive tasks consisted of a simple reaction time task and a go/no-go reaction time. For the simple reaction time task, participants were asked to verbally answer "top" as fast as possible when they heard high-pitched auditory stimuli. For the go/no-go reaction time task, participants were presented high-pitched and low-pitched stimuli. They had to respond "top" as fast as possible only when they heard high-pitched stimuli. For the first continuous cognitive tasks participants had to mentally resolve a series of simple mathematical operations. For the second continuous cognitive task, participants had to count the occurrence of a given digit in an auditory sequence of three-digit numbers. RESULTS: In young adults, while mean velocity remained constant for all conditions, sway area and variability were significantly smaller in continuous tasks as opposed to control and discrete tasks. In older adults, sway area and variability in the anteroposterior direction decreased from control to discrete tasks and remained constant for continuous tasks. Increases in mean velocity and MPF were observed in older adults for the continuous tasks compared to control and discrete tasks. Finally, continuous tasks produced higher sample entropy than control and discrete tasks in both groups. CONCLUSION: Results suggest that performing a concurrent cognitive task promotes the adoption of an automatic postural control in young adults and older adults as evidenced by an increased postural stability and postural sway complexity. Also, while adopting an automatic postural control, stability of older adults seemed to reach a plateau for continuous cognitive tasks, whereas young adults further increased their stability. Finally, results suggest that dynamical measures of sway may be more useful than spatial COP measures to interpret the postural strategy used.

2-H-42 Assessing the effects of sport-related head impacts on football defensive linemen's balance control over the course of a season

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BACKGROUND AND AIM: COP velocity measures have been sensitive enough to identify balance control differences between non-concussed athletes and concussed symptomatic athletes as well as those ready to return to play. Little research has been conducted investigating the cumulative effects of sport-based head impacts on balance control. Sport-based head impacts do not represent any cumulative negative effects from preseason to post season on balance control as per the Balance Error Scoring System. However, the BESS test is unreliable due to learning effects and a decreased sensitivity over time. It is important to incorporate challenging balance tasks along with sensitive higher order measures to determine long term balance deficits. The purpose of this study was to determine if higher-order balance assessments can identify any changes to balance control over the course of a competitive football season in defensive lineman. METHODS: Seven university level defensive linemen participated in weekly static balance testing for nine weeks. Participants stood quietly in a narrow Romberg stance for 45s under four different conditions: 1) eyes open (EO); 2) eyes closed (EC); 3) dual task using an arithmetic; and 4) horizontal head rotations. Ground reaction forces were collected at 100Hz using a Nintendo Wii board which acted as a force plate to allow balance to be quantified through the following measures: AP and ML COP displacement (dCOP, sway magnitude), velocity (vCOP, balance control), and AP COP mean power frequency (MPF, neural contributions). For statistical purposes, three time points (preseason, after week 4, & after week 9) were compared to determine if any changes to balance control occurred over the course of the season. RESULTS: Both AP and ML dCOP RMS showed no difference in displacement magnitude from training camp through to week 9. Furthermore, ML vCOP RMS showed no change in ML balance control throughout the season. The neural contributions to balance control (MPF) also showed no changes across the three time points, with the majority of the power located at 0.1Hz. However, over the course of a competitive football season, the defensive linemen´s AP vCOP RMS decreased, indicating an improved level of AP balance control. AP vCOP RMS was the only measure sensitive enough to reveal significant changes in balance control in all the conditions (EC, math dual task, and horizontal head rotations) ($p<0.005$). CONCLUSIONS: AP vCOP RMS is a sensitive enough measure to detect balance control changes over time. From training camp until the end of the season, the defensive linemen in the current study demonstrated better static balance control (i.e., decreased in vCOP) even though they were exposed to multiple sport-related head impacts on a weekly basis. This increase in balance control is most likely the result of intense training over the course of the season, which may have serve as a neuroprotective mechanism to mask the effects of multiple head impacts.

2-H-43 Distinct patterns of coordination when stepping over obstacles at different distances

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BACKGROUND AND AIM: Balance is a vital component of independent and safe mobility and thus, is a major factor in the maintenance of dynamic activities. Maintaining balance while crossing over obstacles is critical to successfully negotiate obstacles encountered in activities of daily living, including community walking. From a balance perspective, this usually involves an effective regulation of the relationship between the body's center of mass and the center of pressure (CoP). Previous literature has examined various kinematic and kinetic variables while stepping over obstacles of different heights across a wide spectrum of populations. Studies involving obstacle avoidance with different heights of obstacle have determined that postural challenges increase with the increasing height of obstacles. The purpose of this study was to examine the CoP and the trunk angle in anterior-posterior direction while stepping over obstacles placed at different distances in healthy young adults. METHODS: Seventeen healthy young adults (age = 18-40 years) were recruited to step over a wooden frame that was 17 cm high and placed at different distances from a starting position: 1) Near obstacle - 25% of the subject's leg length, 2) Far obstacle - 65% of the subject's leg length, and: 3) No obstacle. Subjects started from a standing position on force plates and were asked to step with their right foot first in each condition, presented in a randomized order. In total, there were 150 trials (50 trials x 3 conditions). Leading (right) foot CoP, trailing (left) foot CoP, and trunk angle were analyzed for the time period from 1 sec before the toe off to the heel strike of the leading foot. RESULTS: Preliminary findings suggest that prior to the leading foot toe off, 1) the leading foot CoP moves less posteriorly in the near obstacle than the no obstacle condition whereas the leading foot CoP movement is not different between the no obstacle and the far obstacle condition, 2) however, the trailing foot CoP moves less posteriorly in both the near and the far obstacle condition when compared to the no obstacle. Interestingly, we also found that the increase in the trunk angle from vertical was less in the far than the near or the no obstacle conditions, after the leading foot toe off. CONCLUSION: Stepping over near and far obstacles places different constraints on upright balance. When stepping over a far obstacle, trunk angle deviates less from vertical than when stepping over a near obstacle. Allowing the large mass of the trunk to deviate too far from vertical may threaten upright stability and the nervous system may adopt a coordination pattern that severely limits trunk excursion. Such results suggest that upright stability may drive the adoption of distinct movement patterns when crossing obstacles.

2-H-44 Modality of a cognitive task impacts postural sway in healthy older adults

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BACKGROUND AND AIM: Recent investigations on the effect of cognitive tasks on postural control have revealed improvements in stability while performing challenging cognitive tasks [1], which is contrary to previous evidence. Improvements could be due to the fact that cognitive tasks divert attention away from postural control, allowing more automatic control mechanisms to emerge [2]. Tasks requiring continuous attention have been shown to improve stability more than tasks requiring intermittent cognitive involvement in healthy young and older adults [3]. Perhaps an intermittent cognitive load is not as efficient to divert attention from posture. The question remains whether the duration of inter-stimulus interval in a cognitive task would impact posture in healthy older adults. Furthermore, visual cognitive tasks have led to increased stability compared to auditory cognitive tasks in young adults [1], an effect which should be verified in older adults. Objectives of the present study were firstly to evaluate the impact of inter-stimulus interval of varied duration on postural sway and secondly to examine the effect of task modality on sway. It was hypothesized that shorter intervals would yield greater stability than longer intervals, since they allow less opportunity to consciously attend to posture, and that visual tasks would lead to greater stability than auditory tasks [1]. METHODS: Fifteen healthy older adults (70±3.2 years, 3 male) were asked to stand with feet together on a force platform while performing auditory and visual cognitive tasks. The auditory task consisted of counting the total occurrence of a specified letter in a series of letters while the visual task consisted of counting the total occurrence of a specified digit in a number sequence. Both tasks were performed with inter-stimulus intervals of 2 and 5 seconds. RESULTS: Results reveal that the 2 second interval led to a reduction in sway variability in the medial-lateral direction compared to the 5 second interval ($p<0.05$). Furthermore, visual tasks led to reductions in sway area and sway variability in both directions compared to auditory tasks ($ps \leq 0.05$). CONCLUSIONS: Results suggest that the inter-stimulus interval has an effect on postural sway, although this effect is very limited. A similar limited effect was observed in young adults [1]. Reductions in sway variability in the medial-lateral direction in the 2 second interval suggest modest improvements in postural control, which is expected due to the shorter lapse of time in which attention could be allocated to posture. The modality of the cognitive task seems to have a much greater effect on postural stability, with visual cognitive tasks promoting increased stability. This is also similar to findings in young adults [1]. It is possible that visual stimuli act as an anchor, yielding reduced sway. Alternatively, reductions in sway may facilitate the execution of a visual task therefore changes in stability may reflect requirements for proper performance of the cognitive task. REFERENCES: [1] N Polskaia & Y Lajoie. J Mot Behav 2016;48;482-8.[2] SF Donker, M Roerdink, AJ Greven & PJ Beek. Exp Brain Res 2007;181;1-11. [3] A Potvin-Desrochers, N Richer & Y Lajoie. Manuscript submitted for publication 2016.

2-H-45 Effects of maneuverability range and acoustic pacing on stride-to-stride dynamics in treadmill walking

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BACKGROUND AND AIM: Quantifying the correlational structure of stride-to-stride fluctuations has gained in popularity, largely instigated by observed differences between healthy and pathological gait. Uncorrelated and anti-persistent stride-to-stride fluctuations indicate aging, disease and pathology while persistence represent healthy physiological functioning. However, these interpretations are not without dispute [1,2] because the correlational structure also varies with task constraints, signifying the tightness of control over particular gait parameters. To further examine this tightness-of-control interpretation, we tested the effects of maneuverability range and acoustic pacing on the correlational structure of stride-to-stride fluctuations during treadmill walking. The nature of the expected tighter control in stride speeds with smaller walking areas was explored with goal-equivalent-manifold (GEM) decompositions. METHODS: Twenty-four healthy volunteers (19 females, 23±2years) walked at their preferred walking speed 280 strides on a 3m long instrumented treadmill onto which short, intermediate and long walking areas were projected, with and without acoustic pacing matching their cadence, in counterbalanced order. The correlational structure of stride-time (ST), stride-length (SL) and stride-speed (SS) series was determined [2], along with a constant-speed GEM decomposition. RESULTS: SS fluctuations exhibited anti-persistence, suggesting that this gait parameter was under tight control, with a stronger degree of anti-persistence for shorter walking areas. Constant-speed GEM decomposition revealed that STs and SLs were simultaneously controlled in order to limit SS fluctuations, most compellingly so for shorter walking areas. With acoustic pacing, both constant-speed and constant-stride-time task goals were satisfied, as evidenced by a strong degree of anti-persistence around the single combination of ST and SL that uniquely satisfied both constant-speed and constant-stride-time goals. CONCLUSIONS: Our results support the interpretation that anti-persistence in stride-to-stride fluctuations reflects the tightness of control over the associated gait parameter (i.e. deviations are rapidly corrected in subsequent strides), while variables that are not tightly regulated show statistical persistence. We extend the body of knowledge by not only showing qualitative changes from persistence to anti-persistence with walking-task variations (without and with pacing) [2], but also by showing significant quantitative changes in the degree of anti-persistence of already tightly regulated SS fluctuations (with changes in walking area). 1. Dingwell JB, Cusumano JP (2010) Re-interpreting detrended fluctuation analyses of stride-to-stride variability in human walking. Gait Posture 32: 348-353. 2. Roerdink M, Daffertshofer A, Marmelat V, Beek PJ (2015). How to sync to the beat of a persistent fractal metronome without falling off the treadmill? PLoS ONE 10: e0134148.

2-H-47 Exploring the relationship between muscle strength and function following perturbations during gait initiation

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BACKGROUND AND AIMS Gait initiation (GI) presents a complex challenge to the central nervous system (CNS) as upright posture must be preserved when transitioning from quiet stance to steady state gait. Proactive strategies must be generated to counter act this internal perturbation and ensure stability [Caderby, J Biomech 2014 25: 565-572]; insight into these strategies can be obtained through measures of gait velocity [Tukuno et al, Gait Posture 2005, 24:424-428]. In the event of an unexpected perturbation (slip upon lead heel contact), even quicker reactions must be generated. In these circumstances muscle strength and power are critical for regaining stability (e.g. altering gait velocity). Our goal was to explore the relationship between measures of strength, power and kinematics during planned GI tasks and those where reactive strategies must be generated following an unexpected perturbation of the support surface. METHODS Preliminary data includes healthy young adults (N=5; mean age 21yrs). Strength testing included two clinical measures: 3 maximal handgrip (HG) trials and number of sit-to-stands preformed in 30 sec (STS test) . Kinematic markers tracked body segments (e.g.

pelvis, feet; 1000 Hz, Optitrack) as gait was initiated from quiet stance on one of two force plates (AMTI; 1000 Hz) mounted on a robotic platform. A total of 36 GI trials were collected: 4 anterior (AP), 6 posterior (PP) and 15 no perturbation (NP); magnitude: 18 cm, 60 cm/s, 2 m/s2) triggered upon heel contact (15% body weight; on plate 2). Gait velocity (m/s) was calculated at toe off (TO) of right foot and at peak robot velocity (RB; or equivalent time point in NP trials). Muscle power was calculated from STS test and max HG. An ANOVA (Bonferroni corrections) was conducted (perturbation direction) and Pearson's two tailed correlations were used to assess the relationship between HG and STS power. RESULTS At TO there was no statistical difference ($p > 0.05$) indicating that gait velocity was similar between conditions pre-perturbation, however at RB (post-perturbation) it was significantly different for all directions ($F (2,4) = 670.8$, $p < 0.05$; Figure 1). Additionally, correlations revealed an association between the two measured clinical strength outcomes, STS and HG ($r=0.828$, $N=15$, $p < 0.05$). CONCLUSIONS During a GI task the CNS must control gait velocity to remain upright and stable; this control is further challenged if an unexpected perturbation of the support surface accelerates the body in the opposite direction. Results to date indicate that, compared to NP trials (self-generated perturbation) velocity is significantly reduced following an AP but rapidly increased following a PP, possibly to control movement of COM in direction of travel (reduce and increase momentum, respectively). Inclusion of older adults in the paradigm is planned to further investigate the associated effects of the age related loss of both muscle mass and strength for the control of this complex gait task.

2-H-48 Healthy aging influences the role of spatially tuned preparatory postural muscle activity during standing reach

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Background & Aim: Reaching is a daily occurrence requiring precise control of the arm, body and limbs to be successfully achieved. Generally, the volitional arm movement is preceded by postural muscle activity in the lower limb and trunk which create movement of the body and center of mass (CoM) towards the target. We have previously shown that in young persons these preparatory postural adjustments (or pPAs) are tuned to the direction of reach, ensuring a smooth transition from initial to final reach postures. However, the extent to which sensorimotor declines with aging affect the ability to produce tuned, direction-specific postural activity is currently unknown. As such, this study characterized muscle activity produced in the lower limb during goal-directed reaching movements while standing. Our aim was to identify the spatial tuning of such muscles in preparation for movement onset and whether muscle activation patterns prioritized balance control (and CoM stability) over goal-directed movement generation. Methods: Ten right-handed older participants (6 males, Age: 68 ± 6 years; Height: 1.70 ± 0.58 m, Mass: 71 ± 6.75 kg) stood in the center of a 180º semi-circular array of 13 light targets spaced at 15º intervals. Participants were asked to reach and point to the illuminated target at a natural speed. Focal muscle activity from the anterior and posterior deltoid (AD and PD) was recorded alongside bilateral lower limb muscles using surface electromyography. These included: tibialis anterior (TA), lateral gastrocnemius (GL), peroneus longus (PL), tensor fascia latae (TFL), vastus lateralis (VL), biceps femoris (BF) and gluteus medius (GM). Movement onset and termination were determined when finger tangential velocity exceeded (or reduced) to 3% of its peak during reaching. Finger kinematics including peak velocity, acceleration and deceleration phases were calculated. Postural adjustments were quantified during the 250 ms prior to movement onset (i.e. pPA period). Results: Finger kinematics showed a clear directional influence with movements to left-sided, contra-lateral targets (especially beyond 135º) resulting in significantly lower peak velocities ($p < 0.001$) and longer acceleration phases ($p < 0.001$). Distinct muscle tuning was also seen for the lower limb and could be spatially grouped. Generally, activity biased muscles on the opposite side to the target. For example, right-sided targets (0º - 30º) were characterized by activity from PD, left BF, left GM and bilateral GL with left-sided (105º - 180º) targets showing preference to the right TA, PL, GM and BF. Conclusion: Considering the changes to finger kinematics and the functional roles of the spatially organised lower limb muscles, pPAs may not continue to produce the necessary dynamics for movement initiation in a healthy aging cohort. Rather, they may act in a more traditional role of CoM stability, especially when the arm is required to cross the midline of the body. Funding: PJS was supported by a National Stroke Foundation Small Project Grant

2-H-49 A 30-km hiking challenge in very vital older adults led to reduced postural stability in quiet stance

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BACKGROUND AND AIM: While static postural control is known to deteriorate with age, it is unclear if the often-overlooked physically fit elderly aged over 80 years are able to maintain their balance performance and how they respond to a physical challenge. The current study investigated a unique sample of the oldest participants in the International Nijmegen 4 Days Marches, who take on the challenge of hiking 30 km for 4 consecutive days. By assessing the postural control effects of this challenge and comparing the results to a control group of elderly, we aimed to gain further insight in the dynamics of maintaining balance at old age. METHODS: This study enrolled 52 older adults between 82 and 91 years old (mean age 84.0 years, 17% female) participating in the 4 Days Marches. We used a force plate to collect center of pressure (COP) data at 1000 Hz for 30 seconds before hiking and immediately after walking 30 km on the first day. Participants stood upright with eyes open and barefoot, with feet standardized at shoulder width and with feet close together. In addition, we carried out the baseline measurement in a control group of 105 older adults aged 82-94 years old living independently without home care (mean age 85.1 years, 52% female). COP data were filtered and analyzed according to global stabilometric descriptors. RESULTS: After the hiking challenge, 4 Days Marches participants in shoulder width stance showed a significantly higher root mean square (RMS) of COP amplitude in the mediolateral (M-L) direction (3.6 vs. 2.7 mm, p=<0.001), but not in the anterior-posterior (A-P) direction (5.3 vs. 4.8 mm, p=0.12). The effect of the hiking challenge turned out to be greater in narrow stance, where the increase of the RMS of COP amplitude in the M-L direction was 7.6 vs. 6.4 mm (p=0.001) and in the A-P direction 5.9 vs. 5.4 mm (p=0.03). Compared with 4 Days Marches participants at baseline, the control group exhibited a significantly higher RMS of COP amplitude in the M-L direction in shoulder width stance (3.3 vs. 2.7 mm, p=0.003), but not in narrow stance. CONCLUSION: These results demonstrate that a 30-km hiking challenge in very vital older adults leads to increased COP sway, with the largest impact on the M-L direction. This effect may be caused by central as well as peripheral (muscle) fatigue. Moreover, the elderly control group performed worse on M-L stability as compared to the physically very fit older adults. In comparison to previous research on hiking effects in healthy young adults, the RMS of COP amplitude in both directions of all of our older participants at baseline is higher, the effect of the hiking challenge on postural control is much larger, and the finding that the effect is most prominent in the M-L direction is consistent. In conclusion, early loss of resilience in healthy older persons may be shown by lower mediolateral postural stability, which is also provoked by a 30-km hiking challenge in very fit older persons.

I Developmental disorders

2-I-50 Where is the subjective straight ahead in Williams syndrome?

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Background: Individuals with Williams Syndrome (WS) are known to have particular difficulties when performing visuo-spatial tasks, which could be related to their difficulties in using a specific reference system to determine spatial relations. The aim of the present study was to assess the internal representation of the body's sagittal plane, which is an important benchmark for an egocentric frame of reference. Method: The results of 18 WS individuals (mean age = 20.5+9.2 years) on the subjective straight ahead (SSA) task were compared with those of two healthy control groups composed of a) 36 participants matched on chronological age (CA), and b) 30 young children (YC) matched on non-verbal intellectual ability. Results: Individuals with WS showed a significant left deviation on the SSA body's sagittal plane representation compared to the CA control group, and a marginal left deviation compared to the YC control group. A comparison with the objective SA (0◦) showed a significant leftward deviation in the WS group, but not in the two control groups. Conclusions: Individuals with WS showed a significant leftward deviation in the SSA task. This bias of the body's longitudinal axe representation could have a negative impact on the use of an egocentric reference system, which could be the cause for their difficulties in defining spatial relations (e.g., location, orientation) necessary for performing spatial tasks. Funding: This work was supported by the Swiss National Science Foundation (SNSF) [10019_166047/1]

J Devices to improve posture and gait

2-J-51 Assessment of individuals with chronic stroke walking with body weight unloading on a treadmill and over the ground

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BACKGROUND and AIM: Body weight support (BWS) systems are often adopted for gait rehabilitation of individuals with stroke. However, it is not clear yet how the percentage of body weight unloading provided by the BWS system and the surface (i.e. treadmill vs. over the ground) it is employed would influence gait performance of individuals with stroke. Therefore, the aim of this study was to investigate individuals with stroke walking on a treadmill and over the ground with different percentages of body weight unloading. METHODS: Eight individuals with chronic stroke (59.6 ± 8.6 years old) took part in in this study. An inertial sensor system (Physilog, Gait Up) was placed on each of participants? foot to measure specific gait parameters, as they walked under different conditions. At first, participants walked back and forth at self-selected speed on a 10 m long walkway (?baseline?), and mean walking speed was calculated. Following, participants walked with a BWS system on a treadmill and over the ground with 0%, 10% and 20% of body weight unloading at 80% of the self-selected speed from baseline. The order of surface that BWS system was employed and percentage of body weight unloading were randomized among participants. Stride length, stride duration, stride speed and total duration of double limb support were compared among conditions. RESULTS: On the treadmill, participants walked with shorter stride length, longer stride duration, lower stride speed and longer duration of double limb support compared to overground walking. With 20% of BWS, participants walked with shorter stride length compared to 0% and 10% of BWS, and with shorter duration of total double limb support compared to 0% of BWS, demonstrating more stability with 20% of BWS. CONCLUSIONS: Based upon these results, we suggest that employing BWS over the ground provides a more stable and faster walking of individuals with chronic stroke. Moreover, 20% of body weight unloading on either surface promotes the most stable walking condition although with a shorter stride length.

2-J-52 A Wearable Control Moment Gyroscope for Postural Assistance and Stabilization

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BACKGROUND AND AIM:Postural stability is essential not only for fall prevention but for realization of broad range of human physical activity on daily basis; locomotion, daily domestic motions, sports motions, and driving a personal mobility. Therefore a device that can comfortably facilitate postural stabilization might broaden and enhance daily activities of healthy people as well as those with special needs. However, it is not easy to control total external moment applied around the center of mass of the body for the postural stabilization by using linked exoskeletons, because of the complexity of the joint wise control to generate appropriate total external moment. Also, the possible external moment is limited according to the feet-ground contact condition. In this perspective, our aim is to propose a wearable device for postural assistance and stabilization, which is known as a control moment gyroscope (CMG). It can apply and impart desired external moment on the human body irrespective of the limb joints state and the feet-ground contact condition. METHODS:A wearable CMG device was developed. It consisted of a rotor and an electric motor within a two axis gimbal mechanism. It was equipped on lower back with a belt and applied external moment responding to the inclination of torso. Specification of the components were determined based on the Euler's equation of the rigid body motion. In the evaluation experiment, nine healthy participants equipped the device, stood on a reaction force sensor, and received the external gyro moment, first, during standing in open and closed eye conditions. Postural motion was measured using a motion capture system (VICON MX). RESULTS:The developed device generated 0.886[Nm] torque when the rotor revolved at 4000[rpm]. Rotation of shoulder around the longitudinal axis of the torso caused by the applied gyro moment and reaction time of the torso rotation after gyro moment application were 3.0[deg] and 0.9[s], 3.5[deg] and 0.5[s], 4.0[deg] and 1.0[s] respectively in standing with open eyes, standing with closed eyes, and forward torso bending conditions. Torso rotation after gyro moment application was larger and faster in the closed eye condition than in the open eye condition. The rotation was larger in the bending condition than in the standing conditions. CONCLUSIONS:We proposed a wearable and light-weight CMG device that generates angular moment for postural assistance and stabilization. Focusing on utilization of the adaptive balance control of the human, we investigated whether posture control is possible by applying gyro moment to the torso body part. Furthermore, we formulated and examined the effect of the developed device in terms of its effect on the body motion. We also discussed about feasibility of equipment development for attitude control of the body by the gyro moment throughout the experiment.

K Effect of medication on posture and gait

2-K-53 The Effect of Stochastic Resonance Stimulation on Multi-sensory Fusion for the Balance in Children with Cerebral Palsy: Preliminary Results

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BACKGROUND AND AIM: Stochastic resonance stimulation (SRS) may be an effective stimulus to up-regulate sensory input in individuals with CP to improve postural control. The phenomenon of stochastic resonance (SR), where random noise improves a nonlinear system's sensitivity to differentiate a weak signal, has been observed in various biological systems. One potential SR neurophysiological mechanism is that the subthreshold electrical noise signals cause small changes in receptor transmembrane potentials, making the sensory neuron more likely to fire an action potential in the presence of a weak stimulus. Despite the potential promise of SR stimulation in improving postural control, it has not been used in patients with CP. We developed a 3-modality experimental paradigm which is able to simultaneously probe interactions between vision, vestibular and proprioceptive inputs. The objective of this study was to investigate the immediate effects of electrical SRS when applied in the ankle muscles (i.e. ankle proprioception) and the vestibular system on multi-sensory fusion in children with CP. METHODS: A total of four children with spastic diplegic CP, (median age: 16.4y) and seven typically developing (TD) age-matched controls (median age: 15.4y) were recruited. All the participants were able to stand independently and the sensory SRS thresholds were determined for each individual. Four different conditions for multi-sensory stimulation were designed to assess the effects of SRS on multi-sensory reweighting: 1) visual stimulation-vibration-GVS (Galvanic Vestibular Stimulation); 2) visual stimulation-GVS; 3) visual stimulation-GVS-SRS to the ankle proprioceptors (SRSp); and 4) visual stimulation-vibration-SRS to the vestibular system (SRSv). Frequency response functions were used to calculate gain, which is the amplitude of the trunk/leg segment sway divided by the amplitude of the sensory input at each stimulus frequency. RESULTS: Results showed that gain of the trunk segment angle relative to vision is highest in the visual stimulation-vibration-GVS condition and lowest in the visual stimulation-GVS-SRSp condition in the CP group. In the TD group, the gain of trunk/leg segment angles relative to vision were not different between the visual stimulation-GVS condition and the visual stimulation-GVS-SRSp condition. Gain of trunk/leg segment angles relative to vision decreased from the visual stimulation-vibration-GVS condition to the visual stimulation-vibration-SRSv condition. DISCUSSION: In CP group, the gain to vision was decreased when the SRS was added to the ankle proprioceptors, indicating that SRS further enhanced proprioception and resulted in visual down-weighting. In TD group, the gain to vision was decreased when the SRS was added to the vestibular system, indicating that SRS further enhanced vestibular and resulted in visual down-weighting. CONCLUSIONS: These results provide evidence that subject-specific SRS may be an effective means to improve proprioceptive impairment and balance in children with CP. ACKNOWLEDGEMENTS AND FUNDING: This study was supported by Shriners Hospitals for Children Research Grant #71002 and Shriners Hospital for Children Research Fellowship #84295.

L Ergonomics

2-L-54 Utilization of Active Cooling on Postural Balance while Wearing Firefighter's Ensemble in Warm Humid Environment

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BACKGROUND AND AIM: Postural imbalance is one of the major factors related to injuries from falling. Industrial hyperthermia [core body temperature (CT) ≥ 38 ºC] reduces voluntary muscle force development during a sustained isometric contraction and this performance impairment can be explained by fatigue. Hyperthermia increases body sway velocity (BSv) implying potential reduction in postural balance. Thermoregulation through active cooling may help to preserve postural balance. The aim of this study is to investigate the effect of hyperthermia and impacts of active cooling on the postural balance of subjects wearing firefighters' ensemble (FFE) while exercising in warm humid environment. METHODS: A portable force platform was used to evaluate postural balance characterized by BSv and other metrics. Seven healthy, physically-fit male subjects (VO2max: 52.73 ± 5.09 mL/kg/min, Age: 26 ± 3 years) were recruited to stand on the force platform for 30 seconds once with eyes open

(EO) and then with eyes closed (EC) before and after exercising inside an environmental chamber. Exercise included treadmill walking while wearing FFE at 40 % VO2max in warm (30°C) and humid (70%) environmental conditions for 40 minutes or until CT ≈ 39 °C. Subjects participated in two randomly assigned sessions of the exercise protocol: control (no cooling) and experimental (active cooling application). For experimental sessions, a cooling garment with tubing sewn into the inside of the fabric was worn underneath FFE and infused with cooled water (18°C) supplied by an external water circulator. Skin surface areas in contact with garment for heat exchange included head, torso, forearm, and thigh area. RESULTS: A non-significant reduction was found with cooling application in the mean difference of CT (-0.39 ± 0.67 °C, p=0.173). Participants' mean BSv was significantly increased following hyperthermia conditions (without cooling application) in EO condition (1.64±0.07mm/s, p=0.001) and also in EC (0.10±0.10 mm/s, p= 0.038). Cooling application induced a significant reduction in mean BSv with EO condition (-0.13±0.07mm/s, p=0.002) but not with EC (0.001±0.23mm/s, p=0.987). CONCLUSIONS: Hyperthermia can negatively alter postural balance which may lead to fall incidents. Active cooling application may help maintain postural balance stability with EO but not with EC. The EC condition removes the ocular afferent, leaving the postural control system to rely on the remaining two afferents, the vestibular and proprioceptive systems. All three systems contribute to maintaining postural balance through feedback mechanisms. With the ocular afferent removed, both vestibular and proprioceptive signaling are overburdened and jeopardize postural balance stability. Therefore, maintenance of safe postural balance in EC condition may require a more drastic cooling application to lower CT below industrial hyperthermia limits.

M Exercise and physical activity

2-M-55 An video analysis of the distribution of uninterrupted walking bout in an older adult population

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Background: Gait analysis is a popular field of research in the assessment of fall-risk. Many physiological characteristics have been analysed using both body worn sensors and using video analysis. Attempts are now being made to perform gait analysis during every day physical activity. However many algorithm rely on long un-interrupted gait bouts in order to perform a successful analysis. The aim of this study is thus to examine how common un-interrupted gait bout are in a free-living situation. Method: A total of 20 older adult participants, 68-90 years (76.4±5.6 years), were recruited from the Trondheim area in Norway. The subjects were recorded performing a free-living protocol of everyday physical activities while wearing a Go-Pro camera attached to their chest and recorded at 30fps and annotated using the Anvil software (v5.1.13) to a precision of 0.04 seconds. The protocol is described in detail by Bourke et al. (Bourke et al.). The total quantity and length of uninterrupted walking bouts, including stair climbing, was identified. Results: A total of 36.94 hours of video annotated physical activity data was analyzed and a summary is presented in Table 1. The longest recorded bout was 2081 seconds (34.68 minutes) in length. A total of 95.86% of walking bouts were below 30 seconds (5199) and 87.06% of walking bouts are below 10 second (4721). A total of 98 walking bouts were longer than 60 seconds and 224 were longer than 30 seconds and 702 walking bouts were longer than 10 seconds. We can thus estimate the frequency of a walking bout occurrence of longer than 10 seconds as (702/36.94) 19.03 bouts per hour, for 30 seconds it is 6.06 bouts per hour and for 60 seconds it is 2.65 bouts per hour. Table 1. Bout range (s) Quantity Total bouts (%) Bin times (s) Bin times (%) < 1 1218 22.46 657.72 1.13 < 5 3958 72.99

7271.25 12.50 < 10 4721 87.06 12626.43 21.71 < 20 5097 93.99 17920.63 30.81 < 30 5199 95.87 20402.93 35.08 < 40 5266 97.10 22731.24 39.08 < 60 5325 98.19 25664.97 44.12 < 100 5365 98.93 28726.17 49.38 < 200 5384 99.28 31365.51 53.92 < 500 5401 99.59 36635.23 62.98 <1000 5416 99.87 47129.61 81.02 <2000 5420 99.94 51980.74 89.36 <2081 5423 100.00 58168.86 100.00 Discussion and conclusions We have examined the distribution of walking bouts in an older adult population using video analysis as a gold standard. This will inform future research on the minimum length of recording in order to obtain a sufficient number of uninterrupted walking bout which can be used for analysis.

2-M-56 Is the baseline performance of a cognitive single-task related to dual-task training effects?

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Background and aim: The potential benefits of dual-task (DT) training for people with Parkinson's disease (PwPD) has received recent attention, however it remains unknown if this training is beneficial for everyone. In a randomized controlled trial on single (ST) and DT-training among PwPD, we found improvements of the dual-task interference (DTI) of the cognitive task but not gait in the training group compared to the controls, indicating different prioritization strategies. Therefore, we aimed to investigate if: (1) the training effects on gait variability differed between those who improved and those who decreased the DTI of the cognitive task; (2) potential between-group differences varied between ST and DT-conditions. Methods: 45 PwPD that had participated in 10-weeks of gait and balance training were included. Gait and a cognitive task (reciting alternate letters of the alphabet) were performed at ST- and DT-conditions. The participants walked at preferred speed upon the GAITRite® walkway system, 6 times per condition. The following gait variability parameters were investigated: step velocity, step length, swing time, step time, stance time and step width. The PwPD were divided into two groups: those showing DTI improvements of the cognitive task were categorized as responders (n=29) and those decreasing the DTI of the same task were considered non-responders (n=16). See Table 1 for baseline demographics. Between-group differences at baseline were analyzed with the Mann-Whitney U test, significance level was set at $p \leq 0.05$. Non-parametric effect sizes (ES) were calculated to assess the magnitude of between group differences, where: 0.1=small effect, 0.3=moderate effect, 0.5=large effect. Results: As shown in Table 1, there were no between-group differences at baseline; except for the performance of the cognitive ST, showing a significantly worse performance among the non-responders. During single-task gait, between-group differences showed moderate and small improvements for step length (ES=0.34) and step width variability (ES=0.23) among the responders. Conversely, the non-responders showed small improvements regarding the variability of step (ES=0.25) and stance time (ES=0.15). During the DT-condition, the responders showed a moderate improvement regarding swing time variability (ES=0.36) and small improvements for the variability of step velocity, step length, step time and stance time (ES=0.17-0.29). Conclusions: No specific prioritization strategies were found, rather these results suggests that those who improved the DTI of the cognitive task also tended to improve gait variability during the DT-condition. This pattern was not evident during the ST-condition, indicating a possible overload among the non-responders during the DT-condition. The one factor separating the groups at baseline was the performance of the cognitive ST, hence future studies may consider investigating if cognitive ST's can predict outcomes of DT-training. Acknowledgements and funding: Parkinsonfonden

2-M-57 Factors related to life-space mobility in patients with chronic stroke

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BACKGROUND AND AIM: Patients with chronic stroke have limited life-space mobility in their community, and the restriction of life-space has been considered as a predictor of functional decline and mortality. However, it is unclear whether restriction of life-space mobility is related to physical and psychological factors in patients with chronic stroke. The aim of this study was to examine the relationship between life-space mobility and both physical and psychological factors in patients with chronic stroke. METHODS: This study was approved by the ethics committee of the Saitama Cooperative Hospital. Thirty-nine stroke survivors (age 74.1 ± 5.7, 21 men) participated in this study. Participants were recruited who were aged ≥ 65 years, had had a stroke at least 6 months previously, and could walk independently. We used a Japanese translation of the Life-Space Assessment (LSA) as a life-space mobility assessment. Potential relevant factors were measured that included age, sex, time post-stroke, stroke type, physical performance [walking speed, Mini-Balance Evaluation Systems Test (Mini-BESTest), Timed Up and Go test (TUG)], activities of daily living (ADL) [Barthel Index (BI) score] and fall-related self-efficacy [Falls Efficacy Scale International (FES-I)]. The relationships between the LSA score and the other measurements were examined using Pearson?s or Spearman?s correlations. Unpaired t-tests were used to compare the LSA score for sex and stroke type. A multivariate linear regression model was used to examine whether the potential determinants were related to the LSA score. For regression analysis, the limits for the entry and removal of variables were $p < .10$ for both. For all analyses, $p < .05$ was accepted as significant. RESULTS: Univariate analysis showed that the LSA score was significantly related to Walking speed, Mini-BESTest, TUG and BI score ($p < .05$). The LSA score was not significant related to age ($p = .31$), sex ($p = .15$), time post-stroke ($p = .82$), stroke type ($p = .18$), or FES-I ($p = .06$). Stepwise regression analysis was used to determine the LSA score based on walking speed, Mini-BESTest, TUG, BI score and FES-I. In the final model, walking speed (beta = .465, $p < .01$), BI score (beta = .348, $p = .01$) and FES-I (beta = .348, $p = .04$) maintained a significant relation with LSA score. The final model explained 58.9% of the LSA score variance. CONCLUSIONS: Walking speed, BI score and FES-I maintained a significant relationship with LSA score in the stepwise multiple regression. These results suggest that the restrictions of life-space mobility in patients with chronic stroke are strongly affected by slower walking speed, ADL difficulty and lower fall-related self-efficacy. These findings give further insight into developing effective interventions for regaining life-space mobility in persons with stroke.

N Falls and fall prevention

2-N-58 Step length as the primary temporal-spatial determinant of minimum foot clearance during overground gait in Parkinson's Disease

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BACKGROUND AND AIM: Subtle alterations in foot clearance are evident even in the early clinical stages of Parkinson's disease (PD)[1] and may contribute to the increased risk of trips and falls in this population. People with PD tend to walk with shorter steps for any given walking speed and pathology-associated differences in foot clearance may be due to walking more slowly with shorter steps[2]. A comprehensive observation of the changes in temporal-spatial gait characteristics during overground walking at different speeds and the resulting foot trajectories will enhance our understanding of the temporal-spatial determinants of foot clearance in people with PD and so inform the design of falls prevention therapies. METHODS: Thirty-six people with PD ($\bar{x}$[SD]age: 70.1[9.7]y, 26m) and 38 adults of similar age and sex ($\bar{x}$[SD]age: 72.4[7.8]y, 21m) completed four intermittent walks at a self-selected preferred and fast gait velocity as part of the ICICLE study. Temporal-spatial characteristics of gait were obtained using an instrumented walkway and foot clearance outcomes (minima, maxima and trajectory gradients)[1] measured with 3D motion capture. General Linear Models evaluated the influence of

group (PD, Control) and condition (Preferred gait velocity, Fast gait velocity) upon gait and foot clearance. Linear regression quantified the variance in minimum foot clearance (MFC) attributed to temporal-spatial gait (velocity, length, time and the walk ratio). RESULTS: People with PD walked faster than controls, regardless of condition (p<.001). Both groups reduced their swing time when walking faster, but this was less evident in people with PD who tended to increase their step length (evidenced by changes in the walk ratio) more than controls (group x condition interaction, p=0.018). Walking faster resulted in increased minima and maxima at both the heel and toe and steeper take-off (toe) and landing (heel) gradients (p<.001). Step length and the walk ratio were most strongly related to MFC in both groups and velocity conditions (Figure 1) however the change in temporal-spatial control to increase gait velocity (i.e. Step length[Fast velocity] - Step length[Preferred velocity]) did not explain the change in MFC (i.e. MFC[Fast velocity] - MFC[Preferred velocity]) in PD. CONCLUSIONS: Increasing step length when walking faster, rather reducing swing time, is responsible for increased MFC in older adults and people with PD. Interventions that specifically address the short step length often observed in people with PD may also improve MFC and so may reduce the risk of trips and falls. REFERENCES [1] Alcock (2016) J Biomech, 49(13),pp.2763-2769 [2] Cho (2010) J Neurophys, 103(3),pp.1478-1489
ACKNOWLEDGEMENTS AND FUNDING ICICLE-GAIT is supported by the National Institute for Health Research (NIHR) Newcastle Biomedical Research Unit based at Newcastle upon Tyne Hospitals NHS Foundation Trust and Newcastle University. ICICLE-PD is supported by Parkinson's UK. The research was also supported by NIHR Newcastle CRF Infrastructure funding.

2-N-59 Contribution of the arms to recovery after a trip in older adults

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Background and aim Falls are common in daily life, and trips or slips cause a large proportion of falls. The often-seen flailing of the arms after a perturbation suggests that humans use their arms for recovery after a trip. Interestingly, previous work has shown that the movements of the arms at the onset of a trip may actually be detrimental to recovery in young adults [1, 2], yet movement of the arms may be beneficial during the recovery [1]. However, it has been suggested that arm swing changes with ageing, and elderly may also adopt a protective rather than a preventive strategy when perturbed; i.e., extending the arms to handle the impact with the ground [3]. Thus, in the current study, we investigated whether and how older adults use their arms after a trip. Methods 18 older participants (11 males, 69.7±2.3 yr, 79±14 kg, 1.68±0.09 m) walked along a walkway, while in random trials they were tripped using a custom tripping device [1, 4]. We evaluated the effect of the arm movements (1) prior to and (2) during the initial tripping response on the recovery after the trip with respect to their younger counterparts [1]. Results Average self-selected walking speed was 1.44±0.12 m/s. The first trip caused 6 participants to fall, and 3 participants to directly grab for the safety harness, out of which 2 fell. Only first trial data for the remaining 11 subjects were further analyzed. The normal arm swing resulted in an angular momentum of the arms at the moment of trip that was detrimental to rotations in all planes (Figure 1). However, arm movements during the tripping response prevented transfer of this angular momentum to the rest of the body, and led to a more favorable rotation in the all planes, such that the body was rotated less forward, more towards the recovery foot, and with less frontal plane rotation. Still, body rotation at recovery foot placement was less favorable in older subjects than was previously reported in young subjects, suggesting that older subjects had less favorable arm movements either during or before the trip. Conclusion Like in young subjects, arm motions after successful tripping in older adults contributed to recovery by allowing a larger recovery step. Moreover, some subjects had responses that would only be useful in our experimental setting, suggesting that "safety strategies" (i.e. grabbing the harness in our experiment) emerge even in novel situations. Differences in arm movements between fallers and non-fallers will be further investigated and discussed. References 1. Experimental Brain Research, 2010. 201(4): p. 689-99. 2. Journal of Experimental Biology, 2010. 213(23): p. 3945-3952. 3. Gait Posture, 2008. 27(2): p. 352-6. 4. Gait & Posture, 2001. 14(1): p. 11-18. Figure 1: Actual rotation of the body (blue) in three planes from time of trip to first recovery foot placement. The contribution of continuation of arm movements at trip initiation (red), indicating an angular momentum of the arms at the moment of trip that was detrimental to rotations in all planes. However, arm movements during the initial trip response (green) prevented the transfer of this angular momentum to the body, and led to a more favorable rotation in the all planes.

2-N-60 Effect of a six-week virtual reality treadmill training falls prevention intervention on macro gait outcomes of free-living walking activity.

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BACKGROUND AND AIM: Gait impairments are frequent among older adults and associated with fall risk. Intervention programmes aiming to reduce fall risk (e.g. balance exercise programs) usually focus on single risk factors (i.e. either motor or cognitive performance). The effects of interventions on free-living walking activity are still not clear and need to be explored. Recently, the V-TIME study showed that a six week multimodal intervention programme of treadmill training combined with a virtual reality component (TTVR) lowered the incidence of falls more than an intensity-matched intervention with treadmill training (TT) only [1]. The aim of this exploratory analysis was to examine the hypothesis that a lower fall risk due to the TTVR intervention would be mediated by change in volume, pattern and variability (macro gait outcomes) of free living walking activity. METHODS: 165 older adults (age: 74±7 years) including: 72 elderly fallers (EF), 24 people with mild cognitive impairment (MCI) and 69 people with Parkinson's disease (PD), who had fallen twice or more in the previous 6 months were assessed. Participants were randomly assigned to TT or TTVR interventions and tested at baseline and after the intervention (1 week, 1 month and 6 months) [1]. For each assessment free-living data were recorded for 7 days with an accelerometer (Axivity AX3) placed on the lower back. Macro gait outcomes representing the volume (% walking time, number of bouts per day, number of steps, mean bout length), pattern (alpha), and variability of free-living walking activity were extracted in MATLAB® (R2012a) [2]. General linear models were used to examine the effect of Group (EF vs PD vs MCI), Time and Intervention on macro gait, controlling for age and sex. RESULTS: Macro gait outcomes did not changed over time (main effect for Time $p > 0.05$). In addition, there were no significant Group x Time or Intervention x Time interactions. This suggests the lack of change was consistent between groups and intervention type. We repeated the analysis including different thresholds of bout length (bouts over 10 seconds and 60 seconds) with similar results. Significant group effects (EF vs PD vs MCI) showed that PD had more variable bout lengths compared to EF and MCI ($p \leq 0.016$). CONCLUSIONS: This exploratory work showed that despite reducing the incidence of falls, a 6 week treadmill training intervention (with or without VR augmentation) did not change macro gait outcomes (volume, pattern and variability) in older adult fallers who managed to sustain free-living walking activity while reducing fall risk. Reduction in falls rate due to treadmill training does not seem to be mediated by a change in macro gait outcomes of free-living walking activity. ACKNOWLEDGMENTS: We thank the V-TIME participants for their time and commitment to the study. We thank all the V-TIME partners. The project was funded by the European Commission (FP7 project V-TIME- 278169). REFERENCES: [1]Mirelman A et al, Lancet, 2016; 388(10050):1170-82 [2]Lord S et al, J Neurol., 2013; 260(12):2964-72

2-N-61 Alterations of gait and balance in relation to urgent desire to void in older female fallers with and without incontinence

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Background and aims: The prevalence of falls is estimated to be 19 to 42 per cent amongst women aged 65 or older, living in the community. Among the risk factors, urgency incontinence is independently associated with an increased risk of falls in older women. Furthermore, an urgent desire to void alters balance and gait in older, continent, people. However, the effect of the urgent desire to void has not been evaluated in female fallers with urgency incontinence. The study objectives were first to show the differences in gait and balance parameters between female fallers with urgency incontinence (I) or without (C) and second to measure how these parameters are altered in a situation of urgent desire to void in these two groups. Methods: Twenty older women without urgency and mixed incontinence (n=10, 75±3 years, BMI: 25.5±3.9) and with urgency and mixed incontinence (n=10, 72±4 years, BMI: 28.4±3.5) were included in this study. Type and severity of the urinary symptoms were determined using the International Consultation on Incontinence Modular Questionnaire (ICIQ). Further, all the participants had a history of at least one fall in the last year. Spatiotemporal, upper trunk and pelvis kinematics and centre of pressure parameters were quantified in twenty consecutive gait cycles using a motion analysis system and an instrumented treadmill, in two conditions: with and without an urgent desire to void. Two one-minute gait trials were recorded: immediately after the participants had emptied their bladder (no urgent desire) and when the participants reported a sensation of moderate bladder fullness (3/5 on the Urinary Scale Sensation). An ANOVA was performed to compare each variable between the two conditions and between groups. Results: There was no statistically significant difference in walking speed between groups (p=0.4, C: 0.75 vs I: 0.65 m/s)). In the empty bladder condition, women with urgency incontinence showed a larger upper trunk mediolateral (ML) acceleration (p=0.012), a larger speed of the center of pressure in the ML direction (p=0.064) and a tendency for larger step width (p=0.07) compared to the women without incontinence. In the condition with a sensation of moderate bladder fullness, both groups showed a decrease in the step width variability (p=0.032), a more backward position of the upper trunk (p=0.021), and an increase of the amplitude of the upper trunk in ML (p=0.10) compared to the empty bladder condition. The total ML amplitude of the pelvis during a stride increased only in continent women (group x condition: p=0.035). Conclusion: There was little difference in gait and balance parameters between continent and incontinent female fallers. However, adaptation of mediolateral pelvis movement was less for females with urgency incontinence than for females without, in the condition of moderate bladder fullness.

2-N-62 Smarter Balance System: Smartphone-based biofeedback technology for clinical and/or home-based balance rehabilitation

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BACKGROUND AND AIM: While conventional physical and balance rehabilitation programs have shown to improve balance performance and increase postural stability, participation in these programs is often limited due to cost, availability of physical therapists, and accessibility to rehabilitation facilities. Additionally, when prescribed a balance rehabilitation regimen for home training, exercise compliance is

affected by a loss of memory and decline in motivation. We have developed the Smarter Balance System (SBS) intended for clinical and/or home-based balance rehabilitation, and assessed its efficacy on physical therapists' recommended dynamic weight-shifting balance exercises (DWSE) in individuals with Parkinson's disease (PD). METHODS: The SBS consists of a smartphone and custom waistbelt housing a miniaturized motion sensor, processing unit, wireless communication module, and tactors. The SBS's custom app generates target movements for the DWSE based on 90% of the user's Limits of Stability (LOS), gives exercise instructions, displays visual biofeedback on the smartphone's screen, wirelessly communicates with the waistbelt to receive user's movements and control vibrotactile biofeedback, and stores target and user's movements. Seven individuals with idiopathic PD having bilateral symptoms with impaired postural stability participated and performed one session of the DWSE in a laboratory setting. The session included a total of 24 trials (12 trials in the anterior-posterior (A/P) and 12 trials in the medial-lateral (M/L) direction). Values of participants' LOS in the A/P and M/L direction were measured at the pre- and post-session. To assess exercise performance during balance training with assistive guidance via the SBS, values for cross-correlation (XCOR) and position error (PE) for all trials was computed using recorded target and participant's movements. The output of the XCOR analysis is a positive value ranging between 0 and 1, where 1 indicates a perfectly matched motion of the participant to the target, whereas the output of the PE is computed as an average absolute difference between the target and the participant's movements in degrees. RESULTS: A significant increase in LOS between the pre-and post-session was observed ($F(1, 9) = 9.73$, $p = .005$). The average XCOR and PE across all participants were 0.88 ($SD = 0.11$) and 1.63 degrees ($SD = 0.66$) for the A/P direction and 0.74 ($SD = 0.11$) and 0.66 degrees ($SD = 0.24$) for the M/L direction respectively. CONCLUSIONS: Two main findings were: 1) individuals with PD could accurately follow the target movements during the DWSE guided by the SBS; and 2) participants' LOS has significantly increased after one session of the DWSE. Future studies will assess the efficacy and acceptability of the SBS during long term in-home rehabilitative training for balance-impaired individuals.

2-N-63 A New Model of Community Fall Prevention: Music-based Multitasking (Jaques-Dalcroze Eurhythmics) for Older Adults and Kinesiology Students

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BACKGROUND: Falls burden many older adults, yet community-based prevention programs are modest in efficacy. Jaques-Dalcroze Eurhythmics, a music-education based on kinaesthetic learning, is known to be highly effective in preventing falls in a community dwelling population with a low dose. A new model of community fall prevention was designed combining Eurhythmics for older adults and a course for kinesiology students. The reception of this pilot program was evaluated. METHOD: A licensed teacher in the Dalcroze method directed activities for older adults at San Marcos Senior Activity Center in California with kinesiology students who assessed and supported them. Activities based on Dalcroze methods were combined with cognitive and sensory-motor activities specific to older adults. The science of balance, coordination, and falls were incorporated into related eurhythmics concepts to develop activities for older adults in an intergenerational and interdisciplinary community program. Concepts from eurhythmics (such as quick reaction, echo, sequence, automatization, spatial perception, and social interaction) were reframed in terms of cognitive skills (such as memory and dual tasking) and sensory-motor skills (such as weight shifting and aiming). Specific issues affecting older adults were considered in designing activities, such as visual dependence, response generation, sensory function, strength, and flexibility. Students led strength and flexibility exercises, designed and conducted activities to address balance, gait and falls, and they took field notes on their observations. The older adults and students participated in focus groups to share their perceptions of the program. RESULTS: Older adults noted the strengths of the program as confidence, social stimulation, improved mobility, balance and health, appreciation for music and dance, metamemory awareness, enhanced creativity, and having a self-paced environment. Challenges included transportation, physical mobility, scheduling, and differences in skill levels. Their recommendations included having more classes with different skill levels and developing individualized transportation options. Students noted the strengths as hands-on learning with older adults, and working in groups. Weaknesses include lack of time to address health issues and to learn the musical concepts, implying a need for more time and training. DISCUSSION: This intergenerational program was perceived positively as providing considerable benefits to both older adults and students. Incorporating standard exercise-based fall prevention elements into eurhythmics activities may further improve its efficacy in fall prevention. We hypothesize that the specific aspects of eurhythmics that confer fall risk reduction include the multiple methods used to train motor response generation through musical and auditory cues. Further work is needed identify specific elements that can be translated into other programs.

2-N-64 Why are Parkinson?s disease patients prone to falls during turning? Can we model dysfunction in healthy young participants?

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Background and aims: Difficulty in turning is prominent among patients with neurological disorders such as Parkinson?s disease and the resulting postural instability increases patients? risk of falling. However, the mechanisms that underlie turning problems have not been fully determined. It has been suggested that eye movement problems in PD patients may contribute towards turning deficits (Anastasopoulos, et al 2011; Lohnes & Earhart, 2011). However, it is not clear whether the changes observed in eye movements of PD patients during turning are a direct consequence of their neuropathology or an indirect effect of altered posture and turning characteristics. Two possible symptoms of Parkinson?s disease that might contribute towards turning deficits are 1) neck and trunk rigidity and 2) bradykinesia (slowness of movements). The main aim of the study was to model these symptoms in young healthy adults and observe the effects on eye movements, whole-body coordination, balance and posture. Methodology: Healthy young participants completed standing turns on level ground through 180°, either to the left or to the right. A 10 camera Vicon Bonita motion analysis system was used to record movement kinematics (Plug-in-gait model) and eye movements were measured using a Bluegain electrooculography system. The turning protocol consisted of three experimental conditions: a) normal unrestricted turning b) increased neck and trunk rigidity (participants wore a neck-chest brace that restricts head movement) and c) slow turning. An animation on a video screen, played immediately before each trial showing the required speed and direction of turn. Trial order was randomised for each participant. Ten trials were recorded for each combination of experimental condition and turn direction giving 60 trials in total. Repeated measures ANOVA was performed to assess the effects of our different conditions. Results: There was a significant main effect of turning speed on the following dependent measures: onset latency, peak head-thorax angular separation, step size, step frequency and number of nystagmus fast phase. See table 1. Experimentally inducing neck rigidity had no effect on any of these dependent measures other than peak head-thorax separation. Conclusion: Our results suggest that increased neck rigidity cannot explain PD-related differences in eye movement and whole-body coordination during turning previously documented. In contrast, it is clear that turning slowly does results in altered eye movement, whole-body coordination and stepping behaviour consistent with differences previously documented exhibited by PD patients. It is likely that bradykinesia is one of the main contributory factors to changes to the eye movements and turning kinematics implicated in increased falls risk in PD patients References: Anastasopoulos D et al. (2011). Movement Disorders, 26(12), 2201 Lohnes, C. A., & Earhart, G. M. (2011). Journal of Parkinson's disease, 1(1), 109.

2-N-65 On-site perturbation-based balance recovery training among residents of retirement communities - preliminary results

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BACKGROUND AND AIM: Approximately half of all falls among adults age 65 and older occur due to tripping. Therefore, improving the ability to recover balance after tripping may be an effective approach for reducing the number of falls among older individuals. Balance recovery training (BRT) is a novel exercise intervention that has the potential to improve balance recovery ability. The goal of this on-going study is to evaluate the efficacy of BRT as an on-site intervention for improving reactive balance recovery ability among residents of retirement communities. METHODS: To date, 24 adults (age 63-93, 14 women) have been assigned to either BRT or an active control using minimization allocation. BRT involved safely and repeatedly exposing subjects to postural perturbations that mimicked a trip using a modified treadmill. Perturbations were elicited while subjects stood still on the treadmill, by abruptly accelerating the treadmill belt to a preselected speed. This perturbation induced a forward fall similar to a trip while walking, and required subjects to take steps to recover their balance. BRT involved 12 30-minute sessions, over four weeks, that consisted of 18-40 trials on the treadmill with direction and speed (0.22 - 1.07 m/s) pseudo-randomized and individualized based upon subject ability and improvement. The active control, group-based Tai Chi, involved the same number and duration of sessions as BRT. Before starting the assigned intervention, and one week, one month, three months, and six months after completing the assigned intervention, a battery of balance tests were performed to assess changes in balance within and between groups. These tests included standardized perturbations on the modified treadmill, and three clinical balance measures (Berg Balance Test, Tinetti Performance Oriented Mobility Assessments for gait and balance, and the Activities-specific Balance Confidence scale). RESULTS: Balance recovery ability improved to a greater extent after BRT than after Tai Chi. More specifically, BRT elicited a longer initial recovery step, shorter reaction time, less harness support, and better subjective assessment of overall balance recovery ability compared to Tai Chi. These improvements persisted for up to three months after completing BRT. Results also suggest that clinical balance measures did not change appreciably after either intervention. CONCLUSIONS: Although these results are preliminary, they provide initial support for: 1) on-site BRT improving a reactive motor skill closely related to fall prevention; 2) Tai Chi not improving the reactive motor skill to the same degree as BRT; and 3) BRT not improving common clinical balance measures. These results support the use of the specificity of training principle among older adults for fall prevention. ACKNOWLEDGEMENTS AND FUNDING: National Science Foundation Award HRD-1502335 and NIH/NIA Award R21AG045723.

2-N-66 Feasibility and efficacy of reactive step training using unpredictable slips and trips in young and older adults

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BACKGROUND AND AIM: Previous studies reported dramatic improvements in balance recovery following repeated perturbations (in a single session). However, these have used a single type of perturbation (e.g. slips or trips only) at a fixed location. Therefore the improvements might be attributed to proactive adaptation or prediction. The purpose of this study was to examine feasibility and efficacy of a single session of reactive step training using both slips and trips in unexpected locations among young and older adults. METHODS: Ten young (29.8 ± 12.8 yr) and ten older adults (71.0 ± 4.4 yr) walked on a novel 11-m trip- and slip-perturbation walkway. Participants were instructed to maintain their usual gait speed using metronome and stepping tiles. Responses to a slip and a trip were captured before and after one session of slip and trip training (14 slips, 14 trips and 4 no-perturbation walks) using an 8-camera Vicon Bonita motion analysis system. Kinematic variables at before and after perturbation onset (slip and trip) were analysed as proactive and reactive adaptations. Anxiety was assessed using a Likert scale during the tests and training. RESULTS: Anxiety increased significantly during training, especially in older adults (Figure 1). One young person and three older people withdrew from training due to anxiety. No significant change in gait speed was observed (young 1.35 ± 0.08 and older 1.19 ± 0.20 m/s) and changes in margin of stability (MoS) before the slip and trip were small (Cohen's d < 0.3). Falls after slips (>30% body weight on harness) decreased from 44.4% (n=4) to 0% (n=0) in the young and 28.6% (n=2) to 14.3% (n=1) in the older participants. No participants fell from trips. Among older participants who completed the training, substantial improvements in MoS after slip (Cohen's d = 1.13) and trip (Cohen's d = 0.93) were observed. CONCLUSIONS: The study results suggest that the reactive step training using unpredictable slips and trips can improve reactive balance control in older adults. However, feasibility of the training was not high due to the high dropout rate and anxiety during training. Older adults may require more individualized and progressive training over multiple sessions.

2-N-67 Protective stepping in people with MS: effects of a single bout of practice

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BACKGROUND AND AIM: Reactive postural control, including protective stepping, is a critical component of fall prevention after a loss of balance. People with multiple sclerosis (MS) exhibit slow reactive steps, possibly contributing to falls. However, whether reactive stepping can be improved in people with MS is unknown. Our aim was to determine whether people with MS can improve protective stepping through repeated exposure to external perturbations, and whether baseline cognitive performance may predict this improvement. We hypothesize that people with MS will improve stepping via practice and that participants with higher cognitive performance will exhibit the most pronounced improvements. METHODS: Protective stepping was elicited in 12 healthy adults and 4 people with moderate MS via repeated movements of the ground underfoot (i.e. postural perturbations) which required a reactive step. We measured changes in protective stepping over the course of 25 backward stepping perturbations. Margin of stability (MOS; distance between the stepping foot and center of mass at instance of first foot contact) and step latency (SLA; time to first foot off) were calculated via motion capture (Vicon Ltd; Centennial, CO) and imbedded force-plates. Cognitive function was also assessed in people with MS via the symbol digit modality test (SDMT). To date, we have collected data on 4 people with MS (mean[SD] of the European Database of Multiple Sclerosis (EDMUS) scale: 5[0.81]) and 12 healthy adults. Data collection on people with MS ongoing. RESULTS: As reported previously, healthy adults improved backward stepping, as demonstrated by increased MOS and decreased step latency over the course of 1 day of protective stepping practice (MOS_start[m]: 0.11 - MOS_end: 0.15; p=0.001; SLA_start [ms]: 293 - SLA_end: 281; p=0.04). In people with MS, MOS and step latency were not significantly improved over practice (MOS_start[m]: -0.22; MOS_end: -0.19; p=0.51; SLA_start[ms]: 349 - SLA_end: 329; p=0.31), due in part to a currently small sample and high variability. However, as noted in figure 1 A & B below, subtle improvements were noted in both variables. Furthermore, although only 4 patients have been collected, cognitive capacity, measured by SDMT, is directly related to improvement in MOS over practice (figure 1c). In other words, people with better baseline SDMT scores exhibited more pronounced improvement in stepping performance over the course of practice. However, it is difficult to draw definitive conclusions based on this small sample, and additional data are currently being collected to better understand this trend. CONCLUSIONS: Although further investigation is necessary, these preliminary findings suggest that improvements in protective stepping in people with MS are variable and likely less pronounced than healthy adults, and baseline cognitive capacity may be predictive of the degree of improvement in stepping.

2-N-68 Does a perturbation based gait intervention enhance gait stability in fall prone stroke survivors?

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Background: Falls are a common problem in community dwelling stroke survivors. For instance, hip fractures as a consequence of a fall result more often in immobility than in healthy older adults, and the loss of mobility may lead to a further decline of daily functioning. This example underlines the importance of developing effective fall prevention programs for stroke survivors. Previous attempts at designing effective fall prevention programs for stroke survivors have been unsuccessful. Most falls occur during walking and we recently found that gait characteristics are the best predictors of fall risk. A recent review indicated that perturbation based interventions (PBI) are effective in reducing falls in older adults and people with Parkinson disease. At present, it is unknown whether this type of intervention is effective in stroke survivors. Thus, as a first step in the development of fall prevention program, we determined whether PBI can enhance stability of gait in stroke survivors. Method: Ten community dwelling chronic stroke survivors who experienced at least one fall in the past six months participated in the PBI. The participants received 12 training sessions over a six-week period. Each gait training contained progressive reactive, unexpected perturbations such as simulated trips and slips and medio-lateral belt translations. Furthermore, proactive, expected perturbations were given by obstacle crossing tasks. To maximize the variety of perturbations, all perturbations were given with varying intensities and were applied at different moments in the gait cycle. Evaluation of gait stability was performed prior to, and after PBI. First, we determined gait characteristics in a standardized laboratory setting. Second, we explored whether participants walked more stable in daily life, by determining gait characteristics in daily life during seven consecutive days. We had previously developed fall prediction models for both gait assessment methods separately. Here, we evaluated whether predicted fall risk was reduced after the PBI according to our standardized laboratory fall prediction model and according to our daily life fall prediction model. Results: Nine out of ten participants improved their gait characteristics in our standardized gait assessment and consequently predicted fall risk based on laboratory measurements was significantly reduced after the PBI. Daily life gait characteristics, however, did not change and thus predicted fall risk based on daily life gait remained unchanged after the PBI. Conclusion: A six week PBI results in more stable gait and thus lower predicted fall risk in a standardized setting, however the more stable gait did not transfer to a more stable gait in daily life.

2-N-69 Elderly fallers enhance dynamic stability through anticipatory postural adjustments during a choice stepping reaction time

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BACKGROUND AND AIM: In the case of disequilibrium, stepping is a natural, effective and privileged strategy to recover balance. The capacity to step quickly is thus critical to avoid falling, in particular for elderly. It can be simply assessed through the choice stepping reaction time test (CSRT), where elderly fallers (F) need more time than elderly non-fallers (NF). However, reasons for this result remain unclear. To answer this, we investigated the characteristics of anticipated postural adjustments (APA) developed by elderly F in a CSRT context and their consequences on the dynamic stability. METHODS: 44 community-dwelling elderly subjects (20 F and 24 NF, mean age 75, height 1.63 m, and weight 66.8 kg) performed a CSRT with four targets (Lateral Left, Central Left, Central Right, and Lateral Right, Fig A). Duration of the step phases, presence of APA error, trajectories of both the center of pressure (CoP) and extrapolated center of mass (XCoM) and size of the margin of stability (MoS) at the foot-off (FO) were analyzed using two-way repeated measures ANOVAs. RESULTS: Total stepping time was longer in F compared to NF, independently of the target direction. This elongation is due to a significant increase of the APA phase duration. Both APA subphases ("loading" and "unloading" mechanisms) were significantly elongated. Elderly F did not make more APA errors than NF but used two distinct balance strategies during APA, depending on the axis (Fig B). In the AP direction, F had a smaller backward movement and slower peak velocity of the CoP. In the ML direction, the CoP movement was similar in amplitude and peak velocity between groups but lasted longer. The biomechanical consequence was an increased MoS at FO in both directions. CONCLUSIONS: The results about the step timings are concurring with previous studies in the literature. The presence of APA error seems however not to be an evident reason for APA elongation in F. Analysis of APA tend to indicate that F voluntarily elongate their APA during a CSRT. This strategy allows increasing the condition for dynamic stability at the end of the APA, i.e. when the base of support is reduced to only one foot. By delaying the FO, elderly F chose to prioritize the stability to the detriment of the objective of the task (a quick step), probably because a higher fear of falling. It is concluded that elderly F used a "safer" balance strategy than NF during the CSRT. If delaying the FO is possible during a voluntary step initiation task, it may however become a severe balance issue in a more demanding context such as protective steps. An elongated APA duration during the CSRT could thus be understood as an indicator of the risk of fall in community-dwelling elderly. ACKNOWLEDGEMENTS AND FUNDING: Romain Tisserand held a doctoral fellowship from La Région Rhône-Alpes.

2-N-70 Deficits in motor imagery of gait among older adults predict future development of fear of falling

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Background and aim: Our recent study showed that older adults with Fear of Falling (FoF) could not accurately imagine their gait performance. However, whether or not this deficit in motor imagery (MI) predicts a new-onset of FoF is still unclear. The aim of this study was to assess the longitudinal relationship between gait-related MI and the future development of FoF. Methods: This cohort study included 151 community-dwelling older adults. At baseline, participants were tested for both imagery and execution tasks of a Timed Up and Go (TUG) test. The participants were first asked to imagine the trial (iTUG) and estimate the time it would take, and then perform the actual trial (aTUG). The difference between iTUG and aTUG (Δ TUG) was calculated. The incidence of FoF in the participants who did not report FoF at baseline was again ascertained two years later. Results: The participants were stratified based on the presence of FoF at baseline, and 51.7% (n = 78) presented FoF (FoF group). The FoF group showed significantly faster iTUG and slower actual ability (AH) than those of the non-FoF group. The adjusted logistic regression analysis showed that Δ TUG was significantly associated with having FOF. After two years, 26 participants in the non-FoF group developed FoF (incidence rate, 35.6%). Of the 73 participants without FoF at baseline, a logistic regression analysis revealed that increased Δ TUG (i.e., overestimation of TUG ability) was an independent predictor of the future development of FoF. Conclusions: Our results indicated an impairment of MI ability, which reflects a functional decline in motor planning, contributes to the development of FoF. Impairment of MI ability (i.e., overestimation of physical ability) can be an additional explanation of the high risk of falls in this population.

2-N-71 Relationship between the balance ability and the acceleration of the start & end movement of sit to stand five times test

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BACKGROUND AND AIM: The balance ability usually decreases, and the risk of falls increases with aging. Various tests have been applied to the study of balance ability and risk of falls. Among them, the sit to stand five times (STS5) test is a commonly used. The duration of STS5 was used for a typical variable for the evaluation. However, inertial measurement unit sensor has been used for the determination of several different movement types and the extraction of dynamic variables. Signals from IMU sensor such as acceleration allow extracting some significant parameters related to transition during timed up and go test and to compare them with the fall risk [1]. The repeated sit to stand transition such as STS5 can show comprehensive balance ability for the elderly with decreased physical abilities. This study tried to find significant parameters for the evaluation of balance ability of the elderly during STS5 movement and to study the relationship between balance ability (fall risk) and derived parameters. METHOD: Eighty-six elderly subjects participated in this experiment (male: 23, female: 63, age: 75.8±5.7years, height: 153.2±9.0cm, weight: 59.2±9.2kg). The subjects were divided by Berg balance scale (BBS, Healthy old (HO): >52(N=53), Impaired old (IO): ≤52(N=33)) and fall experience (Faller: ≥1(N=27), Non-faller: 0(N=59)). The subjects performed the STS5 while a wireless IMU sensor modules (APDM Inc., Portland, OR, USA) attached at the posterior trunk at the L5 level and right frontal thigh [2]. The acceleration signal of the sensors was collected with a 128-Hz sampling frequency, and filtered with low-pass(fcut :3.5-Hz). The transitions of sit to stand (SiSt) and stand to sit (StSi) were measured using the sensor at the thigh. Calculated parameters included the range of acceleration (rangeAcc), integrated acc (iAcc), jerk cost(JC) and range of jerk (rangeJ) during the start of SiSt and the end of StSi for the anterior-posterior (AP) direction. The independent T-test was performed for statistical analysis (α=.05). RESULTS: All parameters were not significantly different between the faller and the non-faller group. The rangeAcc(p=.01*), JC(p=.01*) and rangeJ(p=.00*) at the end of StSi were significantly different between HO and IO group. CONCLUSIONS: Results showed that there was a significant difference at the end of StSi with BBS since the BBS test was based on multidimensional components of balance ability. The acceleration range, jerk cost and jerk range of IO group, were low, which means that IO group moved with more restricted and cautious manner especially during final stand to sit transition movement [1]. However, there was not any difference in the parameters between faller and non-faller group. Therefore, it has a limitation for the prediction of fall risk by these parameters. It is recommended to use these parameters for the comprehensive balance ability assessment in elderly. REFERENCES: [1] Weiss, A. (2011). Physiological Measurement 32(12): 2003-1018. [2] Doheny, E. P. (2013). Gait & Posture 38(4): 1021-1025. ACKNOWLEDGEMENTS AND FUNDING: This research was supported by Basic Science Research Program through the National Research Foundation of Korea(NRF) funded by the Ministry of Education(2016R1D1A3B03930135).

2-N-72 Effects of a busy day on fatigue, physical function and fall risk in older people

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BACKGROUND AND AIM: Fatigue is a common complaint amongst older people. Studies of laboratory-induced muscle fatigue have shown detrimental effects on measures of physical functioning associated with fall risk. However, these protocols do not accurately reflect daily activities of older people. The aim of this study was to compare the effects of a busy day and a restful day on fall-related measures of physical and cognitive function in older people. METHODS: This randomised crossover trial involved 50

community-dwelling adult volunteers, aged 60-88 (mean 72) years. Participants undertook assessments of balance, mobility, sensorimotor and cognitive functions before and after a planned restful and a planned busy day (randomly allocated) at least one week apart. Participants wore an activity monitor on both the rest and busy days. RESULTS: Participants recorded almost double the amount of activity and reported a significantly greater change in feelings of fatigue on the busy day, compared with the rest day. 2x2 repeated measures ANOVA with day (busy/rest) and time (morning/afternoon) as factors, revealed few significant day*time interactions for tests of physical function. The exceptions were joint position sense (p=0.001) and the timed up and go test of mobility (p=0.031), where busy day performance was poorer for the afternoon relative to the morning, compared with the rest day. In addition, standing sway with eyes closed showed a significant day*time interaction (p=0.037), resulting from a reduced sway path in the afternoon relative to morning on the busy compared with rest day. Performance in tests of cognitive function showed no interaction effects across the busy and restful days. CONCLUSIONS: Results suggest that lower limb joint position sense and mobility performance in older people may be impaired following a busy day. Standing postural sway changed in the opposite direction than expected, possibly a response for tightened balance control following the busy day. Overall, this study showed few fatigue-related impairments in physical and cognitive functions in older people and give little reason to suspect that a busy day might pose a significant risk of falling.
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2-N-73 Automated detection of multidirectional compensatory balance responses during gait using wearable IMUs

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BACKGROUND and AIM: One of the most challenging public health problems worldwide is falls, the leading cause of injury-related hospitalizations and a major cause of disability and death among seniors. Compensatory balance responses (CBRs) are reactions to recover stability following a loss of balance, potentially resulting in a fall if sufficient recovery mechanisms are not activated. Our long-term goal is to develop new fall risk assessment tools by quantifying the frequency of CBRs while performing free living activities. Previously, a method to detect lateral CBRs (i.e., cross-over, side-step) was developed using inertial measurement units (IMUs) at the shank, thigh, and sternum and machine learning [1]. While initial results were promising (92.35% accuracy in 3-class detection problem), the method was limited to lateral pushes in a single direction. The aim of the current study is to extend the method to detect CBRs in multiple directions using a perturbation treadmill. This abstract reports results from a preliminary evaluation using a subset of sensor signals (i.e., shank). METHODS: Nine healthy young participants (mean age = 26y) wore IMUs mounted to the right and left shanks while walking on a perturbation treadmill (BalanceTutor, Meditouch, Israel). Four perturbation directions were delivered (right, left, backward, forward) during single support of the left and right legs in a 8-class detection problem. Overall, 720 and 704 trials during single support of the left and right legs were recorded, respectively. To detect CBRs, acceleration in the vertical direction and angular velocity in sagittal direction were logged at ~37 Hz. Similar to previously described methods, trials were segmented based on the total peak magnitude acceleration and 34 IMU-based features were extracted for each trial [1]. The resulting data matrix (1424 trials x 34 features), labeled by type of perturbation, was used to train random forest (RF) and artificial neural network (ANN) models to classify CBRs. The algorithms were tested using 10-fold cross-validation using a 20/80% test/train data split. RESULTS: For a 8-class classification problem, mean accuracies were 71.8% and 63.4% the RF and ANN methods, respectively. CONCLUSION: In the current study, an automated method to detect multidirectional CBRs elicited during single support using wearable IMU signals was developed and evaluated. In comparison to random selection (1 of 8 possible classes = 12.5%), initial accuracy results (71.8%) are promising. To advance the proposed method, a larger number of IMU sensors signals expanding the total number of features from 34 (current study) to 230 using 5 IMUs is under investigation. This study contributes to a long-term project aimed at detecting and tracking the frequency and circumstances of CBRs in everyday life. ACKNOWLEDGEMENTS and FUNDING: Research supported by National Sciences and Engineering Research Council of Canada (NSERC). REFERENCES: Nouredanesh, Mina, and Tung, James. "Machine learning based detection of compensatory balance responses to lateral perturbation using wearable sensors." Biomedical Circuits and Systems Conference (BioCAS), 2015 IEEE. IEEE, 2015.

2-N-74 Younger and Older COPD Patients Demonstrate Balance Deficits as Compared to Controls

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BACKGROUND AND AIM: Patients with chronic obstructive pulmonary disease (COPD) report a higher incidence of falling than their healthy counterparts. Additionally, balance deficits are attributed to the aging process. Research pertaining to balance in COPD typically assesses older patients. Therefore, our purpose was to provide a delineation between deficits due to the presence of disease versus the aging process by investigating balance in both young and older patients with COPD. METHODS: Fifteen patients with COPD and 24 controls, divided into young and older adult groups, agreed to participate in this study (Young Control (n=17): 55.8±6.3yrs; Older Control (n=7): 72.1±5.7yrs; Young COPD (n=7): 58.7±5.6yrs; Older COPD (n=8): 73.3±5.8yrs). Subjects underwent clinical and laboratory-based balance tests including the timed up and go (TUG), Fullerton advanced balance scale (FAB), and the sensory organization test (SOT) and motor control test (MCT) from the Neurocom Balance Manager. The force platform data from the six conditions of the SOT was subjected to both linear and nonlinear analysis of sway patterns. Linear variability was assessed with range, root mean square, and 95% confidence ellipse and nonlinear variability was assessed using sample entropy (m=2, r=0.2). Group differences for the TUG, FAB, and SOT and MCT composite scores were compared using oneway ANOVAs. To compare across conditions within the SOT, repeated measures ANOVAs (group x condition) were used. RESULTS: A significant main effect of group was found for all balance tests except for the MCT. For the TUG, older COPD took longer to complete the task than the young controls (p=0.05). The young and older COPD subjects performed significantly worse on the FAB as compared to the young (p=0.01 and p<0.001, respectively) and older control (p=0.049 and p<0.001, respectively) subjects. The older COPD had a worse SOT composite score than the young controls (p=0.01). The SOT force platform data showed linear variability and regularity of sway increased with condition difficulty (as sensory information was either removed or falsely provided) across all groups. For the older COPD group, range (p=0.002), root mean square (p=0.01), and 95% ellipse (p=0.01) in the mediolateral direction was increased in condition five as compared to all others. Older COPD subjects had a less regular sway in the anteroposterior direction as compared to young COPD (p=0.007). CONCLUSIONS: Older COPD subjects demonstrated differential patterns in mediolateral sway as compared to the other groups. They had the most difficulty during the condition where vision was removed and somatosensory information was falsely provided (i.e., relying on the vestibular system). The FAB proved to be the best test for discriminating between older and younger patients with COPD as compared to younger and healthy controls. A larger sample is still needed to determine if balance deficits are manifest in younger patients with COPD.
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O Habilitation & rehabilitation

2-O-75 The effect of 2 weeks of vibrotactile biofeedback of trunk sway on balance control in multiple sclerosis: a pilot study

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BACKGROUND and AIM: Patients with multiple sclerosis (MS) suffer from diminished balance control due to slowed sensory conduction and possibly delayed central processing. In a first pilot study with 10 subjects we demonstrated that one session of vibrotactile biofeedback (VTf) training of trunk sway could improve balance control in MS patients compared to one training session without feedback. Here, the on-line and carry-over effects of 4 sessions of VTf training over 2 weeks on trunk sway during stance and gait tests was investigated. METHODS: Ten MS patients, 1 male, (9 relapsing-remitting, 1 secondary-progressive, mean age 45.8 ± 14.6 years, mean EDSS 3.2 [range 1.5 - 4.5], mean disease duration 11.4±6.9 years) participated in this study. Trunk sway was measured with body-worn gyroscopes mounted at vertebral level L3-L5. Head mounted VTf of trunk sway was direction specifically active when sway exceeded the subject's 90% limit measured during initial task assessments. Seven different stance and gait tasks were first trained with sway angular VTf for stance and sway angular velocity VTf for gait tasks, 2 times a week for 2 weeks. An assessment sequence of 12 stance and gait tasks with VTf was performed each week after the second VTf training session. After a pause of 1 week, training was continued without VTf for 1 week and assessed without VTf to assess the carry-over effect. RESULTS: In all tasks, assessment with VTf showed a significant decrease in sway after 1 week of VTf training with a further additional decrease after 2 weeks of VTf training. Testing without VTf 1 and 2 weeks later week later after a week of training without VTf showed a lesser reduction but still significant difference with respect to baseline - see figure 1. The greatest effects were found for tests of tandem stance which resulted in a 70% decreased roll sway velocity ($p=0.02$) with VTf and a 62% reduction ($p=0.03$) carry-over effect with respect to baseline values. Gait tests showed smaller but a similar pattern of improvement. CONCLUSIONS: This study indicates that VT biofeedback of trunk sway is likely to improve balance of stance and gait, having a carry-over effect of at least 1 week. Future studies should confirm these results for other groups of MS patients with different patterns of neurological deficits and EDSS scores, and determine the average time course of the carry-over effect in order to determine when training with VTf should be restarted.

2-O-76 The use of rhythmic auditory cues during gait in Parkinson's disease: influence of disease progression on cued response.

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BACKGROUND AND AIM: Gait impairment is one of the major symptoms in Parkinson's disease (PD) and is associated with increased incidence of falls, loss of independence and reduced quality of life. Despite advances in medication, gait impairment still remains problematic in PD and thus additional therapeutic strategies are required. Previously, auditory cueing has demonstrated benefits for gait impairment in PD (Nieuwboer et al., 2007). However, response to cue is varied and the response to auditory cues in both early disease and as disease progresses has not been previously examined. The aim of this longitudinal study was to assess the effect of auditory cueing on gait in a PD cohort of early disease and three years later. METHODS: Participants with idiopathic PD were recruited from the ICICLE-Gait study. At 18 and 54 months post diagnosis twelve participants with PD walked with and without a cue (auditory metronome beat set at individual cadence). Instructions were given to take a big step in time to the beat. Participants walked a distance of 8 meters over a GAITRite and 4 intermittent single walks were performed for each trial. A comprehensive battery of twelve gait characteristics was measured under

both conditions representing domains of pace, rhythm, variability and postural control (Lord et al., 2013). Data analyses were performed using IBM SPSS version 21 with Wilcoxon test. A p value of 0.05 was deemed significant. RESULTS: Disease severity significantly increased over 3 years (UPDRS III, p=0.009). In early disease, characteristics of pace (step velocity, p=0.041) and rhythm (mean step time, p=0.021; mean stance time, p=0.004) improved with an auditory cue, but variability worsened (increased) (step time variability, p=0.026). As disease progressed - after three years, similar improvements in characteristics of pace (step velocity, p=0.006; step length, p=0.008) and rhythm (mean step time, p=0.041; mean stance time, p=0.016) were observed however variability was preserved compared to baseline. CONCLUSION: This study indicates that a rhythmic auditory cue improves discrete gait characteristics in early PD and as disease progresses. However, in early PD this may come at the cost of increased variability which is a risk factor for falls (Hausdorff, et al., 1997). The time when an auditory cue is introduced with respect to disease severity may therefore be a factor that should be taken into consideration. This needs to be validated in a larger cohort. ACKNOWLEDGEMENTS: Financial support for this study came from the National Institute for Health Research (NIHR) Newcastle Biomedical Research Unit, Parkinson's UK and the NIHR Newcastle CRF Infrastructure funding. REFERENCES: Nieuwboer, A., et al. Cueing training in the home improves gait-related mobility in Parkinson's disease: the RESCUE trial. Journal of Neurology, Neurosurgery & Psychiatry, 2007.78(2): p.134-140. Lord, S., Galna, B., Rochester, L. Moving forward on gait measurement: towards a more refined approach. Movement Disorders, 2013. 28(11): p.1534-1543. Hausdorff, J.M., et al. Increased gait unsteadiness in community-dwelling elderly fallers. Archives of Physical Medicine and Rehabilitation, 1997. 78(3): p. 278-283.

2-O-77 The effect of Virtual Reality gait training on motor and cognitive function among children with Attention Deficit Hyperactivity Disorder

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BACKGROUND AND AIM: Attention Deficit Hyperactivity Disorder (ADHD) is a common neurodevelopmental disorder, characterized by cognitive dysfunction as well as poor motor ability that affects social, emotional and academic skills. Standard of care includes use of stimulant medication, which might be partially effective while causing side-effects in some patients. A growing body of studies have begun to explore the use of either physical activity or cognitive remediation as a non-pharmacological alternative to treat children with ADHD. The present study aimed to examine the feasibility and efficacy of a combined motor-cognitive approach, using virtual-reality (VR) gait training to enhance quality of gait, executive function (EF) and behavior in children with ADHD. METHODS: School-aged children, diagnosed with ADHD according to DSM5 criteria were recruited. Children taking medication to improve attention and subjects with other health issues were excluded. Participants received an intensive and progressive VR gait training program, held 3 times a week for 6 weeks. Training included walking on a treadmill while negotiating virtual obstacles. Subjects were tested at baseline, immediately post-training, and at 6-weeks follow-up. A computerized neuropsychological test battery (NeuroTrax) was used to generate index scores of attention, memory and EF, normalized to age (i.e., scores below 100.0 reflect poorer cognitive function). Gait was evaluated under usual and dual task (DT) conditions (i.e., phoneme monitoring), using a 3D-accelerometer attached to the lower back (Opal, APDM). The Conners' Parent Rating Scale evaluated the effects of training on behavioral symptoms. RESULTS: Fourteen children (mean age 9.3±1.2 years, 3 girls and 11 boys) completed the training protocol. Immediate improvement was observed in the EF index, increasing from 88.0±11.0 at baseline to 92.9±8.5 post-training (p=0.042). Memory increased from 93.7±15.6 at baseline to 105.0±6.4

immediately after the training (p=0.001). Attention was unchanged between testing points (p=0.976). Significant improvement was also noted in stride regularity, increasing from 0.42±0.12 at baseline to 0.51±0.10 post-training during usual walking (p=0.03) with similar changes observed during DT (from 0.39±0.11 at baseline to 0.46±0.12 post-training, p=0.026), reflecting greater consistency in the gait pattern after the training. Enhancement in motor and cognitive function resulted in reduced frequency of behavior related to inattention (from 66.8±18.0 at baseline to 54.6±15.6 post training, p=0.005). Gains in memory were sustained at follow-up (p=0.003) while long-term training effects on EF were marginally significant (p=0.075). CONCLUSION: These findings demonstrate the feasibility and efficacy of using treadmill training augmented with VR to enhance gait, cognitive function and behavior in children with ADHD who were not treated with medication. In the future, it may be interesting to also examine the benefits of using this VR approach as adjunct therapy alongside standard of care.

2-O-78 Validation of rating of perceived difficulty scales for balance exercises using postural sway measures

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BACKGROUND and AIM: Balance training has shown benefits in improving balance in older adults and people with vestibular disorders. One of the key elements for prescribing exercise is setting the intensity. However, the evidence for documenting the intensity of exercises that were used during balance interventions is very limited. In clinical settings, time and cost factors make it prohibitive to use forceplates and accelerometers as a way to measure balance intensity. The purpose of this study was to validate two rating of perceived difficulty scales for quantifying intensity of balance exercises, using measures of postural sway as the gold standard. METHODS: Sixty-two subjects (age range 19-85 y, mean 55 + 20 y) participated, with targeted sampling across four different age groupings to ensure a representative distribution of balance ability across the age span. On two separate visits, subjects twice performed 24 balance exercises for 30 s, consisting of a full factorial combination of the following independent variables: vision (eyes open and eyes closed), surface (firm and foam surfaces), stance (feet apart and semi-tandem), and head movement (still, pitch, and yaw). Postural sway (tilt displacement, tilt velocity, and linear acceleration) was measured using an inertial measurement unit (Xsens) affixed to the subject's waist with a belt. After each exercise, subjects provided a rating of perceived difficulty using two different scales: a 0-10 numerical scale with verbal anchors based on the OMNI rating of perceived exertion scale, and a qualitative scale with five balance-related statements ranging from "I feel completely steady" to "I lost my balance". The root-mean-square (RMS) of the postural sway measures was computed for movement in the pitch and roll directions. The qualitative rating scale was converted to an ordinal 1-5 scale. A regression analysis was used to determine the correlation between the rating of perceived difficulty scales and postural sway measures, while accounting for repeated observations within subjects (Bland and Altman, 1995). RESULTS: There were significant positive correlations between the rating of perceived difficulty scales and RMS of trunk tilt displacement and velocity in the pitch and roll directions ($r = 0.37-0.73$, $p < .001$). There was no difference between the 0-10 numerical rating scale and the five level qualitative rating scale. Larger correlations were observed between the rating of perceived difficulty scales and the postural measures in the roll direction compared with the pitch direction. CONCLUSION: Two different rating of perceived difficulty scales were significantly correlated with postural sway measures across a broad range of balance exercise conditions, suggesting that the rating scales can be used as a measure of balance intensity. Clinical use of these rating of perceived difficulty scales may improve prescription and progression of balance exercises. ACKNOWLEDGEMENTS AND FUNDING: This research was performed with support from Prince Sattam Bin Abdulaziz University and the Saudi Arabia Cultural Mission.

2-O-79 Pelvic support vs. pelvic constraints: Immediate after effects of robot assisted gait training in LOPES II on overground walking in healthy subjects

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BACKGROUND AND AIM- Recovery of walking is a primary rehabilitation goal of most stroke survivors. Lateral pelvic displacements of approximately 30 mm are commonly observed in the gait pattern of healthy individuals, yet surprisingly, conventional robot-assisted gait trainers constrain pelvic movements. Novel robot-assisted gait trainers, such as lower extremity powered exoskeleton LOPES-II, are able to support pelvic movements during gait. The aim of this study was to investigate the immediate after-effects of pelvic support (PS) vs. pelvic constraint (PC) gait training with LOPES-II on overground walking in healthy subjects. METHODS - Thirteen able-bodied subjects (22.8±2.1 years) participated in two 20-minute gait training sessions with LOPES-II; one with PS and one with PC. During the PS-training, the lateral displacement of the pelvis was supported, while pelvic rotations were free. During the PC-training, both lateral displacement and pelvic rotations were constrained. The training sessions were separated by a 30 minute resting period. The lateral displacement of the pelvis and spatiotemporal parameters during overground walking were determined at baseline and immediately after the training using 3D gait analysis. RESULTS - Analysis of the first five steps of overground walking immediately following PC-training showed significantly smaller lateral displacements of the pelvis (32.3±12.0mm) compared to PS-training (40.1±9.8mm; $p<0.01$). Compared to baseline (36.1±10.2mm), the lateral displacement of the pelvis was slightly smaller after PC-training and slightly larger after PS-training, but these differences failed to reach significance ($p=0.07$ and $p=0.06$, respectively). During the first five steps, the stepwidth was slightly but significantly smaller after PC-training (0.68±0.10m) than at baseline (0.69±0.09m; $p=0.05$). The lateral displacement of the pelvis and stepwidth post training returned to baseline levels within 10 steps. PC- nor PS-training affected gait velocity, cadence, stride length or stance time. CONCLUSIONS - In healthy subjects, robot-assisted gait training with pelvic constraint had immediate negative after-effects on the overground walking pattern, which was not the case after robot-assisted gait training with pelvic support. Gait training including support of the lateral displacement of the pelvis better resembles the natural gait pattern. It remains to be identified whether pelvic support during robot-assisted gait training may be superior to pelvic constraint to promote gait recovery in neurological patients.

Q Neurological diseases

2-Q-80 Lower-Limb Muscle Strength Associates with Parkinson's Disease Stage Independent of Age

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BACKGROUND AND AIM: Postural instability and gait difficulties (PIGD) in individuals with Parkinson's disease (PD) contribute to their loss of independence in performing activities of daily living and thus, to a reduced quality of life. Although various disease-specific neurochemical contributing factors to PIGD have been identified, neuromuscular factors may also exist. For example, lower-limb muscle strength has been linked to gait and balance difficulties, including increased fall risk, in older adults. Hence, the purpose of this study was to investigate the age-independent association between lower-limb muscle strength and Parkinson's disease stage. METHODS: A total of 40 individuals with PD (sex: 30M/10F; age:

66.2 ± 6.0 yrs; modified Hoehn & Yahr stage: 2.3 ± 0.6; duration of disease: 7.7 ± 5.7 yrs) underwent lower-limb isometric strength testing with a digital handheld dynamometer (microFET2, Hoggan Health Industries). Ankle plantar and dorsiflexors, knee extensors and flexors, and hip extensors, flexors, adductors, and abductors were assessed each over three 5-seconds trials. The maximum force value from the best trial for each muscle group was extracted for statistical analysis. To determine the strength measures that significantly associated with Hoehn and Yahr stage, a measure of Parkinson's disease stage, partial correlations were performed, controlling for age. This latter variable was included as a covariate given that aging is a well-known contributing factor to lower muscle strength. RESULTS: Ankle plantar flexors ($r = -0.366$, $p = 0.022$), ankle dorsiflexors ($r = -0.390$, $p = 0.014$), knee extensors ($r = -0.462$, $p = 0.003$), hip adductors ($r = -0.368$, $p = 0.021$), and hip abductors ($r = -0.450$, $p = 0.004$) were found to be negatively correlated with Parkinson's disease stage, independent of age. Thus, as disease stage advanced, ankle, knee, and hip muscle strength decreased, irrespective of age. CONCLUSIONS: Lower muscle strength of the lower-limb was significantly associated with more advanced Parkinson's disease stage, independent of age. Interestingly, the strongest correlations with disease stage were found for the hip abductors and knee extensors, which are critical to frontal- and sagittal-plane postural stability, respectively, during numerous activities of daily living, including walking, ascending/descending stairs, and rising from a chair. Lower-extremity muscle weakness has been estimated to increase the odds for any fall by 75% and the odds for recurring falls by more than 300%; therefore muscle strength is critical to maintaining one's independence and quality of life. Although it is well-known that aging is accompanied by a decline in muscle strength, age does not appear to contribute to strength decline associated with progression of disease in PD. Future work should focus on potential causes of this declining muscle strength in PD, such as lifestyle (e.g., more sedentary) and/or neurochemical causes (e.g., loss of acetylcholine). ACKNOWLEDGEMENTS AND FUNDING: NIH P50 NS091856

2-Q-81 Gait asymmetry in people with Parkinson's disease is linked to reduced integrity of callosal sensorimotor regions

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Background and aim: Transcallosal communication via the corpus callosum between the left and right hemisphere of the brain plays a key role in the production of integrated motor behavior to generate appropriate, coordinated motor responses on both sides of the body. In people with idiopathic Parkinson´s Disease (PD), the supraspinal control of locomotion is altered and the need for additional volitional neural control contributes to an increase in gait asymmetry and variability. The goal of this study is to compare the integrity of the corpus callosum connecting homologous sensorimotor cortical regions in people with PD and healthy controls (HC) and to evaluate the relationship between the callosal integrity and gait asymmetry. Methods: Ten people with PD (mean age 70; Hoehn & Yahr range 2-4) and 8 healthy controls (mean age 75) underwent high-angular resolution diffusion imaging (HARDI) using a Siemens Tim Trio 3T Scanner with a 12-channel head coil. White matter microstructural integrity of transcallosal fibers connecting homologous sensorimotor cortical regions [primary motor (M1) and somatosensory (S1) cortices, and pre-supplementary motor (PSMA) and supplementary motor areas (SMA), respectively] was assessed. Spatial and temporal gait asymmetry was assessed via wireless inertial sensors (Opals, APDM) and an instrumented walkway (GAITRite). Three 8-meter walks at preferred gait speed were used to determine step length asymmetry and step time asymmetry. A 2-min walk at preferred speed was used to compute the phase coordination index (PCI). We correlated fractional anisotropy (FA) of the callosal regions of interest with gait asymmetry metrics where group performance was different. Results: Our preliminary results show a significant group difference in step length asymmetry, but not for step time asymmetry and PCI. Specifically, those with PD showed significantly greater step length asymmetry compared to their age-matched counterparts. In addition, we report a strong relationship between step length asymmetry and callosal fiber tract integrity (FA) connecting the primary motor cortices (M1: r = -0.37) and the primary somatosensory cortices (S1: r = -0.48). These were also the only sensorimotor callosal regions that demonstrated group differences in white matter microstructural integrity: M1 (PD: 0.43 (0.08); HC: 0.48(0.05)) and S1 (PD: 0.36 (0.08); HC: 0.47 (0.05)). Conclusion: People with PD showed significantly increased step length asymmetries and decreased microstructural integrity of callosal white matter tracts connecting the primary motor and somatosensory cortices. These measures were also strongly associated with each other, indicating that reduced transcallosal structural connectivity may be a significant mechanism underlying bilateral asymmetries in those with PD. Data collection and analyses in a larger sample of participants (>50 PD to date) is on-going to confirm the preliminary trends observed thus far. ACKNOWLEDGEMENTS AND FUNDING This work was supported by the National Institutes of Health (2R01AG006457; KL2TR000152), the Department of Veterans Affairs grant # I01RX001075, the Collins Medical Trust, and the Medical Research Foundation of Oregon.

2-Q-82 The sudden stop-and-start test of the Interactive Walkway affords an innovative evaluation of freezing of gait in Parkinson?s disease patients

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BACKGROUND AND AIM: Freezing of gait (FOG) is an important cause of disability and falls in patients with Parkinson's disease (PD). In both clinical and laboratory settings, FOG episodes are difficult to elicit. Growing evidence suggests that challenging walking tests are more likely to reveal differences in walking ability between freezers and non-freezers compared to standard walking tests. The Interactive Walkway is an overground 10-meter walkway with projected visual context, like stepping targets, obstacles and stop cues, to assess walking during challenging walking tests. Context can be presented in a gait-dependent manner using real-time processed validated markerless Kinect v2 3D motion registration data [1]. The aim of this study is to assess the added value of an instrumented stop-and-start test over standard walking tests in discriminating between freezers and non-freezers. METHODS: A group of 26 PD patients participated in this experiment in the ON state. Based on their score on the New Freezing Of Gait Questionnaire (NFOGQ), patients were classified as freezer (n=13; mean [range]: NFOGQ: 20 [4-24]) or non-freezer (n=13; NFOGQ: 0). There were no significant differences between freezers and non-freezers in age (63 [43-77] vs. 67 [55-85] years; p=0.227), the Movement Disorders Society-Unified Parkinson's Disease Rating Scale motor score (43 [18-79] vs. 34 [7-63]; p=0.232), and Hoehn and Yahr stage ([2-4] vs. [1-3]; p=0.178). Two standard walking tests (i.e., a 10-meter walk test [10MWT] and a Timed Up and Go test [TUG]) were included. Patients also performed two tests on the Interactive Walkway, namely an instrumented 8-meter walk test (IWW-I8MWT), yielding walking speed, step length, step width and cadence, and an instrumented stop-and-start test (IWW-ISST) to assess one's ability to suddenly stop and start walking (Fig 1), yielding success rates, margins to the stop cue (negative margins indicate stepping into the stop cue) and initiation time. A MANOVA was performed to compare these outcome measures between freezers and non-freezers. RESULTS: Time to complete the 10MWT (mean ± standard deviation of freezers vs. non-freezers: 9.2±2.2 vs. 7.9±1.3s) and TUG (10.1±4.5 vs. 10.8±6.7s) was not significantly different between groups. Similarly, no significant differences were found between groups for walking speed (111±27 vs. 121±25cm/s), step length (63±14 vs. 68±11cm), step width (11±3 vs. 9±3cm) and cadence (113±8 vs. 112±13steps/min) on the IWW-I8MWT and success rate (60±24 vs. 70±15%) on the IWW-ISST. Compared to non-freezers, freezers had significantly smaller margins (-3.5±8.2 vs. 5.0±6.3cm; $F(1,24)=8.75$, $p=0.007$) and longer initiation times (1.54±0.35 vs. 1.28±0.12s; $F(1,24)=6.41$, $p=0.018$) on the IWW-ISST. CONCLUSIONS: No significant differences were found between freezers and non-freezers on standard walking tests, but freezers had more difficulty initiating and terminating walking compared to non-freezers. The results of this study indicate that challenging walking tests may be of added value to assess FOG. REFERENCES: [1] Geerse DJ, Coolen BH, Roerdink M. Kinematic Validation of a Multi-Kinect v2 Instrumented 10-Meter Walkway for Quantitative Gait Assessments. PLoS One. 2015; 10(10):e0139913.

2-Q-83 Characteristics of Balance Control to Unexpected Loss of Balance in Stroke Individuals.

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Introduction. Reactive stepping constitutes a critical factor of fall prevention in situations when balance is lost. However, despite the high fall rates among individuals with stroke, there is little evidence of stepping recovery responses within this population, especially in response to lateral perturbations. Aims. 1) To characterize postural responses to unexpected surface perturbations in stroke subjects, and to relate performance to commonly used clinical measures. 2) To determine the effect of brain lesion characteristics on reactive postural responses in stroke subjects. Methods. Fifteen stroke subjects and 15 age and gender matched healthy subjects were exposed to random forward, backward and lateral unexpected surface translations while standing on a movable platform (Balance Tutor, MediTouch). Perturbations increased in six levels of intensity, from lower to higher levels. Fall threshold (i.e. fall into the harness), number of steps to recover balance, time to recover from perturbation and COM (Center of Mass) displacements were recorded. In addition, clinical measures of sensory-motor impairments, balance, mobility and balance confidence were administered. Lesion effect on reactive postural responses was evaluated using VLSM (Voxel-based Lesion Symptom Mapping) analyses. Results. Impaired reactive responses to surface perturbations were observed in the stroke group: ten subjects did not succeed in recovering balance and fell during trials. Most falls were in moderate levels of perturbations, 64% of falls occurred during lateral perturbations (either toward paretic or non-paretic side); Multiple step responses were observed in 70.5% of stepping responses to forward surface translations and in 59.1% of stepping responses to backward surface translations. A preference for initiating stepping responses with the non-paretic leg to forward and backward perturbations was observed in the stroke group. However, when perturbations were toward the paretic side, 80% of stepping responses were initiated with the paretic leg. In most levels of forward and backward perturbations stroke subjects exhibited significantly larger COM displacements and longer duration to recover from perturbations in comparison to controls ($p \leq 0.05$). Although not significant, stroke subjects exhibited smaller COM displacements than controls when surface translations were toward the paretic side and higher COM displacements when surface translations were toward the non-paretic side. Positive correlation was found between fall threshold and the Berg Balance Scale ($r=0.69$, $p \leq 0.05$). Analyses relating structural damage to postural responses will be presented as well. Conclusion. Stroke subjects exhibited impaired reactions to loss of balance. Failure to recover, especially from lateral perturbations and multiple compensatory step reactions, suggests possible targets for rehabilitation.

2-Q-84 Is cognitive decline similar among Parkinson's disease motor sub-types? A prospective study examining changes over time in gait, balance and cognition

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BACKGROUND AND AIM: Parkinson's disease (PD) is traditionally classified into postural instability gait difficulty (PIGD) and tremor dominant (TD) motor sub-types. Mild cognitive deficits are increasingly recognized as a common non-motor symptom in PD, however, cognitive differences among those two motor sub-types have not been well-described and only a few studies reported a higher risk of developing dementia in PIGD patients. We aimed to investigate whether changes over time in cognitive and motor functions differ across the two sub-types. METHODS: Non-demented patients with PD who were previously classified into PIGD (n=30) and TD (n=27) were followed for an average of 60 months. At baseline and at follow-up, participants underwent cognitive testing: the Montreal Cognitive Assessment (MoCA), and a computerized neuropsychological assessment battery (NeuroTrax) that generated index scores of executive function (EF), attention, memory and a global cognitive score. Parkinsonian motor symptoms using the Unified Parkinson's Disease Rating Scale (UPDRS-III), gait under single and dual task condition, the Timed up and Go (TUG) and the Berg Balance test were also evaluated. RESULTS: At baseline, the two sub-types were similar with respect to age (PIGD: 69.31±7.6 yrs; TD: 70.5±12 yrs; p=0.652), disease duration (PIGD: 10.6±3.8 yrs, TD: 10.1±2.9; p=0.628), and all cognitive functions (p>0.29). The Berg balance test was significantly lower (p=0.004) in the PIGD group. At follow-up, subject characteristics were similar in the PIGD and TD, however, the global cognitive score declined by 9.5% in the PIGD group (from: 94.5±11.7 to 85.3±13.6, p<0.001). This decline was significantly larger (p=0.03) than the 4.5% decrease observed in the TD group (p=0.047) and there was group X time interaction effect (p=0.047). Similar group differences (p=0.006) were observed in the decline of EF, where a significant group x time effect was also seen (p=0.008). These interactions remained significant after adjusting for age, disease duration, UPDRS-III and gender. In contrast, the MoCA, memory and attention indices declined similarly in the two sub-types. Regarding motor aspects, there was deterioration in the UPDRS-III in both sub-types, but no interaction effect (p=0.322). Similar results were obtained in regards to gait and balance. For example, stride time variability increased in both groups (p<0.001), however, no interaction effect was found (p=0.398). CONCLUSIONS: In both sub-types, development of clinically significant gait and balance problems were associated with disease progression. Conversely, the course of cognitive decline differed. These findings demonstrate that patients with the PIGD sub-type experience greater cognitive decline, compared to patients with TD, in specific domains of cognitive function, suggesting that perhaps certain treatments should be tailored more specifically to the motor sub-type.

2-Q-85 Gait disturbance in patients with orthostatic tremor

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BACKGROUND AND AIM: Orthostatic tremor (OT) is a rare disorder of unclear etiology characterized by a 13-18 Hz tremor of the legs while standing with resolving symptoms while sitting or walking. OT is associated with other movement disorders such as parkinsonism, essential tremor or cerebellar disorders. Although gait disturbances are frequently described in these diseases, there is no systemic analysis of the gait disorder linked to OT. Therefore, the aim of this study was to systematically investigate the gait performance of patients with OT assessed by a standardized sensorimotor and cognitive walking paradigm. METHODS: Patients with a diagnosis of primary OT were screened and included in this study after informed consent. Gait performance was investigated during 8 different walking conditions using a pressure-sensitive sensor carpet (GAITRite®). Patients walked at preferred, slow and maximum walking speeds (PS, SS, MS), during head reclination and eyes closed conditions (HR, EC) as well as calculatory, semantic and motoric dual task conditions (DTC, DTS, DTM). The gait performance of patients was compared to age-matched healthy subjects. Gait parameters were assessed by a multivariate analysis of variance. RESULTS: Eighteen patients with a diagnosis of primary OT with a mean age of 70.4 ± 5.9 years were included in the study. In all walking conditions gait velocity (p<0.001 PS, MS, EC, DTC, DTM) and step length (p<0.001, expect DTS p<0.05) were significantly decreased. Increased double support with reduced swing phases could be observed during SS and EC ($p<0.001$). The base of support (BOS) was increased during PS ($p<0.05$), SS ($p<0.01$) and EC ($p<0.001$). The coefficient of variation (CV) declined for BOS in SS ($p<0.05$), whereas CV increased for both, step length and stride time, during SS ($p<0.05$), DTC, DTS (both $p<0.01$) and especially EC ($p<0.001$). Increased gait asymmetry was observed during EC ($p<0.001$). CONCLUSIONS: Although OT symptoms diminish during walking, we identified constant impairments of locomotion control. The gait disturbance was characterized by an increased level of a cautious gait (slow, small-stepped, increased double support phases and BOS). Moreover, we identified disturbance of gait stability (increased CV) and interlimb coordination (left-right asymmetry). The specific alterations were found in conditions with increased sensory feedback control as well as attentional cognitive gait control. This implies an impaired integration of sensory feedback, possibly due to a dysfunction of midline cerebellar structures, as cerebellar dysfunction in OT was frequently described. ACKNOWLEDGEMENTS AND FUNDING: The project is supported by the German Federal Ministry of Education and Reserach (BMBF).

2-Q-86 Effect of mild and marked cognitive impairment on gait stability and risk of falls in people with Parkinson's disease

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BACKGROUND AND AIM People with Parkinson's disease (PD) have impairment of postural stability and executive function that confers an increased risk of falls. Mild cognitive impairment (MCI) and dementia also increase fall risk in general older population, but there is scant research on gait stability and fall risk in cognitively impaired PD patients. Thus, the aim of this study was to investigate gait stability and associated risk of falling in people with PD with MCI and dementia. METHODS Two hundred and forty three people with PD were classified into three groups, using the Frontal Assessment Battery (FAB) score: those who were cognitively intact (CI) (FAB score ≥17, n=87), those with MCI (FAB score <16 and >13, n=100) and those with dementia (FAB score ≤12, n=56). Participants walked at self-selected speed along a 18m walkway during which gait speed, step length and gait stability measures (harmonic ratio mediolateral, anteroposterior (AP) and vertical (VT)) were recorded with an accelerometer worn around the waist. They also completed the Physiological Profile Assessment (PPA) to compute their composite risk of fall. They were then followed up for 12-months for falls. Gait speed was included as a covariate in the gait stability measures' analyses of variance (ANOVA). RESULTS The ANOVAs showed main effects of groups on PPA fall risk score, AP and VT Harmonic Ratios (all, $p<0.05$). The MCI group exhibited higher PPA score ($p=0.008$) and lower AP ($p=0.007$) and VT ($p<0.001$) harmonic ratios compared with the CI group. The dementia group exhibited higher PPA fall risk ($p<0.001$) and higher AP ($p=0.045$) and VT ($p=0.002$) harmonic ratios compared with the CI group. No statistical between-group differences were observed for other gait parameters. Compared with the CI group, both MCI and dementia (RR: 2.55, 1.79-3.63; $p<0.001$; and RR: 2.49, 1.71-3.63; $p<0.001$, respectively) conferred a 2 fold increased in fall risk based on prospective falls. Shorter step length and reduced gait speed were correlated with an increased risk of falling (increased PPA score) in all groups ($p<0.05$). CONCLUSIONS Compared with the CI group, those with MCI and dementia exhibited shorter steps and reduced gait speed associated with an increased risk of falling, and also suffered significantly more falls during follow up. Surprisingly however, the people with PD and dementia had greater pelvic harmonic ratios (suggesting better gait stability) compared with the CI group. It is possible that more cognitively impaired PD patients exhibit greater apparent stability than cognitively intact people with PD due to a possible lack of brain connectivity for modulating gait; a factor that might explain their increased risk of falling. Assessments of gait adaptability are required to confirm this hypothesis. ACKNOWLEDGEMENTS AND FUNDING Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) [Grant number: BEX 2194/15-5] for PhD scholarship. Also, this study was supported by National Health and Medical Research Council, Australia.

2-Q-87 The reliability of gait variability measures in Parkinson's disease - Effects of gait speed.

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BACKGROUND AND AIM: Increased step-to-step variability is a geature of gait in individuals with Parkinson?s disease (PD) and is associated with increased disease progression [1,2]. As a reflection of the widespread use of gait variability in research and clinical studies, the importance of optimizing testing protocols to increase the reliability of gait variability measures has been advocated [3].However, the effect of gait speed on the reliability gait variability is sparsely studied. It is suggested that increased swing time variability in PD is independent of gait speed, whereas stride time show a small association with gait speed [4]. Therefore the aim of this study was to investigate the effect of gait speed on the consistency of spatiotemporal gait variability measures (swing time and step length). METHODS:Gait variability was measured twice no more than one week apart in 29 (14 males) individuals with idiopathic PD, Hoehn &Yahr 2 (n=18) and 3, and 24 healthy adults. Participants were 60 years and older, mean age PD = 70.8 (5.4), controls = 68.4 (4.9). Spatiotemporal gait variables were collected at slow, normal and fast walking speeds on a 10 meter pressure sensor mat (GAITRite®). Up to six valid trials for each walking speed were collected per subject. Gait variability was calculated as the within-person standard deviation based on 50 steps (combined left and right) for each speed condition. Test-retest reliability was calculated using Intra-class correlation coefficients (ICCs(2,1)), limits of agreement (LoA), relative LoA (LoA%), standard error of measurement (SEM) and smallest real difference (SRD). RESULTS: Mean gait speed at slow, normal and fast gait speed was: 0.76, 1.23 and 1.66 m/s respectively. Swing time variability was most consistent at normal gait speeds. However, for step length variability, the most consistent measurements were found at fast gait speeds. For both variables, slow gait speeds showed poorest reliability. Preliminary results are summarized in Table 1. CONCLUSIONS:When investigating gait variability in spatiotemporal variables in individuals with PD it is important to consider the effect of gait speed on the consistency of the measured variable. These results suggest that reliability differ when measured at slow, normal and fast gait speeds, and further, that reliable measures are more difficult to obtain at slow walking speeds as compared to normal and fast. Future research should therefore take into account gait speed when considering gait variability measurements in individuals with PD.
ACKNOWLEDGEMENTS AND FUNDING:We thank all participants, especially Beate Eltarvåg Gjesdal, MSc Sports Scientist, Elise Klæbo Vonstad, MSc Motion Scientist, and Marit Eline Spørch, MSc PT, for data collection and processing. This study was supported by grants from the Norwegian Extra Foundation for Health and Rehabilitation, the Swedish Research Council, Vårdal foundation and the Karolinska Institutet.

2-Q-88 Are anticipatory postural adjustments prior to gait initiation compromised in people with Parkinson's disease with freezing of gait?

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BACKROUND AND AIM: Patients with Parkinson's disease (PD) and freezing of gait (FOG) have impaired postural control in comparison to patients without FOG. It is unclear whether impaired lateral weight shifting prior to step initiation contributes to the occurrence of start hesitation. Alternatively, the preparation phase of gait initiation might be normal and start hesitation due to inability to start stepping following an unimpaired anticipatory postural adjustment. The aim of this study was to characterize forces and muscle activation patterns associated with anticipatory postural adjustments during self-initiated gait in subjects with PD with a history of FOG (PD+FOG) compared to those without FOG (PD-FOG) and healthy controls (HC). METHODS: Thirty-three PD+FOG (MDS-UPDRS-III: 44.2 (13.2); age: 69.2 (6.5)), 30 PD-FOG (MDS-UPDRS-III: 41.1 (10.1); age: 69.6 (8.5)) and 32 HC (age: 69.4 (6.8)) were included. Stance (30sec) followed by gait initiation was analyzed without and with a cognitive dual task (DT, consisting in counting backwards by three). Anticipatory postural adjustments were characterized with inertial sensors (waist and shins) and muscle activity of the tensor fasciae latae (TFL), gastrocnemius (GAS) and tibialis anterior (TIB) muscles was captured with EMG recordings. Severity of FOG was quantified with the FOG ratio of horizontal shins accelerations during a 360 degree turning for 1 minute. Eight trials (of 190) were associated with FOG and were not included in this analysis. RESULTS: PD+FOG and PD-FOG did not differ in disease duration, MDS-UPDRS-III, Hoehn & Yahr scale and the three groups did not differ in age or gender ($p<0.05$). PD+FOG had higher PIGD scores (6.4 (3.4)) than PD-FOG (4.8 (2.7)) ($p=0.041$). PD+FOG and PD-FOG did not differ in size of their APAs when testing without DT. In the DT condition, PD+FOG had significantly smaller medio-lateral (ML) and anterio-posterior (AP) size of APA compared to PD-FOG and HC ($p<0.05$). Within the PD+FOG, the ML size of APA (DT) was positively correlated with the severity of FOG (NFOG-Q) ($rho=0.477$, $p=0.025$). The groups did not differ in the amount of co-contraction of bilateral TFL over 2 seconds prior to first step toe-off. CONCLUSIONS: Lateral weight shift prior to step initiation was smaller in PD+FOG than PD-FOG or HC but only in the DT condition. Surprisingly, the worst the FOG, the larger the ML weight shift in the postural preparation phase. Co-contraction immediately prior to step execution cannot explain differences in postural preparation for a step between PD+FOG and PD-FOG. Acknowledgements. Coppenrath-Foundation (Schlenstedt); NIH Career Development Award 4R00HD078492-03 (Mancini); NIH 2R01 AG006457-29 (Horak); VA Merit I01 RX001075-01 (Horak).

2-Q-89 Influence of obstacle height on variability of obstacle crossing step in people with Parkinson?s disease

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BACKGROUND AND AIM: Stumbling during crossing an obstacle is considered one of the major causes of falls in people with Parkinson's disease (PD). Walking variability of the temporal parameters are related to mechanisms that regulate the movement rhythm and central pattern generator, while the variability of spatial parameters of gait is related to the balance control mechanisms. Both parameters help to analyze the online control of the individual and may serve as a sensitive and relevant parameter to quantify adjustments in walking. Previous studies indicated that obstacle height is an intervenient factor in variability of approach phase to the obstacle. However, falls during obstacle avoidance occur in the moment that individuals avoid the obstacle, indicating that a greater variability during this phase could be harmful to the task. Therefore, the aim of this study was to investigate the effects of obstacle height on a variability of obstacle crossing step in people with PD. METHODS: 15 people with PD (PD group) and 13 neurologically healthy individuals (CG) participated in this study. Participants were instructed to walk at their preferred speed and to cross the obstacle avoiding to contact it. Ten trials of following conditions were performed: low, intermediate and high obstacle avoidance (30 trials). Trials were performed in blocks in a randomized order. A carpet with sensors of pressure and an optoelectronic system was used for the acquisition of gait parameters. Variability (coefficient of variation) of stride length, stride width, stride velocity, and toe-clearance (TC) and horizontal distance to obstacle (HDO) for leading and trailing limb were analyzed. The variability of parameters was compared through two-way

ANOVAs for group (PD group x control group) and condition (low x intermediate x high), with repeated measures for condition ($p<0.05$). RESULTS: People with PD presented greater variability of HDO for trailing limb before obstacle crossing ($p<0.001$) and for leading limb after obstacle crossing ($p<0.04$) compared to CG (Figure 1). Regarding condition, high obstacle exhibited greater variability of leading limb TC ($p<0.007$) compared to other obstacles height. For group*condition interaction, PD group increased variability of HDO for leading limb after obstacle crossing compared to CG during low ($p<0.001$) and intermediate ($p<0.01$) obstacle avoidance. In addition, during low obstacle avoidance, PD group revealed greater variability of leading limb TC compared to CG ($p<0.001$). Finally, PD group increased variability of leading limb TC during low ($p<0.002$) and high ($p<0.004$) obstacle avoidance compared to intermediate obstacle avoidance while CG increased variability of leading limb TC during high obstacle avoidance compared to low and intermediate obstacle avoidance ($p<0.001$). CONCLUSIONS: The obstacle height is an important factor that can influence the negotiation to an obstacle. People with PD presented greater variability of obstacle crossing step, which is an indicative that motor control of these population is impaired and they need to adjust obstacle crossing regularly during the task to avoid falls or stumbling, mainly for low and high obstacle. ACKNOWLEDGEMENTS AND FUNDING: FAPESP (#2014/20549-0)/ 2013/21841-3

2-Q-90 Inter-rater reliability of mobile eye-tracking when walking in Parkinson's disease: contextual analysis

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Background and Aims: Tracking eye-movements when walking allows inferences to be made about underlying cognitive and visual processes that may influence gait, particularly in ageing and Parkinson's disease (PD) where such processes are commonly impaired [1]. However, very few studies are concerned with the context of eye-movements (i.e. the location of fixations). This is largely due to such analysis requiring time-consuming manual frame-by-frame inspection of eye-tracker videos [2], which can be subjective because it does not use algorithm-derived objective eye-movement outcomes. Therefore there is potential for a lack of consistency between raters. This study aimed to; 1) modify a previously developed eye-movement objective measurement algorithm [3] to provide still images of fixation locations; 2) develop a classification system for manual fixation location analysis of mobile eye-tracking data obtained when walking; and 3) assess inter-rater reliability of the proposed classification system. Methods: An infra-red mobile eye-tracker (Dikablis, Ergoneers) recorded eye-movements during walking in healthy older adult controls (HC) (n=5) and people with Parkinson's disease (n=5). Raw eye-tracker video data was pre-processed to eliminate tracking errors. Fixations were identified using a previously validated algorithm [3], which was adapted to provide still images of fixation locations. Fixation locations were then manually classified by two raters according to a classification system comprising of pre-defined areas within the measurement field of view. Intra-class correlation coefficients ($ICC_{2,1}$) were used to determine inter-rater reliability. Results: The algorithm successfully provided a total of 116 still images for the start of each fixation identified, allowing manual classification to be performed. Inter-rater reliability for classifying fixation location was high for both PD ($ICC_{2,1}=0.97$, 95% agreement) and HC ($ICC_{2,1}=0.93$, 91% agreement) groups, which indicated that the classification system was reliable. Conclusions: This study developed a reliable semi-automated contextual analysis method for eye-tracking during dynamic gait studies in HC and people with PD. Future studies could adapt this methodology for use within various laboratory or real-world eye-tracking during walking studies, which would establish a time-effective but rigorous methodological approach. With improvements in the spatial resolution of eye-trackers, future studies may also be able to fully automate this process using image detection algorithms. References 1. Stuart et al. (2016) Neuroscience &

Biobehavioural Reviews, 62, p. 76-88 2. Vitorio et al. (2014) Neuroscience, 277, p. 273-80 3. Stuart et al. (2014) IEEE EMBC Acknowledgments and funding Financial support for this study came from the National Institute for Health Research (NIHR) Newcastle Biomedical Research Unit and the NIHR Newcastle CRF Infrastructure funding.

2-Q-91 Dance for Stroke: A virtual-reality dance based exercise to increase cardiovascular fitness and community ambulation in individuals with chronic stroke: A preliminary study

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Background: Recent literature has shown that chronic hemiparetic stroke survivors have profoundly diminished cardiovascular fitness that contributes significantly to poor ambulatory function. Reduced cardiovascular endurance is also an important factor that limits the transfer of walking skills obtained during rehabilitation back into the community environment. Further, patterns of nonuse may negatively affect brain activation and recovery. Thus developing a training paradigm that promotes cardiovascular fitness while addressing ambulatory function might be crucial in addressing community based activity profiles among chronic stroke survivors. Purpose: To examine the effect of a multidimensional, virtual reality-based dance training on improving walking function, cardiovascular fitness and physical activity levels and to further examine if these improvements would be carried over to home and community based activity profiles. Methods: Community dwelling individuals with hemiparethic stroke (N = 12) received a virtual reality based dance paradigm for 6 weeks using the commercially available Kinect dance gaming ? Just Dance 2014 for one hour and thirty minutes. Cardiorespiratory measures of maximum work load and maximum oxygen consumption during peak exercise (VO2 peak) were assessed with submaximal cycle ergometer and pre-post changes in heart rate recovery [HRR] (1 minute after exercise) were measured using Panasonic EW3109W. Gait speed and cadence were recorded using an electronic walkway. Changes in physical activity during community ambulation (one week before and after intervention start) were assessed using Omran HJ-321 Tri-Axis Pedometer. To determine if the changes in functional measures assessing mobility (Berg Balance Scale [BERG]), endurance (six-minute walk test [6MWT]), and gait (velocity and cadence) correlated with improved community ambulation post intervention, the difference in clinical measures and gait performance from pre- to post intervention was linearly regressed with the changes in community ambulation. Results: Cardiovascular outcomes of maximum work load and maximum oxygen uptake increased significantly (pre vs. post, $p < 0.05$). The HRR decreased post-training from 86 ± 6.01 to 75.16 ±3.54 ($p < 0.05$). Community physical activity showed a mean of 2898.1 ± 1312.3 steps per day pre intervention and 3876 ± 171 post intervention.($p = .24$). The change in number of steps recorded in daily living from pre-to post intervention correlated with the pre-post change scores for functional measures BERG ($p<0.05$), 6MWT ($p<0.05$) and gait speed ($p<0.05$) and cadence ($p=0.06$). Conclusion: Virtual reality based dance training provides a benchmark for incorporating long-term adherent physical activity regimen in chronic stroke survivors, which along with improving cardiovascular functioning and walking function, improves home and community based activity profiles.

R Orthopedic diseases and injuries

2-R-92 Differences in gait speed between cognitively impaired and cognitively normal lower extremity amputees: Pilot study preliminary data

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Background and aim: Walking is a complex process that involves coordinating motor and sensory systems through higher-order cognitive processes. Lower extremity amputation (LEA) may challenge these processes through forced learning of new motor patterns for mobility. The older age of those undergoing initial LEA and the dysvascular nature of a majority of amputations, puts a large number of individuals at risk for cognitive impairment. Reduced cognitive resources in these individuals may impact acquisition of prosthetic skills necessary for community ambulation. Previously, cognition and mobility have been studied in isolation in the LEA population. Therefore, this study aims to better understand the role of cognition in mobility through the dual-task paradigm and longitudinal design. Methods: This pilot study is a prospective cohort design; preliminary analysis from initial assessment data will be reported. Sixteen individuals with above knee or below knee (BK) amputations were recruited at discharge from inpatient prosthetic rehabilitation and have completed initial assessment. Follow-up assessment will occur 4 months after discharge. The Montreal Cognitive Assessment (MoCA) was used to dichotomize individuals; scores <26 indicate impairment in cognition. Single task assessment had individuals walk across a 6m GaitRITE®; dual-task paired this with the cognitive task of performing serial subtractions by 3s, starting at 100. Time to complete the single task of serial subtractions by 3s was also recorded. One-way analysis of covariance (ANCOVA) will compare single and dual-task gait speeds between groups, with correlation analysis to determine covariates. Results: Eight cognitively normal individuals (50% male; 87.5% BK; age=62.6±9.0; MoCA=27.88±1.25) and eight cognitively impaired individuals (50% male; 50% BK; age=62.1±7.7; MoCA=23.50±0.93) completed single and dual task walks. ANCOVA analysis revealed that cognitively normal and impaired groups did not have significantly different single task gait speeds when controlling for balance confidence scores and level of amputation, $F(1,12)=1.72$, $p=0.215$. However, dual-task gait speeds were significantly different between the groups when controlling for single task gait speed, balance confidence scores, level of amputation and time to complete single task serial subtractions by 3s, $F(1,10)=5.18$, $p=0.046$. Conclusions: Preliminary data demonstrates that despite having similar gait speeds under single task conditions, cognitively impaired individuals with LEA have significantly slower dual-task gait speeds over 6m compared to those that are cognitively normal. This may translate to difficulties when performing daily activities, as many require the multi-tasking of cognitive and motor tasks. Longitudinal analysis will determine gait speed differences 4 months post discharge. More research is needed to confirm these results in a larger population and to investigate the long-term differences in gait of cognitively impaired and cognitively normal individuals with LEA.

2-R-93 Quantifying stability and asymmetry in individuals with unilateral and bilateral adolescent hip dysplasia during a squatting task

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Adolescent hip dysplasia (AHD) is an abnormal skeletal development that can lead to instability and/or subluxation of the hip joint. Patients initially develop pain due to increased joint reactive forces and later to degenerative changes within the joint. Symptoms are commonly activity-related and may require surgical management. Understanding of the clinical biomechanics of AHD gives insight to the disease, which is imperative to help with early detection and reduce complications later in life. Squatting is a challenging daily task requiring adequate joint range of motion and coordination of the lower limbs. It also requires the hips to link the upper and lower body kinematics. The aim of this study was to determine how patients with unilateral (uAHD) and bilateral (bAHD) AHD complete a squat task, and whether bAHD causes greater postural instability. METHODS: Fifty-two patients (32 bADH [most symptomatic side], 20 uADH) who were scheduled to undergo hip preservation surgery, were instrumented with a full-body, passive marker set. Data were collected using a VICON system and two AMTI force plates. From a standing position, with the feet on separate force plates, patients were asked to squat to their perceived maximal depth, hold the position for 3 seconds and return to standing. Data were low-pass filtered and processed in VICON Nexus. Center of pressure range (COPr) and sway velocity were determined for both the anterior-posterior (AP) and medial-lateral (ML) directions. Area of sway was calculated as a percentage relative to base of support (pBOS), to account for variations in stance. All variables were analyzed during three phases: descent, hold and ascent. Asymmetry comparisons were made between the surgical and non-surgical side, by quantifying their differences using a symmetry index [1]. RESULTS: Greater AP COPr during descent (p=0.03) and ascent (p=0.04) were noted in the uAHD group. pBOS during the hold (p=<0.01) and ascent (p=0.02) phases were also larger in comparison to bAHD. In contrast, bAHD showed greater ML COP ranges (p=0.04) during ascent, and greater pBOS under the non-surgical side during the hold (p=0.01). The symmetry index showed that both groups favored their non-surgical, less symptomatic side. CONCLUSIONS: The uAHD group displayed greater AP motion, which could be attributed to a deeper squat, however, kinematic assessment was not included in the current report. bAHD showed greater ML variability, suggesting more shifting from limb-to-limb during the course of the squat trial, specifically during the hold phase. Unexpectedly, sway velocities were not significantly different between the two groups. References: [1] Robinson, Herzog and Nigg (1987). J Manipulative Physiol Ther

T Psychiatric disorders

2-T-94 The Assessment of Balance Impairment Using VR in Panic Disorder Patients

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BACKGROUND AND AIM: Panic disorder (PAD) is a type of anxiety disorder characterized by spontaneous periods of intense fear. Studies addressing quiet standing have yielded conflicting results regarding the hypothesis that persons with PAD have reduced balance capabilities [1-2]. Aim: to investigate the effect of PAD on postural stability during static and dynamic balance control tasks (i.e., platform perturbations) with and without the presence of additional cognitive load. METHODS: Eleven healthy participants (age: 31.3±6.3y, 5 women) and 11 participants with PAD (36.9±10.3y, 8 women) participated in a balance assessment protocol. All participants were evaluated with psychiatric questionnaires and functional balance assessments (Table 1). Then participants were tested while standing on a computerized movable platform in the following conditions presented randomly: (1) quiet standing with eyes open (EO) - defined as baseline; (2) equivalent to #1 with eyes closed (EC) ; (3),(4) equivalent to #1&2 but while performing a simultaneous cognitive task (dual tasking - DT; serial 7 subtractions), respectively. The dynamic balance control tests included 2 perturbation sessions, each containing 8 perturbations (translations and rotations forward, backward, left and right, in random order) with, and without DT (NoDT). Center of pressure displacement (Dcop), velocity (Vcop) and the change in Dcop from the baseline were extracted from the platform's force plates (120 Hz; 1 mm resolution). For the dynamic trials, time to recovery [3], and the number of Vcop crossing the zero point (i.e., indicative of the number of recovery movements needed, see [4]) were assessed. RESULTS: Results are shown in Table 1. Participants with PAD had higher scores on the anxiety level evaluations (more anxiety) and lower scores on the functional balance tests. For the outcomes of the static physical testing, there was a significant DT effect only within the control group (EO & EC), which is also reflected by the percentile change in Dcop from baseline (i.e., increase). The dynamic physical measures were not statistically significantly different between the groups. CONCLUSIONS: While balance assessments based on self-report and functional testing support the hypothesis that individuals with PAD have reduced balance capabilities, similar support was not evident from objective physical tests. The non-significant DT effect among participants with PAD may point to either large variability in performance or to a salient DT effect in the baseline measurements stemming from the mental condition. The lack of differences in the responses to the perturbations suggests that rapid postural adjustments are not different between the groups. REFERENCES: [1] Goto et al, Neuroscience Let. 2011; 487: 204-206 [2] Redfern et al, J. of Anxiety Disorders 2007; 21:704-716 [3] Brauer et al, J. of Gerontology 2001; 56(8): 489-496 [4] Mok et al, Exp Brain Res 2013; 231(3):305-313

U Sensorimotor control

2-U-95 Moving-light-touch based closed loop control of the centre-of-pressure of a patient with a plexus brachial paralysis

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Background: Lightly touching (<1N) a stable surface with the index halves postural sway magnitude [1]. A sinusoidal motion of the surface, which is lightly touched by the finger, leads the posture to oscillate with the same frequency. Given the small forces in play, the effect of light touch is assumed to be due to the additional sensory input. We have implemented a Closed Loop (CL) control of the Centre-of-Pressure (CoP) position in the Anterior-Posterior (AP) direction by adjusting the surface, and thus the finger, velocity as a function of the distance between a predefined reference and the current CoP position [2]. Aim: Our objective is to support the sensory nature of the Light Touch (LT) effect. To this aim, an experiment, including No Touch (NT), LT, and CL control conditions, has been conducted with a patient presenting a right plexus brachial paralysis. Methods: The patient presented both motor and sensory right side deficits in the areas of the muscular-cutaneous nerves, the medial nerve, and a partial damage of the areas of the radial and ulnar nerves. This results in a loss of kinaesthesia of the elbow, the wrist, the index, the thumb and the middle finger. Moreover, the sensitivity of the ring and the little fingers is reduced. The patient repeated five times in a random way the following conditions: a) NT: the patient is standing and keeping the arms along the body. b) Three LT conditions where the patient touches of a stable surface with the index, the ring of the right hand, or with the index of the left hand. c) Three CL conditions where the patient touches the moving surface with the fingers mentioned above. The predefined path consists of a smooth 8mm forward displacement of the CoP. The CoP and fingers positions, as well as the forces applied to the surface are recorded. Results: LT with the index of the healthy hand halved postural sway in the anterior-posterior direction. Using the fingers of the impaired hand reduced postural sway by only 20%, even if mean of the normal force applied to surface exceeded 2N. In the CL condition, the mean tracking error of the predefined path is of 1mm when using the index of the healthy hand, and exceeded 4mm when using the fingers of the impaired hand. This efficiency decreased despite an increase of the mean force applied on the moving surface (0.3N versus 1.7N). Conclusions: The results of the patient when the healthy hand is used are comparable with those obtained during the participation of people without any known neurologic troubles. Using the impaired hand fingers increased the forces in play while decreasing the effect of LT and the performances of the CL. The results support the sensory origin of LT. [1] J. Jeka et al. Exp. Brain. Res. 1997. [2] F. Vérité et al. IEEE Trans. Haptics. 2014.

2-U-96 Reliance on egocentric frame of reference mediates optic flow influence while stepping in place

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Background. The perception and control of self motion in space is based on the ability to maintain body state with respect to the visual and/or egocentric frames of reference. During walking, optic flow, vestibular and proprioceptive information are congruent. An artificial modulation of speed and direction of the optic flow induces locomotor adjustments to counter the imposed shifts [1]. Our study aims at better understanding how the influence of optic flow is mediated by an intermittent podal contact with the ground while stepping in place and by reliance on the egocentric frame of reference. Methods. 16 young adults participated in the study. Participants stepped in place in a 3D virtual reality environment at their spontaneous stepping frequency with eyes open and eyes closed, 4 times each. They then repeated the task under different visual stimulations and stepping frequencies. A textured tunnel was either static, approaching or receding at speeds of 1m/s or 1.6 m/s. Stepping frequency was spontaneous then matched to a metronome at 1.5 Hz, 2Hz and 2.5 Hz. The 3 trials were recorded per condition, each lasting 30s. Maximum head drift along the antero-posterior axis was recorded with 10 IR cameras (Optotracks system). Results. The ratio between the head drift with eyes open and closed indicates that vision reduces the drift by 26% ($p<.05$). Results also indicate a continuum in reference frame reliance for self-motion perception and control. While stepping in place at the spontaneous frequency, approaching flow resulted in greater drift forward while receding flow limited the forward drift ($p<.05$). Interestingly, the drift under receding flow presents largest inter-individual variability and positively correlates with the absolute drift with eyes closed ($p<.05$). Indeed, young showing less backward or, forward drift while stepping in place under receding flow presents largest drift with eyes closed indicating a poor egocentric reliance. At metronome-matched frequency, increasing the intermittent contact with ground surface suppresses the influence of optic flow ($p<.05$). Conclusions. In our study, the direction of the optic flow modulates self-motion perception and control in young adults while stepping in place, similarly to the optic flow responses observed while walking. In addition, the drift ratio revealed inter-individual variability in frame of reference reliance in order to perceive one?s self motion accurately in space. Interestingly, young adults with poor egocentric reliance show an inverse response to optic flow under receding flow condition. Metronome-matched stepping frequency reduced the influence of optic flow, suggesting that the exploitation of visual frame of reference is influenced by reliance on the egocentric frame of reference as well. [1] Pailhous, J., Ferrandez, A. M., Flückiger, M., & Baumberger, B. (1990). Unintentional modulations of human gait by optical flow. Behavioural brain research, 38, 275-281

2-U-97 Interaction between proprioception and vision during gait in young healthy adults

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Background and aim: Multisensory integration is necessary to maintain balance. However, the weight of each sensory system involved adapts depending on environmental and individual characteristics. Although the effect of stimulation of particular sensory systems has been evaluated during gait, the effect of interactions between sensory systems is less known. For instance, proprioceptive stimulation through vibration on various joints has been addressed under various visual conditions but not between these conditions. This study aimed to assess the interactions between proprioceptive stimulation and visual conditions on balance during gait in young healthy adults. Methods: Sixteen healthy young participants (9 females, 30±6 years old, average height and weight: 1.72±0.09m, 74±12 kg) walked on an instrumented treadmill (Bertec FIT) with at least three infrared markers, for motion analysis, placed on their feet, pelvis and head. Nine experimental conditions, tested in a pseudo-random order between participants, were evaluated as a combination of 3 visual (normal light, dim light, and eyes closed) and 3 proprioceptive (no vibration, posterior neck muscle vibration, and Achilles vibration) conditions. Recordings comprised 5 consecutive strides and started within seconds after vibration was turned on, except during the eyes closed conditions due to the difficulty of maintaining position on the treadmill. The relative anteroposterior positions of the head, pelvis, feet and centre of pressure (COP) were evaluated at heel contact and midstance, and compared between visual conditions, under the three vibration conditions, using 2-way ANOVAs (vision (2) x vibration (3)) and a priori contrasts. Results: Preliminary findings showed that the pelvis position was more anterior during neck vibration ($p<0.046$) in every visual condition. The pelvis position was unaffected by Achilles vibration ($p>0.57$), except at midstance under dim light where the pelvis was more posterior compared to the control condition ($p=0.04$). The pelvis was more anterior at heel contact with eyes closed, independently of the vibration condition ($p<0.001$). Head position was more anterior compared to the pelvis under dim light or with eyes closed ($p>0.02$) and also during neck vibration at midstance ($p<0.03$). Achilles vibration did not affect head-to-pelvis position ($p>0.39$). The COP was more anterior at heel contact during neck vibration, irrespective of vision ($p<0.003$) and during Achilles vibration, only in dim light conditions ($p=0.02$). CP was also more anterior at heel contact in the eyes closed condition compared to eyes open condition ($p<0.01$). Conclusion: Neck vibration had the most consistent effect, with the head, pelvis and centre of pressure shifted anteriorly compared to no vibration in each visual condition. Achilles vibration had little effect. These results showed that the interaction between proprioception and vision is not straightforward and varies with the joint where the vibration is applied.

2-U-98 Gait stability in negative viscous force fields

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Background and Aim Preferred step width is believed to emerge from competing goals to maintain lateral stability (wider is more stable) and minimize energy (narrower is more efficient). However, other strategies for maintaining lateral stability, such as increasing joint impedance, are important when the ability to regulate step width is constrained (e.g. narrow paths). Our purpose was to examine the costs of non-step width related mechanisms of lateral stability. We hypothesized that participants would decrease step width when walking in a destabilizing negative viscous force field that amplified lateral velocity. The selection of narrow steps should minimize lateral center of mass (COM) motion and reduce the magnitude of the destabilizing forces. However, choosing narrow steps in an unstable environment should increase the metabolic cost of transport because alternative energetically-costly strategies to maintain lateral stability will be required. Methods Three healthy subjects performed treadmill walking in three lateral force-fields. The fields were: * Stabilization - walking with stabilizing lateral forces that resisted subject's lateral COM motion. Forces applied to the pelvis via motorized cables were proportional in magnitude and opposite in direction to the subject's lateral COM velocity. * Null - walking with no external forces. * Destabilization - walking with destabilizing lateral forces that amplified subject's lateral motion. Applied forces were proportional in magnitude and in the same direction as the subject's lateral COM velocity. Results In the Stabilization condition all participants decreased step width (1.3 to 11.4%) and 2 of 3 subjects decreased their metabolic cost of transport (1.4% and 7.4%) when compared to the Null condition. In the Destabilization condition, 2 of 3 subjects decreased their step width (1.4% and 8.4%) compared to the Null condition. 1 subject responded to the Destabilization condition by increasing step width (10.8%). All participants increased their cost of transport in the Destabilization condition when compared to the Null (8.5% to 33.5%). Conclusions Decreases in step width and cost of transport when walking in the stabilizing field were consistent with past research. However, results from the destabilizing condition were in sharp contrast to previous research suggesting that people choose to increase step width when frontal plane stability is challenged. Participants in the current study responded to the destabilizing condition by narrowing their base-of-support. Reducing step width decreased lateral motion and in turn reduced the magnitude of the velocity-dependent destabilizing forces experienced. This energetically costly strategy aimed to actively control rather than correct frontal plane COM motion. Acknowledgments Supported by Career Development Award 2 #1 IK2 RX000717-01 from the U.S. Department of Veterans Affairs.

2-U-99 The effect of GVS on path trajectory and body rotation in the absence of visual cues during a spatial navigation task

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BACKGROUND AND AIM: Previous research suggests that applying GVS during straight-line locomotion tasks is not sufficient to determine the effects of a vestibular perturbation on locomotion. However, a sufficient challenge to one's locomotion abilities is through a spatial navigation task, which forces one to rely on idiothetic cues to constantly update one's position. The purpose of the current study was to determine the effects of GVS on both path trajectory and body rotation during a task of spatial navigation in the absence of visual cues, and how accuracy of this task is affected by dance training. It was hypothesized that the delivery of GVS would significantly increase errors during the spatial navigation task, and this error would be reduced in the dancers. METHODS: Two groups of female participants (18-30 years) were recruited for the study. The control participants (n=18) had no experience with spatial awareness training while dancers (n=16) had a significant amount of spatial navigation training through dance, and were still actively training (M=11.5 hours/week, SD=±7.3). Participants were asked to perform a spatial navigation (triangle completion) task in VR (via Oculus Rift DK2). The participants were visually guided to walk along the first two legs of a (3m x 3m or 3m x 2m) right angle triangle. Once participants completed the final leg they were asked turn and navigate towards the starting position in the absence of visual information. On a subset of trials, GVS (3x threshold) was delivered prior to the final body rotation (either in the direction of the turn or opposite) and remained on until the participant reached their end position. Participants completed a total of 48 trials (2 GVS conditions x 2 triangles x 2 GVS directions x 6 trials). Whole body kinematic data were collected at 60Hz using an NDI Optotrak motion tracking system in order to measure arrival and angular error of final position and ML COM variability along the return. RESULTS: No significant group differences were observed with respect to arrival error (p>.05), angular error (p>.05), or path variability (p>.05). However, there was a significant effect of GVS on both arrival and angular error. Conditions without GVS (M=7.430°) had significantly smaller angular error (p<.01) than both GVSaway (M=8.629°) and GVStoward (M=9.258°). In addition, GVS conditions with the perturbation in the same direction as the final body rotation (M=85.953cm) had significantly greater arrival error (p<.001) than both the condition without GVS (M=74.631cm) and with GVS in the opposite direction of the final body rotation (M=79.310cm). There was no significant difference between GVS conditions in path variability during return to the initial position (p>.05). CONCLUSIONS: The findings suggest that regardless of spatial orientation training, the vestibular system contributes to both path trajectory and body rotation during spatial navigation in the absence of vision. ACKNOWLEDGEMENTS AND FUNDING: NSERC

2-U-100 Do older adults (mis)judge their physical abilities consistently over stepping tasks?

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BACKGROUND AND AIM. Before a motor command can safely be executed, a judgment must be made whether the task requirements can be met by one's physical abilities. A large portion of older adults does not judge their physical ability in dynamic gait adequately [1], and these judgement errors could lead to balance loss or falls. There has been successful attempts to quantify the degree to which older adults misjudge their physical stepping abilities [2, 3], but it remains unclear whether misjudgment is task-specific or generalises to other gait/stepping tasks. METHODS. Fifteen older adults (74.4 ± 5.3 years) and nine young adults (24 ± 1.5 years) were instructed to estimate their maximal performance on four different motor tasks requiring a large or high step (figure 1). After their prediction, their actual maximum performance on the task was evaluated by performing the task until they failed to successfully execute the task. Misjudgment was defined as the difference between the estimated maximum (i.e., perceived ability) and the actual maximum performance (i.e., actual ability). Pearson's correlation coefficients were used to reveal the consistency of perceived ability, actual ability and misjudgment over tasks. RESULTS. Actual ability was highly consistent over all tasks (range R [0.77 - 0.90]). Perceived ability was consistent for three of the four tasks (range R [0.38 - 0.78]). There was however no consistency between the misjudgment across tasks (range R [0.01 - 0.34]). CONCLUSION. Although the actual performance as well as the perception of performance were consistent over tasks, we found that the degree of misjudgment did not transfer to other stepping tasks. These findings makes it questionable whether misjudgment as assessed using one method can be predictive of the degree of misjudgment in another balance threatening situations. [1] Butler, A., Lord, S.R., Taylor, J.L., Fitzpatrick, R.C.;Ability versus hazard: risk-taking and falls in older people. Journals of Gerontology: Medical Sciences. 70(5):628-634, 2014. [2] Kluft, N., Van Dieën, J.H., Pijnappels, M.; The degree of misjudgment between perceived and physical ability in older adults. Gait & Posture. 51:275-280, 2016. [3] Sakurai, R., Fujiwara, Y., Ishihara, M., Higuchi, T., Uchida, H., Imanaka, K.; Age-related self- overestimation of step-over ability in healthy older adults and its relationship to fall risk. BMC Geriatrics. 13:44, 2013.

2-U-101 The use of an "anchor system" tied to the fingertip did not reduce body sway in young adults

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BACKGROUND AND AIM. Although the contribution of the haptic information to the postural control has been extensively studied under the light touch (LT) paradigm on a rigid surface, haptic information can be provided to the postural control system by the so-called "anchor system" (AS). The AS consists of a flexible cable hold by the hand with a small mass attached at the other end resting on the ground. Prior comparison of these two paradigms has shown that the LT reduces more body sway than the AS. This difference could be due to the high density of tactile receptors located in the fingertip. The present study compared the effects of both paradigms of haptic contact in two postural tasks (feet together and tandem position), as well as the anchors fixated in the fingertips. METHODS. Twenty-one young adults stood with eyes closed 35 s in a tandem position or with feet together on a force platform. They performed four conditions: (1) control (non-contact condition, NC), (2) touching a rigid surface with the tip of the index finger of the dominant hand (LT), (3) holding one flexible cable (stretched taut) (AS), and (4) adapted AS with the cable tied to the tip of the index finger (AF). For conditions 3 and 4, both hands were used as contact points. RESULTS. Two-way ANOVA (2 postures x 4 conditions) for the center of pressure (COP) ellipse area pointed out main effects of posture ($p \le 0.0001$) and condition ($p \le 0.0001$), as well as an interaction between posture and condition ($p=0.009$). Post-hoc analysis showed that tandem position increased COP area (686.6±73.3 mm^2) compared to the feet together condition (382.9±73.0 mm^2). For the main effect of condition, the post-hoc analysis indicated that both AS (491.3±67.5 mm^2)

and LT (256.7±34.3 mm²) reduced body sway compared to NC (757.5±119.8 mm²) and AF (633.6±70.1 mm²), but AF was not different from NC. Yet, LT reduced even more body sway compared to AS. The interaction effect showed that there was no difference between NC and AF for both feet together and tandem conditions. All other pairwise comparisons were significantly different, showing that both AS and LT reduced COP area compared to NC in both feet position. Yet, LT reduced more body sway compared to AS in both feet position. CONCLUSIONS. Our results showed that addition of haptic information in both AS and LT paradigms reduced body sway, but LT provided better use of haptic information than AS. On the other hand, using the anchors tied to the fingertip did not reduce body sway. Thus, the benefit of the AS does not seem to relate to the density of tactile receptors in a specific region of the hand. The density of tactile receptors is greater in the fingertip than in the palm of the hand and despite of that body sway did not reduce in the AF condition. ACKNOWLEDGEMENTS AND FUNDING. FAPESP/Brazil (Grant #15/02404-7).

2-U-102 The addition of haptic information of two hands using anchor system and light touch tasks is more effective to reduce body sway than one hand

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BACKGROUND AND AIM. The use of additional haptic information provided by either the light touch (LT) or the anchor system (AS) paradigms reduces body sway in young adults. The LT consists of slightly touching a rigid surface with the tip of the index finger. The AS consists of holding in each hand a flexible cable with a light load (125 g) attached at the end that is in contact with the ground. Considering that in these two paradigms different points of contact (palm of the hand for the AS and fingertip for the LT) and different number of points of contact (two hands for the AS and one hand for LT) are involved, analysis of their effectiveness must take such factors into account. Thus, the present study aimed to analyze the effect of adding haptic information to the control of posture in young adults, as well as compare the effect of different points of contact and the number of contact points (both hands, dominant and non-dominant sides). METHODS. Twenty-one young adults stood with eyes closed 35 s in a tandem position or with feet together on a force platform. We manipulated the points of contact (finger and hand for the AS and finger for the LT) and the number of contact points (dominant, non-dominant, or both hands). For the LT condition, participants touched a rigid surface with the tip of the index finger. For the AS conditions, participants held one flexible cable (stretched taut) using the hand or they pulled an attached flexible cable with the index finger (AF). Force transducers were attached to the base of the rigid surface or to the base of AS to measure the forces applied by the participants in each condition. RESULTS. A 3-way interaction involving feet position, points of contact, and number of points of contact showed that the center of pressure (COP) ellipse area reduced when both hands were used for the LT condition in the feet together and tandem conditions ($p \leq 0.0001$). For the AS and AF, the use of one or both hands did not affect COP area in either feet condition, however, in the tandem condition the use of the AS in both hands ($p \leq 0.0001$) reduced the COP area. Yet, ellipse area reduced in both AS and AF when compared to LT. For the force data, the mean force applied on the rigid surface and on the cables of the anchors was not affected by the different conditions (0.44±0.03 N). However, the RMS was larger in the tandem condition than in the feet together condition ($p=0.004$), as well as in the AS compared to AF and LT ($p \leq 0.001$). Curiously, for the LT condition, RMS increased for the dominant hand compared to the non-dominant hand. CONCLUSIONS. The addition of points of contact (two hands vs. one hand) resulted in a more effective reduction in body sway for the LT and AS (only in the tandem position). The mean force applied was below 1N for all conditions, but the variability increased for the most unstable position (tandem) and when using the AS. ACKNOWLEDGEMENTS AND FUNDING. FAPESP/Brazil (Grant #15/02404-7).

2-U-103 Head and neck position sense using a memory-driven joint position matching study: A pilot validation study

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BACKGROUND: The visual and vestibular systems are both located within the head providing a head-in-space representation. This in turn contributes to head-on-body and body-in-space representations, which are integral to movement coordination and postural control. Our aim was to determine head-position acuity in a position-matching study using a novel protocol with a virtual reality head-mounted display (HMD) system (Oculus VR, Menlo Park, California). Sensorimotor information from multiple sources can be used to match remembered head orientation when the visual target in removed. This serves as a pilot study for HMD validation and subsequent psychophysical studies. METHODS: Eight participants (30.2 ± 5.8 years) volunteered to perform 30 position trials that required head movement in the yaw plane from straight ahead to a visual target position at 20°, 39°, or 57°. The matching trial was then performed by rotating to the target location using memory (i.e., visual target removed). Targets were presented in an immersive virtual environment (VE). Motion capture data (Qualisys AB, Gothenburg, Sweden) was collected to measure angular head position. Signed error was calculated as the difference between visual target (i.e. reference angle when visual target was present) and matching trials (i.e. head angle reproduced from memory). Smaller absolute errors represent better accuracy, while positive/negative errors represent target overshoot/undershoot respectively in the matching trial. RESULTS: Left and right head turns were not significantly different for any angle so data were pooled together. Signed errors (mean ± SEM) for condition angles 20°, 39°, and 57° were 3.12±1.30, .74±1.22, and 1.32±1.16. Accuracy significantly improved as yaw angle increased (p=0.018). The gain of errors [(Matching Angle ? Position Angle)/Condition Angle] also significantly increased in the 20° condition (p=0.025). Matching trials also showed a systematic overshoot (p<0.001). CONCLUSION: These results show that yaw plane head position-matching in healthy adults is most accurate at more eccentric angles. The mean signed error from the smallest angle trials (±20°) replicate previous studies of cervical joint position matching, however, our subjects showed greater acuity in larger angle trials. We considered two possible explanations for this. The contribution of somatosensory, vestibular, and stored motor command were available in all trials, but to reach more eccentric targets increased involvement of proprioceptors in lateral neck musculature and cervical articular receptors could provide additional somatosensory input, and increased head-turn velocity could provide a stronger vestibular signal. The HMD position sensors showed excellent agreement with the mocap system (ICC=0.99), which suggests it may offer a reliable self-contained measure for head-position assessment.

2-U-104 Skin sensitivity of the foot sole is altered by posture mediated skin deformation.

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BACKGROUND AND AIM: Skin on the foot has been shown to play a crucial role in gait, postural stability, and balance control. As such, there has been growing interest in the development of interventions to alter cutaneous feedback in athletes, older adults, and patients with neurophysiological deficits. Before implementing such biofeedback interventions, it is necessary to understand how cutaneous sensitivity is altered at different sites on the foot. It is also important to assess how the skin sensitivity of the foot is modified with posture mediated structural deformations, as ankle posture is altered throughout daily life. The purpose of this study is to assess the effect of ankle posture on skin sensitivity of the foot sole. METHOD: 7 healthy subjects (4 female, mean age=22 ± 1) were passively positioned with their right foot in dorsiflexion, plantarflexion, and a neutral posture. Measures of perceptual skin sensitivity were assessed at the heel, medial arch, and first metatarsal on the foot sole. Tactile sensitivity threshold tests included measures of touch contact sensitivity (Semmes Weinstein monofilaments) as well as stretch sensitivity (fastened skin tabs). Stretch sensitivity was evaluated in both the longitudinal and transverse axis. RESULTS: A repeated measures two-way ANOVA showed a significant main effect of site ($p=0.0310$) on the monofilament sensitivity threshold. Specifically, the arch was found to be significantly more sensitive than the heel ($p=0.0257$) across all postures. There was also an effect of posture*site ($p=0.0001$) with the longitudinal stretch sensitivity test. With plantarflexion, the first metatarsal and medial arch site required significantly higher stretch than any other site and posture combination ($p<0.05$) for stretch to be perceived by the subject. Lastly, a significant main effect of site ($p<0.0001$) was found with the transverse stretch test. The arch requires significantly more stretch than the heel ($p=0.0335$) whereas the metatarsal requires significantly more stretch than the arch ($p=0.0429$) and the heel ($p<0.0001$) CONCLUSIONS: Overall, the skin sensitivity of the foot sole was found to be location dependent for both touch contact and stretch application. Perceptual sensitivity to longitudinal skin stretch on the foot sole was shown to be dependent on the test site as well as ankle posture. The skin at the medial arch and first metatarsal required more local stretch to be perceived in plantarflexion than any other posture. Longitudinal skin stretch sensitivity therefore decreases with skin retraction, which occurs on the foot sole with plantarflexion. In conclusion, the ability of skin input to alter gait outcomes may be variable across ankle postures, which will change the effectiveness of application during different phases of a functional task.

2-U-105 Influence of light touch on corticospinal excitability of ankle flexor and extensor muscles during quiet standing

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BACKGROUND AND AIM: Light touch (LT) with a fingertip to a stable object reduces postural sway during quiet standing. The vertical contact force of LT is usually limited to less than 1 N, which is insufficient to provide mechanical support to the body. Thus, postural stability induced by LT is due to neural feedback mechanism. However, the neural mechanism of LT affects postural stability are not fully understood. The purpose of the present study was therefore to examine the influence of LT on corticospinal excitability of tibialis anterior (TA) and soleus (SOL) muscles using transcranial magnetic stimulation (TMS). METHODS: Ten healthy young subjects participated in the experiment after giving their informed consent. Motor evoked potentials (MEPs) evoked by TMS were recorded in TA and SOL muscles while standing quietly on a force platform with LT or no touch (NT). Stimulus intensity was set at about 120% of the motor threshold determined in the muscle giving the smaller MEP. We recorded at least 15 MEPs in each condition. Background electromyography (EMG) activities were calculated from the rectified signals over a 50-ms window just prior to TMS. Root mean square (RMS) of center of pressure (COP) was also calculated over a 10-sec window just prior to TMS. RESULTS: MEPs of TA muscle were significantly larger in LT condition than that in NT condition. On the other hand, MEPs of SOL were not significantly different between two conditions. TA muscle does not show the background EMG activity in both conditions. The amount of background EMG activity in SOL muscle were not significantly different between two conditions. RMS of COP in anterior-posterior and lateral-medial directions were significantly smaller in LT condition than those in NT condition. CONCLUSIONS: MEPs in TA muscle increase in LT condition without background EMG activity despite reducing postural sway. This finding

indicates that LT enhances corticospinal excitability in order to contribute to the regulation of corrective reactions initiated by oncoming disturbances. On the other hand, SOL is tonically activated as antigravity muscle during quiet standing under spinal rather than supraspinal control. Tactile neural feedback is mediated by a supraspinal long-loop pathways. Thus, LT does not enhance corticospinal excitability of SOL muscle, because ongoing SOL activity is mainly controlled by spinal level and tactile feedback is mediated via supraspinal pathway.

V Tools and methods for posture and gait analysis

2-V-106Accelerometer based measurement of balance and gait after treatment for lower extremity musculoskeletal cancer in the clinic: A feasibility and validity study

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Background and Aim: Major surgery for lower extremity musculoskeletal cancer can severely impair balance and gait [1]. However, quantitative measures of balance and gait are not part of routine clinical practice [1]. The aim of this study was therefore to develop, validate and assess the feasibility and acceptability of novel tools for quantitative balance and gait assessment in this patient group. Methods: This was a prospective cross-sectional study of patients treated for lower extremity musculoskeletal tumours. Balance and gait were quantified using a tri-axial accelerometer (Axivity, AX3) placed on the lower back (L5 level). Patients performed standard activities including standing with eyes open and fast walking. Summary measures of balance; (area (ellipsis), magnitude (RMS), jerkiness (jerk), frequency (f95) of postural sway), and gait (temporal outcomes, step length and step velocity) were derived from raw accelerometer data using validated algorithms in Matlab. Outcomes were compared to control groups. Balance and gait outcomes were compared to existing outcome measures [disability scale (Toronto Extremity Salvage Score (TESS)), impairment scale (Musculoskeletal Tumour Rating System (MSTS)) and Quality of life (QoL) scale) to establish convergent validity. Results: Of 40 patients recruited, data from 34 adults of mean age 43 (19-89) years were analysed. Patients were treated for tumours in the femur (19), pelvis/hip (3), tibia (9), or ankle/foot (3). 27 had limb sparing surgery (LSS) and 7 amputation (AMP). Balance and gait assessments were acceptable, comfortable, feasible to obtain, and valid in these patients. Older patients presented with a higher area (ellipsis) and magnitude of postural sway (RMS) than controls ($p<0.05$) (Figure 1). Furthermore, patients walked with a lower step velocity compared to controls. Whilst, MSTS was a significant predictor of balance and gait, balance (RMS_AP) and total gait time negatively predict TESS and QoL ($p<0.05$). Conclusion: This study supports the feasibility and validity of using a tri-axial accelerometer to quantify balance and gait in the clinic in patients treated for lower extremity musculoskeletal cancer. Balance and gait are significantly affected after treatment. Poor balance and gait outcomes are significantly associated with reduced activity levels and a worsened QoL. This is important clinical information to guide rehabilitation strategies. References 1. Furtado, S., et al., Objective Clinical Measurement of Physical Functioning After Treatment for Lower Extremity Sarcoma?A Systematic Review. European Journal of Surgical Oncology, 2016. In Press. Funded by Children with Cancer, Sarcoma UK and Shears Foundation

2-V-107Gait analysis by newly developed sensor of Mimamori-gait system

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Background: Gait analysis is important for the evaluation of equilibrium functions in patients with dizziness and/or vertigo in addition to a variety of neurological disorders. However, much space and very expensive devices are needed for the detailed analysis of gait. For the purpose of assessing gait performance, three axis acceleration sensor system(Mimamori-gait system) was recently developed by LSI Medience Cooperation, Japan. This device only measures 5x7.5x2cm and 120g, so it can be fixed by a band on the lower back. In order to ascertain the usefulness of this device we have used it to examine several patients with vertigo and/or dizziness. Metods: This device was placed at the center of the patient's lower back with a band, and patients were asked to walk freely for 6 meters back and forth with eyes open and closed. Sequences of detailed data regarding three axis (horizontal, vertical and antero-posterior) acceleration was obtained by this sensor device at a frequency of 100Hz during gait and computer aided analysis was performed on the data afterwards. With this device, cadence, gait speed, CV value of stance (each foot), three axis movements along with their changes of acceleration in each plane and so on can be analyzed.In this study, we have examined six cases with acute vestibular lesions, mostly vestibular neurinitis during its acute and recovery stage and a few patients with central vertigo. Results: This system showed the following changes in cases with peripheral vestibular lesions, especially during acute stages:slower gait speed, greater CV value of stance, smaller step length, larger transverse movement along with smaller vertical (up-down) movement, irregular acceleration especially during stance on the lesion side foot and so on. Most of these abnormalities in gait returned normal in the recovery period. In some cases with central disorder, unique acceleration patterns were revealed. Conclusion: Many devices have been reported on and utilized for the assessment of human locomotion, and most of them needed much space and are not easily available because of their high price. Even so, each device should be used in accordance with its purpose. From a clinical point of view, it is convenient if we can use a handy device such as this Mimamori-gait system to assess gait performance along with analysis of data obtained. This device which measures the change of three axis accelerations during gait will be quite useful for the assessment of gait stability in conjunction with the character of gait performance.This device can also record gait performance for more than 70 hours at a time so that we can use it like an ECG halter. Since our usage of this device is still limited, we need to confirm its usefulness further along with elucidating disease specific changes that can be observed using this system.

2-V-108A new clinical test for measuring gait adaptability in children

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BACKGROUND AND AIM: Many children with motor problems show walking difficulties (1), often leading to tripping or falls. Gait adaptability, defined as "the ability to adjust gait to environmental circumstances" (2), is important for maintaining independent mobility in daily life (3). However, there is a lack of measurement tools for gait adaptability in children that are easy to administer in clinical practice. The novel speed agility ladder test can possibly fill this gap. It covers several domains of gait adaptability: obstacle negotiation, temporal demands and postural transitions, where most other measurements for gait adaptability only cover one or two domains (4). The aim of this study was to determine the feasibility of the speed agility ladder test in typically developing children, and to identify relationships between age and performance. METHODS: The sample consisted of 57 healthy children from six to twelve years old who performed the speed agility ladder test. The test involved stepping in a 10-meter speed agility ladder, containing 19 targets. Target sizes incrementally decreased by 2 centimeters each, yielding sizes that varied from 64 to 28 centimeters. The children were instructed to complete the ladder back and forth, first with one foot in each target, and after that with two feet in each target (two attempts for each task). Completion time and number of failures (touching a bar) were registered for the two tasks and the quickest attempt was included in further analyses. Feasibility was determined by calculating the percentage of participants that could complete the test. Spearman´s rank correlation coefficients were used to explore the relationships between age and performance on the speed agility ladder test. RESULTS: All participants (100%) were able to complete the test. There was a significant moderately strong relationship between age and the four performance outcomes (table 1), with older children completing the test faster and more accurately. Until the age of twelve the performance kept improving, so there appeared to be no ceiling effect. CONCLUSIONS: The speed agility ladder test appears to be a feasible clinical instrument for gait adaptability, because all children were able to perform the task. The significant associations with age and the lack of a ceiling effect within the tested age group indicate the discriminative ability of the test, particularly concerning the task with both feet. In fact, even the twelve-year old children reported that they found this task quite difficult and they still made several errors. Future research should focus on the test-retest reliability and construct validity of the test, and on its utility for identifying impaired gait adaptability in children with motor control problems. REFERENCES: 1) Fong e.a., Gait Posture, 2016; 43: 60-64. 2) Houdijk e.a., Phys Ther, 2012; 92: 1452-1460. 3) Hollands e.a., Gait Posture, 2016; 43: 170-175. 4) Balasubramanian e.a., Stroke Res Treat, 2014.

2-V-109Stitching together short gait trials is not reliable to estimate stride-to-stride dynamics.

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BACKGROUND AND AIM: Recent evidence suggested that stitching together short gait trials to create a longer series of stride time intervals provided similar information about gait dynamics compared to long gait trial. However, 'stitched' time series were not compared to continuously recorded time series, and the 'stitched' time series were short, approximately 125 stride intervals, compared to the large quantity of stride intervals required for a proper estimation of the scaling exponent α. This project aims to compare long continuous gait trial to shorter trials 'stitched' together in healthy young adults, subjects with Parkinson's disease and age-matched controls. METHODS: Data collection is in progress, thus only results from healthy young adults will be reported here. 15 healthy young adults (mean age 22.77 ± 1.96) were instructed to walk on a 200m indoor track at a comfortable and regular speed for the entire session in all conditions, all trials. They performed three conditions, presented in a randomized order: '15 min', i.e. one trial of 15 minutes around the track; '3 min', i.e. walking for five trials of 3 minutes around the track; '30 sec' i.e. walking for thirty trials of 30 seconds around the track. Recording started after 10 seconds of practice for each conditions to reduce the effects of gait initiation and acceleration to preferred walking speed. Stride time intervals were extracted from heel-strike events recorded with a footswitch with force sensor placed under the heel. In the '3 min' and '30 sec' conditions, the first and last four strides within each trials were removed before concatenation of all trials to obtain 'stitched' time series. To provide reliable comparisons, further analysis considered only the first 500 stride time intervals. Detrended fluctuation analysis (DFA) was used to estimate α-values. One factor (3xCondition) ANOVA and intra-class correlation (ICC) were run on the mean, standard deviation and α-values of stride time intervals. RESULTS: There were no significant differences between conditions for both the mean stride time intervals and the α-values ($p=0.77$ and p=075, respectively). The standard deviation on stride time intervals was slightly higher in the '30 sec' condition ($p<0.01$). The Cronbach's alpha from the ICC were very high for the mean and standard deviation of stride time intervals ($\alpha ICC=0.971$ and 0.921, respectively), but low for the DFA results ($\alpha ICC=0.404$). CONCLUSIONS: Results from the ICC suggest that stitching together short gait trials does not seem reliable for estimating an individual's own gait dynamics. There were no significant differences between condition for this group, probably because every α-values were within the same range in the three conditions. Our results will be compared with healthy elderly and people with Parkinson's disease to determine if the stitching procedure could be used for different groups or if it is not reliable and should not be used at all. ACKNOWLEDGEMENTS AND FUNDING: This work was supported by the University Committee on Research and Creative Activity of University of Nebraska at Omaha, and by the Center for Research in Human Movement Variability of University of Nebraska at Omaha, NIH (P20GM109090).

2-V-110Can machines learn how to perform movement analysis?

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Advances in machine learning algorithms and data mining techniques can nowadays help in the research, study and work in several different areas. A wide variety of algorithms and techniques exist. In the field of movement analysis the use of these techniques has already started but in a sporadic manner. In this work we will show how automatic learning from data (machine and statistical learning, artificial intelligence, data mining, knowledge discovery...) can help the research in the field of movement analysis. We will investigate how machine learning can augment movement analysis in different aspects and the fields and experiences where it has already proven useful. The usefulness of machine learning is due to its capacity of automatically identifying classes (e.g. pathological vs control) and activities (e.g. sit-stand-walking) learning from examples, analyzing and reducing high dimensional datasets, finding outliers (i.e. samples that show abnormal behavior), and so on. We will focus on gait analysis and highlight the promises and the issues of machine learning. Among the issues, we identified the lack of standardization, of metrics and of a common methodology of evaluation of results. These issues are especially important when using the results of movement analysis to build a clinical decision support system. We will also show how machine learning concepts can be adapted to movement analysis in a perspective of augmenting current techniques of movement analysis.

2-V-111A method for estimating ground reaction forces with limited gait measurements

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Several measurement systems and analysis methods have been developed for wearable gait monitoring systems. However, gait analyses with wearable measurement systems are usually limited due to the insufficient measurement information. Most of the commercial wearable systems lack kinetic information, giving only kinematic information such as step lengths and walking speeds. Wearable ground reaction force (GRF) measurement systems have been developed using various force transducers, but also have limitations. For instance, many of those systems only measure uniaxial plantar forces, and might have undesirable effects on the natural gait due to the sizes and weights of the force transducers. Instead of approaching this issue with hardware improvement, we suggest a method for estimating GRFs by simulating a walking model. Based on the previous studies which showed that the human gait dynamics relies on vibratory characteristics, we developed a method for estimating GRFs from a simple spring-mass walking model with an accelerating pivot. The model consists of a few model parameters such as leg length and spring stiffness, together with initial conditions. Among these simulation conditions, we chose a set of tuning parameters and tuned them to best match the limited measurements. GRFs were obtained from the simulation, calculated as the resistive forces exerted by the springs. To test the suggested method, we collected GRF data from eight healthy young male subjects walking at the various walking speeds, ranged from about 0.9m/s to 1.9m/s. GRFs were estimated from limited sets of data, for example, from ground contact timings and the average walking speed for the most extreme case. Using the proposed method, GRFs were estimated reasonably well with the limited gait measurements. For the most extreme case, with only ground contact timings and the average walking speed, the estimated GRFs showed the average normalized RMS error of 8.24±2.40% in the anterior-posterior (A-P) direction and 12.50±4.73% in the vertical direction, respectively, with the average correlation coefficient of R = 0.969±0.022 and 0.891±0.101. When vertical GRFs and center of pressure (CoP) profiles are available, assuming wearable plantar pressure measurement systems, the A-P GRF estimation showed more accurate match with the measured data with RMS error of 7.03±1.78% and R=0.982±0.009 at the various walking speeds. The results imply that the human gait dynamics have vibratory characteristics as assumed with the model. The knowledge of the human gait dynamics such as the vibratory characteristics could be used to enhance the use of wearable gait measurement systems. By obtaining more gait information from the limited measurements, a broader range of gait analysis would be possible using the wearable gait measurement systems.

2-V-112Validating a skin mounted inertial sensor to measure postural control of people with multiple sclerosis

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BACKGROUND AND AIM： Postural instability is common in individuals with neurological disorders including persons with multiple sclerosis (PwMS). Postural analysis in quiet standing is a key component in the clinical evaluation. Acceleration-based postural balance assessment has been proven to be a reliable method. However, most inertial sensors are relatively cumbersome and need to be secured to the body with straps. Recently, a light weight, wireless, flexible, skin-mounted inertial sensor (BioStampRC®, MC10 Inc.) has been developed. However, the BioStampRC has not been validated for postural assessment in PwMS. Therefore, the aims of this study were: 1) evaluate the concurrent validity of the BioStampRC inertial sensor with a reference inertial sensor (MTx, Xsens Inc.) in postural balance assessment; and 2) determine if the BioStampRC and MTx sensors can distinguish postural sway measurements between healthy and PwMS across various conditions. METHODS: A total of 45 PwMS with a range of disability and 15 healthy controls participated in this study. The balance assessment consisted of two 30-second quiet standing trials in each of three conditions: eyes open/firm surface (EO), eyes closed/firm surface (EC), and eyes open/ foam surface (FEO). Postural sway was measured simultaneously with a BioStampRC sensor and a MTx inertial sensor. Both sensors were placed on the posterior trunk at L5, with the MTx sensor superimposed on the BioStampRC sensor. Cross-correlation analysis was performed on the gravity-corrected acceleration time series (anterior- posterior and medial-lateral direction) to determine the agreement between sensors. Postural sway measurements (JERK, acceleration sway path length, root mean square (RMS) acceleration) were derived from the acceleration data, and the agreement between devices was evaluated with intra-class correlation coefficients (ICC). Repeated measures ANOVA was performed on sway measurements for each device to examine if both can detect differences between groups and conditions. RESULTS: The cross-correlation coefficients (XCOR) between acceleration time series across all test conditions and groups range from 0.80 - 0.92 in AP direction and 0.30 - 0.86 in ML direction. The ICCs of sway measurement between sensors across all test conditions and groups were moderate to excellent (0.68 - 0.97 for JERK, 0.74 - 0.99 for acceleration sway path length, 0.49 - 0.98 for RMS acceleration). Strong ICCs and XCORs were observed in EC/FEO conditions and in AP direction, but not in EO condition or in ML direction (in which the range of body sway was minimum), indicating that the range of body sway may affect the measures used to quantify agreement between sensors. The BioStampRC and MTx sensors both consistently

detected balance performance difference between groups and conditions. As expected, the balance challenging conditions (EC/FEO) had greater sway than EO condition and PwMS displayed increasing postural instability compared to control participants. CONCLUSION: BioStampRC inertial sensor demonstrated good concurrent agreement with the reference inertial sensor in postural sway assessments, and successfully distinguished postural sway performance between PwMS with diverse impairment across multiple sensory conditions.

2-V-113The reaction time of the postural system

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We lack a stabilometric parameter that gives us information on the reaction time of the upright postural control system, and yet this information is contained in an analysis of this signal, known and used since 1993, the 'diffusion analysis' of the time series of the positions of the center of pressure [1]. The question is simply to find the best way to extract this information from this analysis. One can notice that all the experimental points of the diffusion analysis represent a covered distance based on a time, so the equation with dimensions is that of a speed, LT -1, a stabilization speed for the points of the first part of the curve. Collins et al. [2] then Lacour et al., found that the first part of this experimental curve varied fairly systematically with the age of the subjects. This variation, in time, of the speed of the center of pressure can be represented by the acceleration of the center of gravity. Thanks to the proposal of Ouaknine [3] the function of autocorrelation is used instead of the curve of Collins. As the stabilometric parameter that gives us information on the reaction time of the upright postural control system we propose, after some experimental studies, the value of the abscissa of the 0.5 crossing of the autocorrelation function of the time serie of the acceleration of the center of gravity. References 1. Collins J, Luca C, Exp Brain Res. 1993; 95: 308-318. 2. Collins J et al. Exp Brain Res. 1995;104(3):480-492. 3. Ouaknine M. XIX conference of the ISPGR; 2009 22-25 Juin 2009; Bologna.

2-V-114Which is the pertinent feet position for clinical stabilometry?

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[Background] For the last few decades, stabilometry has been used as equipment for balance disorder evaluation in clinical practice. During this period of time, much effort has also been put to increased diagnostic specificity by updating several analytical methods. However precise data may be altered significantly by changing the feet position and posture for stabilometry. These may eventually influence sensitivity as a clinical test. Therefore, we have comparatively examined the changes of stabilogram caused by the differences of standing posture, in order to discover a pertinent posture for clinical stabilometry. [Methods] 30 normal and healthy subjects, 5 cases of vestibular neuritis, 3 cases of spinocerebellar degeneration were recruited for stabilometric examination on two difference feet positions, i.e., closed parallel and 30degree(30d) open at the tip of a toe (30d-position). Sum of total moving distance, outer circumference of moving area, deviation of center of the movement and eight directional velocity vectors of the movement were used as parameters for analysis. Comparison of means were made using the two-tail t-test, with $p<0.05$ as the criterion for statistical significant. [Results] Taking account of the sum of total moving distance, outer circumference of moving area in normal subjects, 30d position had smaller value compared to that of closed parallel feet position, indicating more stable in 30d feet position. The results of eight directional velocity vectors of the movement for normal subjects with closed parallel feet position showed higher velocity in the horizontal (right-left) plane than that of antero-posterior plane. On the other hand, 30d position revealed almost equal velocity in both horizontal and antero-posterior plane. Figure 1 shows the results in a case with left vestibular neuritis under eyes closed (Figure 1-a: closed parallel, 1-b: 30d). In this figure, the velocity of left to right directional movement is faster than that of right to left directional movement under closed parallel, indicating the change of postural shift caused by the peripheral lesion and its up-righting reflex. This difference disappeared in 3 ~ 4 days after onset. [Discussion] In Japan, stabilometry has been widely used in a daily clinical practice. Not only quantitative but also qualitative analyses have been performed in many diseases and their stages. So far, more than fifty parameters have been carefully investigated for the analysis. Each parameter has been examined clinically to elucidate disease specific trait from view point of postural control. As has been shown in this presentation, closed parallel feet position looks somewhat unstable, but this instability could indicate meticulous change of human postural control system. 30d feet position, which is applied in various countries, presents more stable posture, and this might be good for physiological exploration. However this position could hinder minor but important change because of its stability. Thus, we believe and strongly suggest that closed parallel feet position is best feet position as a test for clinical evaluation of postural instability.

2-V-115The Sliding Phenomenon on the Tibial Articular Surface of Femur during Stance Phase

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[Background & Purpose] Because of the so-called soft tissue artifact and a flexible knee joint axis, it is difficult to measure the knee joint's accurate angle during gaiting. Therefore, an accurate angle measurement was examined using a recently developed method. By the new measurement method, not only the angle of knee joint but the distance between femur and tibia joint surfaces were measured. The purpose of this study is to make momentary changes of angle and movement of the bones during stance phase clear. [Method] Subjects, comprising 20 healthy women (21.5±0.4 years old), gave their informed consent. Positions of femur and lower leg were measured by imaging markers and the knee angle was calculated from digitized coordinates. Marks were placed at two points between the greater trochanter and lateral epicondyle when trisected (mark 1 and 2 in order from the most proximal site). Similarly, marks were placed at two points between the head of the fibula and lateral malleolus when trisected (mark 3 and 4). Furthermore, the position of greater trochanter and the thigh epiphysis was calculated on the basis of mark 1 and mark 2 by measuring the length of the thighbone. Similarly, the position of tibia's upper edge and lateral malleolus was calculated on the basis of mark 3 and mark 4. As for the animation photography, digital camera (Casio EX-FH100, Japan) was used and the frequency was set at 60Hz. A form finder (I.N.C. Co., Japan) was used for digitizing the images, and the digital data were calculated using a personal computer. Usually, knee joint angles were calculated from the greater trochanter, femur epicondyle and lateral malleolus. However, with the newly devised method, the knee angle was calculated from the straight line passing through mark 1 and 2 and the straight line passing through mark 3 and 4. The hip joint angle was calculated as an angle between the straight line of femur and the perpendicular line. [Results] In about five of 10 subjects, a momentary horizontal sliding phenomenon of femur were observed at 16.2±3.4% of time of the stance phase, and the momentary movement distance was 2.0±0.2mm. The phenomenon was observed at the same time when the knee bent maximally and when the hip joint started an extension from maximal flexion after heel contact. [Conclusion] The momentary movement of the knee cannot be measured by conventional gait analysis method. By our devised method, the horizontal distance between the femur and the tibia was observed during stance phase. The phenomenon showed that osseous friction occurs, and it is thought that it is one of the origins of knee OA. Exercise therapy needs to pay attention to that phenomenon.

2-W-116 The recurrence quantification analysis of the postural balance for differentiating the patients with vestibular impairment from the healthy subjects.

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The nonlinear analysis has been used to assess the balance ability in patients with disequilibrium. However, its clinical significance and usefulness remain unclear. We investigated a clinical usefulness of the recurrence quantification analysis (RQA) to differentiate the patients with unilateral vestibular dysfunction (UVD) from the healthy subjects in this study. This study consisted of 25 dizzy patients (average age: 52.9 ± 11.2 years old) with the UVD and 25 age-matched subjects without vestibular disorders (average age: 51.7 ± 13.9 years old) as controls. The center of pressure (COP) signals for static stance was collected using a single standard force platform. The total excursion area (AREA), the mean velocity (MV) and the RQA parameters of recurrent rate (RR), determinism (Det) and entropy (Entr) were calculated from the COP series data. The RR of the COP signals under the eyes closed (EC) condition in UVD group was 0.044 ± 0.015, which was significantly higher than that in the control group (0.032 ± 0.006, $p < 0.001$, Z=3.47). On the Receiver Operating Characteristic (ROC) curve, the area under the curve (AUC) of the RR under the EC condition was 0.73 (95%CI: 0.59 ? 0.88). The higher RR under the EC condition in the UVD patients may indicate that a loss of the vestibular information increases the regularity of the fluctuation under EC condition, resulting in inducing a highly constrained postural behavior and unsteadiness. The absolute value of the RR under the EC condition may have an acceptable discrimination to detect the UVD patients regarding the AUC of the ROC curve.

2-W-117 Effects of noisy vestibular galvanic stimulation on standing up motion balance in older adults

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Aim: Previous studies have reported that the upright body sway could be controlled by galvanic vestibular stimulation (GVS). Moreover, the body sway could be improved by GVS with the addition of noise, which is supposed to sensitize the detection of sensory input. This phenomenon is known as stochastic resonance. The type of noise, which is typically classified by noise power such as white and pink, and its effect on dynamic stabilization remain unclear. Our study aimed to investigate the effects of different noises and stimulus intensities during standing up. Methods: Healthy older adults (n = 14; men = 7; mean age: 67.9 ± 3.9 y) from the community center participated in this study. Participants were instructed to stand up on a foam rubber from a sitting position five times while wearing earmuff and eye mask. The top of the head and L3 marker displacements were recorded by 3-dimensional motion capture (VICON system) with 100-Hz sampling. Center of foot pressure (CoP) was recorded using a force plate (AMTI Japan) with 1000-Hz sampling. Noisy GVS was applied via both mastoids with the right anode. We used white and pink noises (0-dB). Noise intensities were 30%, 60%, and 90% of the sensory threshold level. Thus, seven conditions were analyzed, including the sham condition. The mediolateral direction of root mean square (RMS) and length (LNG) at CoP, head, and L3 markers during standing motion were measured. Ratios were calculated based on the sham condition. We used two-way analysis of variance to compare noise types and intensities. The optimal stimulus intensity for each participant was defined as that RMS and LNG at CoP variables were simultaneously smaller than other intensities. We compared these variables between sham, white, and pink noises with paired t-test. The

significance was set at 5% using Holm?s correction method. Results: No significant differences were observed between noise types and intensities. The CoP-RMS and head-LNG tended to be lowest at 60% intensity stimulus in both white and pink noises, and CoP-RMS and L3-LNG were at 30%. When comparing between noise types at optimal intensity (white, 57.5%; pink, 58.9%), CoP-RMS, CoP-LNG, L3-RMS, and L3-LNG were significantly lower in both white and pink noises compared with sham condition ($p < 0.05$). Conclusion: We found that the noise type and intensity were not conspicuous for suppressing the dynamic stability. Generally, the pink noise is suppressed as high frequency power, and is thus effective for relaxation in human beings (as observed on electrocardiogram and electroencephalogram). However, this is true in stable conditions; hence, we speculate that the pink noise is not adequate for dynamic stability. Additionally, CoP and L3 tended to improve at 60% intensity level and the participant?s optimal intensity was also around 60%. It is reported that the CoP sway improved by almost 20% by noisy GVS during stable upright position, which is supported by our results.

2-W-118 Feasibility and effects of an intensive 1-week day camp program on vestibular function and functional gait in children with Developmental Coordination Disorder (DCD)

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BACKGROUND AND AIM: Developmental Coordination Disorder (DCD) is a motor skills disorder that affects the child's ability to coordinate movements and to learn and perform age-appropriate motor skills. The cluster of motor problems in DCD (e.g. poor coordination, posture, balance and muscle tone) can be due to or exacerbated by the presence of an altered vestibular function. Vestibular rehabilitation has been shown to be effective in children with a vestibular dysfunction. Further, paediatric rehabilitation delivered in a day camp format was also shown to yield positive outcomes in children with conditions such as cerebral palsy. This study aimed to determine the feasibility and effects of an intensive 1-week day camp program of vestibular rehabilitation on vestibular function and outcomes of functional gait and motor outcomes in school-aged children with DCD. METHODS: Ten children with DCD (6-10 yrs) participated in this multiple pre- multiple post- sequential design study. The intervention consisted of a 1-week (total of 22.5 hrs of therapy over 5 consecutive days) vestibular rehabilitation day camp comprising of activities targeting static and dynamic balance, gaze stability, tone, coordination and proprioception. Participants were assessed twice pre-intervention (week1 and week2), immediately after the intervention (week4) and at a 4-week follow-up (week8). Outcomes of gaze stability (Dynamic Visual Acuity; DVA), balance strategies (Sensory Organization Test; SOT), gait function (Functional Gait Assessment; FGA), motor proficiency (motor subtests 5 & 6 of the Bruininks-Oseretsky Test; BOT-2) and participation (Miller Function and Participation Test; MFUN) were collected and analysed using repeated measure ANOVAs or Friedman tests. As outcomes were similar between pre-intervention time points (week 1 & 2), repeated measure analyses were performed using outcomes collected at week2, week4 and week8. RESULTS: FGA scores significantly improved post-intervention compared to pre-intervention and this improvement was maintained at follow-up ($p< 0.001$). Number of children with abnormal DVA scores dropped from 3 to 1 to 0 between pre-intervention, post-intervention, and follow-up. Mixed findings were observed on the SOT, BOT-2 and MFUN, with no significant differences across measurement time points ($p>0.05$). There was a 100% attendance rate in the camp and assessment sessions. CONCLUSIONS: Results indicate that intensive vestibular rehabilitation delivered in a day camp format is feasible and can enhance functional gait as well as gaze stability in school-age children with DCD. The lack of changes in other outcomes may be explained by the limited sensitivity of available assessment tools, variability in the children's cooperation during assessment and limited duration of

intervention and assessment time frame. This study provides foundational knowledge that will help inform the design of a larger scale, randomized control trial. Funded by CRIR.

2-W-119 Postural Response to a Sudden Released Pulling Force in Patients with Benign Paroxysmal Positional Vertigo

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BACKGROUND AND AIM:Benign paroxysmal positional vertigo (BPPV) is one of the most common causes of peripheral vestibular vertigo in adults. Vestibular system is an essential component contributing to well-controlled balance tasks, such as standing and walking, consequently patients with BPPV might have problems performing these balance-related tasks. The purpose of the study was to investigate the postural responses to a sudden released pulling force in patients with BPPV in comparison with healthy young adults. METHODS:Thirty healthy young adults (22.4±2.0 years) and 30 patients with BPPV (51.0±15.5 years), diagnosed by Dix-Hallpike test, were recruited in the study. Patients whose Dix-Hallpike test result was negative were excluded. All participants were instructed to stand on a force plate and perform a hand-held horizontal pulling task with a weight of four kilogram. Postural response was recorded while the pulling force was suddenly released. Centre of pressure (COP) was analyzed from the force plate during the task. Reaction time, and displacement and velocity of the COP in anterior-posterior (AP) and medial-lateral (ML) direction during the postural perturbation were measured. Peak COP sway velocity in AP and ML direction in the duration of recovering to a stable position was also measured. Independent t test was used to compare the differences of the postural response between the two groups. Significance level was set at $p<0.05$. RESULTS:The BPPV patients demonstrated a significantly longer reaction time than the healthy controls. The AP and ML displacement were significantly larger in the BPPV patients than healthy controls during the perturbation. Significantly greater ML sway velocity was also found in the BPPV patients than the healthy controls when facing a sudden postural perturbation. Furthermore, BPPV patients showed greater peak ML sway velocity in the duration of recovering to a stable position. CONCLUSION: BPPV patients required longer reaction time, larger postural sway, and greater ML sway velocity in response to a sudden postural perturbation, as well as larger ML sway velocity in the recovery phase than healthy controls. The results suggested that patients with BPPV might have poorer reactive postural control when facing an external postural perturbation, which possibly associates with their vestibular disorder, and may result in a higher risk of falling. Therefore, balance training should be considered in addition to the repositioning maneuver for BPPV patients. ACKNOWLEDGEMENTS AND FUNDING:We thank Ministry of Science and Technology of Taiwan for supporting this study (MOST 104-2314-B-006-040- and MOST 105-2314-B-006 -017 -MY2).

2-W-120 Visual verticality perception after stroke: a systematic review of methodological approaches and suggestions for standardization

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Objective: Visual vertical (VV) measurements are being increasingly used for routine clinical assessment of spatial cognition, to investigate otolithic vestibular function and identify altered verticality perception as a possible cause of postural disorders after stroke. The objective of this paper was to synthesize knowledge of assessment methods for testing VV after stroke. Methods: The systematic review,

following the PRISMA statement, involved a search for articles in MEDLINE via PubMED published up to November 2015 by using the search terms "visual vertical," "verticality perception" and "stroke.". We included only case or group studies on VV perception after hemispheric, brainstem or cerebellar strokes. Two authors independently assessed data on patients' and VV assessment characteristics, outcome measures, ranges of normality and psychometric properties. Results: We assessed reports for 61 studies (1,982 patients) of VV for hemispheric (n=43), brainstem (n=18) or cerebellar (n=8) stroke. VV assessment procedures varied widely in paradigm, type of stimulus, patient posture, number of trials and outcome measures. However, some emerging guidelines recommend assessing VV in absolute darkness, with an even number of trials, from 6 to 10, with the body maintained upright (at least the trunk). Under these conditions, normal VV orientation (mean of VV estimates) can be considered from -2.5° to 2.5° and is highly reliable for use in clinical practice and research. A difference ≥ 2° between repeated measures for a given patient can be interpreted as a real change in VV perception. Myriad of protocols have been proposed, for which psychometric properties must be better analyzed. Conclusions: This first review of VV assessment methods after stroke shows a great heterogeneity of procedures and points to some procedures and parameters for standardization.

X Visual function and disorders

2-X-121 Glaucoma, Gait and Attention

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Primary open angle glaucoma (POAG) leads to peripheral visual field loss and may deteriorate balance and gait. While mechanisms of postural instability are not well understood in glaucoma, these impairments may have a central component due to the structural and functional connectivity alterations recently reported in various regions of the brain in patients with POAG. An example of a specific central mechanism possibly contributing to balance and gait impairments in patients with POAG may be attention-related due to the neurodegenerative component of glaucoma. It is well established that balance and gait require attention. In older adults for example, postural control performance deteriorates when attentional demands are increased. Thus, goal of the proposed study is to examine whether similar attentional mechanisms are involved in POAG. We will focus on gait and use well-established dual tasks paradigms. Ten older adults (age = 70.9±8.7 years) diagnosed with early (N=5), moderate (N=1) and advanced (N=4) primary open angle glaucoma were recruited. The disease stage classification is based on that of Hodapp and colleagues, with the visual field mean deviation (MD) averaged across both eyes. More specifically, early, moderate and advanced POAG stage is defined as an average MD greater than -6 dB, ranging between -12 and -6 dB, and less than -12 dB, respectively. Participants completed gait assessments including dual-task paradigms using an auditory choice reaction time (CRT) task. Attention performance was assessed using the CRT task mean reaction time and primary gait variables included gait smoothness and gait speed. Linear regression analysis was performed to determine the relationship between outcome measures (reaction time, gait smoothness and gait speed) and POAG severity (visual field MD). Baseline gait characteristics were associated with glaucoma severity; specifically, POAG patients in more advanced disease stages, i.e. smaller visual field MD, walked slower (r=0.4) and with less smooth gait patterns (r=0.4). The impact of the dual-task on gait characteristics was also a function of visual field MD. In particular, the impact of the POAG disease stage on gait was greater when performing the CRT task compared to no task; the correlation between the visual field MD and gait smoothness was r=0.7 and r=0.4 with and without the CRT task, respectively. Similarly, the relationship between the visual field MD and gait speed were stronger when performing the CRT task compared to baseline. Lastly, patients in more advanced disease stages were slower to respond to the auditory stimuli in the CRT task. The results of this study show that gait and attention performance are associated with glaucoma severity and give insights into the potential central mechanisms of mobility impairments in patients with glaucoma.

Thursday, June 29, 2017

A Activity monitoring

3-A-1 Reliability and validity of Tractivity sensors for monitoring functional ambulation in community-dwelling stroke survivors

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Background: Activity monitoring via wearable sensors has significant implications for rehabilitation. Given the many available commercial wearable sensors, it is important to test the reliability and validity of these prior to its application with a patient population. The aim of this study was to examine the reliability and validity of the Tractivity® sensor (Kineteks Corp.) for assessing gait function in healthy young adults at various speeds and gait patterns. Methods: Fifteen healthy young subjects (age 25.67+2.059) and 15 people with chronic (> 6 months) hemiparetic stroke participated in the study. The same accelerometer based Tractivity sensor was used throughout the study to maintain the reliability of the study. Participants were asked to walk at their preferred, slow and fast speed while wearing the sensors on the GaitRITE mat for the duration of a trial which lasted for 5 minutes. Young participants also performed a step-to and step-through gait pattern at their self-selected speed using a cane to mimic gait patterns of people with other orthopedic of neurologic conditions and relying on an assistive device for functional ambulation, while the participants with chronic stroke only performed the step through gait. Three trials were performed for each speed and each condition. Subjects were brought back after a week and tested again using the same paradigm. The data from the Tractivity software was retrieved electronically and verified manually and compared with the data that was retrieved from the GaitRITE software. Paired-t test was used to compare the gait speed and the number of steps between the sensor and the GaitRITE. Intraclass co-relation co-efficient was used for test-retest reliability of the sensor for each of the variables in both groups. Results: For both the groups there was no significant difference in the number of steps recorded for all the conditions between the sensor and the GaitRITE mat ($p>0.05$), except for the slow gait speed where GaitRITE recorded significantly more number of steps. The step-to and step through gait patterns also yielded no difference in the outcome variables between the two instruments ($p>0.05$). There was no difference in the number of steps and gait speed recorded on the tractivity between the two sessions as well ($p>0.05$). Conclusion: In conclusion, the Tractivity device is a reliable sensor with having excellent validity at preferred and fast speeds and moderate for slow speeds. Community ambulation and physical activity could thus be accurately measured using this sensor in community-dwelling stroke survivors and other people with chronic disabilities.

3-A-2 Turn around freezing and falls: measuring turning at home in Parkinson's disease

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BACKGROUND AND AIM: Difficulty turning during gait is frequent in Parkinson's disease (PD) and leads to significant disability, falls, and loss of function. Moreover, the assessment of turning mobility in the clinic may not adequately reflect typical mobility function or its variability during daily life. We hypothesized that quality of turning mobility during daily life in patients with PD would be related to both freezing of gait (FoG) and to falls. Here, we investigate the value of measuring (with a single inertial sensor) turning quality during daily life as it relates to FoG and to risk of falls in people with PD. METHODS: Ninety-five subjects with PD (age: 65±9; disease duration: 5.6±3.4; Motor UPDRS Score ON: 34.2±12.3) wore a DynaPort hybrid sensor (McRoberts) on a belt on the lower back during normal daily activity consecutively for 3 days. An algorithm identified periods of walking from the 3D accelerations (longer than 10 sec) and calculated the following turning metrics that occurred while walking (mean and coefficient of variation, CV): 1) number of turns occurring in each 30 min period, 2) turn angle amplitudes, 3) turn durations, 4) turn velocities, 5) turn medio-lateral (ML) jerk and 6) turn ML range. Based on the future falls (information collected monthly), participants were grouped as non-fallers (N=55) and fallers (one or more falls in the 12 months after the testing, N=40). Twenty-five out of 95 subject reported FoG. A 2x2 repeated measures ANOVA was carried out to investigate the effects of angle amplitude small (>40° and <120°) vs large (>120° and <260°), group (freezers and nonfreezers), and interaction. RESULTS: Turning duration and its variability, and the CV of turn velocity, ML jerk, and ML range were significantly positively associated with UPDRS Motor scores (Pearson r ranging from 0.22 to 0.55, p-value ranging from 0.03 to <0.0001). Freezers, compared to nonfreezers, showed a slightly faster turning velocity during turns (69.5±11°/s vs 66.5±9°/s for small angles and 78.5±16°/s vs 73.6.5±13°/s for large angles), a significantly higher jerk and ML jerk (group: F=7, p=0.009; angle: F=32.2, p<0.0001, interaction F=0.9, p=0.3), and a significant lower CV turning angle amplitude (group: F=4, p=0.04; angle: F=0.2, p=0.6, interaction F=4.3, p=0.04). However, number of turns (21±9.5/30min in freezers, 20±4.2/30min non-freezers) was similar in the two groups. Freezers, compared to nonfreezers, showed more turning impairments in the turns with larger angles. In addition, fallers showed reduced variability of quality of turns for larger angles compared to nonfallers. CONCLUSION: Our findings suggest that continuous monitoring of turning during daily activities among patients with PD is related to disease severity, freezing of gait, and future falls. Although the number of turns was the same for freezers and nonfreezers, freezers restricted their turns to smaller turning angles and their large angle turns were jerkier. In addition, variability of quality of large turning angles could also predict future falls in PD. Clinical decision-making and rehabilitation assessment may benefit from measures of quality of turning mobility during daily activities.

B Adaptation, learning, plasticity and compensation

3-B-3 Influence of social evaluative threat during a mathematical anxiety task on standing balance

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Background and aim: The postural control system is able to produce adaptive responses when environmental conditions change. For example, when standing on a highly threatening environment comprising standing on an elevated surface similar to standing at the edge of a building, a reduction in postural sway and increased ankle stiffness is observed (e.g. Carpenter et al. 2001). This response has been attributed to the fear and anxiety induced by the elevated surface. However, little is known about whether this response is an elevated-surface-specific (or task-specific) mechanism or a general threat-related mechanism that can also be induced by cognitively or socially-induced anxiety and threat. The aim of the present study was to assess threat-related adaptive changes in postural sway using mathematical anxiety and social evaluative threat, both of which have been shown to induce a high stress response. Methods: Thirteen young adult volunteers (age range 19-26 years, 9 female) participated in the study. Participants were asked to perform a simple arithmetic task, comprising additions of pairs of one- two- and three-digit numbers appearing on a screen, and a balance task (standing on a sway referenced surface). After establishing a baseline level of performance in the two tasks, the experiment?s three main blocks commenced. In block 1, participants performed the arithmetic task while standing on the sway referenced surface. In block 2 (mathematical anxiety), they performed the same task but a progress bar appeared across the screen in each trial. The progress bar comprised a green part (1/3 of its length) followed by a red part. The duration of the red part of the progress bar was 70% of participants? mean reaction time in the previous block, but they were told that it was the average reaction time in their age group, in order to increase anxiety levels. Before the start of block 3 (social evaluative threat) the participant was told that his/her performance was poor relative to other participants tested and that he/she had to try harder. Then block 3 commenced. Finally, the block 1 and the two baseline blocks were repeated. Stress was evaluated in the end of each block using self-report. Results: Self-reported stress linearly increased up to block 3 (social evaluative threat) and then gradually decreased again, confirming that our stress manipulations were successful. Reaction times were significantly faster when the progress bar was introduced (block 1 vs. block 2) and became significantly slower when the social evaluative threat was added (block 2 vs block 3). In contrast, postural sway amplitude and path length increased when the progress bar was introduced (block 1 vs. block 2) but was then reduced again when social evaluative threat was added (block 2 vs. block 3), in line with previous studies on postural threat. Conclusions: Our results suggest that the adaptive postural responses observed under conditions of threat may not be limited to posture-related threat but may also generalize to high threat and stress induced in non-posture-related contexts. Future research comparing different types of threat would be useful in evaluating the common characteristics of this adaptive postural response.

3-B-4 Sway referencing in sitting: visual/vestibular feedback, motor learning, and cognitive influences

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BACKGROUND AND AIM: Surface sway referencing (SR) is an established tool for assessing visual and vestibular contributions to standing balance. However, SR in standing has limitations. The test does not provide specific information about sensorimotor control of the upper body, which is needed in most daily activities, nor is the test available for populations that cannot stand independently. Therefore, we adapted the standing SR test to focus on the upper body in sitting and characterized the influence of visual feedback, cognition, and motor learning. We hypothesized that SR in sitting would exhibit similar sensory reweighting mechanisms as those observed in standing. We also tested the hypothesis that subjects would improve their performance with repeated tests and retain this improvement one week later. METHODS: Our SR system was developed with an articulating bench that tilted in proportion to the instantaneous body sway angle in the frontal plane. Twelve healthy subjects were tested in two sessions separated by one week. In each session, subjects completed 10 tests. Conditions were randomized and included eyes closed (EC) or open (EO), cognitive task (cog) or listening to white noise (white). In each session, the EC white test was repeated 4 times. The remaining tests were repeated 2 times. Each test consisted of 30 s of quiet sitting, followed by 2.5 min of SR, followed by 30 s of quiet sitting. Body sway angle and angular velocity were represented in the time domain (RMS) and frequency domain (amplitude spectra ~0.04-3Hz). Subjects also rated their own performance and perceived difficulty in tests following each session. RESULTS: Body sway in SR was 7 times larger than quiet sitting, exhibited a unique frequency profile compared to quiet sitting, and was not correlated with quiet sitting across subjects. Motor learning across repeated EC white tests was evident in SR, with statistically significant reductions in body sway (~22%) that were retained one week later. EO tests resulted in significantly lower sway across a wide range of frequencies. The cognitive task increased sway in EO conditions and affected sway across a wide range of frequencies. Perception of difficulty with cognitive tasks was significantly correlated with performance in EO tests. CONCLUSIONS: We suggest sitting SR is a valuable tool for assessing and highlighting visual and vestibular contributions to upper body posture control, similar to SR in standing. Subjects demonstrated modest motor learning that was retained one week later. Both cognitive and visual conditions influenced sway across a broad range of frequencies consistent with the idea that occlusion of vision and dual tasking lowers accuracy of the internal estimate of body in space. This result is also consistent with the correlation between perceived difficulty in cognitive tasks and EO tests. ACKNOWLEDGEMENTS AND FUNDING: NIH R03 DC013858 and University of Hartford ITR grant

3-B-5 Does step training in specific directions induce negative transfer effects in untrained directions?

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BACKGROUND AND AIM: Step training is an emerging form of balance training to prevent falls and directly addresses impaired stepping capacity - an important fall risk factor in older people. Although step training improves the ability of quick stepping, some home-based step training systems train limited stepping directions (often without diagonal directions) and may cause harm by reducing stepping performance in untrained directions. This study examines the possible transfer effects of step training on stepping performance in untrained directions in older people. METHODS: Fifty four older adults were randomized into: forward step training (FT); lateral plus forward step training (FLT); or no training (NT) groups (Trial registration: ANZCTR 369066). FT and FLT participants undertook a 15-minute training session involving 200 step repetitions using the choice stepping reaction time (CSRT) system. Prior to and post training, response and movement times and stepping kinematics (i.e. peak stepping speed, stepping accuracy and precision) in forward, diagonal and lateral directions during the CSRT task were assessed. RESULTS: Significant improvements were observed in response and movement times, and peak stepping speed in all directions among all groups ($P < 0.05$). Significant interactions of group and time (pre/post-assessment) were evident for the first step after training indicating negative (delayed response time) and positive (faster peak stepping speed) transfer effects in the diagonal direction in the FT group ($P < 0.05$). However, when the second to the fifth steps after training were included in the analysis, there were no significant interactions of group and time for any outcome measures in the diagonal stepping direction. CONCLUSIONS: Step training only in the forward direction improved stepping speed but may acutely slow response times in the untrained diagonal direction. However, this acute effect appears to dissipate after a few repeated step trials. Step training in both forward and lateral directions appears to induce no negative transfer effects in diagonal stepping. These findings suggest home-based step training systems present low risk of harm through negative transfer effects in untrained stepping directions. The transfer effect of longer-duration step training on step performance in untrained directions and the generalizability of these findings to real life situations require further study.

3-B-6 Cortical processing underlying split-belt treadmill gait adaptation: an EEG study

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Background and aim: Adaptability of human locomotion has been studied using split-belt treadmill walking. While a number of studies have examined split-belt treadmill walking adaptation, there is still limited direct evidence about the role of the central nervous system during locomotor adaptation. In the present study, we aimed to examine the role of cortical processing during locomotor adaptation based on electroencephalogram (EEG) recordings. Methods: Thirteen healthy participants were asked to walk on a split-belt treadmill. The walking trial was divided into three period:(1) baseline (both belts at 0.4 m/s for the slow and 0.8 m/s for the fast sessions, 2 min each), (2) adaptation (right belt at 0.4 m/s, left belt at 0.8m/s, 10 min), (3) washout (both belts at 0.4 m/s, 6 min). During the trial, we recorded EEG (31ch, 10/10 system), electromyography (EMG) of the bilateral tibialis anterior muscles (TA), ground reaction forces, and limb kinematics. To characterize the process of behavioral adaptation, integrated TA EMG in stance phase, peak anterior force, and step length at each step were calculated. EEG data was analyzed by applying independent component analysis to remove artifacts induced by motion, muscle activity and eye movements. Next, we computed the spectral power of the EEG in three distinct frequency bands [α (8 to 13 Hz), β (14 to 20 Hz) and low-γ (21 to 40)] at three electrode locations (Fz, Cz and Pz) during each gait cycle. Results: In the adaptation period, the behavioral parameters showed rapid changes in first 3 minutes and gradually reached a steady-state level during mid-late the period (3 to 10 min), as previously reported On the other hand, the EEG power at Fz and Cz were almost constant in first 3 minutes and then increased gradually during mid-late adaptation period (3 to 10 min). The EEG power at Pz was almost constant throughout the adaptation period. In the washout period, while the behavioral parameters exhibited clear aftereffect and then gradually recovered, the cortical activities showed similar changes to those at the beginning of the adaptation period. Conclusions: Our results clearly demonstrate that the time course of adaptation observed by cortical EEG activity was different from that detected by the behavioral parameters. The longer time course of adaptation observed in EEG data may be due to the fact that subjects still feel odd perception even after the behavioral parameters reached a steady-state level during split-belt walking. As previous modeling studies suggested, motor memory obtained during the mid-late adaptation period is robust. These long-lasting cortical activities may have relevance to the formation of motor memory during locomotor adaptation. The similar cortical activates in both adaptation and washout period implies that washout period also required similar extent of cortical involvement. These results give important information for understanding the mechanisms underlying human locomotor adaptations.

C Aging

3-C-7 Effect of Age on Gait Based on Elevation Angles

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Background/aim: During walking, coordination among leg segment elevation angles (EAs) reflects key aspects of control. In healthy walking, these EAs form a loop and lie tightly in a plane (i.e., linear co-planarity of elevation angles, LCEA), while during development, infants initially learning to walk do not show LCEA and its features develop over the ensuing decade. Although LCEA during gait is a strong invariant kinematic signature, subtle change in loop shape and plane orientation can occur with increased gait speed. LCEA may be able to characterize subtle loss of coordination in gait during aging. The aim of this study is to compare LCEA between young and old adults at usual and fast walking speeds. Methods: We studied participants from the Baltimore Longitudinal Study of Aging aged 80 years and older (n=36, mean 84.5±3.0) and aged 50 years or younger (n=35, mean 40.1±6.8). To assess healthy aging effects, we excluded participants with stroke, Parkinson's disease, head injury, dementia, peripheral neuropathy or arterial disease, severe pain or shortness of breath during walking, poor eyesight, and multiple falls. Participants walked at usual and fast speed with full-body kinematic recording. Frontal plane EAs were calculated for thigh, shank and foot for each speed. Principle component analysis on EAs yields 3 eigenvectors; u1, u2 and u3 (with corresponding v1, v2, and v3 for variance explained). U1 and u2 identify the best fitting plane, v1+v2 describes the variance explained by the plane, and v1 and v2 describe the loop shape. Angles between eigenvectors and segment coordinates describe plane orientation (e.g., u1t is the direction cosine of u1 to thigh coordinate). For each outcome variable, between-group and between-speed comparisons with interaction are tested with a Bonferroni adjustment. Results: LCEA (v1+v2 > 99%) is observed and no difference found in explained variance by age group or walking speed. Loop shape differs significantly by speed in both age groups (v1 increase and v2 decrease with speed), and by age group for both speeds (v1 smaller and v2 larger in older adults) (see Table). Age affects plane orientation (e.g., u1t) at fast speed but not usual speed. Conclusions: Speed affects loop shape and plane orientation in both older and younger adults. Healthy older adults maintain LCEA, but loop shape is significantly different, indicating an altered phase relationship between segment coordination. Older adults also have lower u1t, indicating lower mechanical energy during gait. LCEA has potential to capture subtle loss of coordination in gait during aging.

3-C-8 Sensory Reweighting, Muscle Co-contraction and Postural Illusions in Healthy and Fall-prone Older Adults

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BACKGROUND AND AIM: Adaptive multisensory integration is an essential component of the postural control system. Yet, evidence suggests that sensory reweighting is less efficient in older adults. This can be manifested in large postural sway aftereffects, such as those seen when transitioning from a sway-referenced support to a stable support. Recent research from our lab indicates that this sway aftereffect is accompanied by a similar lower limb muscle co-contraction aftereffect. The current study examined how these postural aftereffects may differ in healthy and fall-prone older adults and whether they could be related to a delayed perception that the platform had stabilised. METHODS: 11 healthy young (M age = 24.18 ± 4.24), 11 healthy older (M age = 72.09 ± 5.50) and 11 fall-prone older adults (M age = 72.09 ± 5.39) took part in blind-folded postural assessment on a fixed platform (baseline: 2mins), followed by a sway-referenced platform (adaptation: 3 mins) and finally on a fixed platform again (reintegration: 3 mins). During the reintegration phase, participants were asked to press a push-button whenever they perceived that the platform had stopped moving. Anterior-posterior (AP) sway was assessed from a motion tracking marker placed on the L5 vertebrae. Surface EMG was recorded from the tibialis anterior and gastrocnemius medialis muscles. RESULTS: Both groups of older adults showed a significantly larger and longer AP sway aftereffect once the platform had stabilised, compared to young adults. Additionally, the size of this aftereffect was larger in fall-prone compared to healthy older adults. Both older groups also demonstrated a muscle co-contraction aftereffect, whereby co-contraction levels did not return to baseline until 30s after the platform had stabilised. Despite this, only fall-prone older adults showed higher muscle co-contraction than young adults, which lasted throughout the reintegration phase. Fall-prone older adults also showed a pattern of higher muscle co-contraction throughout all postural phases. Interestingly, it took both older adult groups five times longer (Ì(OLDER) = 40.45s ± 10.76, Ì(FALLER) = 43.98s ± 7.41) than young adults (Ì = 8.27s ± 2.86) to perceive that the platform had stopped moving. CONCLUSIONS: Sensory reweighting is delayed in older adults, as shown by the large postural sway aftereffects observed in this age group, especially in fall-prone older adults. This delay may consequently instill a perceptual illusion in this population that the platform is still moving. In order to cope with this postural sway, older adults continue to co-contract their lower limb muscles. However, this may be a maladaptive strategy as higher muscle co-contraction has been associated previously with greater postural sway and fall risk. As a result, fall-prone older adults' dependence on this strategy may become a vicious cycle, whereby increased use of it also places this population at greater risk of a fall.

3-C-9 Normative instrumented straight walking database for an elderly population over 6 years observation time

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Background and aim: Aging is a physiological process that affects biological systems. Movement, particularly walking, has been shown to deteriorate over the years in older adults even without an obvious underlying pathology. Here we present first analyses on the effect of aging on straight walking in a large and still ongoing longitudinal cohort using wearable sensors. Methods: The cross-sectional analysis included data of 1089 healthy older adults (m=548, f=541, mean age 63 years, range: 50-80 years), and the longitudinal analysis (6 years observation time, 4 visits) 486 participants (m= 227, f=261, mean age at baseline 63 years, range: 50-80 years) from the TREND study (TübingeR Evaluation of risk factors for NeuroDegeneration). Data was obtained from wearable sensors (McRoberts® and/or OPAL (sensors), APDM®) during 20-meter straight walking tasks. Tasks were performed with normal pace, fast pace, and under dual tasking conditions (DT, checking boxes and serial subtraction, respectively). The following gait domains were extracted and analyzed using a validated and already published algorithm (1): pace, length, rhythmicity and asymmetry. Preliminary statistical comparison was performed with ANOVA (cross-sectional analysis) and an exploratory analysis of mean (longitudinal analysis). Due to space limitations, only results of the fast pace walking data are presented here. Results: In the cross-sectional analysis, step time and step length ($p \leq 0.001$) showed a linear deterioration from the younger to the older age groups (50-59, 60-69, 70-84y), but not the parameters from the rhythmicity and asymmetry domains. In the longitudinal analysis, step time, step velocity and gait asymmetry ($p \leq 0.0001$) showed relevant age dependency. Parameters such as step length and step velocity variability were not relevantly associated with age. Conclusion: Cross-sectional and longitudinal quantitative analyses of straight walking from this large prospective cohort of basically healthy older adults argue for an age-dependency particularly of pace-associated gait parameters. These data can further shed light on aging aspects of single- and dual task walking in older adults, and serve as a normative dataset for future pathology- and disease-oriented studies and trials in the field. References: (1) Del Din et al, JBHI, 2016; 20(3):838-847

3-C-10 Effects of visual input and support-base width on muscle coactivation during standing in the elderly

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BACKGROUND AND AIM: The elderly demonstrate greater postural sway compared with young people in static standing; this is considered to be associated with the risk of falling. Visual input and support-base width are both important sources of sensory information in the elderly for balance maintenance. Some recent studies have shown that the elderly demonstrate greater muscle coactivation than young people during static standing. However, the relationship between sensory information and muscular coactivation remains unknown. The purpose of this study was to clarify the effects of visual input and support-base width on muscle coactivation during standing in the elderly. METHODS: Nine healthy older subjects (5 males, 4 females; age: 74.7 ± 3.4 years) participated in this study. The task was to maintain static standing for 30 s. The subjects were required to stand upright on the floor barefoot with arms comfortably at their sides. Four conditions were selected with different visual inputs and support-base widths (eyes opened/closed, comfortable/narrow support-base width; EO_CSW, EC_CSW, EO_NSW, EC_NSW). The subjects were allowed to stand with preferred width after several stepping in CSW. They were instructed to stand with feet together (touching each other) in NSW, similar to the manner of standing in Romberg's test. Surface electromyography (EMG) of the tibialis anterior (TA) and soleus (SOL) muscles in the dominant leg was collected. We normalized the EMG amplitude with the data from the maximum voluntary contractions. To evaluate the relative level of coactivation of TA and SOL, the co-contraction index (CI) was calculated according to the method reported by Falconer and Winter (1985). In the statistical analysis, after application of the Shapiro-Wilk test, Friedman's test and post-hoc analysis were performed using Wilcoxon's signed-rank test with Bonferroni correction. The significance level was set at 0.05. RESULTS: In the EC_NSW condition, elderly subjects demonstrated a greater CI compared with that in the EO_CSW and EC_CSW conditions ($p < 0.05$, 31.42% ± 13.83%, 15.05% ± 7.54%, and 13.45% ± 5.26%, respectively). There were no statistically significant differences with respect to CI between the conditions (EO_CSW vs. EC_CSW, EO_CSW vs. EO_NSW, and EO_NSW vs. EC_NSW). CONCLUSIONS: Increased muscle coactivation was identified as a result of the stiffening strategy to control posture. Closing the eyes reduces visual information and standing on a narrow support-base width is difficult, resulting in negative effects on postural control in the elderly. Our results showed that a narrow support-base width increased ankle muscular coactivation more effectively than a visual input. However, the visual input was able to compensate for the postural threat of a narrow support-base width in the EO_NSW condition.

3-C-11 Aging effects on the temporal modification of muscle activation patterns during split-belt treadmill walking

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People adapt their gait every day under all kinds of different circumstances, e.g. are slowing down, speeding up or turning. A way to study gait adaptations in a laboratory situation is by using a split-belt treadmill, a treadmill with two belts that can run with different velocities. By suddenly changing the speed of one of the belts, participants have to adapt their gait to successfully walk on the split-belt. Previous split-belt studies have shown a decrease in adaptation performance in older adults compared to young adults, especially in the temporal parameters1. In a previous split-belt study with healthy young subjects, 4 basic muscle activation patterns of the muscles of the lower leg have been suggested to underlay the adaptation during split-belt waking. Observed changes in the temporal EMG patterns were related to kinematic events like toe-off time and contact time2. In the present study we examine whether or not the muscle activity patterns of the lower leg and the temporal modulation of those patterns during split-belt walking change with age. 24 healthy young and older volunteers participated. The age groups are between 20 ? 30 and 50 ? 60 year of age. During the treadmill conditions, the participants will walk on a M-Gait treadmill (Motekforce Link) with two belts, which can be controlled separately and with embedded force-plates. Participants start with 3 min walking with tied belts at 1.4 m/sec, and 3 min. with tied belts at 0.7 m/sec (baseline), followed by 10 min. split-belt walking (fast belt at 1.4 m/sec and slow belt at 0.7 m/. Finally, the belts are tied again and participants walk for 3 min. at a speed of 0.7 m/sec. Muscle activity was recorded (Trigno wireless system) bilaterally: biceps femoris (BF), semitendinosus (ST), rectus femoris (RF), vastus medialis (VM) medial gastrocnemius (MG), soleus

(SOL), tibialis anterior (TA) and gluteus medius (GM). EMG data are high-pass filtered (30-Hz cut-off) offline using a 2nd-order, Butterworth filter, then full-wave rectified and low-pass filtered (10 Hz). EMG data will be time-interpolated to 100 points over a gait cycle for inter-stride averaging. Nonnegative matrix factorization was used to identify underlying temporal patterns in the EMG data. We hypothesize that in young adults 4 modes represent temporal muscle activation during split-belt walking. We anticipate that temporal shifts in the EMG patterns will be related to time of push-off in the fast limb and heel contact in the slow limb. In addition, we hypothesize that older adults will have more difficulties with temporal modulations as revealed by a different representation of the muscles in the modes and/or a reduction in basic activation patterns3. Age effects might be due to central as well as peripheral mechanisms such as an increased muscle activity in the hip muscles, more co-activation in the leg muscles increased necessity of cognitive control and age related alterations in proprioception. Preliminary analysis on a subset of the data revealed age related temporal modulation of muscle activation patterns, during the early and late adaptation phase. 1) Bruijn et al., 2012, J Neurophysiol; 108: 1149 - 1157 2) MacLellan, et al., 2014, J Neurophysiol;111:1541 ? 1552 3) Clark, et al., 2010, J Neurophysiol 103: 8

3-C-12 The effect of aging on muscle material properties of ankle plantarflexor and dorsiflexor muscles

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BACKGROUND AND AIM: Decreased mobility with increasing age is often attributed to reduction in muscle strength. However, training focused just on increasing muscle strength does not always improve mobility. Compliance of the musculotendon unit affects the force generating capacity in amplitude and generation rate. Although, increased tendon compliance due to age is related to decreased joint power during push-off at late terminal stance, the effect of aging on muscle stiffness is unknown. This lack of evidence has primarily been due to methodological limitations of joint-torque based estimates of muscle stiffness. Here we use shear wave (SW) ultrasound elastography as a measurement of muscle stiffness by measuring the velocity at which SWs travel through the muscle. The faster the SWs, the stiffer the muscle. Thus, to investigate the effect of aging on passive muscle stiffness and the contribution of muscle stiffness to joint stiffness, the aim of this study was to compare the SW velocity of the ankle plantarflexor, medial gastrocnemius (MG), and dorsiflexor, tibialis anterior (TA), and joint stiffness in younger and older adults. METHODS: Nine young adults (four males, five females, 21.03.6 yrs) and five older adults (four males, one female, 68.85.4 yrs) participated in the study. Subjects were seated with their knee in maximum extension and their foot secured to a platform of a dynamometer (System3Pro, Biodex). B-mode and SW elastography ultrasound measurements (Aixplorer, SuperSonic Imagine) of MG and TA muscles were captured, as well as joint angle, torque, and electromyography (Delsys) with the ankle at different angles (0 degrees dorsiflexion (DF), 15 degrees plantarflexion (PF), maximum DF, maximum PF, and two other intermediary angles) while the muscle was passive. RESULTS: Our main findings show that SW velocity in the MG of younger adults was 36% greater than older adults ($p<0.001$) across the ankle range of motion and 54% greater at maximum DF (Fig. 1). There was a significant correlation between joint stiffness and SW velocity in the MG only in the younger adults ($r2=0.46$, $p<0.001$); there was no significant correlation between joint stiffness and SW velocity of the TA in both groups. CONCLUSIONS: These findings indicate that muscle stiffness of the MG is greater in younger adults compared to older adults across the ankle range of motion with the largest difference when the muscle was at the longest. Changes in stiffness may be due to changes in composition (e.g. collagen) and architecture of the extracellular matrix. The lack of difference in SW velocity in the TA due to aging suggests that these changes may not be systemic such that all muscles are not affected equally. Tissues other than the primary plantarflexor and dorsiflexors of older adults may contribute less to joint stiffness than in younger adults. This work has implications for refining and developing training programs focused on muscle properties to prevent mobility loss.

3-C-13 Effect of plantar stimulation on postural control in elderly

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BACKGROUND AND AIM Plantar cutaneous afferents provide useful information for postural control . Different studies showed that mechanical vibratory stimuli of plantar sole cause postural reactions, predicable and oriented. This work is based on the hypothesis that plantar cutaneous stimuli used in podiatry influence the postural control in elderly. METHODS Nine elderly (67 ± 2,3 years), healthy and without history of fall, participated in this study. The acquisitions occurred according six randomized conditions: barefoot, foam, anterior podiatric bars (3 and 5mm, respectively) and posterior podiatric bars (3 and 5mm, respectively) were interposed bilaterally under the feet of the subjects. Two force-plats (Kistler®) were used to record stabilometric parameters related to plantar pressure center (CoP) RESULTS The anterior bar of 5mm induces a change in the average position of the CoP (p=0,01) and an increase of the oscillations of CoP (p=0,01) in the sagittal plane. The rear bar of 5mm induces an increase of the oscillations of CoP (p=0,03) in the sagittal plane. CONCLUSIONS Plantar stimulations cause postural reactions characterized by movements of the CoP and that reflect the individual organization used by the CNS for postural control. These results confirm the fundamental role of the foot in postural regulation and in particular the role of its sensory function related to cutaneous mechanoreceptors of the foot sole.

D Biomechanics

3-D-14 A bipedal walking simulation using an inverted double pendulum model with a reduced number of body segments

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BACKGROUND AND AIM: Quantitative evaluation of the quality of daily walking is one of the important challenges to enhance one's quality of life since bipedal walking is one of the essential activities of daily living and a popular exercise for health promotion. Recent advances in wearable sensor technologies have allowed us to measure gait characteristics in activities of daily living. However, for the ease of daily use, the number of sensors should be minimal, which requires a modeling technique to simplify walking dynamics, focusing on key gait characteristics. We have previously evaluated sagittal plane postural dynamics during walking using an inverted double pendulum model (Fig.1), and found that the upper inverted pendulum angle (UIPA, Fig.1) was a key variable associated with walking performance, where increased UIPA was observed with increased walking speed. However, this UIPA was calculated based on a 13 body segment model (Fig.2), and the number of segments should be further reduced. Considering the difference in segmental body mass, UIPA would be less affected by excluding body segments with a smaller mass. Therefore, the purpose of this study was to investigate the effect of excluding body segments from the current 13 segment model on UIPA. METHODS: Six healthy young male adults walked at their self-selected speed. Whole-body kinematic data during walking were obtained using an optical motion capture system to calculate UIPA. Body segments in the upper and/or lower limbs were excluded from a 11 segment model with the feet segments already excluded, which resulted in 9 modeling conditions with a combination of 3 upper limb and 3 lower limb excluding conditions (Table 1). Mean absolute errors over one gait cycle in the UIPA calculated with the 9 modeling conditions from that calculated with the 13 segment model were calculated. RESULTS: UIPA without upper arm and foot segments information (Condition 3) had the lowest error (0.25±0.04 deg), followed by the models without forearm and foot segments (Condition 6, 0.40±0.12 deg), without forearm, thigh, and foot segments (Condition 4, 0.44±0.19 deg), and without both arm and foot segments (Condition 9, 0.48±0.30 deg) (Fig.3). CONCLUSIONS: The estimation errors increased as the number of excluded segments increased. However, considering that the errors were within 0.5 degrees even when 6 segments were excluded from the initial 13 segment model such as Condition 4 or 9, 7 segment model could be used to assess UIPA during walking without severely affecting its accuracy. This finding would help us determine the number of sensors needed and segment priorities for installation of sensors to assess upper body dynamics during walking. ACKNOWLEDGEMENTS AND FUNDING This work was supported by JSPS KAKENHI Grant Number JP15K21498.

3-D-15 The effect of lower extremity peripheral nerve function, hip abduction strength, and one legged balance capacity on elderly motor vehicle driver egress time

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BACKGROUND AND AIM: With the aging population it may be important for motor vehicle designers to take into account the known age-related degradation in sensorimotor function that can accumulate with age. We tested the null hypothesis that neither lower extremity peripheral nerve function, hip abduction strength, nor one legged balance capacity would significantly affect the time it takes an elderly driver to exit a vehicle. METHODS: We recruited 47 older community-dwelling drivers with ages ranging from 67 to 89 years (23 females) and varying degrees of sensorimotor function; 12 subjects with osteoarthritis (OA), 12 with peripheral neuropathy (PN), and 23 healthy controls. All subjects were screened by a physiatrist for eligibility to participate in the study. Subjects with a BMI exceeding 25 kg/m^2 were excluded. On the first visit, anthropometry, hip abduction torque, timed one legged balance, and lower extremity peripheral nerve function (Michigan Diabetic Neuropathy Score, MDNS) were measured in the U-M Biomechanics Research Laboratory, among other sensorimotor capacities. On the second visit, subjects' time to get in and out of the driver's seat of a car was measured in the Ford Motor Company Human Occupant Package Simulator Laboratory. Standard motion analysis techniques involving surface markers were used along with a reconfigurable setup simulating 7 different car models. The egress times for each subject were averaged across the 7 car models to exclude the effect of individual cars on the outcome. The hypothesis was tested using multivariate linear regression using R base package (version 3.3.1) and lattice with an alpha value less than 0.05. RESULTS: As an indicator of mobility in terms of their ability to rise from a chair, walk and turn without assistance subjects' Timed Up and Go (TUG) test times ranged from 7 to 20 seconds in this cohort of older drivers. One leg balance time, MDNS, and hip abduction strength were all correlated with driver egress time [figure]. The best predictor of driver egress time was a model that included MDNS and hip abduction strength normalized by the product of stature and body weight. The regression coefficients were: HipABd = -3.07 [p= 0.011] and MDNS= 0.067 [p= 0.015], with R^2 = 0.245. If one leg balance time was added as a 3rd dependent variable, it did not improve the model because it was significantly correlated with MDNS (r = -0.39 [p = 0.007]). Addition of age and/or gender did not improve the model significantly. We also examined the relation between egress time and one leg balance time alone and found a regression coefficient of -0.04 [p = 0.012] with R^2 = 0.135. CONCLUSIONS: Lower extremity peripheral nerve function and hip abduction muscle strength significantly affected elderly driver egress time in this group of older subjects. Our results suggest that the design of vehicles might be reviewed to facilitate the egress of elderly drivers with loss of sensorimotor capacities or mobility-related pain.

3-D-16 Reliability of peroneus longus and abductor hallucis electromyography during walking

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BACKGROUND: The peroneus longus (PL) is a rearfoot evertor, important in controlling frontal plane foot motion. Previous electromyography (EMG) studies have reported poor between-day reliability of PL during walking, limiting our ability to study intervention effects in this muscle [1]. Due to its close proximity to adjacent muscles EMG measures of PL may be susceptible to crosstalk, thus correct electrode placement is vital. The abductor hallucis (AbH) is considered important in foot function by assisting medial arch support, however it is challenging to record EMG from such a small muscle. AIM: To use ultrasound to aid placement of small EMG electrodes and determine the between-day reliability of PL and AbH in walking. METHODS: Healthy participants (n=10, age=28±4 yrs, height=1.69±0.07 m, mass=67.13±9.22 kg, mean±SD) performed six walks in standardized shoes twice over two days. Walking speed was controlled. Muscle bellies were located using ultrasound at 5-8 MHz (Telemed Medical Systems). EMG signals were collected on the right side with surface electrodes (Trigno? Mini, Delsys, Inc.) at 2000 Hz. Amplitude was normalized to the peak per gait cycle and time normalized to the gait cycle. A 75 ms window was used to calculate the route mean squared per trial and averaged from all included gait cycles. Reliability was assessed with the coefficient of multiple correlation (CMC) and the standard error of measurement and the intra-class correlation coefficient (ICC) for peak amplitude and timing of the peak. RESULTS: Both muscles demonstrated repeatable EMG profiles (Fig 1.) and good CMCs (0.88 and 0.85 for PL and AbH respectively). For PL, reliability was moderate for the peak (SEM: 4% of peak, ICC: 0.44) and very good for the timing of the peak (SEM: 2% of gait cycle, ICC: 0.72). For AbH, reliability of peak amplitude was moderate considering the ICC value (0.63), but poor based on the SEM (14% of peak). Reliability of the time of peak AbH was poor (SEM: 8% of peak, ICC: -0.03). CONCLUSIONS: The PL EMG profile and discrete variables were repeatable, supporting the use of this protocol in future work. The general pattern of activation for AbH was reliable, however individual variability was greater than in PL. The use of discrete variables for AbH requires caution depending upon the precise nature of the research question. Activation of PL can be confidently studied in a repeated-measures study design like an intervention, while AbH activation over time requires more consideration.
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3-D-17 Associations between task performance and trunk coupling during a balance-dexterity task

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BACKGROUND AND AIM: The aim of this study was to investigate relationships between trunk coupling and task performance measures in a balance-dexterity task. The task requires controlled compression of a spring with one leg while balancing on the other leg. Coupling of the upper trunk and pelvis must presumably be controlled to allow both lower limbs to operate independently of each other. We hypothesized, therefore, that a higher degree of coupling of the upper trunk and pelvis would be associated with better performance on the dexterity task and in the balance task. METHODS: Six participants (4 females, 2 males) with no history of trunk or lower extremity injury in the last six months volunteered for the study according to Institutional Review Board guidelines and approval. Average age was 30.3 yrs (±4.2). Participants completed three 20-second trials of a balance-dexterity task involving controlled compression of a compliant spring with the dominant lower limb and concurrent single-limb balance with the contralateral limb. Trunk kinematics were collected using a Qualisys Motion Capture System. Ground reaction forces and center of pressure (CoP) motion under both the compliant spring and the stance limb were collected with AMTI force plates. Dexterous task performance was quantified with root-mean-squared error of the force produced under the spring relative to an individual's maximum consistent force production. Balance task performance was quantified using mean CoP sway velocity, and trunk coupling was quantified by calculating a linear correlation coefficient for an angle-angle plot of thorax and pelvis motion in the frontal plane. Relationships between task performance and trunk coupling were investigated using Pearson correlation statistics. RESULTS: There was a significant negative association between trunk coupling and mean CoP sway velocity ($r = -0.82$, $p = 0.047$) indicating that participants who had more independent trunk motion (lower r-value) also had greater CoP sway velocity. There was no association between trunk coupling and variability of the vertical force produced under the compliant spring ($r = 0.29$, $p = 0.576$) indicating there was no relationship between trunk coupling and dexterous spring control. CONCLUSIONS: Coupling of the upper trunk and pelvis was associated with reduced sway but not with improved performance on the dexterous control task. Thus, control of trunk coupling appears to be necessary for optimal balance control. It is possible that dexterous control of the spring, however, involves redundant systems that can automatically compensate for variations in pelvic motion. Future studies will investigate these relationships in persons who suffer from recurrent low back pain, a population known to have altered trunk mechanics and balance. ACKNOWLEDGEMENTS AND FUNDING: American Society of Biomechanics Grant-In-Aid 2016

3-D-18 Validation of centre of pressure gait event detection in young healthy participants and stroke survivors during target stepping.

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Background: Target-stepping paradigms are increasingly used to assess and train gait adaptability. Accurate gait-event detection (GED) is key to both locating targets relative to the ongoing step cycle and measuring foot-placement error. GED can be based on either kinematics or centre of pressure (CoP) and both have been previously validated with young healthy (YH) [1]. However, CoP based GED has not been validated for stroke survivors (SS) who demonstrate altered CoP trajectories [1]. Additionally, stepping to targets requiring step length changes may alter CoP GED in both SS and YH. AIM: To establish the accuracy of CoP based gait event detection in relation to two kinematic GED methods during target stepping for SS and YH. Methods: GED based on verticies of CoP cyclogram [2] and two different kinematic criteria [2, 3] : a/ minimum vertical heel displacement (VHDmin) and b/ maximum forward heel displacement (VHVmin) for FC, and for FO a/ minimum vertical heel velocity (VHVmin) and b/positive forward toe velocity (FTVO) were used while YH and SS stepped to targets requiring shortening, lengthening (25%) and narrowing (tandem walk) of usual step length and width (60 steps in total). Kinematic HC and TO were matched within 200ms with CoP gait events and the mean difference between matched events for YH and paretic leg (P) and non-paretic leg (np) in SS analysed. Percentage of non-matched gait events was used to determine the success of the GED method and a one sample (two-tailed) T-Test against a reference value of zero was used to identify significant differences between CoP and kinematic GED methods. Results are as in Table 1. Conclusions: GED based on CoP is the most appropriate method to compare YH and SS when target stepping. While VHDmin and VHVmax detected gait events successfully in YH [2], it was unsuccessful in 51% of FCP in SS. When comparing the VHVmin and FTV0 kinematic GED [3] With CoP GED offsets where similar for SS an YH and within 100ms. The magnitude of the mean and 95% CI of differences between CoP and VHVmin and FTV0 indicates sufficiently accurate and reliable CoP based GED to enable delivery of target stepping cues and foot-placement error within a given phase of the gait cycle. 1. Wong, A.M., et al., Foot contact pattern analysis in hemiplegic stroke patients: an implication for neurologic status determination. Arch Phys Med Rehabil, 2004. 85(10): p. 1625-30. 2. Roerdink, M., et al., Online gait event detection using a large force platform embedded in a treadmill. J Biomech, 2008. 41(12): p. 2628-2632. 3. Zeni, J.A., Jr., J.G. Richards, and J.S. Higginson, Two simple methods for determining gait events during treadmill and overground walking using kinematic data. Gait Posture, 2008. 27(4): p. 710-4.

E Brain imaging/activation during posture and gait

3-E-19 Associations between leg strength asymmetry and mobility impairment in multiple sclerosis: a case for tDCS?

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BACKGROUND AND AIM: Multiple Sclerosis (MS) is an inflammatory autoimmune disease of the central nervous system, damaging myelin and axons to varying degrees. Importantly, one of the early signs of MS is weakness in one limb, primarily the leg, which has been determined to be a significant cause of progressive worsening of activities of daily living. An inability to generate and modulate force production in the more-affected limb causes increased energy demands and early fatigability in people with MS. Anodal transcranial direct stimulation (tDCS) is a non-invasive brain stimulation technique that can modulate cortical excitability and improve motor function (e.g. walking) in healthy subjects, older adults, stroke, and patients with Parkinson's disease. The aims of the current study are to: 1) compare knee extensor strength between sides of the body in PwMS, 2) identify associations between strength asymmetries and functional mobility tasks, and 3) determine whether tDCS can increase strength of the more-affected leg muscles, thereby reducing interlimb strength asymmetries and ultimately resulting in improved mobility of PwMS. METHODS: Thirty-seven PwMS (aged 56 ± 12 yrs) with mild-moderate disability (Patient Determined Disease Steps score 0-6) completed a series of maximal voluntary contractions (MVCs) of the knee extensors on each leg. A symmetry index was calculated for leg strength to identify the more- and less-affected side of the body. Self-report was used if the symmetry index was less than 10%. Subsequently, participants performed a timed 25 foot walk test, five repetitions of the sit-to-stand test (STS), and a timed-up-and-go (TUG) test. Finally, the falls Efficacy Scale International (FES-I) was completed. RESULTS: MVC forces were greater for the less-affected than the more-affected knee extensors (364.6 ± 95.7 N and 324.7 ± 102.6 N; $P = 0.002$). Regression analysis indicated that PwMS with greater MVC forces of their more-affected leg performed better at the timed 25 foot walk test ($R2 = 0.27$, $P = 0.001$), the TUG ($R2 = 0.21$, $P = 0.004$), and the FES-I ($R2 = 0.18$, $P = 0.009$). CONCLUSIONS: These results suggest that PwMS with greater knee extensor strength of their more affected leg perform better on commonly used functional tests and, importantly, may also experience a reduced risk for falls. Our preliminary findings indicate that motor function may begin to deteriorate in the early stages of MS and highlights the importance of bilateral leg assessment and the need for therapies targeted at reducing such differences early in the disease process. Current literature indicates that strength training alone may not be sufficient to ameliorate mobility deficits and comprehensive intervention programs may benefit from the addition of tDCS as an adjunct treatment modality. Data collection and analyses is on-going to assess the acute effects of tDCS on lower extremity force production to reduce strength asymmetries and improve mobility in PwMS.

3-E-20 Reliability of tibialis anterior intramuscular coherence during overground walking in older adults: preliminary findings.

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BACKGROUND AND AIM: A shift from the term sarcopenia to dynapenia was recently introduced to describe the age-associated loss of both muscle mass and strength[1]. Mounting evidence points to changes in neurophysiologic factors that contribute to muscle weakness; e.g. worsening of the neural drive to the muscle[2]. Intramuscular coherence by means of surface Electromyography (sEMG) can be used to assess the central drive to the muscles during gait[3]. However, it is unknown whether EMG-EMG is a reliable measure of the neural drive to the muscles during locomotion in older adults. This study aims to assess the test-retest reliability of intramuscular coherence in M. Tibialis Anterior (TA) of older adults while walking. METHODS: Intramuscular coherence was measured in nine community-dwelling healthy older adults on two separate days (48-hours in-between), during self-paced overground walking. Proximal and distal sEMG electrodes were placed over both left and right TA. The TA-TA coupled activity included for the analysis was 500 ms pre-heel strike. A 95% confidence interval was used to determine significance from the coherence spectra in the alpha, beta and gamma frequency bands of the maximum peak of coherence (CohPEAK), the average peaks amplitude (CohAVG) and the area under the coherence (CohAREA) delimited by the CohPEAK and the confidence limit. Test-retest reliability was assessed by Intraclass Correlation Coefficient (ICC(2,1)), Standard Error of Measurement (SEM), Minimal Detectable Change (MDC) and their respective percentage values. RESULTS: Moderate to high reliability was found in CohPEAK , CohAREA and CohAVG in the alpha frequency band of both left and right TA (ICC(2,1) = 0.71, ICC(2,1) = 0.70, ICC(2,1) = 0.76 and ICC(2,1) = 0.66, ICC(2,1) = 0.54, ICC(2,1) = 0.56; respectively) with SEM / SEM percentage (0.09 / 27.83%, 0.30 / 30.90%, 0.07 / 24.61% and 0.10 / 22.87%, 0.45 / 31.33%, 0.11 / 27.70%; respectively) and MDC/MDC percentages (0.24 / 77.14%, 0.83 / 85.64%, 0.19 / 68.21% and 0.27 / 63.40%, 1.26 / 86.85%, 0.30 / 76.78%; respectively). Low to moderate reliability was found in CohPEAK , CohAREA and CohAVG in the gamma frequency band of left TA (ICC(2,1) = 0.39, ICC(2,1) = 0.52, ICC(2,1) = 0.67) with SEM / SEM percentages (0.04 / 16.98 %, 0.21 / 10.58 %, 0.01 / 11.07 %) and MDC/MDC percentages (0.10 / 47.06 %, 0.58 / 29.32 %, 0.04 / 30.67%), while low or non-significant reliability was found in the same frequency band of the right TA and in the beta frequency of both left and right TA. CONCLUSIONS: Intramuscular coherence analysis during walking seems promising for assessing neural drive to the muscles while walking. Further research in bigger samples of various populations is warranted in order to confirm or refute the results. [1] Clark B. C. et al., J GERONTOL A BIOL SCI MED SCI 63(8): 829-834 (2008) [2] Manini T. M. et al., CURR OPIN CLIN NUTR METAB CARE 16(1): 21-26 (2013) [3] van Asseldonk E. H.F. et al., PloS one 9(2): e88428 (2014)

3-E-21 Postural and Cortical Responses following Visual Occlusion in adults with and without ASD

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BACKGROUND AND AIM: Sensory impairments are now accepted as core symptoms of Autism Spectrum Disorders (ASD) (DSM-5). Motor impairments are also common in this group. The influence of sensory processing on motor control can be investigated using posturography. Electroencephalography (EEG) during posturography allows us to record the brain responses to postural disturbances (PER). Evidence suggests isolated PER components represent specific aspects of postural disturbance processing; P1 reflects the detection and N1 the evaluation of postural instability. The aim of the study was to compare PERs to visual perturbation under varied postural stability conditions in adults with and without ASD. METHODS Thirteen male adults with ASD (24.5±2.5 years, 175.1±7.2 cm, 71.9±9.8 kg) and typically developed (TD) adults (24.3±4.2 years, 181.9±6.8 cm, 79.5±14.7 kg) participated in this study. All participants were barefoot and either stood (STAND) or sat on a customized stool with the force platform underneath (SIT) whilst looking at a computer screen 1.5 meters away. During STAND or SIT, participants wore liquid crystal spectacles to occlude vision (VO). VO occurred at unpredictable time intervals during the trials which were 5 seconds long. In between trials participants completed simple mental maths problems to maintain attention. EEG signals were recorded based on the International 10-20 System. Centre of pressure data was obtained using force platform. General linear model analysis: dependent variables were the amplitude of P1 and N1 and the sway path in the anterior-posterior (AP) and medial-lateral (ML) directions. Independent variables were group (ASD, TD) and posture (STAND, SIT). RESULTS Both groups responded to an unexpected VO by leaning slightly backward (ASD: -6.90 mm (±4.11); TD: -8.08 mm (±2.63)) and then forward (ASD: 8.06 mm (±2.42); TD: 2.43 mm (±2.76)) in the first 5 seconds of standing. For P1 amplitude there was no effect of group (TD/ASD) ($p=.9412$) or posture (SIT/STAND) ($p=.1096$). N1 amplitude was larger in the ASD group ($p<.0001$) and in the standing posture for both groups ($p=.0037$)($R2=.397$). AP sway path and ML sway path were larger in the ASD group (AP: $p<.0001$; ML: $p=.0095$) and in the standing posture for both groups (AP: $p<.0001$; ML: $p<.0001$) (AP: $R2=.986$; ML: $R2=.975$). CONCLUSIONS Adults with ASD detected the VO event (P1) similarly to the TD adults. The difference in N1 between sitting and standing indicates an equivalent ability to detect changes in postural set. This finding supports evidence suggesting the processing of proprioceptive information is intact in adults with ASD. However, the postural and cortical responses to VO in adults with ASD were larger compared with TD adults regardless of posture. These findings support the role of the N1 as the cortical signal for the automatic postural response with appropriate latency, relationship to postural set and postural sway. It is also the first evidence indicating that whi

3-E-22 A comparison of the neural correlates of complex walking in healthy young adults and middle-aged adults during real locomotion

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BACKGROUND AND AIM: Steering of gait is a complex locomotor task that can be compromised by impaired sensorimotor function and gait abnormalities that arise in healthy aging. These age-related impairments tend to accelerate after middle-age (>65) and can lead to turning difficulties and falls. At present, the central motor control of steering of gait and potential changes that occur with age are poorly understood. Moreover, it is unknown whether this modulated control of locomotion arises during middle-age, prior to the onset of clinically diagnosed gait impairments. Therefore, the aim of the present study was to use [18F]-fluoro-deoxy-glucose positron emission tomography ([18F]-FDG-PET) to compare whole-brain metabolic activity associated with real steering of gait to straight walking in healthy young adults and determine if these neural networks modulate in middle-age. METHODS: Seven young healthy subjects (4 females, mean age: 24±3 and five middle-aged healthy adults (1 female, mean age: 59±3) completed overground steering of gait (SG) and straight walking (SW) tasks. For these tasks, four walking lanes (1.5 m by 32 m) were defined by cones. In the straight walking task, participants remained in the centre of the lanes, whereas in the steering task, participants followed a trajectory around yellow coloured cones placed in a semi-random order. An upright standing (US) task was also included in the young subjects. US and SW served as reference tasks to isolate activations associated with SW (i.e., SW-US) and SG (i.e. SG-SW), respectively. Prior to locomotor tasks, a radiolabelled glucose analogue, [18F]-FDG, was injected to allow for quantification of regional cerebral glucose metabolism. After injection, each task was performed continuously for 40 minutes followed by PET image acquisition. Movement outcomes (i.e., gait speed, number of trajectory errors, and collision errors) were obtained via video-based analysis. RESULTS: Results showed significant bilateral activations in primary motor cortex, premotor cortex, cerebellum, and occipital areas in both SW and SG. Further, SG bilaterally recruited higher-order processing parietal structures (i.e., superior parietal lobule and anterior parietal sulcus). The same regions were activated for SG in middle-aged subjects, but a laterality index revealed a more asymmetric activation pattern than their young counterparts that was not region-specific (p=0.01). Further, behavioural analyses showed that both groups walked slower during SG as compared to SW (young: -0.34 m/s; old: -0.52 m/s, p=0.04). No significant differences in either error types were observed across groups. CONCLUSIONS: These findings provide the first quantification of brain activity during real steering of gait in healthy individuals and demonstrate that parietal regions play an important role in steering of locomotion. Further, results suggest that a modulation of activation pattern arises in middle-age that may be related to subclinical sensorimotor and gait impairments. ACKNOWLEDGEMENTS AND FUNDING: This research was supported by the Natural Sciences and Engineering Research Council of Canada, Canada Foundation for Innovation, and Heart and Stroke Foundation of Canada

3-E-23 Neural Control of Anticipatory Postural Adjustments

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BACKGROUND AND AIM: Anticipatory postural adjustments (APAs) act to counteract the internal perturbation that may arise from an impending voluntary movement. For example, when pulling a handle towards the body, activation of the soleus (SOL) and the forward displacement of the center of pressure (COP) serve as the APA and help to minimize body movement towards the anterior edge of the base of support. When larger movements are expected, larger APAs are required [1]. While increases in cortical excitability, which may reflect a greater involvement of the motor cortex for APA generation, are known to begin at 75 ms prior to APA onset [2], it is unknown whether the timing and amplitude of neural excitability depends on APA magnitude. Therefore, the purpose of this study was to examine whether APA magnitude modulates corticospinal and spinal excitability during a handle pull task. METHODS: Nine adults (23±1 y) participated in two experimental sessions. For each session, participants stood on a force plate while they performed 60 handle pulls at 50% (low force) and 75% (high force) of their maximum pulling force. During these trials, peripheral nerve stimulation (session 1) or transcranial magnetic stimulation (session 2) was applied at 75 ms or 0 ms prior to APA onset in order to obtain SOL Hoffmann reflexes (H-reflexes) or motor-evoked potentials (MEPs). Control H-reflexes and MEPs were collected while the participant was awaiting the start of the subsequent handle pull trial. For each trial, the SOL electromyographic (EMG) amplitude and the peak forward COP displacement prior to each handle pull were calculated to quantify the APA magnitude. Spinal and corticospinal excitability were measured as the peak-to-peak H-reflex and MEP amplitude, respectively. RESULTS: Larger APAs, reflected by an 11% and 29% increase in SOL EMG amplitude (p=0.024) and COP displacement ($p<0.001$), respectively, were observed during the high compared to the low force condition. Although both corticospinal and spinal excitability increased as the APA onset drew nearer, the amount of change was not different between force conditions. Compared to the control condition, SOL H-reflexes increased by 2% (p=0.848) and 25% (p=0.008) at 75 ms and 0 ms prior to APA onset, respectively, across both force conditions. Similar effects were observed at the corticospinal level, with SOL MEPs greater by 7% (p=0.340) and 66% (p=0.009) at 75 ms and 0 ms prior to APA onset, respectively. CONCLUSIONS: The larger increase of corticospinal compared to spinal excitability prior to APA onset is consistent with previous findings and suggest that APAs are controlled in the motor cortex [2]. The lack of difference in corticospinal and spinal excitability with increasing APA magnitude may suggest that neural excitability is modulated during rather than prior to the APA. REFERENCES: [1] Weeks (1994). Aging Clin Exp Res. 6:323-333. [2] Peterson et al (2009). Exp Brain Res. 193:161-171.

3-E-24 Activation of the supplementary motor area differentiates between preparation of compensatory balance responses with stepping and feet-in-place strategies

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BACKGROUND AND AIM: Balance control is a complex motor task coordinated across multiple levels of the central nervous system. Recent studies have associated the activity of the supplementary motor area (SMA), anterior cingulate cortex (ACC), and posterior parietal cortex (PPC) with preparation of postural responses and detection of balance instability [1-2]. Yet, it is unclear which cortical processes support these functions. The aim of this study is to identify oscillatory dynamics that differentiate the preparation of compensatory balance responses using stepping and feet-in-place strategies. It is expected that updates to the central set will result in stronger cortical activation during preparation of responses with the more challenging strategy. METHODS: Ten healthy participants (24±3.5 years) responded to backward movements of the support surface using stepping or feet-in-place strategies. To enhance the contrast between strategies, the support surface moved at maximum acceleration that could be overcome without stepping. The experimental trials (50 per strategy) included three phases: cue observation, response preparation, and response execution. High-density electroencephalogram was decomposed into cortical activity and artifacts by means of independent component analysis [3]. Activity of the SMA, ACC, PPC, and the left and right sensorimotor cortices (SMC) was analyzed in the time-frequency domain to reveal event-related (de)synchronization (ERD, power decrease; ERS, power increase) of intrinsic cortical rhythms [4], which are known correlates of cortical activation. Time-frequency maps showing ERD/ERS within each cortical location were computed and evaluated for significant differences between strategies (alpha = 0.05, corrected for false discovery rate). RESULTS: Stronger SMA activation occurred in trials that required the feet-in-place strategy (Fig. 1). Theta (6 to 9 Hz) and alpha (9 to 13 Hz) ERD were significantly stronger shortly after cue onset (between 400 and 800 ms). Alpha ERD was significantly stronger through most of the response preparation phase. ERD of a lower gamma rhythm (31 to 34 Hz) reached statistical significance during intervals of the cue observation and the response preparation phases. Additional ERD and ERS occurred without significant differences between strategies, suggesting common mechanisms of preparation and execution of compensatory balance responses. CONCLUSION: In the SMA, the dynamics of the theta, alpha, and gamma rhythms differentiate the preparation of compensatory balance responses with distinct postural demands. Theta ERD may reflect a greater perceived threat, whereas alpha and gamma ERD may be involved in upregulation of subcortical postural circuits. FUNDING: 4D-EEG is funded by an ERC Advanced Grant (#291339; TSE, ACS); EMBalance is funded by the European Union FP7-ICT (#610454; JK); Balroom is funded by STW (#10737; DdK, VW) REFERENCES [1] Jacobs and Horak (2007), J Neural Transm, 114:1339-48 [2] Bolton (2015), Neurosci Biobehav Rev, 57:142-55 [3] Raimondo et al. (2012), Comput Intell Neurosci, 2012:206972 [4] Pfurtscheller and Lopes da Silva (1999), Clin Neurophysiol, 110:1842-57

F Cognitive impairments

3-F-25 The interaction of cholinergic activity, gait, balance, and attention in mild cognitive impairment

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Background and Aims Mild cognitive impairment (MCI) is defined as cognitive decline greater than expected for age and education. Gait and balance dysfunction, measured by subject analysis, has been observed in MCI populations. Despite executive function being a major factor in MCI, gait dysfunction has been observed in early stages of MCI. Emerging literature suggests that cognitive information is critical for motor performance, particularly for complex tasks. The aim of this investigation is to relate cholinergic tone to objective measures of balance, gait, and attention in a MCI and control group. We hypothesize that people with MCI will have low cholinergic tone, which will reduce attention that relates to worse gait and balance dysfunction, compared to controls. Methods 80 subjects will be recruited. To date, 3 MCI and 6 non-MCI subjects have been tested. Each participant completed a quiet standing (60 s) and walk test (2 min), both with and without an attention demanding, secondary task. Balance variables include the 95% ellipse sway area, jerk, and RMS sway. Gait variables include gait speed, percent of time in double support, and number of steps in a turn. Objective gait and balance measures were recorded via 6 inertial sensors. Dual task (DT) cost was calculated for each gait and balance variable. The Attention Network Test (ANT), a computerized test of attention is also administered. The ANT provides 3 outcome variables, alerting efficiency, orienting efficiency, and conflict resolution efficiency. Cholinergic tone is assessed via the transcranial magnetic stimulation modality, short-latency afferent inhibition (SAI). Results Preliminary data indicate large effect sizes (Cohen's d) for effect of MCI on the dual task cost for the 95% ellipse sway area (MCI: 0.47±0.50; Control: -0.10±0.21; d = 2.00), the DT cost for the percent of time in double support (MCI: 0.07±0.01; Control: 0.03±0.02; d = 2.58), and SAI (MCI: 88.94±33.65; Control: 62.98±13.32; d = 1.25). Further, Spearman's correlations indicate a significant correlation between SAI and DT cost on jerk ($\rho = 0.73$; $p = 0.03$) and RMS sway ($\rho = 0.68$; $p = 0.04$). There were only weak effect sizes for the ANT task results. Conclusion The effect size analyses of these preliminary data indicate promising results towards support for the hypothesis that MCI is associated with impaired balance and gait, especially when a cognitive task is combined with balance and gait. Further, the significant correlations between SAI and DT cost on jerk and RMS sway indicate SAI may be a factor in balance dysfunction. Not only does the MCI group show a trend of lower cholinergic tone, a trend is present that they also show greater DT cost in both balance and gait tasks. Furthermore, relationships between SAI and objective balance measures are beginning to emerge. Older people with low cortical cholinergic tone could be at greater risk of gait and balance dysfunction in real world conditions (e.g. DT scenarios). Supported by Pacific Udall Center

3-F-26 Gait impairment in Dementia with Lewy bodies: A useful clinical biomarker?

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BACKGROUND AND AIM: Dementia with Lewy bodies (DLB) encompasses 15-20% of all dementia cases. It is characterised by cognitive impairment and motor deficits. Gait disorders are common in DLB but there are limited quantitative studies reporting impaired gait characteristics. Gait impairments can occur up to 12 years prior to onset of cognitive decline and studies have reported that deficits in pace, rhythm and variability correlate with dementia subtype. Signatures of gait impairment in DLB may therefore compliment diagnostic criteria, and improve early diagnosis and access to interventions to slow disease progress. This study aims to investigate gait characteristics between DLB and older adult controls under single- and dual-task conditions. METHODS: Seven people with probable DLB (Age; MMSE) and 12 age-matched controls were recruited. Gait was assessed using an instrumented walkway (GAITRite) under two conditions: single-task walking and dual-task walking (maximum forward digit span task). Participants walked at their comfortable walking pace for 6 trials in each condition. 16 gait characteristics were used to comprehensively describe gait and grouped into 5 independent domains (pace, rhythm, variability, asymmetry and postural control) to facilitate interpretation according to a previously validated model (Lord et al., 2013). Data was processed and averaged to create mean scores of each variable. Variability was calculated as the within-person standard deviation of left and right steps calculated separately (and only then combined), and asymmetry was calculated as the absolute difference between the mean of the left and right steps. Due to the non-parametric distributions, Mann-Whitney U tests were used to compare groups. RESULTS: Individuals with DLB demonstrated impaired Pace (slower step velocity (p=.003) and shorter step length (p=.007)); Variability (increased step time variability (p=.001), increased swing time (p=.002), stance time (p=.001), and step length variability (p=.002)); and Rhythm (increased stance (p=.009) and step time (p=.043)). Individuals with DLB also had impaired Pace (shorter step velocity (p=.018)); Variability (increased stance time (p=.018), step time (p=.018) and swing time variability (p=.028)) and Rhythm (increased stance (p=.009) and step time (p=.018)). No group differences were found for asymmetry or postural control in either condition. CONCLUSION: Discrete differences in gait characteristics between DLB and controls under both single and dual-task conditions are evident. Such findings in a DLB group with confirmed diagnosis could provide a foundation for establishing early clinical diagnostic markers. Misdiagnosis rates are high between DLB and AD with reports of 34-65% at autopsy. This can hinder effective drug therapy; accurate diagnosis is vital for ensuring best treatment outcomes. Future research should therefore compare common dementia subtypes, such as DLB and Alzheimer's disease (AD) in order to define gait profiles in dementia sub-types. ACKNOWLEDGEMENTS AND FUNDING: Financial support for this study came from the National Institute for Health Research (NIHR) Newcastle Biomedical Research Unit and Alzheimer's Society. Lord et al., Move Disorder, 2013 28(11): 1534-1543

G Cognitive, attentional, and emotional influences

3-G-27 Effect of Speed and Age on Cognitive Motor Interference during Walking

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Background:Dual-tasking results in cognitive-motor inference (CMI) during walking in young and older adults is well-known. Further, such interference pattern also seems to be affected by complexity of cognitive tasks (Patel, P.et al 2014). Considering that community ambulation demands modulation of walking speeds, this study aimed at investigating the effect of various gait speeds, different cognitive tasks and aging on cognitive motor interference. We hypothesized that faster speed will increase difficulty in performing dual tasks, irrespective of the task and increase in age will differentially have an effect on the cognitive motor interference at different speeds.Methods: Ten community dwelling older adults and ten young adults performed walking in slow, preferred and fast speeds on an electronic walkway with and without a cognitive task (dual task-DT and single task-ST respectively). The DT included three cognitive conditions: visuomotor reaction time -VMRT, Serial Subtraction -SS, Word list generation-WLG which were performed in walking and standing. The order of ST and DT trials and the DT trials for all the tasks was randomized. Reaction time and correct responses were recorded for the cognitive tasks and gait velocity was recorded for walking task. Motor and cognitive costs were calculated using the formula (ST-DT/ST*100).Results: Healthy older adults showed higher motor costs for VMRT at preferred speed and SS tasks at preferred and slow speeds. The between speed comparison showed higher motor cost for fast speed in WLG task compared to the other two speeds, whereas for SS both preferred and fast speeds had higher motor costs than the slow speed for both the healthy young and older adult groups. Whereas for VMRT, slow speed had the highest motor cost for both groups. Comparison between the tasks for young showed highest motor cost for WLG during both fast and preferred speeds followed by SS and then VMRT. However, for healthy older adults motor cost was equal in WLG and SS and higher than VMRT. There was no difference in motor costs between tasks for the slow speed. In both groups WLG had highest cognitive cost in fast speed compared to the slow and preferred speeds, whereas SS task had equal costs in preferred and fast speeds which was higher than in slow speed. Between tasks for both groups VMRT task showed highest cognitive cost in slow speed and WLG the lowest. Older adults had greater cost than young for SS and WLG for preferred and fast speeds. Conclusions: In both the groups, slow walking assisted in reducing the motor cost and cognitive costs for tasks involving higher level processing via semantic or working memory while fast speed assisted in reducing cost for reaction time task. Dual-task training paradigms should consider and utilize such differences seen in interference patterns for designing dual-task training paradigms individualized to meet client's attentional, environmental and functional demands of daily living.

3-G-28 The Attentional Demands of Haptic Modalities during Overground Walking

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BACKGROUND AND AIM: Attentional capacity decreases with age, which may increase fall-risk [1]. Adding sensory information via haptic input may improve balance [2] and decrease fall-risk. Traditional fall prevention modalities (i.e. canes) have been associated with increased attentional demands (ADs) [3]. The increased ADs result in decreased performance in a multi-task protocol. The objective of this study is to examine the ADs and any associated effects on walking when using two different haptic modalities. METHODS: Haptic anchors (125g weights attached to strings) and light touch (~ 1 N) on a rail were used to add haptic input during walking. ADs were probed using a verbal reaction time (VRT) task [1, 3, 4]. 3D kinematic data were collected at 100 Hz with an 8-camera VICON system, while participants walked 10 m normally (baseline), lightly touching the railing, or using the anchors, with or without a VRT task. The VRT task required individuals to indicate whether a tone was low or high pitched. Responses were captured using a wireless voice recorder (Philips Voice Tracer 2000). The VRT task was administered at foot contact midway through the walking path. Participants were instructed to "walk at a comfortable pace and try to keep equal focus on all tasks." Participants were able to practice walking with the modalities and completing the VRT task prior to data collection. VRTs were determined from the tone onset to the response initiation using Praat (v6.0.19). Custom-made Matlab (R2006b) routines were used to filter kinematic data with a 4th order low-pass Butterworth filter (f_c = 10 Hz). Kinematic outcome variables included stride velocity (SV) to evaluate walking performance and mediolateral centre of mass (COM) displacement standard deviation (SD) to assess balance control. Multiple 3 (Haptic condition) x 2 (Tone) repeated-measures ANOVAs were performed with Bonferroni post-hoc (SPSS v24.0) ($\alpha = 0.05$). RESULTS: To date, 11 young adult participants (25.3 ± 3.1 years) have completed the testing protocol. No significant interactions were observed. Main effects of condition revealed no significant differences in VRTs ($p = .874$) and SV ($p = .075$); however, COM SD was significant ($p = .011$). Post-hoc analysis revealed COM SD when walking with the railing was significantly decreased compared to walking with the anchors ($p = .021$). CONCLUSIONS: Preliminary results suggest walking with haptic modalities require minimal ADs. Similar VRTs between conditions may have been observed due to the familiarization period for participants prior to data collection [4]. Furthermore, light touch on the railing improved balance compared to anchors suggesting railings may be more effective for fall prevention. Future work will include continuing collection and examining ADs of haptic modalities during a challenging walking condition (i.e. obstacle crossing). REFERENCES: 1. Siu et al. (2009) Brain Res,1248:59-67 2. Dickstein & Laufer (2004) Gait Posture,20(1):41-47 3. Wellmon et al. (2006) J Geriatr Phys Ther,29(2):74-80 4. Worden & Vallis (2014) J Mot Behav,46(5):357-368

3-G-29 Defining approach/avoidance in whole-body behavior

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How are emotions coupled to postural changes? An emerging line of research has repeatedly shown that emotional states have clear impact on the way humans regulate static balance and locomotion, but the mechanism by which this operates is unclear. It is generally agreed that (pleasant and unpleasant) emotions induce an incentive to act. In general, humans are inclined to approach a pleasant situation and to avoid an unpleasant one. These motivational tendencies are often operationalized as the ease (e.g., faster reaction times) with which one approaches or avoids pleasant and unpleasant stimuli. However, various theoretical perspectives exist on how approach and avoidance should be defined. The Distance Regulation (DR) perspective states that approach should be defined as a decrease in distance between the self and the stimulus, while avoidance entails an increase in distance. A competing theory is the Evaluative Response Coding (ERC) theory. The ERC states that approach or avoidance do not depend on the physical distance change, but on how movements are mentally represented in cognition. In practice, these theories are difficult to disentangle, since both have the same prediction: it is easier to approach pleasant stimuli and avoid unpleasant stimuli. The difference lies in the supposed mechanism of how approach and avoidance operate. We have performed a series of experiments and used a unique way to tease the theories apart, using a set-up involving whole-body movements (step initiation) in an approach / avoidance context. Participants were standing in the middle of a 1x1m force platform and were instructed to step to the left or right, as quickly as possible from a quiet standing posture, in response to the appearance of happy or angry faces. We reasoned that happy faces would elicit approach behavior, whereas angry faces would elicit avoidance behavior. By varying the instructions, both within and between experiments, we had the opportunity to test the specific predictions of the two theories. Participants saw a happy or angry face on one side of the screen and always a white square on the other side. Important for this experiment is that various step instructions were given, thereby changing the verbal coding of the respective movements. Participants were instructed to step either towards or away from the face or towards or away from the square. According to the DR, in a happy-trial, participants should be faster to decrease the distance to the happy face, regardless of instruction. That is, 'step away from the square' (flanked by a happy face), or 'step towards the face' (flanked by the neutral square) should be equivalent. However, according to the ERC, participants should be faster in the conditions where the movement is defined as 'approach' (towards face/ towards square) compared to 'avoid'-instructions (away from face/ square), regardless of the actual change in distance to the happy face. By performing a series of step initiation experiments, which are currently in progress, we expect to find results that shed more light on the question whether approach and avoidance behavior are directly mediated by distance change, or whether these behaviors are cognitively mediated.

3-G-30 The Effects of Task Priority on Postural-suprapostural Task in Elderly Adults and Early-stage Parkinson's Disease

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BACKGROUND AND AIM: Maintaining postural stability with simultaneously performing another task (suprapostural task) is very common in our daily lives. For a postural-suprapostural task, appropriate prioritization is necessary to achieve task goals and maintain postural stability, especially for the elderly adults and early-stage Parkinson's disease (PD) whose balance ability may not severely affected. The aim of this study was to investigate the effects of task-priority strategies on postural-suprapostural performance in elderly healthy adults and patients with PD in early stage. METHODS: Nine elderly healthy adults (≥65 years) and eight patients with PD in early stage (Hoehn and Yahr stage ≤ 2) were

recruited in this study. Each participant was requested to perform a force-matching precision grip task (suprapostural task) while maintaining balance on a stabilometer (postural task) under postural focus (PF) and suprapostural focus (SF) conditions. The behavioral data, including task accuracy (postural error and force-matching error), were analyzed as dual-task effect (DTE: % change in dual-task condition; positive value: dual-task benefit, negative value: dual-task cost). RESULTS: For both elderly and early-stage PD groups, larger DTE values of posture error and force error were found of the SF condition, comparing to the PF condition. CONCLUSIONS: This preliminary study suggests that focusing on the suprapostural task would increase postural stability and force accuracy in both elderly healthy adults and the PD patients in early stage, which was not in line with previous studies, which argued that older adults and PD patients should focus on posture in postural-suprapostural dual-tasking. Future investigations are necessary to further explore based on these preliminary findings.
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3-G-31 Exploring the relationship between threat-related changes in attention processing and postural control

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BACKGROUND AND AIM: Research shows that individuals direct more attention to movement processes, threat-related stimuli and self-regulatory strategies under height-related threat and these attentional changes relate to changes in postural control [1]. However, this work relied on open-ended questions to assess attention processing and may not generalize to other types of threat experiences [2]. This study aimed to a) quantify changes in attention processing to the threat of perturbation and b) examine whether threat-related changes in attention processing predict changes in postural control. METHODS: Eighty young adults stood on a force plate fixed to a translating platform. Threat was altered through expectation of a platform perturbation. Two 30 s stance trials were performed with no threat of perturbation (NT) at the start and end of the study. Two more 30 s stance trials were performed under threat of perturbation either prior to (PT) or after (AT) experiencing forward or backward perturbations. After each trial, participants rated their anxiety as well as 5 elements of attention processing (movement processes, task objectives, threat-related stimuli, self-regulatory strategies, task-irrelevant information) using 9-point Likert scales (developed from [1]). Mean electrodermal activity (EDA) and anterior-posterior center of pressure (COP) mean position (MP), root mean square (RMS) and mean power frequency (MPF) were calculated. Repeated-measures MANOVAs were conducted for a) attention, b) anxiety/EDA and c) COP measures with a within subject factor of threat (NT, PT, AT). Regressions were performed to examine if the change in attention, anxiety or EDA predicted the change in COP between PT-NT and AT-NT conditions. RESULTS: With threat (PT and AT), participants were more anxious, had higher arousal and directed more attention to movement processes, threat-related stimuli and self-regulatory strategies and less to task-irrelevant information. RMS and MPF increased when threatened with greater increases in MPF and smaller increases in RMS observed for the AT versus PT condition. Regression for the change in RMS between PT-NT conditions was significant; larger anxiety changes were related to larger RMS changes. Regressions for the change in MP, RMS and MPF between AT-NT conditions were significant; larger changes in attention to movement processes were related to larger MP and RMS changes, while larger changes in attention to self-regulatory strategies were related to larger MPF changes. CONCLUSIONS: This study was the first to quantify attention processing changes under a direct threat to stability. Threat-related changes in postural control were accounted for by changes in anxiety before perturbation experience, but changes in attention processing after perturbation experience. Future work will explore these relationships in older adults and people with balance problems. ACKNOWLEDGEMENTS AND FUNDING: Funded by NSERC. REFERENCES: [1] Zaback et al 2016 Gait Posture [2] Shaw et al 2012 Gait Posture

3-G-32 The influence of unexpected perturbations during standing and walking on the performance of a concurrent cognitive task among young adults

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BACKGROUND AND AIMS: Most falls occur during walking after a sudden unexpected loss of balance. Since walking is influenced by higher cognitive functions, performing a concurrent cognitive task (i.e. dual task walking) might have a diminishing effect on stability while walking. It was hypothesized that balance recovery response to an unexpected loss of balance is a reflex-like response, i.e. the motor as well as cognitive responses will be similar in single-task (ST) and dual-task (DT) conditions. Only a few studies have investigated the effect of unexpected perturbations while walking on performance in the cognitive tasks and vice versa. We aimed to (1) investigate the effect of unexpected balance loss while standing and walking on concurrent cognitive task performance. (2) Compare the stepping threshold under ST and DT conditions. METHODS: A convenience sample of 15 young subjects was recruited. The study protocol included six conditions; (1) performing the cognitive task while sitting (ST sitting); (2) unexpected perturbations while standing (ST standing); (3) concurrent cognitive task during unexpected perturbations while standing (DT standing); (4) unexpected perturbations while walking (ST walking); (5) concurrent cognitive task while walking (DT walking-cog); (6) concurrent cognitive task while walking during unexpected perturbations (DT walking). Subjects were exposed to six levels of progressive unexpected surface perturbations in both ST and DT conditions in standing and walking. Our primary outcome measures were; (1) Concurrent cognitive task performance (i.e., the number of cognitive task errors, and the amount of successful cognitive performance per minute). (2) Stepping thresholds, defined as the minimum disturbance magnitude that consistently elicits a single compensatory step; (3) comparison in step thresholds between the medio-lateral (ML) and anterior-posterior (AP) unexpected perturbations. RESULTS: The cognitive performance in DT standing was reduced compared with ST sitting. However, the performance of cognitive task during DT walking was significantly better than all other DT conditions and also better than ST sitting. Significant differences were also found between stepping thresholds in ML-compared with AP-directions while standing, in both ST (9.75cm compared to 10.75cm, respectively), and DT conditions (9.23cm and 12.23cm, respectively). There were also significant differences between the mean stepping threshold between ST and DT conditions (both in the ML and in AP perturbations). CONCLUSIONS: In standing, the motor task require more cognitive resources, thus loss of balance in standing is not a reflex like response. Young subjects chose "posture first strategy" in standing and hence cognitive performance was reduced compared to sitting and walking. In walking, however, it seems that balance recovery response to an unexpected loss of balance is a reflex-like response. ACKNOWLEDGEMENTS AND FUNDING:none.

H Coordination of posture and gait

3-H-33 Proprioceptive signals dominate control of postural sway in healthy older adults until vestibular signals become the most reliable

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BACKGROUND AND AIM: Peripheral sensory signals- including vision, proprioception, and vestibular signals - are integrated in the central nervous system facilitating control of upright posture. Postural sway increases with age and when sensory function is degraded. It is unclear whether peripheral sensory function is related to postural sway independent of age in healthy adults, and whether specific sensory signals dominate control of postural sway under different balance conditions. Here we investigated the relationship between tests of visual function, vestibular function, proprioceptive function, age, and postural sway under different balance conditions in healthy adults. METHODS: 366 community dwelling healthy adults (mean age 72.7 (12.6) years, range 27-93 years) participating in the Baltimore Longitudinal Study of Aging were tested. Lower visual field deficit (VISFIELD) was defined as the percentage of missed points in the lower visual field. Proprioceptive threshold (PROP) was evaluated with passive motion detection at the right ankle. Vestibular semicircular canal function (CANAL) was evaluated using quantitative vestibulo-ocular reflex gain measurement. Vestibular otolith function (OTOLITH) was measured with cervical and ocular vestibular evoked myogenic potentials. Participants stood for 40 seconds while wearing BalanSens (BioSensics, LLC) to quantify center of mass sway area (COM) with eyes open then closed on firm and then a foam surface. Multiple linear regressions were used to examine the association between COM and VISFIELD, PROP, CANAL, and OTOLITH separately and combined in a multi-sensory model while controlling for age and gender. RESULTS: In multivariate sensory models adjusting for age and gender, only PROP was significantly associated with COM sway across all balance conditions such that a 1-degree increase in proprioceptive thresholds was associated with a 0.09-0.20 cm^2 increase in COM sway. The only exception was the foam eyes closed condition, where bilateral CANAL function loss was associated with an increase in COM sway of 2.1 cm^2. CONCLUSIONS: There was a shift in the primary sensory system associated with postural sway area from proprioception to vestibular function as visual and proprioceptive information were successively reduced. Moreover, these data suggest that much of the influence of age on postural sway is explained by peripheral sensory function. Even in the presence of vision and available vestibular function, proprioceptive function was the most critical for postural control. Only when body sway magnitude is likely under-reported by proprioception while standing on foam with eyes closed does vestibular input became the most representative of total body sway. ACKNOWLEDGEMENTS AND FUNDING: Supported in part by NIDCD K23 DC013056 and NIDCD T32 DC000023 Figure 1. Standardized Betas for sensory function from the multi-sensory linear regression models for each balance condition. The dominant sensory contribution to postural sway was proprioception when standing on the floor with eyes open and closed and when standing on the foam with eyes open. For the foam eyes closed condition, there is a dramatic shift to rotational vestibular function as the dominant sensory component.

3-H-34 Body weight support training and movement coordination during walking on different surfaces in individuals with stroke

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BACKGROUND AND AIM: Intra-limb coordination during walking can represent the nature of the synergies between the joints of the body, and can be an important measure to verify the effects of any changes on gait. Hemiparetic gait presents differences in the patterns of walking of individuals who suffered a stroke. This is caused mainly by the difference between paretic and non-paretic sides. Body weight support (BWS) systems are commonly employed with a treadmill and are used in gait rehabilitation. Training with BWS systems while walking on an overground surface or on the treadmill surface could result in different outcomes. The aim of this experiment was to assess the effects of BWS training on gait coordination while walking on different surfaces. METHODS: Twenty-eight stroke patients were recruited and were randomly separated in two groups: overground group (OG) and treadmill group (TG). They participated in two evaluations of overground walking at preferred speed: T0 (pre-training) and T1 (post-training). A video system of movement capture (VICON) was used to obtain the kinematic data and reconstruct hip, knee, and ankle joint angles for both paretic and nonparetic limbs. After the T0 evaluations, the individuals participated in six weeks of treadmill or overground training, three sessions per week (18 sessions). Discrete relative phase (DRP) between the occurrence of peak hip-knee and knee-ankle flexion for the paretic and non-paretic side was calculated. RESULTS: Mixed model analysis showed limb effects for the DRP of hip-knee, were the paretic limb had greater out-of-phase coupling than the nonparetic limb ($p<.001$). Interaction between group, evaluation and limb showed that the TG further increases the DRP from T0 to T1 for the paretic limb to more out-of-phase, while the OG group showed a decrease in relative phase towards a more in-phase synchronous coupling, similar to the one observed in the nonparetic limb ($p=.012$). CONCLUSIONS: These results indicate important differences in treadmill and overground BWS training, with the OG training group showing reduced coordination asymmetry between paretic and nonparetic sides based on their intralimb joint coordination patterns.

3-H-35 Determining which action strategy individuals use to walk through misaligned apertures

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INTRODUCTION: How individuals guide their path trajectory when walking through apertures remains unclear. Cinelli and colleagues (2008) demonstrated that individuals attempt to equalize the space between the shoulders and the obstacles, by walking through the center of an aperture (Cinelli, Patla & Allard, 2008). However, the behavioural dynamics model argues that path selection is determined by the attraction of the end-goal (Fajen & Warren, 2003). As these investigations were based on passing through a single aperture, the observation that individuals walk through the center of an aperture may be explained by the fact that the attraction of the end-goal is pulling them there, and not because of a need to maintain an equally-sized spatial margin. PURPOSE: The current experiment attempted to delineate between these competing hypotheses by evaluating crossing behaviour for multiple apertures, where the center of the aperture is misaligned with the end-goal. METHODS: Participants were instructed to walk along an 11m path through three separate apertures towards an end-goal. The first and last apertures were fixed such that they were both either 0.9 or 1.7x the shoulder width. The second aperture was either 0.9, 1.3 or 1.7x the shoulder width and shifted either 25, 50 or 75cm off the midline of the path. Participants were permitted to rotate their shoulders if they felt inclined to do so. RESULTS: Findings revealed that the attraction of the end-goal, and not the middle of the aperture, played a major role in guiding crossing behaviour. This was evident by three major findings: 1) the center of mass position at the time of crossing was closer to the obstacle nearest midline ($F(2, 36) = 362.33$, $p<0.001$) 2) regardless of aperture size, the space between shoulder and obstacle at the time of crossing (spatial margin) decreased as the size of the middle aperture increased ($F(2, 36) = 52.47$, $p<0.001$); and 3) as the shift of the middle aperture increased, individuals rotated their shoulders more frequently ($F(2, 36) = 11.25$, $p<0.001$). CONCLUSION: The findings suggest that when walking through multiple, misaligned apertures, individuals will choose to walk closer to the obstacle nearest midline and reduce the size of the spatial margin at the time of crossing. This is likely an attempt to maintain the straightest possible walking path. Interestingly, as the shift of the middle aperture increased, the desire to maintain a straight walking path elicited shoulder rotations, regardless of whether the aperture width required a rotation (i.e., whether it is too small to walk straight through). As such, it appears that the desire to walk a straight path overrides the desire to maintain an equally-sized spatial margin on either side of the shoulders. Therefore the results of this study support the predictions of the behavioural dynamics model, where path trajectory is guided by the attraction of the end-goal and suggests that in single aperture crossing, individuals walk through the centre of the aperture because the attraction of the end goal is pulling them there.

3-H-36 Feasibility of using dynamical system's analyses to observe gait coordination ability in hemiplegic cerebral palsy

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Background and aim: Cerebral palsy (CP) is the most common neuromuscular disorder in children, and is associated with various symptoms such as impaired gait coordination. While muscle activation patterns have been able to identify possible neuromotor mechanisms explaining how CP affects gait coordination, these analyses do not allow for the locomotor system to be fully described. Dynamical systems analyses, on the other hand, can assess the regularity of locomotor behavior and therefore can provide measurements theorized to reflect its overall flexibility (adaptability) to the environment. Our aim was to use dynamical systems analyses to detect differences between limb movement patterns for individuals with and without hemiplegic CP. We hypothesized that a more regular (inflexible) behavior in affected limbs/individuals would be observed, in concurrence with previous muscle activation literature. Methods: 6 individuals with CP (16.2 ± 3.6 years) and 4 without (16.0 ± 1.4 years) walked undisturbed on a split-belt treadmill. All 6 individuals with CP ranked either on level 1 or 2 of the Gross Motor Function Classification System. Measurements of sagittal hip, knee, and ankle joint angles were collected and analyzed from 20 consecutive gait cycles of kinematic data recorded during the task. Recurrence Quantification Analysis (RQA) was used to measure the regularity within each joint using three metrics: (1) recurrence [signal regularity (REC)], (2) determinism [pattern regularity (DET)], and (3) entropy [pattern length regularity (ENT)]. Cross-Recurrence Quantification Analysis (CRQA) was used to measure REC, DET, and ENT between joints. Alpha level was set at .1 for determining significance. Results: Ankle DET, ENT, and knee DET revealed significant increases in the regularity ($p<.1$) of the affected side compared to the unaffected side within individuals with CP. All hip-ankle and knee-ankle metrics revealed similar findings ($p<.07$). Furthermore, when compared to healthy controls, the affected side of the individuals with CP revealed greater regularity with all metrics for the ankle and the knee ($p<.1$). Similar comparisons were seen with hip-ankle REC, ENT, and knee-ankle DET ($p<.1$). Conclusions: Both RQA and CRQA appear to be able to detect differences between affected and unaffected limbs. These analyses suggest that hemiplegic CP causes the affected side to have a more regular behavior than both the unaffected side and a healthy individual's limb. This supports the loss of complexity hypothesis and what has been observed in previous literature on muscle activation patterns. Also, greater differences were observed in distal joints, where previous research has suggested a greater manifestation of symptoms occur for individuals with CP. Further investigation is required to see if such analyses are associated to functional outcomes.

3-H-37 Is Faster Always Better? A Description of How Temporal Gait Asymmetry Changes with Increased Walking Speed Following Stroke

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BACKGROUND AND AIM: Temporal gait asymmetry (TGA; gait phase inequality between limbs) is common post-stroke. Retraining gait at faster speeds has been recommended. However, how increased speed impacts TGA is unknown. We aimed to describe TGA changes with increased walking speed post-stroke, and to compare clinical characteristics and changes in spatiotemporal gait parameters between individuals who improve (IM), do not change (NC), or worsen (W) TGA with increased walking speed.

METHODS: Demographics, clinical measures (Montreal Cognitive Assessment, Chedoke McMaster Stroke Assessment and Berg Balance Scale) and spatiotemporal parameters of preferred (PP) and maximal pace (MP) gait of 96 people post-stroke were extracted from a database. Swing ratio=larger swing time/smaller swing time, walk ratio=step length/cadence, and changes in spatiotemporal parameters with increased speed =MP value-PP value were calculated. People were classified as symmetric (SYM; swing ratio≤1.06) or asymmetric (ASYM; swing ratio>1.06) at PP and then grouped as IM, W, or NC in TGA at MP. Changes in spatiotemporal parameters from PP to MP were assessed with paired t-tests. Group differences (IM/NC/W) in changes in spatiotemporal parameters with increased speed and clinical measures were investigated with one-way ANOVAs. RESULTS: Both SYM (n=55) and ASYM (n=41) significantly changed spatiotemporal parameters (all p<0.01). SYM did not change in swing ratio (PP=1.03, MP=1.03, p=0.40) but ASYM did (PP=1.18, MP=1.12, p<0.01). ASYM also significantly decreased walk ratio (p<0.05). Within ASYM there were 31/9/1 people grouped as IM/NC/W, respectively. Within ASYM, NC people had lower PP swing ratio (1.08, p<0.05), faster PP velocity (p<0.01), and higher walk ratio (p<0.05) than IM people. When walking faster, IM people decreased paretic terminal double support and non-paretic initial double support more than NC people (p<0.05). Within the SYM group there were 9/33/15 people classified as IM/NC/W, respectively. Of the 15 people in W, 5 became asymmetric at MP (crossed 1.06 threshold) and increased their paretic swing phase (non-paretic single support) more than the rest of SYM (p<0.005). There were no between-group differences in demographics or clinical measures for IM/W/NC within SYM or ASYM. CONCLUSIONS: Most individuals with TGA at their preferred pace are more symmetric when walking faster. This was achieved by reducing the time to load the non-paretic limb and to unload the paretic limb in double support, but with a reduced walk ratio (which is typically speed-independent). However, 9% of individuals who walk symmetrically at PP become temporally asymmetric when walking faster by using the non-paretic limb more which is contrary to the common rehabilitation goal of increased paretic limb use. Thus training at faster gait speeds should be done with careful observation of the impact on the gait pattern. Clinical characteristics that may differentiate groups remain unclear.

3-H-38 Lower-limb joints stabilize trailing toe height during repeated obstacle crossing

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BACKGROUND AND AIM: To cross an obstacle without tripping, the toe height must be greater than the obstacle height and toe height variability should be minimal. This is consistent with the reduced variability in foot placement during challenging locomotor tasks (Rosenblatt et al., 2014). Yet, Heijnen et al. (2012) report a decay (1 mm/trial) in toe height during repeated obstacle crossing. Here, we use the uncontrolled manifold (UCM) method to explore the variability in the trail toe height viewed as an output of the lower-limb joint angles. Two UCM analyses are performed: (1) to account for the drift, the data is divided into five bins and analyzed separately within each bin, and (2) the entire data set is used for the analysis. For each analysis, the joint angle variance is partitioned into good variance (Vu) along the UCM and bad variance (Vo) orthogonal to the UCM. Good variance reflects compensation across joints. If one joint deviates (e.g. over-extends), others compensate to stabilize the toe height. Conversely, bad variance implies lack of compensation. Note that drift in toe height suggests the latter. However, given the importance of maintaining the toe height, we expect that most of the joint-angle variance will be channeled into the UCM so that the toe height is stabilized (i.e., variance is minimized) for both analyses. METHODS: Ten adults (20.7±1.5 yrs) crossed an obstacle (height 25% of leg length), placed at the center of an 8 m walkway 145 times. Trials where subjects tripped on the obstacle (0.4%) were included in the analysis. In each trial, the ankle, knee, and hip sagittal angles for both limbs and the trail toe height were isolated at the frame when the trail toe was over the obstacle (Fig 1A). The UCM, Vu and Vo are obtained from this data using established methods (Freitas et al., 2010). The synergy index, ΔVz, is computed as the (z-transformed) relative amount of Vu per degree of freedom in the total joint-angle variance. ΔVz > 0.8047 indicates that the limb joints covary synergistically to stabilize toe height, and a higher ΔVz indicates a stronger synergy. RESULTS: The UCM analysis in the five separate bins consistently showed Vu/DOF > Vo (Fig 1C), and yielded ΔVz=1.46±0.34 [ΔVz > 0.8047; t(49)=13.399; p<0.01] (Fig 1D). Four subjects displayed decay (-0.4±0.3 mm/trial), and three displayed an increase (0.6±0.2 mm/trial), (p<0.01) in toe height with repeated trials. Despite the changes in toe height, the UCM analysis using the entire data set consistently showed Vu/DOF > Vo, and yielded ΔVz=1.36±0.26 [ΔVz > 0.8047; t(9)=6.778; p<0.01]. More data is needed to identify patterns in ΔVz, Vu and Vo for individuals demonstrating specific drift directions in toe height. CONCLUSION: Despite the changes in toe height across trials, the limb joint angles display synergistic covariance that stabilizes the trail toe height as it crosses the obstacle. UCM analyses may help identify individuals that are more prone to trips and falls.

3-H-39 Influence of Age and Physical Activity on the Fractal Structure of Postural Center of Pressure

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BACKGROUND & AIM: Previous research indicates standing postural sway, characterized by center-of-pressure (COP) dynamics, exhibits fractal-like scaling. That is, when fluctuations occurring over various time scales are log-transformed, a linear relationship emerges, indicating scale invariance. A slope (i.e., α) of 1.0 on this log-log plot is thought to represent optimal fractality. While the COP profiles of young adults are often reported close to α = 1.0, older adults have displayed deviation from optimal fractality, i.e. closer to α = 1.5. However, to date physical activity (PA) has not been accounted for. That is, are observed age-related discrepancies in fractality actually a result of reduced PA? METHODS: Fourteen young (9F, 5M, age 29.4±5.5 yr, height 169.1±10.2 cm, mass 73.7±10.4 kg) and nine older (6F, 3M, age 64.9±2.4 yr, height 167±9.9 cm, mass 75.4±9.7 kg) adults participated in this experiment. Each participant reported achieving at least 150 minutes per week of moderate-intensity PA. Participants stood on a force treadmill, and were instructed to stand with feet hip-width apart and arms crossed to opposite shoulders under three conditions: 1) eyes open, quiet stance, 2) eyes closed, quiet stance, and 3) relaxed standing. For quiet stance, participants were instructed to stand as still as possible, while relaxed standing entailed instructions to stand as if waiting for a bus. Each trial lasted 45 seconds, and tri-axial kinetic data were collected at 360 Hz. Medial-lateral (ML) and anterior-posterior (AP) COP data were then down sampled to 90 Hz. Detrended fluctuation analysis was used to determine fractality. RESULTS: Older adults exhibited greater deviation from optimal fractality (α = 1.16±.14 vs. 1.03±.13 in young, p = .039) during quiet stance in the ML direction. However, in the eyes closed condition, differences between age cohorts disappeared. That is, older adults shifted their fractal scaling from 1.16 to 1.08±.13. Though not significant (p = .23), the altered fractality yielded values similar to young adults (α = 1.04±.13, p > .05). No differences emerged between age groups in the relaxed standing condition. Self-reported moderate and vigorous-intensity PA values were not different between groups. However, linear and quadratic regressions applied to the older adults' eyes closed ML and AP conditions indicated fractality shifted closer to α = 1.0 as amount of vigorous-intensity PA increased (ML p=.07, r^2=.3, AP p=.02, r^2=.65). CONCLUSIONS: The strengthened α in older adults during the eyes closed condition may represent a functional adaptation to imposed constraints. Specifically, this may represent increased interactivity of processes across temporal scales in response to lost visual information. Moreover, fractality closer to α = 1.0 in older adults that reported greater vigorous-intensity PA may be an indication that fractality is sensitive to PA, and that more active adults may exhibit more adaptive postural control.

3-H-40 Sleep Deprivation and Balance - Is it time to wake up?

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Background and Aim: Sleep is a crucial element in human function. Withholding sleep causes a decrease in cognitive capabilities such as memory, attention control and reaction time. Sensory feedback and neuromuscular function are well-known contributors to postural control and recent studies show that attention control and cognitive processing are also necessary to maintain postural control. Our aim was to evaluate the effect of lack of sleep on postural control. Methods: A pre-post quasi experimental study was employed. Eight healthy young adults were given a 24-hour strict sleep deprivation regimen and were monitored throughout the night. Static and dynamic balances as well as cognitive function were assessed pre and post 24 hours of sleep deprivation. Results: Consistent with our hypothesis, mean sway area increased during quiet standing following sleep deprivation {pre: 89.06±31.28, post: 106.71±47.65 (mm^2/sec); p=0.036}. In contrast, the total number of steps decreased during a dynamic test of balance following sleep deprivation {pre: 10.87±3.40, post: 10.08±2.71; p=0.041}. Similarly, the average step length increased post sleep deprivation {pre: 0.58±0.12, post: 0.62±0.12 (m); p=0.036} as did gait speed during this test of balance {pre: 0.85±0.32, post: 0.99±0.40 (m/sec); p=0.036}. Conclusions: These initial findings suggest that lack of sleep has a negative effect on static balance. On the other hand, dynamic balance did not deteriorate after sleep deprivation. Perhaps this disparity in response is related to compensatory mechanisms that are activated during dynamic balance and not during static balance. Additional studies are required to replicate these findings and to more fully assess the underlying mechanisms and the apparent disparity between effects of sleep deprivation on static and dynamic postural control in healthy young adults.

3-H-41 Gaze-body coordination during overground locomotion and avoidance of virtual human-like avatars

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BACKGROUND AND AIM:Obstacle circumvention is a common task performed by humans as they move about their environment. Previous research has shown that avoiding an object on ones path heavily relies upon vision and is accomplished through the coordination of multiple body segments, such as the head, thorax, pelvis and feet. The coordination of gaze and body segments used to circumvent dynamic obstacle approaching from unpredictable directions, however, remains poorly understood. Moreover, wether an altered gaze-body coordination could explain the altered obstacle avoidance strategies observed in stroke survivors remains unknown. To address these questions, we first characterized gaze and body segment coordination of healthy young individuals as they walked towards a target and circumvented virtual avatars (interferers) approaching randomly from different directions (from 40° right or left, head-on (0°) or no obstacle).METHODS:The experiment took place during overground locomotion and the virtual environment, representing a large room (8m X 5m), was visualized in a helmet mounted display (NVisor SX60). Eye movements were recorded using a head-mounted eyetracker and body movements were recorded with a Vicon system that tracked the 3-D position of 41 reflective markers placed at different anatomical landmarks. Medio-lateral (ML displacement) as well as the pattern of gaze and head reorientation in the horizontal plane were examined.RESULTS:Participants (n=6) avoided the human interferers using a same-side strategy for diagonally approaching obstacles

(left ML displacement for left obstacle approach, right ML displacement for right obstacle approach). Participants veered either left or right for the head-on approach. Maximum ML displacements were twice as large for head-on (0.85±0.09m) vs. diagonally approaching obstacles (right: 0.44±0.10m; left: 0.39±0.2m, mean±1SD). ML displacements were preceded (≈ 50 ms) by a head yaw in the same direction (range: 6-9°). Halfway through the ML head displacement, a head yaw (range: 11-20°) in the direction opposite to that of the ML displacement was observed. This bi-phasic head rotational pattern was accompanied by complex smooth and saccadic displacements of the eyes of amplitudes ranging from 5° to 10°. Gaze was effectively maintained within 10° of the target at all time.CONCLUSIONS:These findings suggest that head and eye movements during obstacle circumvention may serve the function of directing towards and stabilizing gaze on the target to optimize the uptake of visual information about one's position with respect to final destination.ACKNOWLEDGEMENTS AND FUNDING:Funded by CIHR (MOP-77548).

3-H-42 The ability to switch anticipatory locomotor adjustments in accordance with environmental and time constraints

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BACKGROUND AND AIM: The ability to avoid obstacles and accommodate height changes is crucial to safe locomotion. Strategies for these two anticipatory locomotor adjustments (ALA) are known to be different: knee flexors to stepping over obstacles and primarily hip flexors to step up to a new height for the lead limb. It is unknown, however, whether we can switch between ALAs during either planning or execution. To study this, we used a virtual environment (VE) to instantaneously change environments from what was initially planned. METHODS: Nine healthy adults (21.7 +/- 1.9 yrs; 4 females) walked in a VE simulating the laboratory as projected in an Oculus Rift head mounted display (HMD) in which either an obstacle (O) or a platform (P) was presented (each with heights of 15% of lower limb length). VEs were presented in blocks of an initial O or initial P to be planned, with the random possibility of instantaneously changing at either lead foot contact (2 steps back) or lead foot toe-off (about 1 step back) into the opposite environment (O to P or P to O on 20% of the blocked trials for each timing). VEs allowed instantaneous changes that were impossible within a physical environment, yet the corresponding final physical condition was preset between trials without the subject's knowledge. Motion capture (Vicon) of HMD and whole body movements provided the ability to immerse the subject within the VE and view their limb movements. Lower limb kinematic data were also synchronized to force plate data under each foot to estimate the net muscle work related to power bursts for lead limb knee and hip flexor strategies. Work for ankle push-off and upward hip lift around toe-off were also estimated and minimum foot clearance (MFC) was measured. Repeated measures ANOVAs were used to compare changes across conditions ($p \leq 0.05$). RESULTS: No changes in ankle push-off work were found. MFC was higher for O and adapted to the final environment for the early change, but remained at the height appropriate to the initially planned environment for the late change. Knee flexor generation strategies showed the same results. Hip flexor work was not adapted significantly, while hip lift tended to be used slightly more for O. CONCLUSIONS: While avoidance strategies have previously been shown to be adaptable during their execution for the same base behaviour, the present findings showed that multiarticular lead limb ALAs cannot be switched as execution begins (1 step back), but can be changed during final planning at two steps back. Thus it appears that specific ALAs are fixed by execution, even though both strategies involved limb lifting ability. Findings also support the fundamental importance of the knee flexor generation strategy to vertical foot lift. The results have further implications for gait rehabilitation and robotics. ACKNOWLEDGEMENTS AND FUNDING: We thank N. Robitaille, S. Forest and G. St-Vincent for valuable technical assistance and NSERC for funding.

3-H-43 Are the characteristics of a human obstacle transferable to virtual reality during aperture crossing?

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BACKGROUND: Avoidance behaviours change (i.e., critical point) when participants pass through apertures that are smaller than 1.4x their shoulder width. However, critical point has been shown to increase from 1.4 to 1.7 when passing through a gap created by human obstacles compared to poles. Individuals have demonstrated the ability to perceive and accommodate for the possibility of movement by an obstacle, and thus elicit more cautious behaviour during avoidance. This movement is generally conducted in the direction an obstacle is facing, and thus the orientation of an obstacle may have an effect on avoidance behaviours. Quantifying human-human interactions is challenging without a controlled, experimental environment. Virtual reality (VR) can provide a controlled environment; however, it is unknown whether human obstacle characteristics are transferable to an avatar in VR. Therefore, the purpose of the study was to use VR to determine if individuals' aperture crossing behaviours differed between pole and avatar obstacles, suggesting that individuals' behaviours are affected by obstacle characteristics. METHODS: Participants walked (in VR) along an 8m path towards a goal, half way along the path were two obstacles that created apertures which were 0.8, 1.0, 1.2, 1.4, 1.6, or 1.8x the participant's shoulder width. Obstacle configurations include: (1) two poles, (2) two virtual avatars facing towards the participant, or (3) two virtual avatars facing away from the participant. Participants completed a total of 54 (6 widths x 3 obstacle configurations x 3 trials) randomized trials and were outfitted with Optotrak (NDI) markers to examine avoidance behaviours (ML COM, aka safety margin) at the time of aperture crossing. RESULTS: ML COM positions at the time of crossing were significantly larger (i.e., deviation around obstacles) for aperture widths 0.8-1.2 than those 1.4-1.8 ($F=11.37$, $p<.001$), suggesting the critical point was 1.4x shoulder width. Furthermore, ML COM at the time of crossing was larger for avatars than for the poles ($F=3.81$, $p=0.05$), which was most likely due to participants leaving greater space when passing around avatars as the critical point was not different across the different obstacle types. CONCLUSION: Unlike previous findings, the critical point in the current study was unaffected by obstacle type. This suggests that path selection (through or around obstacles) is body scaled (i.e., based on one's body dimensions), which is determined by visual information. However, individuals' avoidance behaviours are based on obstacle characteristics, such that avatar obstacles repel one's locomotor trajectory (i.e. safety margin) more than poles.

3-H-44 Increase in walking speed leads to faster reaction time in older adults

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BACKGROUND AND AIM: Previous research has demonstrated that as the complexity of the postural task increases, there is a concomitant increase in attentional demand [1]. A study examining the attentional demand of walking at various speeds in young adults reported significantly longer reaction times (RT) at slow compared to self-selected and fast speeds, while walking at a fast speed led to significantly shorter RTs than a self-selected speed [2]. However, it is unclear if the same pattern would be observed in an older population. Therefore, the objective of this study was to examine RT at various walking speeds in older adults by replicating the protocol of Lajoie et al. [2]. METHODS: Ten older adults (6 females, 4 males; 69.5 ± 2.12 years) were instructed to walk along a 10-meter path at three different walking speeds: self-selected, 30% slower and 30% faster. During each trial, auditory stimuli were randomly presented and participants were instructed to respond "top" as quickly as possible while maintaining the required walking speed. RESULTS: Results revealed a significant main effect of walking speed on RT ($p < 0.01$). Walking at a fast speed produced shorter RTs (0.339 ms) than self-selected (0.366 ms) and slow (0.374 ms; $ps < 0.05$). No significant difference was found between the slow and self-selected speeds ($p > 0.05$). CONCLUSIONS: The shorter RTs observed during fast walking may be due to familiarity of walking at fast speeds and higher arousal levels induced by the task. [1] Lajoie et al., Exp Brain Res 97 (1993) 139-144. [2] Lajoie et al., J Mot Behav 48 (2016) 153-154.

3-H-45 Gait coordination in acute myelopathy patients before and after gait treatment using a powered exoskeleton

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BACKGROUND AND AIM The Ossification of the Posterior Longitudinal Ligament (OPLL) is a complex disease which may result in compressive myelopathy. In severe cases, patients undergo decompression surgery but some have residual motor impairment. The Hybrid Assistive Limb® (HAL) robot is designed to support and enhance the lower extremities performance of patients based on wearer?s motion intention by using their own bioelectrical signals. We hypothesize that using HAL as a coadjuvant therapy for OPLL patients after surgery may enhance the function of the patent motor pathways and promote the remodeling of the central nervous system (CNS) to optimize the motor performance during gait. In this study, we conducted gait analysis from the view point of limb coordination before and after HAL treatment in patients with motor disturbances subsequent to OPLL in acute and chronic stages after surgery. METHODS Nine patients distributed in acute (2 women, 2 men, age 64.2 years; 22.7 days from surgery), and chronic groups (5 men, age 67.4 years; 32.7 months from surgery) underwent 10 sessions of HAL treatment. In the first and last session, a motion capture system (VICON MX, 100Hz) was used with Plug-in gait lower limbs marker-set to record segmental kinematics. The data was analyzed regarding the elevation angles (EA) described for the thigh, shank and foot. Planar covariation of the EA was calculated using principal component analysis. The third principal component scores (PC3) were compared before and after HAL treatment in terms of standard deviation (SD) and proportion of variance (PV). Analysis was also performed by comparing the highest and lowest peaks and their difference of the EA before and after HAL treatment. RESULTS Planar covariation fitted better the plane after HAL treatment for acute group. Quantitative comparisons between PC3 SD before and after HAL treatment was also significant in acute group (t-test, P-value for acute: 0.039, chronic: 0.967). PV was not significant; however, the P-value was close to significance for acute group (0.0502) but chronic (0,997). Pre-post peak comparisons were significant only for foot elevation angle (t-test; P-value for max peak: 0.036, min peak: 0.0306, difference max-min: 0.0243). Other comparisons for acute group and all comparisons for chronic group did not show significance. CONCLUSIONS In this study, improvement in planar covariation fitting and peaks changes in acute group suggest an improvement in intersegmental coordination of the lower limbs, implying coordination improvement by the CNS. On the other hand, segment-wise analysis showed significant change only in relation to the foot. It may suggest that HAL treatment improved central coordination rather than segment-wise adaptation. In our previous study the improvement of gait performance factors for chronic patients was already verified; however they may have achieved some degree of gait coordination through self-learning before starting HAL treatment.

3-H-46 Characteristics of collision avoidance strategy during locomotion: effect of the obstacle position and direction of avoidance

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BACKGROUND AND AIM: Locomotion requires adaptation of movement to avoid collisions. To avoid obstacles safely, pedestrians rotate their shoulders or change their travel path to maintain sufficient spatial margins. This strategy is affected by the surroundings of the pathway such as the position and width of the obstacle. This study investigates the strategy of maintaining spatial margins with obstacles in various positions. METHOD: Ten young participants walked a travel path under eight different obstacle position and avoidance direction conditions: a condition with the obstacle in front of the path, and with obstacles 1.0 times the shoulder width (1.0 times condition), 1.5 times the shoulder width (1.5 times condition), or 2.0 times the shoulder width (2.0 times condition), with either right or left avoidance. We measured the spatial margin between the obstacle and participant's clavicle at the moment of passing the obstacle. We also calculated mediolateral displacement of the clavicle marker position from the first position of measurement. Two-way repeated ANOVA was used to determine the effect of obstacle positions and direction of travel path on each measurement variable as described above. If a main effect was found, post hoc analysis was performed using Sidak's test. A p-value of ?0.05 was considered statistically significant. RESULTS: Spatial margin showed a significant main effect for obstacle position ($F_{3,27}=10.660$, $p<0.0001$) and direction of avoidance ($F_{1,9}=70.801$, $p<0.0001$), but interaction effects were not significant ($F_{3,27}=0.221$, $p=0.888$). Post hoc analysis revealed a significant difference between the 1.0 times and 1.5 times conditions ($p=0.060$), the 1.0 times and 2.0 times conditions ($p=0.040$), the 1.5 times and 2.0 times conditions ($p=0.026$), and the in front of travel path and the 2.0 times conditions. Mediolateral displacement of the clavicle marker also showed significant main effects of obstacle position ($F_{3,27}=560.358$, $p<0.0001$) and direction of avoidance ($F_{1,9}=5.307$, $p=0.047$), but interaction effects were not significant ($F_{3,27}=1.126$, $p=0.356$) (Figure 1). Post hoc analysis revealed a significant difference in clavicle displacement in all combinations of obstacle position conditions ($p<0.0001$). CONCLUSIONS: In our study, spatial margins were the same except between the 2.0 condition and other conditions. These results showed that the position of the obstacle had no impact on the spatial margin during passing the obstacle. Moreover, we calculated mediolateral displacement of clavicle marker from the initial position and the results showed that participants changed the direction of their travel path to clear the obstacle by means of maintaining the spatial margin. Finally, our analysis of the difference in collision avoidance caused by the direction of avoidance while traversing the travel path showed that obstacle avoidance was different depending on whether the movement was to the right or the left.

3-H-47 Walking adaptability training in people after stroke: a randomized controlled trial

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BACKGROUND AND AIM: The ability to adapt walking to environmental properties and hazards, a prerequisite for safe walking in everyday life, is often impaired in persons after stroke. This likely contributes to their increased risk of falling. Stroke patients may thus benefit from walking adaptability training. This study aimed to compare the effects of two different walking adaptability training interventions in persons post-stroke: treadmill-based C-Mill therapy (therapy program with augmented reality content projected on the walking surface) and the overground FALLS program (conventional therapy program with an emphasis on adaptive stepping) (Figure 1). We hypothesized that C-Mill therapy would result in better outcomes than the FALLS program, owing to its expected greater amount of walking practice. METHODS: This was a single-centre parallel group randomized controlled trial with pre-intervention, post-intervention, retention and follow-up tests (Timmermans et al., 2016). Forty persons after stroke (≥3 months) with deficits in walking and/or balance were randomly allocated to 5 weeks of C-Mill therapy or the FALLS program. Both interventions incorporated practice of walking adaptability and were matched in terms of frequency, duration and therapist attention. Main outcomes were walking speed (assessed with a 10 Meter Walking Test; 10MWT) and walking adaptability (using 10MWT with context and/or cognitive dual-task and Interactive Walkway assessments). The amount of walking practice (the number of steps taken per session), which is generally seen as a key parameter linked to the potential efficacy of the therapy, was scored using the treadmill's inbuilt step counter (C-Mill therapy) and video recordings (FALLS program). RESULTS: Preliminary results showed that both groups showed a significant increase in walking speed during the walking adaptability tests, whereas walking speed during the 10MWT did not increase significantly after training in both intervention groups. Furthermore, there was a significant difference in the amount of walking practice between the two interventions, with on average 90 percent more steps taken during C-Mill therapy than during the FALLS program. CONCLUSIONS: This study examined the effects of treadmill-based C-Mill therapy compared to the overground FALLS program and thereby the relative importance of the amount of walking practice as an essential aspect of effective intervention programs after stroke. Both walking adaptability interventions led to task-specific improvements, as walking speed only improved for the adaptive walking assessments and not for the conventional 10MWT. Preliminary analyses revealed that the greater amount of movement practice observed for the C-Mill group (in terms of number of steps taken per session) did not translate to superior outcomes. Timmermans C, Roerdink M, van Ooijen MW, Meskers CG, Janssen TW, Beek PJ. Walking adaptability therapy after stroke: study protocol for a randomized controlled trial. Trials. 2016;17:425. doi: 10.1186/s13063-016-1527-6.

3-H-48 KEY SPATIOTEMPORAL COMPONENTS OF GAIT IN CHILDREN WHO ARE PRESCHOOLERS

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BACKGROUND AND AIM: Spatiotemporal parameters (STP) are often used to assess dynamic balance control. However, covariance among STP is high, suggesting redundancy.(1) Principal component analysis (PCA) can be used to determine which key-spatiotemporal components can be distinguished during walking.(1) In samples consisting of older adults, such PCA's revealed two balance-related components: variability (step length- and width variability) and postural control (mean step width).(1-3) During the preschool years, walking stability still increases with increasing age.(4,5) Therefore, to assess dynamic balance control in preschoolers, PCA of STP could contribute to the identification of key spatiotemporal components of gait in this population as well. METHODS: Thirty-three preschoolers with typical development (58.9 ± 15.6 months old) walked on treadmill at three age-specific walking speeds (range 2 - 4.5 km/hr). A PCA with varimax rotation was performed to detect relations between walking speed, age, BMI and leg length and mean values and variability (SD) of step time, -length and -width. RESULTS: PCA revealed three key spatiotemporal components (Figure 1). The first component, rhythm & pace, showed high loadings for mean step length (0.921), walking speed (0.901), age (0.897), leg length (0.881), and step time variability (-0.723), explaining 39.15% of the variance. The second component, variability, loaded with step width variability (0.856) and step length variability (0.809), explaining 16.80% of the variance. The third component, postural control, showed high loadings for mean step time (0.763), BMI (0.670) and mean step width (0.554), explaining 13.43% of the variance. CONCLUSIONS: Our model of gait revealed that STP can be reduced. Rhythm & pace is prone to maturation. Variability and postural control can provide valuable information regarding balance control during walking in preschoolers. These findings are similar to those found in adults, suggesting further investigations regarding the clinical implications of these parameters towards the evaluation of balance control seems valuable. ACKNOWLEDGEMENTS AND FUNDING: none to declare. REFERENCES: (1) Lord S, Galna B, Verghese J, Coleman S, Burn D, Rochester L. Independent domains of gait in older adults and associated motor and nonmotor attributes: validation of a factor analysis approach. J Gerontol A Biol Sci Med Sci. 2013 Jul;68(7):820-7. doi:10.1093/gerona/gls255. (2) Verghese J, Wang C, Lipton RB, Holtzer R, Xue X. Quantitative gait dysfunction and risk of cognitive decline and dementia. J Neurol Neurosurg Psychiatry. 2007 Sep;78(9):929-35. (3) Hollman JH, McDade EM, Petersen RC. Normative spatiotemporal gait parameters in older adults. Gait Posture. 2011 May;34(1):111-8. Doi: 10.1016/j.gaitpost.2011.03.024. (4) Sutherland D. The development of mature gait. Gait Posture. 1997 Jul;6(2):163-170 (5) Sutherland DH, Olshen R, Cooper L, Woo SL. The development of mature gait. J Bone Joint Surg Am. 1980 Apr;62(3):336-53.

3-H-49 Neuromuscular organization during balance-correcting responses induced with platform-translation and shoulder-pull perturbation methods

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BACKGROUND AND AIM: Balance correcting responses have been shown to be fast, accurate, and both functionally- and directionally-specific. However, there remains a lack of clarity in the literature with respect to how balance-correcting responses are organized, perhaps due to use of various perturbation methods. The current study examined neuromuscular organization of balance-correcting responses induced using two different common perturbation methods: platform-translation (PLAT) and shoulder-pull (PULL). METHODS: Fifteen young healthy males (24±3 years, 181±6cm, 82±14kg) participated. Unexpected PLAT and PULL perturbations were induced with eyes-open and eyes-closed; trials were blocked by perturbation method. Equivalent perturbation stimuli (Verniba and Gage, 2014, ISPGR) were delivered with both methods. Only forward stepping trials were analyzed. Muscle activation latency from the following muscles, bilaterally, were examined: rectus abdominis (RA), rectus femoris (RF), tibialis anterior (TA), erector spinae (ES), biceps femoris (BF), and gastrocnemius medialis (GM). RESULTS: The effect of vision was not significant for any of the recorded muscles. Activation latencies (~210ms) were similar between perturbation methods across anterior muscles; the only significant differences were observed following PULL perturbations. The stance limb TA activated earlier than RA, and the swing limb TA activated earlier than RF. Bilaterally symmetrical distal-proximal activation of posterior muscles between 70ms and 260ms was observed during PLAT trials: muscle activation order was GM, BF, and ES, on the stance and swing sides. In contrast, following PULL perturbations, a pattern of proximal-distal activation of posterior muscles between 70ms and 130ms was observed on the stance side; the activation latencies (~80ms) were not different between the stance side posterior muscles. CONCLUSIONS: The current data reveal different neuromuscular responses to two different postural perturbation methods that utilized, importantly, equivalent perturbation intensity. Furthermore, the same individuals completed both perturbation methods. Previous examinations of methodological comparisons have tended to compare results across publications, and generally have not accounted for different stimulus characteristics. Significant differences in activation latency were observed in the posterior muscles. On the stance side, activation order was reversed between perturbation methods, representing distinct distal-proximal and proximal-distal activation patterns. On the swing side, the same distal-proximal activation pattern was observed in response to the PLAT perturbation, but all posterior muscles activated very early and simultaneously in response to the PULL perturbation. Interpretation of functional balance recovery responses requires clear understanding of the nature of the perturbation, including perturbation intensity.

3-H-50 A Multicenter Study Evaluating Balance Control During Dual-Task Walking in Adolescent Athletes Following Concussion

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BACKGROUND AND AIM: The decision of when an athlete should return to play (RTP) after concussion remains among the most difficult in sports medicine. Currently, RTP decisions are based on resolution of clinical symptoms and basic cognitive, neuropsychological, and standing balance tests. However, assessments of higher level activities such as walking in combination with simultaneous cognitive tasks have shown lingering impairments despite normalization of basic functions. Such dual-task assessments are not typically incorporated into RTP decisions, but may be useful for revealing remaining balance control deficits. Two-thirds of sports related concussions occur in teenage or younger patients, but detailed analyses of concussion recovery in this group have been largely overlooked. Therefore, the purpose of this study was to determine if concussed adolescent athletes exhibit remaining deficits in dual-task balance control at the time of RTP clearance. We hypothesized that adolescents cleared based on current clinical criteria would walk significantly slower with greater medial-lateral (ML) sway during cognitive function tasks compared to non-concussed peers. METHODS: This prospective multicenter study examined 16 concussed patients (9 male) and 15 controls (9 male) ages 11-17 years (mean 14.2, SD 1.9) following written informed consent. Patients were examined within 1 week of RTP clearance. All subjects participated in a single test session in which they underwent motion analysis testing while walking at a self-selected speed during 3 tasks: 1) walking only, 2) a simple cognitive task reciting the months of the year backwards and 3) a continuous 1-second interval audio Stroop test. Walking velocity and ML center of mass displacement and velocity adjusted for body size using non-dimensional normalization were compared among groups and tasks using two-way ANOVA (including interaction term) and pairwise Bonferroni adjusted posthoc tests. RESULTS: The average time from concussion to testing was 57 days (SD 46, range 12-170). Walking speed and ML displacement differed significantly among tasks ($p<0.01$) but not between groups ($p>0.55$) (Table 1). Walking speed was slower for both dual-task conditions compared with walking only ($p<0.05$). ML displacement was larger for the cognitive dual-task compared with walking only ($p<0.05$). ML velocity did not differ significantly with task or group ($p>0.14$). CONCLUSIONS: In contrast to adult athletes, adolescent athletes demonstrated no difference in dual-task balance control compared to controls at the time of clearance to RTP. This may reflect the more conservative approach to concussion management in this age group as patients were returned an average of 2 months after concussion compared with 2 weeks for older athletes. Future studies are needed to corroborate these preliminary findings due to variability among participants, particularly the controls.

J Devices to improve posture and gait

3-J-51 A mathematical model of cane assisted upright human balance

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BACKGROUND AND AIM: Understanding the mechanisms associated with postural instability is of great importance for rehabilitation and fall-prevention in older adults as well as neurologically impaired individuals. Recent mathematical models of bipedal stance (Chagdes et al. 2016a; Chagdes et al. 2016b) have demonstrated that there are two types of instabilities - a decreased ankle stiffness induced leaning

instability and an instability resulting in excessive oscillation as a result of increased neuromuscular time-delay. While these models provide insight into the stability of bipedal stance, they are not sufficient for individuals that require the aid of assistive technologies, such as a passive-cane or a walker. This abstract presents our initial study of the effect of a cane as an assistive device using a nonlinear, time-delayed feedback model which incorporates the effect of coupling between human postural system, neural feedback, and cane dynamics. The developed model is then used to investigate the effect of musculoskeletal and control parameters on the effect of postural stability. Effect of both the loss of stiffness as well as the onset of increased time-delay is presented. METHODS: We model cane-assisted human balance using a two-degree-of-freedom, five-bar mechanism to represent the human body, upper arm, forearm, cane, and ground (Figure 1). Following the work of Peterka (2002) the human body (excluding the arm assisting balance) is modeled as a simple inverted pendulum with corrective torque generated at the ankle joint. Additional corrective torques are generated at the shoulder, elbow, and wrist joints while fixing the bottom of the cane to the ground. A parametric study was completed to understand how changes in the model control parameters associated with the onset of aging or neurological impairments affect the stability of cane-assisted upright human stance. We specifically varied passive ankle stiffness to mimic the effects of muscle loss/gain and neuromuscular time-delay to mimic the effects of impairment to the neuromuscular system. Additionally a parametric study was completed to understand how changes to the cane affect the stability of balance. The parameters of the cane that were varied were mass and length. RESULTS: The mathematical model predicted that a simple control strategy was able to stabilize cane-assisted upright balance. It was shown through the paramedic study that the use of a cane benefited individuals with low levels of ankle stiffness allowing for stable posture when ankle stiffness value was insufficient for stable bipedal balance. The cane had minimal benefits for individuals with increased time-delay. Changing the length of the cane was found to have an effect on the stability of balance; changes to its mass had little effect. CONCLUSIONS: Such a mathematical model can aid in the design of customized passive or active assistive technology for people of difference physical properties and impairments. REFERENCES: Chagdes JR, et al (2016a), J Sport Heal Sci 5:14-24. doi: 10.1016/j.jshs.2016.01.005 Chagdes JR, et al (2016b), J Biomech 49:1170-1179. doi: 10.1016/j.jbiomech.2016.03.005 Peterka RJ (2002), J Neurophysiol 88:1097-1118. doi: 10.1152/jn.00605.2001

3-J-52 Differential effects of cueing and feedback on gait and fatigue in people with Parkinson's disease

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BACKGROUND AND AIM: To improve physical fitness and day-to-day functioning in people with Parkinson's disease (PD), regular 30 minute brisk walks are advised. Augmenting such prolonged walks with continuous auditory cueing (ConCue) has been shown to maintain gait quality but may also cause excess fatigue. Therefore, in the current study the effects of two intelligent methods to provide external input were investigated on both gait quality and fatigue. METHODS: 28 people with PD (Hoehn and Yahr stages I-III) and 13 aged-matched healthy elderly people (HE) performed four 30 minute walk tests, with a one week interval between tests. During the tests they were exposed to either 1) continuous cueing (ConCue), 2) intelligent cueing (IntCue), 3) intelligent feedback (IntFB) or 4) no information (NoInfo) delivered via headphones. ConCues consisted of continuous rhythmic beats matching the participant's baseline cadence. A bout of intelligent input was provided each time the cadence over five consecutive strides deviated from baseline. Corrective input involved 10 beats (IntCue) or a verbal instruction to adapt speed (IntFB). Cadence was considered as the primary outcome reflecting gait quality and was recorded via APDM Mobility Lab. Physical fatigue was quantified as the change in fatigue scores on a visual analogue scale (VAS) taken before and after each 30 min walk. RESULTS: If no external information was provided, patients with PD showed a significant decline in cadence during the 30 minute walk. However, when ConCue or IntFB was provided, the original cadence was maintained even during the last 15 minutes of walking (Δ >2.25 steps/min compared to NoInfo; p≤0.03). The downside of applying this external input was a significant increment in physical fatigue in the PD group compared to the HE (ConCue (median (IQR): PD: 11 (6 - 25), HE: 2 (1 - 10); p=0.04); IntFB (PD: 20 (3 - 32), HE: 4 (1 - 8); p=0.004)). IntCue did not improve cadence, but also did not increase fatigue levels in PD. Fatigue also did not increase during NoInfo in PD. In contrast to the PD group, the HE group showed no differences between conditions, showing that cadence and fatigue were not influenced by external guidance. CONCLUSION: Augmenting a prolonged walk with ConCue or IntFB is effective to maintain gait quality in PD. However, walking under ConCue and IntFB was more fatiguing for people with PD than for their healthy peers. Further investigation is needed into the source of this fatiguing effect and whether it is due to the input itself or to the corrective behavior it instills.

3-J-53 Effects of muscle vibration on gait initiation in Parkinson's disease with and without Freezing of Gait

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BACKGROUND AND AIM: People with Parkinson's disease (PD) and more so those who experience Freezing of Gait (FOG) show gait initiation deficits (GID): hypometric and slower postural adjustments, slower first step and movement execution (entire task: postural adjustments step). FOG have an impaired weight-shifting ability, mainly in the anterior-posterior (AP) direction. Therefore, the aim of this study was to investigate the effects of muscle vibration (a wearable device able to induce postural adjustments and to reduce FOG severity) on gait initiation in FOG . METHODS: Nine FOG , 9 PD patients without FOG (NFOG) and 11 healthy elderly performed gait initiation with and without muscle vibration applied simultaneously on the tibialis anterior, rectus femoris and trapezius superior, in order to shift the body forward (a required postural adjustment during gait initiation). The first step, anticipatory postural adjustment (APA) characteristics, and the center-of-mass (CoM) behavior were assessed by an optoelectronic system (Optotrack Certus [NDI®]). RESULTS: FOG showed an impaired gait initiation performance (slower step velocity, slower task completion time and reduced AP-CoM displacement during APA compared to other two groups. Muscle vibration reduced APA duration ($F[2,26]=6.40$, $p=0.017$) and the speed of task completion ($F[2,26]=8.25$, $p=0.007$) in all groups. Additionally, as expected, vibration elicited a CoM forward displacement before the movement onset ($F[2,26]=16.12$, $p<0.01$) and reduced the CoM A-P displacement during APA in all groups ($F[2,26]=46.50$, $p<0.01$) . Both PD groups showed step adaptations with the use of vibration: while FOG reduced the first step length ($p<0.01$), NFOG took a longer time to execute the first step ($p=0.01$). No effects on step width and CoM mediolateral displacement were found. CONCLUSION: Vibration replaced the voluntary anterior CoM shift expected during APA, thereby reducing the APA duration. As a result, a faster movement execution was observed in all groups with the use of vibration. We believe that healthy elderly could process the new motor plan elicited by vibration in a faster way than other groups, since no adaptions in step were found for this group. On the other hand, although both PD groups used different strategies, they needed to adapt the first step as a result of adaptations elicited by vibration: NFOG needed more time to process the new motor plan (increasing the step time). In a different way, FOG executed a more conservative strategy with the use of vibration (reducing the step length). Since no mediolateral

adaptations (step with and CoM displacement) were observed, we do not believe that vibration elicited an unstable situation. Muscle vibration may be an interesting and safe tool to reduce GID in FOG .

K Effect of medication on posture and gait

3-K-54 Effect of medication on habitual gait in people with Parkinson's disease: a feasibility study.

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BACKGROUND AND AIM: Gait impairments are typical in Parkinson's disease (PD) and are associated with increased risk of falling and poor quality of life [1]. Motor symptoms can be alleviated by pharmacological treatment but the biphasic response to medication and symptom fluctuations would be better understood with continuous and longitudinal evaluation. Wearable technology (WT) facilitates such an approach by quantifying clinically relevant gait outcomes in habitual environments [2]. This feasibility study aims to investigate the acceptability of WT to monitor medication times and concordance to gait performance. METHODS: 20 PD participants (age 69±10 years) and 20 age-matched controls (CL) enrolled in ICICLE-GAIT were tested [1]. Data were recorded continuously for 7 days with an accelerometry-based WT (Axivity AX3) placed on the lower back. Of the 20 PD participants, 5 were also asked to simultaneously wear a wrist-worn WT (Parkinson's KinetiGraph Data Logger (PKG)) which served as a reminder (prompt) and recorder of medication intake time over 7 days (PDP). The remaining PD participants were asked to take their medication as normal (no prompt, PDN). Daily time-series of 14 clinically relevant gait characteristics were evaluated [3], Fig.1a. To investigate the effects of medication, gait characteristics trends were analysed for each period between medication intakes and classified into increasing (I), decreasing (D) or peak-presence (P) cases, Fig.1b. For P cases wear-off effects were evaluated via a scoring system which was designed to yield higher scores for characteristics which exhibit a better response to medication (minimal wear-off effect) and vice versa, Fig.1c. Between-group differences (PDP vs CL, PDN vs CL) were evaluated using independent t-tests. RESULTS: Preliminary results showed that PDP had a significant higher number of I cases (increase trend) and lower number of P cases for stance time variability, higher number of I cases for step length asymmetry and a higher average daily number of I cases (considering all gait characteristics) compared to CL ($p \leq .043$). No significant differences were found between PDN and CL. Although not significantly, in general PDP had higher scores (minimal wear-off effects) compared to PDN possibly due to PDN non-adherence to prescribed but not prompted intake times. CONCLUSIONS: These preliminary results suggest it is feasible to use WT in PD to monitor medication intake times and modified gait characteristics. Some variability and asymmetry gait characteristics seemed not to be optimally controlled by medication and tended to increase between intake times in PDP when compared to CL. Although PKG values may serve as a prompt, true patient adherence to medication intake times remains challenging. Future work will investigate medication effects also on walking activity. ACKNOWLEDGMENTS: This work is supported by NUIA Early Career Researcher Funding. Financial support for this study came also from the National Institute for Health Research (NIHR) Newcastle Biomedical Research Unit, Parkinson's UK and the NIHR Newcastle CRF Infrastructure funding. REFERENCES: [1]Lord, Front Aging Neurosci, 2014 [2]Godinho, JNER, 2016 [3]Del Din, JNER, 2016

M Exercise and physical activity

3-M-55 Daily Bicycling in Older Adults is Effective to Reduce Fall Risks - a Case Control Study

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BACKGROUND AND AIM: The popularity of bicycle transportation mode due to urban policy of operating public bicycle networks in cities worldwide increase the cyclist population who would expected ageing with cycling habits. Due to the postural control demand during two-wheel bicycle riding, we aimed to explore whether older persons who cycling regularly have faster voluntary stepping times and better balance, factors that associated with risk for fall[1], and their severity[2]. METHODS: Case-control study of 20 older adults aged 65 to 85 who live in agricultural community village that were classified as bicyclists (i.e., self-reported>15 accumulating min/day at least 5 days/week for the past 20 years), and 30 matched sedentary older adults who live independently in the community. Balance control (i.e., postural sway and stabilogrm diffusion analysis (SDA)), voluntary step execution test, self-reported function and fear of fall were performed. Differences between the two groups were analysed by Independent T-test if normally distributed and Mann-Whitney U tests if not normally distributed. RESULTS: Compared with sedentary controls, cyclists showed significantly lower Mediolateral (ML) sway range, Mean Sway Velocity, sway Area, lower critical displacement and lower short-term diffusion coefficient of SDA, both in the ML direction. Cyclists also had significantly faster step times and swing phase durations, had lower BMI and higher Advanced lower extremity function score in the Late Life Function and Disability Instrument compared with the controls. CONCLUSIONS: Older adults ageing with cycling habits show benefits in unique aspects of postural control while standing and stepping, both related to risk of falling among the elderly population. The results suggest that cycling regularly in older adults preserve balance control particularly in the ML direction and preserve speed of voluntary stepping. ML balance is the most challenging aspect of bicycling, especially in low velocity riding, characteristic the use of bicycle as a daily rural transportation means. the results also suggest that the faster step execution caused mainly due to a faster swing phase duration can also be attributed to the requirement of explosive muscle power when cycling. The results should be treated in caution since cyclists were older adults who selected active life style (i.e., bicycling and lived in agricultural community village) which may bias the results. 1)Melzer I, Kurz I, Shahar D, Levi M, Oddsson L. Application of the voluntary step execution test to identify elderly fallers. Age Ageing. 2007 Sep;36(5):532-7. 2)Kurz I, Oddsson L, Melzer I. Characteristics of balance control in older persons who fall with injury--a prospective study. J Electromyogr Kinesiol. 2013 Aug;23(4):814-9.

3-M-56 Responders to a highly challenging balance training in Parkinson's disease

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BACKGROUND AND AIM: We have developed a novel balance training program, the HiBalance program (1), where specific components of balance control related to Parkinson's disease (PD) symptoms are targeted by highly challenging, progressive and varying training conditions. Although this program has been shown to induce improvements on balance, gait and daily activities in people with PD (2) the responsiveness of highly challenging dual-task training on balance performance across different spectrum of age, disease severity and physical capacities is unclear. We aim therefore to explore the characteristics of individuals with PD who improved their balance performance after participating in the HiBalance program. METHODS: Forty-seven elderly people (28 male/19 female) with mild to moderate PD were randomized to participate to a group training 3 times/week for 10 weeks, trial registration: NCT01417598. The mean age was 73 years (SD 6) and mean UPDRS III score 36 (SD 10). Balance performance (Mini-BESTest, score 0-28) were assessed pre- and post-intervention, and participants was classified as responders if they improved their score by≥2 points between pre and post assessments. Independent t-test and X2-test were used to investigate the baseline characteristics of the responders in

terms of age, disease severity (UPDRS and Hoehn & Yahr), gait and balance performance and health related quality of life (PDQ-39 and SF-36). RESULTS: Thirty-five participants (74%) were responders in terms of improved balance performance. The responders demonstrated worse balance performance (Mini-BESTest), perceived higher mobility impairments (PDQ-39, mobility domain) and worse health related quality of life (SF-36, general health) compared to non-responders at baseline (p=0.021, p=0.042 and p=0.012, respectively). We found a significant higher proportion of Hoehn & Yahr stage 3 amongst responders (63%) compared to non-responders (42%), p=0.009. CONCLUSIONS: People with PD with lower balance performance, moderate disease severity, lower perceived mobility and health related quality of life seem more likely to improve with a highly challenging balance training. Multivariate analysis is needed to determine independent predictors. ACKNOWLEDGEMENTS & FUNDING: We first like to express our gratitude to all the patients participating in this study. Further, we like to acknowledge the physical therapists, master and PhD students training and collecting data. We are also grateful for the financial support from the Swedish research council, the Swedish Research council for Health, Working life and Welfare (FORTE), 'Vårdalstiftelsen' and the Swedish Parkinson Foundation.
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3-M-57 Changes in physical activity during hospital stay for patients after stroke

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Background and aim: Early mobilization has proven to be an important factor in stroke treatment while hospitalized. However, too early and too intense mobilization may cause unfavorable outcome 3 months later. Hence, there is a need for more research to get a deeper understanding of physical activity during the initial hospital stay in patients after stroke. This study aimed to describe changes in physical activity over 3 to 7 days for patients admitted to a comprehensive stroke unit. Methods: 58 patients diagnosed with acute ischemic stroke were included within one week post stroke. Two activity monitors (ActivPAL Professional sensor system from PAL Technologies Ltd) were attached, one at the middle part of sternum and one at the unaffected sides` thigh up to one week or until discharged, to continuously during 24 hours monitor physical activity. Data from the two sensors were processed in Matlab R 2015B, and coded to get information about time in lying, sitting, and upright position and number of transitions from lie-to-sit and sit-to-stand per day. Time effect over one week was analyzed using Friedmans test. Results: There were relatively large between-patients variations within each day for both sitting time (IQR 3.9-10.7 hours) and time in an upright position (IQR 0.3-1.0 hours). Median time spent sitting increased from 31 % to 45 % throughout the week, while median time in an upright position remained roughly the same, (4.2-4.5 %) (attachment 1). Number of lie-to-sit transitions (12-14.5 transitions) and sit-to-stand transitions (21-27 transitions) changed throughout the week. Patients with complete measures for 7 days (n=30) showed significant time effects with increased time spent both sitting (p=0.01) and upright (p=0.03) from the first to the seventh day, but not for any of the transitions up. Conclusion: Patients spent less than 10% of a 24-hour period in an upright position, while time spent in a sitting position increased significantly over 7 days for patients admitted to hospital after undergoing a stroke. Number of transitions up to sitting and standing position remained the same during the hospital stay. Acknowledgements and funding: We thank the Department of Stroke and the Department of Neurology for collaboration throughout the project, and patients for their participation. This study was funded by Liaison Committee between the Central Norway Regional Health Authority and the University Colleges.

3-M-58 Physiological and perceived exertion responses to a novel walking exercise, "i-Walk"

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BACKGROUND AND AIM: We have proposed a novel walking exercise, called "i-Walk", as an easily implementable walking exercise in activities of daily living. i-Walk adds a longer step after a gait cycle of normal walking: two normal steps with leading and trailing limbs, followed by about one foot longer step with the leading limb (Fig.1). We previously demonstrated that i-Walk required larger hip and knee extensor torques than those during normal walking, indicating that i-Walk may provide an additive training effect on normal walking in lower extremity muscular strength. However, it is currently unclear to what extent i-Walk would impose physiological demands and perceived exercise intensity as compared to other forms of walking, which would help us to determine training regimens for health promotion. Therefore, the objective of this study was to compare differences in physiological and perceived exertion responses to i-Walk, normal walking, and long step walking. METHODS: Nine healthy young male adults walked on a treadmill for five minutes at their self-selected comfortable speed of normal walking, with the following three walking conditions in a random order: 1) normal walking (NW); 2) long step walking (LW); and 3) i-Walk. Physiological and perceived exertion measures were assessed with oxygen consumption, heart rate (HR), and Borg's rated perceived exertion scale (RPE). HR and RPE were collected every one minutes. Separate one-way repeated measures ANOVAs were performed to compare physiological and perceived exercise intensity measures between three walking conditions. Shaffer's post hoc testing was conducted as needed. RESULTS: Significant differences between three walking conditions were found in oxygen consumption ($p<0.001$), HR ($p<0.001$) and RPE ($p<0.001$) (Fig. 2). The LW condition had the highest amount of oxygen consumption (15.7±2.4ml/kg/min) and HR (105.7±9.7bpm), followed by the i-Walk (oxygen consumption: 13.2±1.9ml/kg/min, HR: 98.1±12.6bpm), and then the NW conditions (oxygen consumption: 10.6±1.4ml/kg/min, HR: 92.0±10.4bpm). The i-Walk condition scored lower on RPE compared to the LW condition; however, no difference between the i-Walk and NW conditions was observed in RPE scores (NW: 7.9±1.1, i-Walk: 8.8±1.5, LS: 10.0±1.8, $p=0.09$). CONCLUSIONS: i-Walk condition demonstrated the higher oxygen consumption values than NW did while no significant difference was found in perceived exertion intensity between i-Walk and NW. Oxygen consumption during LW was the highest, while the level of perceived exertion intensity was also the highest. These findings indicate that i-Walk could require a greater physiological demand than NW with a comparable level of perceived exercise exertion. i-Walk may serve as an alternative style of walking in activities of daily living, which could impose additional physiological demands to NW without increasing perceived exercise exertion.

N Falls and fall prevention

3-N-59 Pre-impact fall detection and the development of a hip protection air bag system

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BACKGROUND AND AIM: Falling is major cause of injuries and deaths in elderly adults. As for intervention strategies, one of the important problems in preventing or reducing the severity of injury in the elderly is to detect falls before the impact. Many studies have been done to prevent from falling by using alarms or airbags. However, there were limitations such as a poor effectiveness of the detection algorithm and the usage of gunpowder for the airbag inflator. A pre-impact fall detection algorithm using an inertial sensor and a spring-trigger type airbag system to protect from fall damages were developed in this study. The effectiveness of the algorithm was also tested. METHODS: Four different simulated falls tests were performed to 20 healthy volunteers (23.4 ± 4.4 years) and six different daily activities were also tested for fourteen elderly subjects (71.8 ± 4.0 years). An inertial sensor unit (MPU-9150, Invensens®, USA), placed at the waist, was used to measure acceleration, angular velocity, and vertical angle during all those activities. Acceleration of 0.9G, the angular velocity of 50º/s, and vertical angle of 25º were set as the threshold of the pre-impact fall algorithm based on the fall data. The belt-type airbag system with a buckle wearing structure was composed of a polyurethane inner skin and an artificial leather outer shell. A spring-trigger type inflator and a helium gas cartridge were used to inflate the airbag when falls were detected based on the algorithm. RESULTS: For the evaluation of the developed airbag system, a human model dummy and ten healthy adult males (28.5 ± 2.7 years old) were fitted with an airbag system and performed the same activities three times. The simulated fall test results showed that for every fall, the airbag inflated (100% sensitivity) by detecting a fall before 401.97 ± 46.94 ms of impact. In all daily activities, no airbag inflation was found (100% specificity). CONCLUSIONS: In this study, the pre-impact fall detection algorithm with acceleration of 0.9G, angular velocity of 50 º/s, and tilt angle of 25º was developed by measuring accelerations and angular velocity signals during fall and daily activities. The developed algorithm was embedded in a belt-type airbag system to protect hip joints before the impact caused by falls. Test results showed both 100% sensitivity and 100% specificity of the developed algorithm for all simulated falls and fully inflated by detecting 402 ± 46.9 ms before the impact. In this study, a spring-trigger type inflator for the airbag system was also successfully developed to overcome the limitation of the gunpowder system. ACKNOWLEDGEMENTS AND FUNDING: This research was supported by The Leading Human Resource Training Program of Regional Neo industry through the National Research Foundation of Korea(NRF) funded by the Ministry of Science, ICT and future Planning (No.2016H1D5A1909760).

3-N-60 Catch-the-ruler: Measuring response inhibition in healthy older fallers and non-fallers using the ReacStick test

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BACKGROUND AND AIM: Postural control is attentionally demanding. These demands increase with age and as the complexity of the task increases. Poor cognitive functioning, especially executive function, has been associated with increased gait variability, postural instability and fall risk. Executive function refers to the ability to inhibit inappropriate responses, selectively attend to relevant environmental stimuli and plan to react appropriately to task-relevant stimuli. We developed the ReacStick to provide a low-cost clinical measure of executive function and response inhibition. The aim of this study was to validate the ReacStick test as a new clinical measure of executive function and a risk factor of falls in healthy older adults.
 METHODS: 140 community-dwelling older adults (77.2±5.4 years) performed the ReacStick test. All participants underwent physical and cognitive tests (Physiological Profile Assessment-PPA, Victoria Stroop test) and gait quality was analysed based on one week of daily life accelerometry (MoveMonitor, McRoberts). 30 participants performed the test twice (1 week apart) to evaluate test-retest reliability. During the ReacStick test, time in milliseconds (ms) to catch the ReacStick was measured during the Simple Reaction Test (SRT) and number of errors for ON (do catch) and OFF (do not catch) trials were measured during the Recognition Reaction Test (RRT). RRT is similar to SRT, with an inhibition component added (see Figure 1).
 RESULTS: All participants were able to complete the ReacStick test, taking longer on RRT than SRT trials (247.3±32.6 versus 172.6±16.8 ms). A median of

2 out of 10 errors were made during ON trials (Inter-Quartile Range, IQR=2) and a median of 6 out of 10 errors during OFF trials (IQR=4). Test-retest reliability for all ReacStick measures were excellent for SRT times (Intra-Class Coefficient, ICC=0.987) and good for RRT ON and OFF errors (ICC=0.773 and 0.839, respectively). Construct validity was confirmed by significant correlations between SRT and processing speed (hand reaction time: $r=0.175$, $p<0.05$) and response inhibition (Stroop Intrusions: $r=0.287$, $p<0.01$), and between RRT errors and executive function (Stroop Efficiency: $r=0.220$, $p<0.01$). Discriminant validity was confirmed by slower SRT time with increasing age ($p=0.047$), number of medications ($p=0.017$) and fall risk (PPA) score ($p=0.010$) and with daily life gait measures (longer stride time, $p=0.010$; trend for poorer dynamic stability, $p=0.088$); and by a higher number of RRT OFF errors in people with a fall history ($p=0.001$) and poorer daily life gait characteristics (trends for stride time, $p=0.072$ and dynamic stability, $p=0.087$).
 CONCLUSIONS: Both SRT and RRT were feasible for older adults, reliable and correlated with validated cognition tests. RRT errors were able to distinguish fallers from non-fallers, suggesting subtle impairments of inhibitory control in fallers, possibly caused by cognitive overload due to the increased working memory demand, suggesting less efficient information processing. The ReacStick could provide a novel way to assess cognitive function and explore cognitive mechanisms of risk of falling in older adults.

3-N-61 Walking-adaptability assessments with the Interactive Walkway: Between-systems agreement and sensitivity to task and subject variations

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BACKGROUND AND AIM: A prerequisite for safe walking is one's ability to adapt walking to environmental circumstances, termed walking adaptability. Patients with a reduced walking adaptability are more likely to experience walking-related falls. Therefore, it is important to include walking adaptability in a comprehensive assessment of walking ability, yet walking adaptability is difficult to assess. The Interactive Walkway was developed for an overground assessment of walking adaptability (Fig 1). The Interactive Walkway is a 10-meter walkway equipped with multiple integrated Kinect v2 sensors for markerless 3D motion registration, a set-up which has recently been validated for quantitative gait assessments against a gold standard [1]. To evoke step responses to environmental context, the Interactive Walkway uses a projector to present gait-dependent visual context on the walkway, such as obstacles, based on real-time processed Kinect data. The so-obtained gait-environment interactions enable an assessment of walking adaptability. In this study we determined Interactive Walkway's usability for walking-adaptability assessments in terms of between-systems agreement and sensitivity to task and subject variations. METHODS: Under varying task constraints, 21 healthy subjects performed various assessments of walking adaptability (i.e., obstacle avoidance, sudden stops and starts and targeted stepping; Fig 1). Body points' time series were recorded with the Interactive Walkway and the gold-standard Optotrak system, from which multiple walking-adaptability outcome measures were derived (i.e., available response time, obstacle-avoidance margins of trailing and leading limbs, initiation time, stepping accuracy, step lengths and walking speed). Furthermore, success and failure for obstacle-avoidance and sudden-stop tasks were documented. The main study outcomes were between-systems absolute agreement and the sensitivity to task and subject variations for the walking adaptability outcome measures. RESULTS: Walking-adaptability outcome measures generally agreed well between systems (high intraclass correlation coefficients for absolute agreement, low biases and narrow limits of agreement) and were highly sensitive to task and subject variations. Success and failure ratings varied with available response times and agreed between systems for 85-96% of the trials. CONCLUSIONS: We conclude that Interactive Walkway walking-adaptability outcome measures are reliable and sensitive to task and subject variations, even in high-functioning subjects. We therefore deem Interactive Walkway walking-adaptability assessments promising for obtaining an objective and more task-specific examination of one's ability to walk, which may be feasible for both high-functioning and fragile populations since walking adaptability can be assessed at various levels of difficulty. REFERENCES: [1] Geerse DJ, Coolen BH, Roerdink M. Kinematic Validation of a Multi-Kinect v2 Instrumented 10-Meter Walkway for Quantitative Gait Assessments. PLoS One. 2015; 10(10):e0139913.

3-N-62 Failures in adaptive locomotion: Knowledge of obstacle contact is instrumental to guide limb trajectory

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BACKGROUND AND AIM: Knowledge of obstacle characteristics, termed obstacle memory, must be available for the trail limb to successfully cross an obstacle, since this limb is not visible during crossing. This obstacle memory appears to change as a function of repeated trials, as trail foot clearance decreased linearly by 1 mm per trial and continued to decrease until an inadvertent contact occurred (Heijnen et al., 2012). The somatosensory information from the contact provided knowledge of results, which was used to update obstacle memory, as indicated by a large increase in foot clearance following obstacle contact. In the present study, this knowledge of results was removed to determine if obstacle memory could accurately guide the trail limb over an obstacle. Participants crossed an obstacle with their lead limb, but directly following lead limb crossing, the obstacle was lowered (Fig 1), which removed knowledge of results. It was predicted that foot clearance would either decrease linearly below the actual obstacle height or demonstrate an asymptotic curve that gradually approached obstacle height. METHODS: Young adults (N=21, 19.9±0.9 yrs) crossed a 20 cm obstacle in a 12 m walkway, for 150 trials. In each trial, after the lead limb crossed the obstacle, the obstacle lowered (from 20 to 12.5 cm) without participant knowledge (Fig 1A-C). Foot clearance (vertical distance between the foot and obstacle) and failures (obstacle contacts if the obstacle had not been lowered) were calculated for the trail limb (Fig 1D, E). To quantify foot clearance as a function of repeated trails, adjusted R^2 values of a linear and exponential regression were calculated for each participant. RESULTS: The average trail limb failure rate was 8%, greater than the 1-2% reported for stationary, visible obstacles, indicating that knowledge of obstacle contact is instrumental in guiding limb trajectory. Foot clearance change over successive trials varied across participants (Fig 1), and was categorized as 1) asymptotic curve (Fig 1D, N=11, 52%), 2) linear decrease (Fig 1E, N=7, 33%), and 3) stable (no change) (N=3, 14%). The asymptotic and stable groups appear to have reasonable knowledge of obstacle height; the linear group does not seem to be aware of obstacle height. This interpretation is consistent with the observed failure rates for each group: 8, 19%, and 0%, for asymptotic, linear and stable groups, respectively, $p=0.01$). The range of behaviors may relate to gaze behavior; visual information of obstacle characteristics may be gathered differently between groups and highlights the importance of studying failures in individuals in order to prevent falls. CONCLUSION: Knowledge of obstacle contact is instrumental to update obstacle memory to guide the trail limb over an obstacle; visual information alone is insufficient for most participants. These findings highlight the importance of examining failures in addition to successes to understand inadvertent failures.

3-N-63 Validating Virtual Time to Contact with Home-Based Technology

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BACKGROUND AND AIM: Falls are the leading cause of injury-related death in older adults. It has been consistently shown that postural stability is a risk factor for falls. One method of measuring postural stability is virtual time to contact (VTC). VTC estimates the time required for center of pressure (COP) or center of mass (COM) to reach one's stability boundary. VTC is commonly calculated using a force platform or high speed motion capture cameras. A more feasible, inexpensive option of measuring VTC may include home-based technology such as the SALUS-Kinect. Therefore, the aim of this study was to validate VTC derived from the SALUS-Kinect system in various static balance conditions. We hypothesized that VTC derived from the SALUS-Kinect is comparable to that from a force platform, the gold standard of assessing postural stability. METHODS: 10 healthy, young adults (age: 24 ± 4.22 yrs) and 5 healthy, older adults (age: 68 ± 5.76 yrs) participated. To determine the stability boundary, participants leaned as far as possible in a counterclockwise circular direction pivoting at the ankle for 30 seconds. Participants then completed two trials of static balance tests under 5 conditions for 30 seconds each: 1) eyes open 2) eyes open with a dual task 3) standing on a foam with eyes open 4) eyes closed 5) standing on a foam with eyes closed. All trials were completed standing on a force platform (Bertec Co., Columbus, OH) and in front of a Kinect camera system (Microsoft Co., Redmond, WA). The force platform measured COP while the Kinect camera system recorded virtual marker position. The hip markers were used as an estimate of COM. The stability boundary and VTC for each condition were calculated, and the average of the 2 trials were determined. Spearman rank-order correlations were performed to determine the relationship between VTC for the SALUS-Kinect and force platform. A 2X2X5 mixed measure ANOVA with age as the between subject factor and device and condition as the within subject factor was conducted. RESULTS: Average VTC was strongly correlated between the SALUS-Kinect and force platform in all conditions (rho=0.77-0.878, $p<0.001$). Average VTC recorded by both the force platform and the SALUS-Kinect was significantly greater in young adults than older adults in all conditions ($p<0.001$). There was a significant main effect for condition ($p<0.001$), with decreases in VTC with postural challenge. CONCLUSIONS: These results indicate that VTC derived from the SALUS-Kinect system is a valid measure of postural instability. The SALUS-Kinect as a home-based technology system has potential to assess postural stability. Next steps should examine reliability and feasibility in home settings.

3-N-64 Brake and loading impulse characteristics when responding to a forward loss of balance in people with stroke

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BACKGROUND AND AIM: Reactive balance control is related to increased falls risk for individuals with stroke [1]. The ability to arrest a forward fall (arresting forward momentum) is directly related to biomechanical strength [2], captured by anteroposterior (AP) braking impulse [3]. The capacity to arrest a rapid forward fall, based on biomechanical strength, has not been examined in individuals in the sub-acute and chronic stages of stroke recovery. Therefore, the purpose of this study was to determine kinetic brake impulse characteristics of individuals with sub-acute and chronic stroke in response to a rapid forward loss of balance. METHODS: Individuals with sub-acute (<3 months post-stroke) and chronic stroke (>6 months post-stroke) were assessed [4]. Participants wore a safety harness attached to a cable and load cell assembly and leaned forward with ~10% body weight supported by the cable. The cable was released at an unpredictable point in time, causing a forward fall that required a reactive step to regain balance. Participants performed 5 trials of two conditions: usual response (UR) and encouraged use (EU, lead limb most often used during UR trials was blocked by a clinician) to ensure stepping responses with both limbs (paretic vs. non-paretic) were captured. Stepping (number of steps, lead with paretic or non-paretic limb) and kinetic data (AMTI, USA) was collected. The current abstract focuses on brake impulses between paretic and non-paretic legs, both normalized to body weight, for the first 500ms following step touchdown; additional data (i.e. EU vs. UR condition impulses,

comparisons to standard clinical tests) will be presented at the conference. RESULTS: Four individuals per group (sub-acute and chronic) have been analyzed to date. Preliminary analyses revealed no significant interaction ($p=0.44$) of group x stepping limb. A main effect of group ($p<0.001$) was observed, wherein individuals with sub-acute stroke produced significantly less brake impulse (-0.35±0.20 Ns/kg) than individuals with chronic stroke (-0.58±0.24 Ns/kg). There was no main effect of stepping limb ($p=0.25$). Additionally, no main effect of group ($p=0.097$) was observed for number of steps per trial. CONCLUSIONS: Preliminary results indicate that individuals with sub-acute stroke have greater impairment in initial brake generation in response to a rapid, forward fall. While previous work in healthy individuals has found a relation between the number of steps taken and brake force production (smaller, multiple steps require less biomechanical strength) [3], analyses to date revealed brake impulse differences with no difference in step rate. Further analyses of the EU and UR conditions, and comparisons to standard clinical tests will aid our understanding of how reactive balance control is impacted by stroke. FUNDING: Canadian Partnership for Stroke Recovery. REFERENCES: [1] Mansfield et al (2015) Physiotherapy 95(5):700-9 [2] Hsiao-Wecksler (2008) J Electromyogr Kinesiol 18:179-87 [3] King et al (2005) Gait Posture 22(3):219-24 [4] Inness et al (2015) Gait Posture 41(2):529-34

3-N-65 Falls in cerebellar ataxia: causes and predictability

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Background and aims: Falling is a major problem in patients with cerebellar ataxia. Recently, increased gait variability was found to be associated with a history of falls. However, due to the complex and multifactorial nature of falling, falls prediction and prevention remains a challenging task for healthcare givers. The aims were to (1) investigate and categorize the circumstances of falls, and to (2) examine if increased gait variability and symptom severity can predict the occurrence of different types of falls in patients with cerebellar syndromes. Methods: This work is part of a prospective cohort study on fall risk in patients with vertigo and balance disorders (trial number: DRKS00006243). At baseline, a complete clinical examination is conducted, including scoring of disease severity (SARA score) and assessing gait and balance. Gait is tested using a GAITRite® sensor mat. During the following year, patients keep a fall diary and receive monthly telephone interviews about their fall events. Preliminary data of 24 patients with cerebellar syndromes during a 6-months observational period is presented. Results: Mean age and SARA score were 47.5 ± 14.0 and 12.2 ± 4.4, respectively. Twenty out of 24 patients reported on a total number of 135 falls (including near-falls). The most common three fall categories were falls due to 1) transferring from one position to another (n=22 of 135 falls), 2) tripping while unperturbed walking (n=21 of 135 falls), and 3) managing stairs (n=20 of 135 falls). Only falls due to tripping while unperturbed walking were associated with an increase in stride time CV and stride length CV. Gait variability was positively correlated with the SARA score. Accordingly, higher SARA scores were only predictive for falls due to tripping while unperturbed walking. Conclusions: Two risk factors have been identified to be predictive for the occurrence of falls due to trips while unperturbed walking. Other types of falls, such as falling on stairs and falling while performing transfers, could not be predicted by the same factors. Identification of specific risk factors for different types of falls is necessary to develop target-oriented fall prevention measures.

3-N-66 A Study on Fall Prediction Using the Linear/Nonlinear Analysis of Postural Sway in the Elderly

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BACKGROUND AND AIM: Unstable postural control was known as one of the typical characteristics of the fallers. However, since postural instability was appeared not only in the fallers but also in the patients with neuropathy or stroke which are related to the decreased balance ability [1], it is difficult to develop a fall prediction model. Therefore, it is necessary to study fundamental characteristics of the fallers using not only the linear variables which reflect the instability of postural control but also the nonlinear variables which reflect the irregularity, long range correlation, and sensitivity to the initial condition for postural control. Thus, the purpose of this study was to develop a fall prediction model based on various variables with linear and nonlinear analysis. METHODS: Total 94 subjects in the local community (23 fallers (age: 77.6±6.2years, weight: 62.5±10.7kg, height: 155.2±8.1cm) and 71 non-fallers (age: 76.6±4.9years, weight: 61.2±10.2kg, height: 157.1±8.9cm)) participated in this experiment. The criteria of the faller were those who had at least one or more fall accidents in the last year. The static standing test was performed for one minute, and postural sway was measured by an IMU sensor module (APDM Inc., Portland, OR, USA) attached at subject?s waist. Acceleration signals (mediolateral [ML], anterior-posterior [AP], and resultant [Res] directions) from sensor module were collected and used to calculate linear and nonlinear variables. As linear variables, total sway area, Root Mean Square, Mean velocity, Mean distance, Path length, and Range of acceleration were used. As nonlinear variables, Sample entropy (SamEn), Multiscale entropy (MSE), Composite multiscale entropy (CMSE), Hurst exponent (HE), Detrended fluctuation analysis (DFA), and Largest Lyapunov exponent (LLE) were calculated. MATLAB v. 7.7 (MathWorks Inc., Natick, MA, USA) was used to calculate all variables and the derived variables were used to develop the logistic regression model for fall prediction by using SPSS v. 19 (IBM SPSS Inc., Armonk NY, USA). RESULTS: The included variables in the regression model were SamEn, LLE and HE in AP direction which are nonlinear variables (Table 1). Accuracy of this regression model for fall prediction was 81.9% (sensitivity: 43.5%, specificity: 94.4%). CONCLUSIONS: Results showed that it was possible for the regression model to discriminate between fallers and non-fallers with about 82% accuracy, and nonlinear variables were more useful than linear variables for fall prediction model. REFERENCES: [1] Mancini M, Horak FB. The relevance of clinical balance assessment tools to differentiate balance deficits. Eur J Phys Rehabil Med 2010;46(2):239-48.

3-N-67 Instrumented assessment of wheeled walker use in geriatric rehabilitation patients

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Background and aims: Wheeled walkers are used to improve mobility and safety in older persons, especially during rehabilitation. However, less is known about the actual use of wheeled walker during walking. Therefore, the aim of this study was to objectively measure the proportion of wheeled walker use while walking in older persons with prescribed wheeled walkers. Methods: Physical activity was assessed in 23 patients of a geriatric rehabilitation clinic aged 65 or older years using a thigh-worn accelerometer (activPAL3, PAL Technologies, Glasgow, Scotland). The device was worn over 24 hours for three consecutive days. Walking duration was determined by the provided software. Furthermore, wheeled walkers of the patients have been instrumented by attaching an additional activPAL3 device to the left wheel of the wheeled walker. Wheeled walker activity was determined by a specifically developed algorithm. Results: The average daily walking duration was 38.9 (standard deviation (SD)=16.2) minutes. During walking episodes, the wheeled walker was used 26.1 (SD=14.2) minutes per day, which corresponds to 67%. Conclusion: A large proportion of walking episodes have been performed without using the wheeled walker. New approaches are needed to encourage people using their wheeled walker prevalently.

3-N-68 A cross-sectional study of set shifting impairments and falling in individuals with and without Parkinson's disease

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BACKGROUND AND OBJECTIVE. Individuals with PD are at increased risk for falls, and some exhibit characteristic deficits in executive function, including set shifting, which can be measured as the difference between parts B and A of the Trailmaking Test. The objective of this study was to investigate whether impaired set shifting was associated with previous falls in community-dwelling, nondemented individuals with and without PD. METHODS. We conducted a cross-sectional study using existing baseline data of PD patients with and without freezing of gait (n=69) and community-dwelling neurologically-normal older adults (NON-PD) (n=84) who had previously volunteered to participate in rehabilitative exercise programs. Multivariate logistic regression analyses were performed to determine associations between set shifting, PD, and faller status, as determined by ≥1 self-reported falls in the previous 6 months, after adjusting for demographic and cognitive factors and clinical disease characteristics. Individuals with likely dementia (Montreal Cognitive Assessment<18) were excluded. RESULTS. The final study sample after applying exclusion criteria (n=73 NON-PD, n=65 PD) included 51 fallers. PD was associated with substantially increased prevalence of previous falls (OR=4.15 [95% CI 1.65-10.44], P<0.01) after controlling for age, sex, and overall cognitive function. Among PD patients the presence of freezing of gait (FOG) was associated with substantially increased prevalence of previous falls (OR=3.63 [1.22-10.80], P=0.02). Impaired set shifting was associated with previous falls after controlling for age, sex, overall cognitive function, PD, FOG, and PD disease duration (OR=1.29 [1.03-1.60]; P=0.02). Although the strongest associations between set shifting and falling were observed among PD without freezing of gait (OR=2.11) compared to HOA (OR=1.14) and PD with FOG (OR=1.46) in a multivariate model that allowed for interaction between set shifting and PD status, there was insufficient evidence to reject the null hypothesis of no interaction. CONCLUSIONS. The set shifting component of executive function is associated with previous falls in non demented older adults with and without PD. ACKNOWLEDGMENTS AND FUNDING: NIH/NCATS UL1 TR000454, KL2 TR000455, TL1 TR000456, NIH R21 HD075612, Department of Veterans Affairs R&D Service N0870W.

3-N-69 Restrictive trunk postural strategy when walking identifies fallers but not freezers

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Background and aim: While individuals with freezing of gait (FoG) are at high risks of sustaining falls, the underlying mechanisms of FoG and falls and their relationship are still not well understood. The aims of this study were to determine if trunk postural strategies and postural stability while walking and standing could differentiate between freezers and non-freezers as well as between fallers and non-fallers. Methods: Twenty-five individuals with Parkinson?s disease (PD) and seventeen healthy controls participated in the study. As a baseline to assess postural stability, participants had to stand quietly for 30s on a force platform. Then, a more challenging task consisted of either standing quietly on a force platform for 30s or walking for 30s along a 15m walkway according on a visual cue (Walk or Stop). Root-mean-square (RMS) displacement amplitude of the center of pressure (CoP) (RMSCoP) and mean velocity (VCoP) in the anterior-posterior (AP) and medial-lateral (ML) directions were calculated. Using six accelerometers (wrists, ankles, lumbar spine, and sternum), we collected gait spatial-temporal characteristics, trunk range of motion (RoM) and peak trunk velocities. To compare postural stability and trunk strategies between groups, participants were first divided between freezers (n=12) and non-freezers (n=13). In a second analysis, groups were divided between fallers (n=11) and non-fallers (n= 14) on the basis of self-reported falls. Results: FoG Trunk frontal RoM and velocity were larger in controls compared to freezers and non-freezers ($p<0.05$). Controls had larger trunk sagittal peak velocity compared to freezers ($p<0.05$). No differences were seen between freezers and non-freezers. CoP velocity in ML was smaller in baseline compared to the challenging standing task in both controls ($p<0.01$) and non-freezers ($p<0.05$), while no changes were seen in freezers. Fall Trunk frontal RoM and velocity were larger in controls compared to fallers ($p<0.01$) and non-freezers ($p<0.05$). Trunk sagittal RoM and velocity were larger in controls and non-fallers compared to fallers ($p<0.05$). CoP velocity in ML was smaller in baseline compared to the challenging standing task in both controls ($p<0.01$) and non-fallers ($p<0.05$), while no changes were seen in fallers ($p<0.05$). Conclusions Trunk frontal motion was smaller in individuals with PD independently of the group characteristics, which suggests a need for larger postural control in the ML direction. Differentiation between individuals with PD was possible only when divided on the basis of falls, with both trunk sagittal RoM and velocity being smaller in fallers compared to non-fallers. Interestingly, postural stability during the standing conditions did not differ between the PD groups when divided either on the basis of falls or FoG. However, both fallers and freezers showed inflexibility in the postural strategies between the standing tasks. All together, these results suggest that while most freezers were also fallers, close regulation of both static and dynamic postural stability could be a postural strategy primarily implemented by fallers to avoid postural instability when both standing and walking rather than being related to FoG.

3-N-70 Fall incidence and associated risk factors among people with a lower limb amputation during various stages of recovery - a systematic review

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Background and aim: People with a lower limb amputation (PwLLA) cope with several problems which increase their fall risk [1-2]. This increased fall risk may limit functional mobility in daily life thus compromising their health-related quality of life (QOL) [3]. There are only a handful of studies on fall incidence and associated fall risk factors in PwLLA, and none thoroughly discusses fall risk incidence and factors across the stages of recovery from amputation. Presumably, during this course, risk of falling would change due to the clinical and functional progression of the individual with amputation. The aim of this work was to estimate fall incidence and describe associated risk factors among PwLLA during various stages of recovery: the surgical ward, in-patient rehabilitation and return to community life. Methods: A systematic search of relevant English language articles was performed using PubMed and EMBASE. Out of 238 initial 'hits', six retrospective cohort studies, one prospective cohort study and nine cross-sectional studies from which fall incidence and risk factors could be extracted, were selected for critical review. Fall incidence and associated risk factors were extracted and analyzed in the context of various clinical stages of recovery after amputation. The studies were evaluated for quality using the 'Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies' [4]. Results: Table 1 depicts the results. During all stages of recovery, PwLLA are at increased risk of falling compared with able-bodied individuals, as well as other clinical populations. Each stage of recovery is associated with different fall risk factors. Conclusions: Definition of the most relevant risk factors at each recovery stage may ultimately lead to more focused and effective methods of reducing or even preventing falls at any given point post-amputation. Targeted training programs, instruction to the patients and caregivers, and technological solutions for fall prevention should be developed for PwLLA based on the patient's post-operative stage. This review highlights the need for prospective longitudinal studies of fall risk among PwLLA and the necessity for continuous, accurate and complete records of fall incidence in the clinical wards. The main contribution of this review is the ability to identify specific risk factors for falls over the various stages of recovery in PwLLA. References: [1] Tesio L et al, Clinical Biomechanics. 1998;13:83-90.

[2] Kulkarni J, Prosthetics and orthotics international. 2008;32:434-7. [3] Bolger D et al, Clinical Biomechanics. 2014;29:1039-47. [4] Systematic Evidence Reviews and Clinical Practice Guidelines, http://www.nhlbi.nih.gov/health-pro/guidelines Acknowledgments: Gesner Fund for medical research

3-N-71 Support leg muscle activity during online adjustments of trip recovery

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BACKGROUND AND AIM: Elevating trip recovery responses are generated synchronously in both legs [1]; the support leg generates push-off and counteracts the forward angular momentum of the body [2] as the tripped leg clears the obstacle. We have shown that these recovery responses can be modified online if one needs to avoid an additional obstacle in the foot landing position [3], most frequently by step shortening involving a two stage muscle activity response in the tripped leg [4]. Here we investigated whether the support leg contributes to these online adjustments of tripping responses and whether the two legs act synchronously. METHODS: Sixteen young adults walked at their comfortable speed over a walkway equipped with hidden obstacles that could cause a mid-swing trip (eliciting an elevating strategy; [2]). Participants were tripped 10 times in between a random number of normal walking trials. In 5 trips participants had to avoid a forbidden zone (FZ, 30x50 cm) shown at trip onset in the preferred foot landing position. We analyzed kinematic data of ankle, knee, and hip joint angles and electromyographic data of gastrocnemius medialis (GM), tibialis anterior (TA), rectus femoris (RF), and biceps femoris (BF) of seven subjects (24.6±3.2 years, 1 female), who successfully avoided the FZ by step shortening in all trials. EMGs were preprocessed, average normal walking activity was subtracted from the trip activity and the residual activity was aligned to trip onset and normalized to maximal normal walking EMG. Performance on trips with a FZ adjustment was compared to normal trips using wavelet functional ANOVA [5] with statistical significance set at $p < 0.05$. RESULTS: Muscle activity in the support leg's BF (from 250 ms) and GM (from 190 ms) decreased and muscle activity in TA increased (from 280 ms), leading to less knee and hip extension and decreased ankle plantarflexion, consistent with less need for propulsion and support. Muscle activity changes related to online adjustments of trip responses started 15 - 109 ms later in the support leg compared to the tripped leg (BF 235 ms, GM 107 ms, TA 171 ms)[4]. CONCLUSIONS: In contrast to the simultaneous bilateral responses seen during normal tripping, muscle activity related to trip recovery adjustments occured with a delay in the support leg compared to the tripped leg, indicating trip recovery adjustment is primarily a reaction of the tripped leg. Once step shortening starts in the tripped leg, support leg adjustments follow, probably to reflect new mechanical requirements of a shortened step. ACKNOWLEDGEMENTS AND FUNDING: Supported by European Commission through MOVE-AGE, an Erasmus Mundus Joint Doctorate program (2011-0015) and partially through the FP7 project CoDyCo (no. 600716). REFERENCES: [1] Pijnappels et al. J Biomech, 2005 [2] Pijnappels et al., Gait Posture, 2001 [3] Potocanac et al., Exp Brain Res, 2014 [4] Potocanac et al., J Neurophysiol, 2015 [5] McKay et al, J Neurophysiol, 2013

3-N-72 Gait perturbations to discriminate between older adults with and without history of falls

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BACKGROUND AND AIM: While falls among older adults are considered a major health problem, the sensitivity of conventional fall risk assessments to identify individuals at risk is poor [1]. Among the main risk factors for falls are balance and gait impairments [2]. The ability to resist or recover from gait perturbations to prevent falling requires fast and accurate responses and might discriminate between fallers and non-fallers. We therefore investigated the ability to discriminate between older adults with and without history of falls using medio-lateral and anterior-posterior gait perturbations. METHODS: Twenty-five older adults (14 females; 74.0±11.1 years of age) walked at a fixed treadmill speed (1.03±0.20 m/s) on the GRAIL (Motekforce Link BV, Amsterdam, The Netherlands). Trunk and lower limb kinematics were collected (Vicon, Oxford, UK) during steady state walking and in response to four types of perturbations: ipsi-lateral and contra-lateral platform sway and unilateral belt acceleration and deceleration. Maximum pelvic velocity per step in the medio-lateral and anterior-posterior direction was calculated during baseline walking and the first step after each perturbation. Participants were categorized as fallers or non-fallers based on their self-reported fall history over the past 12 months. Additionally, falls efficacy score (FES), physical activity questionnaire (PAQ), one-legged stance test (OLST) and the timed up and go (TUG) test were assessed. Differences between fallers and non-fallers were analysed using one-way ANOVAs. RESULTS: Seven participants (28%) reported at least one fall in the past 12 months and were categorized as fallers. Fallers showed significantly lower maximum pelvic velocity in response to the deceleration perturbation compared to non-fallers ($F=5.651$; $p=0.026$). No significant differences in maximum pelvic velocity were found during baseline walking and for the other perturbation types (Figure 1). Moreover, no significant differences were found between fallers and non-fallers for the conventional measures (i.e. the FES, PAQ, OLST and TUG). CONCLUSIONS: We successfully discriminated fallers from non-fallers based on the recovery from deceleration perturbations, while we were not able to do so by means of the conventional measures. Fallers had more difficulties in maintaining walking speed as indicated by the lower maximum pelvic velocity. On average, their maximum pelvic velocity was negative, meaning that their position on the treadmill became more rearward after the deceleration perturbation. Therefore, assessing the ability to recover from deceleration perturbations may be used to identify fall risk in older adults. The added value of other perturbation outcomes and strategies to recover from perturbations will be discussed. [1] Gates S. et al. (2008). J Rehabil Res Dev, 45(8): 1105-16. [2] Ambrose, AF et al. (2013). Maturitas, 75(1): 51-61.

3-N-73 Merging virtual reality and post-stroke fractal gait rehabilitation

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International Society for Posture and Gait Research (ISPGR) Conference abstract (3000 character limit) Conference dates: June 25- June 29, 2017 Location: Ft. Lauderdale, FL Title: Merging virtual reality and post-stroke fractal gait rehabilitation Authors: Stout, R.D & Rhea, C.K. Background and aim: Healthy gait is composed of predictable variation in stride timing, a characteristic termed fractal gait. This characteristic has been suggested to reflect the ability to adaptively alter gait as needed to functionally interact with the environment. Stride timing after a stroke can be altered and rhythmic auditory stimulation (RAS) is commonly used to retrain the desired gait timing. However, RAS provides a non-variable auditory cue to which the participant is to synchronize their gait cycle. Since healthy gait is naturally variable (i.e., fractal), providing a non-variable cue to retrain gait may not be a best practice. Previous work with healthy adults has shown that a fractal cue provided during gait training can alter stride timing in a predictable way. The purpose of this study was to determine whether fractal gait training had a similar effect in a persons who survived a stroke. It was hypothesized that stroke survivors would develop a stronger fractal gait pattern after training. Methods: Participants (N=9, 60.4 ± 5.2 years) who were post-stroke (34.56 ± 27.24 months) performed three 10 minute walking trials on a treadmill in the following order: (1) walking at a self-selected pace with no cuing (pre-test), (2) synchronizing their gait to a fractal cue (training), and (3) walking at a self-selected pace with no cuing (post-test).The fractal training consisted of left and right flashing footprints presented in virtual reality on a projection screen in front of the treadmill, providing a visual prescription of the desired stride timing. The timing of the footprints was variable and had a fractal structure quantified by detrended fluctuation analysis (DFA) of 0.98. The dependent variable was stride time of the affected and unaffected limb during each walking trial as quantified by DFA. A 3 trial (pre-test/training/post-test) × 2 limb (affected/unaffected) repeated measures ANOVA was used to determine the influence of fractal gait training. Results: A main effect for trial was observed, $F(1,8) = 20.176$, $p=.002$, $\eta 2 = .716$. Specifically, there was no difference in DFA of stride time between the pre-training ($M = 0.72$, $SD = 0.14$) and training ($M = 0.71$, $SD = 0.08$) trials, but a significantly higher DFA was observed when comparing pre-training and post-training ($M = 0.80$, $SD = 0.11$) trials. No difference between limbs was observed for DFA of stride time in any of the three walking trials. Conclusions: The fractal walking cue presented in virtual reality strengthened the fractal gait patterns in our stroke survivor population in the post-test, despite a lack in an elevated DFA during the training trial. Future work will examine why this may have occurred, including focusing on the lower SD of fractal gait that emerged during training and how this type of training effects stroke survivors with a more asymmetrical gait pattern.

3-N-74 Circumstances of imbalance leading to falls during sit-to-stand transfers in older adults

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BACKGROUND AND AIM: The ability to get up safely from a chair is essential to mobility, physical activity, and independence. Aging is associated with difficulties in performing this task, and one in seven falls among older people in long-term residential care (LTC) occurs during rising from a seated position (Robinovitch et al., 2013). Improved knowledge of how falls occur during transferring should help to elucidate targets for intervention. Therefore, we investigated the characteristics of falls during sit-to-stand transfers among older people in LTC. METHODS: We collected video footage of 217 falls experienced during sit-to-stand transfers by 128 residents (mean age 80±8 yrs; 50% women). We used a structured questionnaire (Yang et al., 2013) to identify the circumstances of each fall, including the phase of the transfer when imbalance was perceived to occur, the direction of the fall, and attempts to recover balance. RESULTS: In 71% of falls, the onset of imbalance occurred during the initiation or rising phase of the transfer, and in 29% of falls imbalance occurred during the termination or stabilization phase. In 57% of falls, a wheelchair was in use. The hands were occupied with an object at the time of imbalance in 86% of falls, most commonly the chair or wheelchair (82% of falls). Imbalance during rising was 8.7 (95%CI 4.0-18.9) times more likely due to loss of support with an external object compared to imbalance during stabilization. The initial direction of the fall was most often backward (40%), followed by sideways (26%), straight down (22%) and forward (11%). Attempts at balance recovery by stepping occurred in 25% of falls, and were 4.3 (95%CI 2.2-8.6) more likely when the imbalance occurred during stabilization compared to rising. Recovery attempts through grasping occurred in 27% of falls and were 2.0 (95%CI 1.0-3.7) more likely when the imbalance occurred during stabilization compared to rising. Most recovery attempts involved multiple steps (70%), which were 5.5 (95%CI 2.1-14.9) times more often directed backward for imbalance during rising compared to stabilization, and 3.7 (95%CI 1.3-10.9) times more often sideways when imbalance occurred during stabilization compared to rising. CONCLUSIONS: We found that two-thirds of falls during sit-to-stand transfers in older people in LTC were due to imbalance during the initiation or rising phase of the transfer, and one-third were due to imbalance during movement termination and stabilization. The most common fall direction was backward, suggesting insufficient forward momentum. Falls due to imbalance during stabilization were often accompanied by (failed) attempts to recover balance, primarily through grasping or sideways stepping, which suggest either that mediolateral balance was challenged or that backward stepping was impeded by the chair. These observations should help in designing exercise programs and environmental modifications to promote safe transferring.

3-N-75 Evidence from Video Capture of the Characteristics of Falls Leading to Hip Fracture in Older Adults in Long-Term Care

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BACKGROUND AND AIM: Over 90% of hip fractures in older adults are caused by falls (Grisso et al., 1991). A better understanding of the biomechanical characteristics of falls that involve hip fracture may inform improved prevention efforts. In this study, we analysed video footage to describe the initiation, descent and impact stages of falls that resulted in hip fracture in two long-term care (LTC) facilities. METHODS: Between April 2007 and October 2015, we captured video footage of 23 falls resulting in hip fracture, as part of a larger cohort study of falls in LTC (Robinovitch et al., 2013). The mean age of fracture patients was 85 (SD 9) and 73% were female. We analysed each video with a structured questionnaire; portions of the questionnaire have been previous described (Yang et al., 2013). We also acquired medical records on fracture type for consenting individuals. RESULTS: All 23 falls were from standing height and resulted in impact between the pelvis and the floor (see Figure). All hip fractures occurred on the same side of the pelvis that impacted the floor. The floor material was vinyl in 87% of cases, carpet in 9% and bare concrete in 4%. The activity at the time of falling was walking in 48% of cases, standing in 48%, and transferring in 4%. Attempts to recover balance by stepping occurred in 74% of cases. The initial fall direction was sideways in 65% of cases, forward in 22%, and backward in 13%. However, sideways rotation during descent was common, and impact to the pelvis occurred on the posteriolateral aspect in 65% of cases, lateral in 22%, posterior in 9%, and anteriolateral in 4%. The first body part to impact the ground was the pelvis in 35% of cases, the knee in 57% and the hand in 39% (simultaneous impacts were common). At the instant of pelvis impact, there was also ground contact to the knee in 61% of cases, the hand in 62%, and foot in 100%. In all cases, the pelvis was the site of greatest perceived energy absorption. We observed one case of a potential spontaneous hip fracture (where the fall was initiated by limb collapse). Among six cases with medical records available, five were femoral neck fractures and one was an intertrochanteric fracture. CONCLUSIONS: In this first detailed study of the circumstances of falls resulting in hip fracture, we found that all cases involved falls from standing height with the pelvis impacting the ground on the fracture side. Impact was most often to the posteriolateral aspect of the pelvis, which others have found to be the weakest loading configuration for the proximal femur (Keyak et al., 2001). While impact to the hand and knee was common, the pelvis was always the site of greatest perceived energy absorption. Only one possible spontaneous fracture was observed. These results may contribute to the improved design of wearable hip protectors and compliant flooring, and exercise-based strategies to reduce hip fracture risk in falls.

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3-O-76 Modification of the temporal gait asymmetry between laboratory and community environments in post-stroke individuals: preliminary results

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1) Background and aim: After stroke, individuals often walk slowly and with an asymmetric pattern (different left and right steps). Locomotor asymmetry (LocAsym) may be a limiting factor for post-stroke community-ambulation. To date, it is not clear how LocAsym changes between clinical/laboratory and community/ecological environments, or how it is affected by a demanding walking task such as access

ramps. The aim of this study was to determine the effect of the environment on temporal gait parameters in post-stroke individuals, during different walking tasks. 2) Methods: Preliminary data were collected for seven chronic hemiparetic individuals, who were independent walkers with residual lower-limb motor deficits. A 350m walking circuit was tested in a shopping mall (Montreal) and in our gait laboratory (Rehabilitation Institute of Montreal). Participants wore 6 wearable inertial sensors (OPAL, APDM inc.) fixed at the ankles, thighs, pelvis and chest. The specific sections of the circuit that were analyzed were eight 10-m sections of level walking, and four going-up and down sections on an access ramp. A 10-Hz Butterworth filter was applied on gyroscopic data recorded by shank sensors, and minimal angular velocity peaks (in sagittal plane) were used to define heel-strike (HS) and toe-off (TO) instants of both limbs. Mean stance and swing times were estimated for paretic (PAR) and non-paretic (NPAR) sides, based on HS and TO instants. Ratios (NPAR/PAR) were then calculated and considered symmetrical if they stayed between 0.95 and 1.05. A Wilcoxon's test was used to assess the effect of the environment on mean ratios for level walking, and going-up and going-down the access ramp. 3) Results: Walking speed ranged from 0.36 to 1.03 (mean: 0.77) m/s in the mall, and from 0.47 to 1.2 (mean: 0.75) m/s in the lab. During level walking, stance time ratio was asymmetrical in the mall (PAR < NPAR, ratio = 1.13 (0.1)) and significantly greater than in the lab (1.06 (0.12), $p<0.05$). Swing time ratios were asymmetrical in both environments (PAR > NPAR), but were significantly greater in the mall (ratio = 0.84 (0.12)) than in the lab (0.92 (0.16), $p<0.05$). When participants went up and down the ramp, stance and swing ratios were considered similar ($p>0.05$) but asymmetrical in both environments (mean stance ratio: 1.1 (0.1); mean swing ratio: 0.84 (0.09)). 4) Conclusions: These preliminary results showed that temporal LocAsym increased when walking in the community compared to walking in a controlled environment, such as a gait lab. When walking in more demanding conditions, such as going up-and-down an access ramp, LocAsym was not affected by the environment but appeared more pronounced than during level walking. Therapists should consider these locomotor variations when they assess gait abilities of post-stroke individuals, in clinical environments. An algorithm is currently being optimized to calculate spatial parameters both in ecological and lab environments.

3-O-77 Does functional electrical stimulation have greater therapeutic effects on walking than ankle foot orthoses for foot-drop?

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Background: Foot-drop of central neurological origin affects 20-30% of people who suffer a stroke and is also prevalent in other central nervous system (CNS) disorders. There are two commonly used devices for correcting foot-drop, ankle foot orthoses (AFO) [1] and functional electrical stimulators (FES) [2]. Meta-analysis of randomised controlled trials (RCT) comparing the effects of sustained use of FES or AFO on various outcome measures with them in-situ found no clear differences [3]. The use of either device for a sustained period of time is also believed to impact on a person?s unassisted walking (therapeutic effect), with authors suggesting FES may have positive and AFO negative effects. However, a direct comparison has yet to been done. Aim: To compare the therapeutic effects on walking of AFO versus FES for foot-drop caused by a CNS disorder through a systematic review of RCT literature, including meta-analysis. Methods: An a-priori strategy was used to search MEDLINE (Ovid), CINAHL (EBSCO), CENTRAL, Scopus (Elsevier), REHABDATA, PEDro & clinicaltrials.gov databases plus reference lists, citations, key authors and journals. Screening was performed by two reviewers independently and data were extracted using a pre-designed proforma; quality was assessed using the Cochrane risk of bias assessment tool. Meta-analysis was planned, where possible. Primary outcomes were activity (measured using monitors) and impairments in electromyography and kinematics; all other walking outcomes were classed as secondary. Results: Seven RCTs were included. These were deemed to be of moderate methodological quality overall. Meta-analysis was only possible for the secondary measure of walking speed, with data taken from five trials (N=327; MD= 0.03 [-0.02, 0.08]; I2=0%; p=0.24, Fig.1.) Conclusions: The therapeutic effects on walking speed for CNS foot-drop are not greater for FES than AFO. Therefore, if the aim of treatment is to increase unassisted walking speed, either can be used. However, none of the primary measures of interest could be analysed due to their inconsistent use. Therefore whether the observed gait speed increases are associated with increased activity in the users own environment remains answered. Further, it remains unknown whether the increase in speed was a result of motor recovery (e.g. improved volitional muscular activation) or compensatory strategies, or both. Further RCTs should use appropriately justified outcome measures that reflect actual performance and mechanisms-of-action. 1. Intercollegiate Stroke Working Party. National clinical guidelines for stroke. 2016, Royal College of Physicians (RCP): London. 2. National Institute for health and Care Excellence (NICE) Functional electrical stimulation for drop foot of central neurological origin. 2009. 3. Prenton, S., K.L. Hollands, and L.P. Kenney, Functional electrical stimulation versus ankle foot orthoses for foot-drop: A meta-analysis of orthotic effects. J Rehabil Med, 2016. 48(8): p. 646-656.

3-O-78 Increased neural activity in the motor areas after robotic gait training in stroke patients

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Background: The neural substrates associated with gait recovery are only beginning to be understood due to difficulties in using neuroimaging techniques during walking. The aim of this study was to assess the effect of a gait rehabilitation intervention on cortical activation of stroke patients during robotic-gait training. Methods: Nine acute stroke patients with moderate and severe walking disabilities participated in a rehabilitation intervention for 1.5 months involving robotic-gait (Lokomat) training and physiotherapy. Electromyography and spectral patterns in the neural sensorimotor rhythms were assessed at the second (baseline) and last robotic-gait training, as well as clinical scores and leg muscle activity. At the last training, patients walked at their maximal performance (post-active) and the settings at baseline (post-passive). A cluster-based permutation test (Maris and Oostenveld, 2007) was used to assess differences on the topographic distributions and strength of the event-related desynchronization (ERD). Results: A significant increase in Berg Balance Score (p=0.003), a significant decrease in bodyweight support (p<0.001) and guidance force (p<0.001) was found. Leg muscle activity was increased at the post-active measurement. The healthy hemisphere was predominantly more active than the lesion hemisphere. ERD was stronger during post-active walking compared to baseline (p<0.001) and post-active walking compared to post-passive walking (p<0.001) in the leg motor cortices and the posterior parietal cortex. Conclusion: Robotic-gait training in combination with physiotherapy has a beneficial effect on the lower limb motor functionality of acute stroke patients. This benefit effect is associated with stronger neural activity in the motor areas after robotic gait training.

3-O-79 In sync with the groove: How is synchronization accuracy altered by cue pace and perceived groove during rhythmic auditory stimulation?

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Background: People have an automatic desire to move when they hear music, and listening to music can regulate movement patterns. Rhythmic auditory stimulation (RAS) is a therapeutic strategy that applies this principle in rehabilitation among people with abnormal gait (such as Parkinson's disease or stroke). During RAS, users are typically instructed to synchronize footsteps with a musical beat that is presented at a speed individualized to match or be slightly faster than the user's baseline walking pace.

Spatiotemporal parameters of gait (e.g., stride length) during RAS can be influenced by musical groove (how much the music induces a desire to move) and instructions (to synchronize steps with music); however, few studies have examined how these factors influence synchronization accuracy. Aim: Using data from a larger study, this exploratory investigation examines: (1) how ability to synchronize with music is altered by the pace of the cue delivered and (2) how perceived groove/instructions to synchronize influence synchronization accuracy. Methods: 150 healthy young adults walked to either non-accelerated (n = 65) or accelerated (n = 85) rhythmic auditory cues. Within those groups, participants were randomized to instruction conditions (instructed to walk at comfortable pace or instructed to synchronize with music). In both conditions, participants walked across a 16-foot sensor walkway 16 times to determine baseline gait parameters. Participants then walked to high- and low-groove music that was adjusted to either match (in beats per minute) or be 15% faster than individual baseline cadence (steps per minute). In each condition, participants performed two trials to low groove music (does not induce desire to move), and two trials to high grove music (induces desire to move). Synchronization was assessed by comparing cadence (steps per minute) to stimulus beats per minute. Results: Preliminary analyses of non-accelerated RAS suggest that groove impacts synchronization accuracy. In high groove conditions, participants accurately match the target cadence; however, low groove music elicits significantly fewer steps per minute than the target. At this stage, instructions to deliberately synchronize (versus walking at a chosen pace) do not appear to influence synchronization accuracy. Further analyses will examine how pace of a stimulus (accelerated or non-accelerated) impact accuracy of synchronization while walking. Conclusions: Results indicate that a person's ability to synchronize, both spontaneously (when not instructed to synchronize) and deliberately (when instructed to synchronize), is dependent on musical groove. RAS utilizing low groove music may hinder a person's ability to accurately walk in time with the music, therefore impeding on uptake of that rhythmic pattern in their gait.

3-O-80 Multi-session transcranial direct current stimulation (tDCS) improves the physiologic complexity of dual-task postural control in functional-limited older adults

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Background and aim: The postural control system is dependent on numerous inputs interacting across multiple temporal-spatial scales. As such, its output, i.e., postural sway, is physiologically complex. Standing postural sway complexity is often diminished by performing a concurrent cognitive dual task, and this dual-task cost (i.e., the percent decrease from single- to dual-task standing) is often greater in aging and disease. Recent studies have shown that tDCS improves dual-task performance in healthy older adults. We therefore hypothesized that a 10-session tDCS intervention would reduce the dual-task cost to postural sway complexity in functionally-limited older adults. Methods: Sixteen older adults (aged 79.7±10.2 years) with mild-to-moderate executive dysfunction and slow walking speed (<0.09 m/s) completed 10 sessions of daily 20-minute real or sham tDCS targeting the left prefrontal cortex over a two-week period. Standing postural control was assessed at baseline and at 1 and 14 days following intervention. Postural sway fluctuations were recorded while participants stood quietly (i.e., single-task) on the force plate or stood while performing serial subtractions of three from a random 3-digit number (i.e., dual-task). The complexity of postural sway in both anterior-posterior (AP) and medio-lateral (ML) directions was quantified using multiscale entropy. Results: Real tDCS reduced the dual-task cost to complexity in both AP and ML postural sway fluctuations and such effects were sustained over the 2-week follow-up period ($F>3.2$, $p<0.04$, Figure 1). The dual task cost to complexity was not influenced by sham stimulation. Moreover, neither real nor sham tDCS changed the degree of complexity associated with single-task postural sway. Conclusions: Multiple sessions of tDCS targeting the prefrontal cortex reduces the dual-task cost to postural sway complexity in older adults with functional limitations. As effects were sustained for at least two weeks, this form of brain stimulation may be an effective strategy to enhance the postural control system's capacity to adapt to stressors in everyday life.

Q Neurological diseases

3-Q-81 Effect of obstacle contrast on visual behaviour in Parkinson's disease

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BACKGROUND AND AIM: The ability to safely negotiate obstacles is important for independent mobility. Appropriate processing of visual information helps to identify and distinguish environmental obstacles and their location. Visual function is compromised in Parkinson's disease (PD) with respect to appropriate observation of the environment and is linked to poorer attention[1] and impaired contrast sensitivity[2]. Together they may contribute to falls in PD during challenging tasks such as obstacle crossing[3]. The aim of this study was to determine the effect of obstacle contrast on visual behaviour and whether this was altered in PD. METHODS: Seventeen mild-to-moderate PD fallers ($\bar{x}$[SD]age:71.1[8.2]y, 10m) and 18 older adult non-fallers($\bar{x}$[SD]age:64.4[7.0]y, 9m) participated. Participants began the walking trials with their eyes closed and when prompted opened their eyes and walked to the end of a 10-metre walkway. An obstacle of high or low contrast (HxWxD 15cmx60cmx2cm) was placed half way down the walkway and the presentation order was counterbalanced. Visual behaviour was monitored using a mobile eye-tracker (Dikablis) and contextual outcomes were extracted from the approach phase (Approach time[s], movement latency[s], time spent looking at the obstacle[%], time spent looking at the ground preceding the obstacle[%] and time spent looking at the ground past the obstacle[%]). Contrast sensitivity was measured binocularly (Mars CS chart). Group medians were used to complete non-parametric comparisons between groups and obstacle conditions. RESULTS: Contrast sensitivity was reduced in PD ($\bar{x}$[SD]:1.51[0.16] vs. 1.64[0.07],p=.006). There were no group differences in visual behaviour when negotiating the high contrast obstacle in approach time (p=.126), movement latency (p=.858) and the time spent looking at the ground past the obstacle (p=.143). There was a trend for PD to spend longer looking at the obstacle but this was not significant (p=.067). In the low contrast obstacle condition, PD took significantly longer during their approach to the obstacle (4.2s vs. 3.1s, p<.001) and spent longer looking at the obstacle as a proportion of the approach phase (51.5% vs. 22.7%, p=.025) compared to the older adults who spent proportionally more time looking at the ground beyond the obstacle (75.0% vs. 29%,p=.007). CONCLUSIONS: The clarity of obstacles influences visual behaviour. Our findings suggest that increased contrast improves visual behaviour in PD so that it becomes similar to older adults. When obstacle contrast was low, participants with PD prolonged their visual attention to the obstacle to gather sufficient information regarding the obstacle proximity and dimensions which limited their capacity to scan for future obstacles. Future studies will explore the manipulation of contrast within natural environments where the presence and location of trip hazards such as obstacles are not known.
REFERENCES: [1]Galna 2012 BrainRes 1473 35-43 [2]Hwang 2013 J Neurosci 33 14989-14997 [3]Gazibara 2014 Geriatric Nursing 35 364-369 ACKNOWLEDGMENTS AND FUNDING We thank the V-TIME participants for their time and commitment. We thank all the V-TIME partners. The project was funded by the European Commission (FP7 project V-TIME-278169)

3-Q-82 The effects of transcranial direct current stimulation on gait initiation in people after stroke

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Background and aim Chronic stroke patients have lower gait initiation speed than healthy controls[1]. As transcranial direct current stimulation (tDCS) has been reported to improve hand motor control in people with stroke[2], we aimed to investigate whether tDCS would also have a beneficial effect on gait initiation. For patients, 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 leg motor output. Methods We included 7 chronic supratentorial stroke patients, 10 healthy age-matched controls, and 10 healthy young adults. Participants completed three sessions on separate days (one week apart), receiving 15 min of anodal, cathodal or sham stimulation (2mA) over the primary motor cortex in an order balanced across participants. For healthy controls, side of stimulation was balanced between hemispheres. After stimulation, participants were instructed to initiate gait with their preferred leg as fast as possible in response to a visual cue (12 trials). So far, we determined onset latencies of tibialis anterior (TA) and rectus femoris (RF) of the stepping leg, as measures related to the anterior postural adjustments (APA). As the data was not normally distributed, nonparametric tests were used to identify the effects of tDCS. Results No differences were found in the effects of stimulation between stroke patients and healthy controls. For TA, c-tDCS showed a trend towards delayed motor responses compared to sham stimulation (148 vs. 141ms, p=0.061), which was not found for RF (148 vs. 148ms, p=0.393). In both muscles, a-tDCS did not influence onset times compared to sham stimulation (TA: 138 vs. 141ms, p=0.970; RF: 141 vs. 148ms, p=0.141). In both muscles, c-tDCS delayed reaction times compared to a-tDCS (TA: median 148 vs. 138ms, p=0.026; RF: median 148 vs. 141ms, p=0.035). Four out of 7 stroke patients stepped with the ´stimulated´ leg (directly by a-tDCS or indirectly by c-tDCS). In controls, this was the case for 9 out of 20 participants. We did not observe differences in the effect of tDCS between subjects who stepped with the ´stimulated´ leg and those who did not. Conclusion Contrary to our expectations, we found no evidence of any tDCS-induced benefits in muscle reaction times of gait initiation. Remarkably, c-tDCS tended to delay reaction times in all groups, where a beneficial effect was specifically expected in the stroke patients. It must be noted, however, that these results apply to a limited set of outcome variables, which findings do not yet rule out any effects of tDCS on other relevant characteristics of gait initiation (e.g. size of APA or step onset). These results will be included at the time of the conference. [1]Tokuno and Eng. Gait & Posture, 2006 24(4):424-8 [2]O´Shea et al. NeuroImage, 2014 (85):924-933

3-Q-83 The Turning Point: Dynamic stability in people with Parkinson's disease

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Background and aim: The ability to turn safely while walking is crucial for functional mobility. Even early in the disease, people with Parkinson´s (PD) experience difficulties turning. Recently, we showed that people with PD who have dyskinesia walk and turn more quickly when taking levodopa, but become unstable during standing and fall more in daily life. The goal of this study is to determine the contributions of dyskinesia to abnormal turning mechanisms. Methods: Participants performed preplanned turns to the left and right, at different turn angles (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. Participants were tested in the practical OFF state, after withholding their antiparkinsonian medication for at least 12 hours. Subsequently, they were retested in their ON state, 1 hour after taking a suprathreshold dose of levodopa; i.e., 1.25 times of their regular dose. To capture full body kinematics and center of mass (CoM), 30 reflective markers were attached to the participants´ anatomical bony landmarks. The reflective markers were tracked using a 12-camera motion analysis system sampling at 120Hz. Data collection and analysis is ongoing; a total of 15 people with PD have been assessed so far. Results: Preliminary results suggest that people with PD walk and turn faster when in the ON medication state. Furthermore, participants turned with a wider arc when ON medication. This was even more prominent in people with PD who showed clinical signs of dyskinesia during testing in the ON state (see Figure 1). Figure 1 illustrates turns of 90 and 135 degrees at fast walking speed of the same individual. Gray lines are given as reference for the turn angle in increments of 45 degrees. Trajectories of the CoM (blue line) and the velocity adjusted position of the CoM (i.e. extrapolated CoM (XcoM), red line) are shown with respect to the base of support (BoS, dashed line), which was defined by the excursion of the lateral malleoli. Dynamic stability is reduced when the XcoM is outside or very close to the stepping BoS. Conclusions: The increase in turning speed and wider turn radius are signs of disinhibition in PD with levodopa-induced dyskinesia. This disinhibition may lead to more unsafe turning strategies. Further analysis will be performed to confirm our observations. Acknowledgements and funding: This work was supported by the Medical Research Foundation of Oregon.

3-Q-84 The effects of a cognitive dual-task on reactive postural control in people with Parkinson's disease

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Background and aim: Parkinson's disease (PD) is characterized by loss of automaticity due to dysfunction of the basal ganglia. Dual-tasks (DT) can be used to assess the load on attentional processes needed for task execution. Previous research has shown that balance and gait deteriorate more under DT conditions in people with PD compared to healthy elderly, and this is associated with falls. However, the effect of a cognitive DT on reactive postural control is yet unknown. Therefore, this pilot study aimed to determine the effect of a cognitive task on the quality of reactive postural control in PD. Methods: Reactive postural control was assessed in 16 patients with PD ON-medication and 12 age-matched healthy elderly in a single task (ST) and a DT. Participants were instructed to maintain their balance while standing on a moveable platform, which was translated in forward, backward and lateral (i.e. left and right) directions (3 perturbations in each direction). Surface translations were applied in two conditions: 1) quiet standing (ST) and 2) quiet standing while performing the Forward Digit Span (FDS) delivered by headphones (DT). Subjects were asked to divide attention equally over both tasks. The FDS was also performed in sitting. Postural task performance was measured by center of pressure (CoP) displacement in the perturbation direction (i.e. anteroposterior for forward and backward translations and mediolateral for lateral translations). Results: In all directions, CoP displacement in response to a surface translation was not significantly different between people with PD and healthy elderly. However, a non-significant trend (p=.07) indicated that the CoP displacement was greater in people with PD than in healthy elderly for backward surface translations. Irrespective of group, the CoP displacement was greater in the DT than the ST condition for posterior (p=.032) and anterior (p=.018) surface translations. A non-significant trend (task x group interaction effect: p=.053) indicated that for backward translations people with PD tended to have a greater increase in CoP displacement in the DT compared to the ST than healthy elderly. People with PD performed worse on the FDS than healthy elderly (p=.016). However, no differences were found between ST and DT. Conclusions: Overall, the impact of a cognitive DT on reactive balance tended to affect backward translations in PD. Irrespective of group, the cognitive DT influenced reactive postural control only in the anteroposterior, and not in the mediolateral direction. In both ST and DT, people with PD performed worse on the cognitive task compared to healthy elderly, suggesting that task prioritization was similar in both groups. We explain the relatively minor impact of DT on reactive balance in PD, as possibly due to the insufficient load of the DT, ON-medication status, the lack of statistical power or the fact that reactive postural control is less influenced by cognitive processing.

3-Q-85 The Spatiotemporal Gait Adjustments during a Virtual Obstacle Crossing Task in Adults with Diabetes

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A precise motion execution such as stepping over an obstacle relies intensely on the top-down motor control. This neuromuscular control in patients with diabetes mellitus (DM), however, has been shown deteriorated over time and developed as diabetic peripheral neuropathy (DPN). Patients with DPN demonstrated a prolonged reaction time, poor postural control, and a higher risk of falling/tripping. Therefore, this study aimed to compare the different motion executions conducted in DM, DPN and age-matched healthy group by investigating the gait adjustments while being confronted with forthcoming virtual obstacles. We hypothesized that DPN would show the lowest task successful rate during an obstacle crossing task (OCT) and the decreased maximal toe elevation (MTE), step length, stride length, and increased step width, stride/swing/stance time. Also, DPN would increase the variability of the spatiotemporal gait characteristics when stepping over the virtual obstacles. Thirty-two subjects [11 Type 2 DM, 10 DPN and 11 age-matched healthy young adults (HYA)] were recruited to perform a virtual OCT which was projected ahead and created with the dimensions of 45cmx20cmx15% subject's leg length using D-flow software. The virtual obstacles appeared at the end of the corridor and moved towards subjects. Subjects were instructed to step over the virtual obstacles starting with their dominant leg. After the familiarization of six-minute treadmill walking at the self-selected pace, subjects completed ten virtual OCT on the treadmill. Three-dimensional spatiotemporal kinematic data were collected using VICON motion capture system at 100 Hz and processed along with Nexus. The spatiotemporal gait characteristics including toe elevation of dominant leg before, during, and after crossing event (i.e. planning, crossing, and recovery phases) were calculated using MATLAB. For comparing the between-group difference, the Kruskal-Wallis one-way analysis of variance by ranks test was adopted following by Mann-Whitney U test for multiple comparisons. The Friedman analysis of variance by ranks test was adopted for testing the within factor difference (i.e. phase effect) following by Wilcoxon signed-ranks test as multiple comparisons. Subjects with DPN showed the lowest OCT successful rate than HYA (by 15%) and DM (by 2%). In the spatial gait domain, DM showed a significantly decreased in the leading MTE when compared to HYA during the crossing phase of OCT. In the temporal gait domain, DPN showed a significantly increased stride time and stance time in the recovery phase when compared to the HYA. Concerning the variability, DPN and DM significantly decreased their step length variability when compared to HTY in the recovery phase. The non-significant changes in spatial gait domain may be caused by the constraint of treadmill walking which was different from overground walking. DPN demonstrated prolonged temporal gait characteristics in the recovery phase of OCT and which could beinferred as a compromised top-down neuromuscularcontrol. The unexpected findings of reduced step length variability can be explained as both DM and DPN tended to be more rigid (less varied) in gait and cautious after the event of OCT to retain their dynamic balance.

3-Q-86 Evaluation and implementation of highly challenging balance training in clinical practice for people with Parkinsons disease: protocol for the HiBalance effectiveness-implementation trial

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BACKGROUND AND AIMS: The HiBalance program is designed to target balance impairments in Parkinson's disease (PD) and has been shown effective at improving balance control and gait in a previous randomized controlled trial (RCT). If people with PD are to avail of evidence-based rehabilitation, programs such as HiBalance must be adapted and tested in clinical effectiveness studies in order to strengthen their evidence base. We are carrying out an effectiveness-implementation trial that will assess the clinical effectiveness the HiBalance program for people with mild-moderate PD while simultaneously collecting data describing how the program is implemented. Study aims are to i) determine the effectiveness of the adapted HiBalance program on performance and self-rated outcomes such as balance control, gait and physical activity level ii) conduct a process evaluation of program implementation at the various clinics iii) determine barriers and facilitators to program implementation in these settings. METHODS: This effectiveness-implementation type 1 hybrid study will use a non-randomized controlled design with consecutive inclusion of people with PD (n=100) at multiple outpatient sites in Stockholm, Sweden. Clinical effectiveness outcomes concern performance of balance, gait and physical activity level, measured using; Mini-BESTest; 10-meter walking test; Timed Up and Go test; accelerometer data and self-reported measures. The Consolidated Framework for Implementation Research (CFIR) will guide the collection of data concerning barriers and facilitators to program implementation. The HiBalance program will be provided by physical therapists as a part of standard rehabilitation care at the clinical sites, while evaluation of the implementation process will be performed by the research group and funded by research grants. Program adaptations include reduction of the training dose from 30 to 20 group training sessions and selection of outcomes measures more suited to clinical practice. A pilot study was performed among 13 people with mild-moderate PD (mean age 69 years; male/female; 5/8) to test the feasibility of these adaptations. PRELIMINARY RESULTS: Findings from the pilot study indicate that the adapted HiBalance program appears feasible in less-controlled clinical settings regarding patient safety, pain and excess fatigue. Compliance to group training sessions was very high (90%). A majority (66%) of patients reported that their balance was challenged to 'a large extent'. CONCLUSIONS:An effectiveness-implementation study design benefits patients by speeding up the process of translating findings from research settings to routine health care. Findings from this study will be highly relevant for those working with neurological rehabilitation when faced with decisions concerning the translation of training programs from efficacy studies to everyday clinical practice. ACKNOWLEDGEMENTS AND FUNDING: The authors wish to acknowledge all patients and physical therapists actively involved in the trial. This study has been funded by The Swedish Research council for Health, Working life and Welfare (FORTE), The Swedish Research Council, 'Vårdalstifelsen' and the Swedish Parkinson Foundation.

3-Q-87 Effect of botulinum toxin-A injections for spasticity management on volitional and compensatory stepping

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BACKGROUND AND AIM: Spasticity - increased resistance to passive movement - is a common consequence of stroke, with a prevalence of 38% in the first year after stroke[1]. Lower limb spasticity negatively impacts gait speed[2]; but, the impact of spasticity on balance control has not been fully explored. Spasticity management with focal injections of botulinum toxin improves gait outcomes[2]. However, in a recent systematic review, we found few studies examining the effect of botulinum toxin injections on balance using quantitative outcomes[3]. This study aimed to determine whether injections of botulinum toxin in lower limb muscles enhance balance control. METHODS: Individuals with stroke scheduled to receive botulinum toxin injections in the lower limb were recruited. Assessments took place at 4 time points: 4 weeks prior to scheduled injection, 2 weeks prior to injection, 4 weeks after injection and 8 weeks after injection. Participants performed between 1-3 repetitions of a single volitional step with their preferred leg. In addition, 1-3 perturbations were applied using a lean-and-release system. Time to stabilization of the centre of pressure (COP; time elapsed for COP velocity returned to that of prior to instability) was the primary outcome measure. Modified Ashworth Scale score (MAS), Chedoke-McMaster Stroke Assessment (CMSA foot and leg) and Berg Balance Scale (BBS) were also used to characterize spasticity, impairment, and functional balance, respectively. RESULTS: To date, 4 participants (2 female, 61 (12) years) in the chronic stage of recovery (8-128 months post-stroke) have been enrolled (3 with complete assessments, 1 assessment ongoing). Despite clinically significant reduction in the median MAS at the ankle 1 month after injection (MAS = 3,3,2,3 across time points), no clinically significant changes in CMSA (foot = 2 at all time points, leg = 3 at all time points) or BBS (24-26 across time points) were observed. In volitional stepping, the mean (SD) time required to achieve stability was 0.97 (0.33), 0.87 (0.42), 0.67 (0.32), and 0.93 (0.63) seconds across time points. Two participants completed perturbation testing. Mean time to stabilization was 1.24 (0.14), 1.17 (0.25), 1.14 (0.20), and 1.52 (0.17) seconds across time points. CONCLUSIONS: Preliminary data reveals that administration of botulinum toxin reduces spasticity, but does not improve balance, based on clinical outcomes. Time to stabilization following a volitional step and postural perturbation is reduced 4 weeks after the administration of focal injections of botulinum toxin A to lower limb muscles, but increases after the effects of the injections have subsided. One possible mechanism is reduced co-contraction in the stance limb which may facilitate weight transfer and reduce loading time on the stepping limb. Data collection is ongoing. References: 1) Watkins C, et al. 2002, Clin Rehabil, 16; 2) Lamontagne A, et al. 2001, APMR, 82(12); 3) Phadke C, et al. 2014, ExpRevNeurother, 14(3). ACKNOWLEDGEMENTS AND FUNDING: This work is supported by a Canadian Partnership for Stroke Recovery Catalyst Grant (GM).

3-Q-88 Obstacle height or quantity: which causes more gait adaptations during approach phase in Parkinson's disease?

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BACKGROUND: Previous studies have indicated that in the presence of obstacle, people with Parkinson`s disease (PD) decrease stride length, swing phase duration and gait velocity, and increase double support duration compared to healthy older people [1, 2]. Since we face a large variety of size and amount of obstacles every day, can obstacle height or quantity influence gait in PD? To answer this question, this study aimed to analyze the influence of obstacle height and quantity during walking in gait parameters in people with PD. METHOD: Nineteen people with mild-moderate PD and 19 age and sex matched healthy individuals (control group) were required to walk at a self-selected speed on a pathway in five conditions (three trials per condition): no obstacle (NO), low single obstacle (LSO), low double obstacles (LDO), high single obstacle (HSO), and high double obstacles (HDO). The second obstacle was positioned 108cm from the first in double obstacles conditions. The obstacles were made of foam (low: 5cm; high: 15cm). Stride length, width, duration, and velocity, and percentage of time in swing phase, single support, and double support were calculated for the approach phase (last stride before the obstacle) and mid-pathway stride in NO condition. A carpet with pressure sensors (GAITRite®) was used for gait parameters acquisition. ANOVA two-way, with repeated measures, was performed to compare experimental conditions and Bonferroni post hoc tests were used to localize the differences (p<0.05). RESULTS: PD group, in all conditions, presented shorter stride length and higher double support time in relation to control group. PD group also showed lower single support in NO, HSO and HDO and lower swing phase in LSO and LDO compared to control group. In addition, both groups decreased stride length in LSO, LDO, HSO and HDO in comparison to NO (mean reduction for PD= 9.73% and control group= 3.92%). PD group decreased both the single support in HSO and HDO compared to NO, LSO and LDO and swing phase in LSO and LDO compared to NO, HSO and HDO, and increased double support in all obstacle conditions compared to NO, while these variables remain unchanged in control group. Participants also decreased the stride velocity in all obstacle conditions, with slower stride velocity for PD group than control group. CONCLUSIONS: Older people, in general, modulate gait spatial parameters during approach phase. However, PD group also modulate temporal parameters, increasing double support and decreasing swing phase/single support, which can be interpreted as conservative strategy [1]. Our results highlight that the PD gait modulations depend more on the obstacle height than on its quantity. In high obstacle, the modulation occurs earlier (single support - two-steps before obstacle) than in low obstacle (swing phase - last step before the obstacle). FUNDING SOURCE: This study was supported by the Fundação de Amparo à Pesquisa do Estado de São Paulo as a scholarship (FAPESP # 2013/27032-0). REFERENCES: [1]Vitório et al. (2010) Gait Posture; [2]Galna et al. (2010) Hum Mov Sci.

3-Q-89 What is the relation between Unilateral Spatial Neglect and biases in Verticality perception after stroke?

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background Unilateral spatial neglect (USN) and biaises in verticality perception are frequently associated after right hemispheric cerebral stroke (Pérennou et al 2006). These troubles in spatial cognition have also in common to present different clinical types, according to the space considered: personal (PN) and extra-personal neglect (EPN), and biases in the visual (VV) or the postural (PV) vertical. Here we hypothesized that PN is specially related to a biased PV, and that EPN could be more related to a biased VV. Methods Forty-six patients (25 females, 41 right-handed, mean age = 62) were submitted to neuropsychological and verticality perception assessment at 30, 60, and/or 90 days after a first right hemispheric stroke. Z scores on neuropsychological tests were used to compute a composite score for PN (based on Bisiach test, thumb find test, Comb test, Fluff test and 4 items of the Catherine Bergego Scale, CBS) and EPN (based on bells cancellation test, clock drawing test, overlapping figures task, copy of a landscape, text reading, and 4 items of the CBS). A diagnosis of PN or EPN required at least two abnormal tests. Verticality assessment comprised both VV and PV, considered abnormal for a contralesional bias over 2.5°. We tested the link between neglect and verticality perception by conducting linear regression analyses, on NC and NEC, with VV and PV as predictors. Results PN and EPN were found in 28 and 32 patients, respectively. A biased verticality perception was found in 24 patients for VV; among them, 5 without NSU, 12 had PN+EPN, 1 PN, 6 EPN and in 17 patients for PV; among them, 1 without NSU, 13 PN+EPN, 3 EPN. Regression analyses showed that PV was significantly associated to PN (F=15.4; p<.001) but also to EPN (F=9.4; p<.01). No significant effect was found for VV. Discussion Findings confirm the link between neglect and verticality perception. However, instead of showing specific links VV-EPN and VP-PN, results showed that both EPN and PN severity predict a biased PV (but not a biased VV). The stronger links was found between PV and PN, in relation with the body space.

3-Q-90 Do Individuals with Parkinson's Disease Initiate or Suppress Unintentional Saccade Eye Movements to Incoming Visual Stimuli?

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Background and Aim: Control of saccadic eye movements following concussion injury is coming to the forefront of research in diagnosis and management of concussion injuries. Data from our laboratory using interactive gaming technology has consistently observed that athletes who have sustained a concussion injury display an inability to stabilize gaze on a central area and make significantly greater "off-target" saccadic eye movements to incoming visual stimuli. These observations suggest disruption to inhibition of the superior colliculus via the basal ganglia. The implication of basal ganglia dysfunction following concussion injury posed an interesting research question regarding whether Parkinsonian patients would exhibit similar behaviour. Therefore, the purpose of the current study was to determine if individuals with Parkinson's disease display an inability to suppress saccadic eye movements to incoming visual stimuli during a task where the goal was to stabilize gaze in the centre. Methods: Twelve individuals (ages 37-70) with Parkinson's disease (Hoehn & Yahr stages 1-3) participated in the study. Participants completed several motor tasks to describe their motor symptoms: the Timed Up and Go test (TUG) including cognitive and manual subtests; the motor portion of the Unified Parkinson's Disease Rating Scale (UPDRS); and the Falls Efficacy Scale (FES) questionnaire. During interactive game play, participants stood on the WiiFit (Nintendo, Kyoto, Japan) Wii Balance Board (WBB) and played four trials of the WiiFit Soccer Heading Game. Eye movements were recorded using a monocular eye tracker at 30 Hz (Mobile Eye-XG, ASL, Bedford, MA) and electrooculography (EOG) were collected at 1000 Hz (iWorx, Dover, NH). The eye tracker was used to measure the location of saccadic eye movements while the EOG facilitated better temporal resolution for the saccadic eye movements. Results: Preliminary analyses indicate that individuals with Parkinson's disease make few saccades from the centre of the screen. This is in contrast to what we have observed in athletes with concussions. However, variability among the Parkinsonian participants points to some role of experience and disease severity in this behaviour. Detailed analyses are ongoing and additional testing sessions are scheduled for examination of behaviour over repeated play. Conclusions: This work provides an interesting comparison of context specific saccade behaviour between concussion injuries and Parkinson's disease. It may provide further insight into the role of the basal ganglia-superior colliculus pathway in selective visual attention of targets.

3-Q-91 Time course of gait improvement in patients with idiopathic normal pressure hydrocephalus after lumbar puncture over 72 hours

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Background and aim: Determination of gait improvement after lumbar puncture (LP) in idiopathic normal pressure hydrocephalus (iNPH) is crucial, but the best time to do this assessment is unclear. The aim of the study was to determine the time course of walking improvement after LP for single task (ST) and dual task (DT) walking conditions in iNPH. Methods: In iNPH patients, sequential recordings of gait velocity were obtained prior to LP (TP0), 1-8 hours after LP (TP1), 24 hours after LP (TP2), 48 hours after LP (TP3), and 72 hours after LP (TP4). Gait analysis was performed using a pressure sensitive carpet (GAITRite) under four conditions: Walking at preferred velocity (STPS), walking at maximal velocity (STMS), dual task "serial 7" (DTS7), and dual task "verbal fluency" (DTVF). Results: Twenty-four iNPH patients with a mean age of 76.1 ± 7.8 years were included in this study. Objective responder status moderately coincided with the self-estimation of the patients with high false positive subjective results (83%). The extent of improvement was higher for ST compared to DT ($p<0.05$). Significant increases of walking speed were found at TP2 for STPS ($p=0.042$), and DTVF ($p=0.046$), and at TP3 for STPS ($p=0.035$), DTS7 (p=0.042), and DTVF (p=0.044). The enlargement of ventricles (Evans? Index) positively correlated with early improvement. Gait improvement at TP 3 correlated with the shunt response in 18 patients. Conclusions: Quantitative gait assessment in iNPH is important due to the poor self-evaluation of the patients. The maximal increase in gait velocity can be observed 24 to 48 hours after LP. This time point is also best to predict the response to shunting. For DT paradigms the maximal improvement appears to be later (48 to 72 hours). Assessment of gait should be performed at day 2 or 3 after LP.

3-Q-92 Subthalamic deep brain stimulation frequency differentially modulates motor and cognitive control of gait initiation in PD patients

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Background: High frequency deep brain stimulation of the subthalamic nucleus (DBS-STN) is an efficient treatment to improve motor and non-motor signs in Parkinson's disease (PD) patients. However, its effect on gait disorders and postural instability, including the freezing of gait (FOG) phenomenon, is controversial with some patients being improved while others reported an aggravation. The influence of the stimulation frequency of DBS-STN has been suspected with low-frequency DBS-STN producing clinical improvement in some patients. To further understand the effects of the DBS-STN frequency on the control of gait and balance, we examine the effects of low (80 Hz) vs high (130 Hz) frequency DBS-STN on gait initiation process in PD patients in a double-blind randomized cross-over study. As the FOG preferentially occurs during conflict situations, we coupled gait initiation with a conflict paradigm. Methods: Nine PD patients (age: 57 ± 12 years) candidates for DBS-STN and 14 controls (age: 65 ± 5 years) were recruited. The gait initiation process was recorded with a force platform while subjects were asked to initiate gait both normally and during a visual conflict task that consisted to initiate gait or not depending on a pictogram projected onto a screen. The pictogram used was the pedestrian of the traffic light with 2 colors, red and green, and 2 positions, static and mobile. The patients were asked to initiate gait depending on the color or the position of the pedestrian. The following anticipatory postural adjustments (APAs) and execution biomechanical parameters were measured: the maximal posterior and lateral displacements of the CoP during the APAs, the length, width and velocity of the first step and the APAs and double stance time durations. PD patients were examined both before surgery without (OFF) and with (ON) levodopa treatment and after surgery with low (80 Hz) and high (130 Hz) DBS-STN. Results: In comparison to normal gait condition, the conflict-gait induced a significant increased reaction time in both controls (p<0.001) and in all treatment conditions for PD patients (p<0.001). In control subject, the conflict-gait task induced an improvement in both phases of gait initiation. However, no significant changes in the APAs and execution parameters were found in PD patients before surgery (OFF and ON levodopa). After surgery, the conflict-gait task induced a significant increase in the APAs phase and double-stance time duration and significant decrease in the anteroposterior and mediolateral CoP displacements and step length when high-130 Hz DBS-STN was applied. Conversely, no significant change in APAs or execution phases was observed during the conflict task when low-80 Hz DBS-STN was applied. Conclusions:Our study reveals for the first time that high frequency DBS-STN provokes an inability to simultaneously process motor and cognitive information leading to an aggravation of the gait initiation process. Conversely, low frequency DBS-STN has no deleterious effect on this processing. These results suggest that low and high frequency DBS-STN differentially modulate neuronal networks involved in these two distinct information processing. Finally, this also argues for the use of low frequency DBS-STN in PD patients that suffer

3-R-93 MoCA Item Score Analysis and Relationship to Rehabilitation Outcomes in Lower Extremity Amputees

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Background and aim: Diabetes and peripheral vascular disease are common causes of amputation that may also cause impairment in cognition. Cognitive impairment has implications for physical functioning following lower extremity amputation (LEA). The objective of this study is to investigate the association between cognitive functioning, as measured by the Montreal Cognitive Assessment (MoCA), and functional outcomes following prosthetic rehabilitation in those with LEA of dysvascular etiology. Methods: A retrospective chart audit on consecutive admissions (n=130, age 66.21 ± 11.19 years) of LEA that had data at admission and discharge from inpatient prosthetic rehabilitation. Cognitive status was assessed using the MoCA. The L Test and the 2 Minute Walk Test (2MWT) were used to estimate functional mobility and walking endurance. Analysis of variance (ANOVA) was used for determination of variance of L Test and 2MWT scores across MoCA items. Multivariable linear regression was used to evaluate the strength of associations between items on the MoCA and functional mobility and walking endurance, measured by the L Test and 2MWT respectively. Results: Variability was seen in L Test scores across MoCA items of visuospatial/executive functioning ($p<0.001$), naming ($p=0.006$) and orientation ($p=0.006$), and in 2MWT scores across items of visuospatial/executive functioning ($p<0.001$), attention ($p=0.033$) and orientation ($p=0.015$). In multivariable linear regression analysis, time to complete the L Test for those that scored the lowest on the MoCA items of visuospatial/executive functioning and delayed recall, and 3 on attention (/6) were significantly different than those who scored the highest. For the 2MWT, those who scored two on the visuospatial/executive (/5) or language (/3) items had statistically different distances walked in two minutes, compared to those that scored the highest. These values were not clinically relevant. Conclusions: This study demonstrates that cognitive functioning impacts functional mobility following rehabilitation for LEA, as lower scores on MoCA items of visuospatial/executive functioning, attention and delayed recall were associated with a longer time to complete the L Test. Individuals with LEA have an increased risk for cognitive impairment related to amputation etiology, highlighting the importance of cognitive testing for this population.

3-R-94 A Computational Algorithm of Whole Spine Posture Tracking for the Gait Analysis of Patients with Spine-Related Disease

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BACKGROUND AND AIM: Having a kinematic model of the entire spine during gait would be a useful tool for monitoring a spine-related disease. A skin marker-based motion capture system is a non-invasive method without contraindications for patients health. However tracking the whole spine posture in a clinical setting is not easy due to inaccurate markers placement by palpation or markers detection loss. Especially for long time walks, manual correction task is quite demanding. Therefore we propose an algorithm to compute the whole spine posture including spinal angles. METHODS: We developed: 1. Segmentation of relevant time ranges. The experimental walkway consisted of 2 straight paths and 2 semicircular ones. Steady gait on the straight path was detected and the gait cycles therein are extracted. Two strides at the beginning and at the end of the walk were extracted for comparison purposes. 2. Spine markers labeling, correction and computation of range of motions (ROMs) according

to Cobb method. Labeling and correction were done by imposing constraints using a 3D fitting of the static data to the dynamic data, in case of missing marker. As for ROMs, the two lines passing through the previous and the next vertebra of the ones of our interest were detected and used to compute the vertebral deformity angle. The algorithm was tested with a 23-year-old female patient who was diagnosed with dropped-head syndrome. Lateral view showed cervical kyphosis centered on the mid-cervical spine. The experiment was conducted at University of Tsukuba Hospital using a motion capture system (VICON MX). The patient was attached with 47 markers-15 of them on the spine-and 6 EMG sensors (Delsys Trigno), and was asked to walk at her comfortable pace for 800 m on the walkway. Spinal angles and EMG data were normalized according to the detected step cycles and used to evaluate kinetic changes after long distance walking due to kyphosis. RESULTS: The patient walked without pain. Even though the raw data had several missing values the spine posture was successfully obtained. By comparison of the kinetic values between the first and the last strides, slight increase of kyphotic angle was observed in C6-C7, T2-T3, T3-T4, T5-T6 and decrease in C7-T2, T4-T5. Muscular activation increased in bilateral paraspinal muscles and left latissimus dorsi, and decreased in right latissimus dorsi and bilateral erectus spinae (Table). CONCLUSIONS: The proposed method solved the labeling and correction problem, and computed spinal angles and trunk muscle activation during gait using a novel algorithm for a case with dropped-head syndrome. For future works comparison between the markers positions and the spinous processes positions taken from the x-ray image is expected, in order to overlay the correct position and alignment on the markers trajectory. Knowing the vertebrae shape can improve the precision of ROMs as well.

T Psychiatric disorders

3-T-95 Lower extremity kinetics during gait in individuals with bipolar disorder

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BACKGROUND AND AIM: Bipolar disorder (BD) is a psychiatric disorder that is defined by mood instability and changes in energy and motor behavior. Previous studies suggest that BD may be associated with changes in gait kinematics but investigating lower extremity gait kinetics may be useful for more precisely understanding changes in energy and motor behavior that occur during different phases of BD. We aimed to investigate joint moments and powers in the lower extremity during gait in BD. METHODS: Bipolar patients (n=18) and healthy controls (HC; n=13; age=41.9±13.1 yrs; BMI=25.7±5.3) recruited from the Prechter Longitudinal Study of Bipolar Disorder walked at comfortable, slow and fast speeds. We used the Altman Self-Rating Mania Scale (ASRM) and the Patient Health Questionnaire (PHQ-9) to classify bipolar patients by phase into hypomanic (HG; n=3; age=51.7±13.7 yrs; BMI=24.5±2.35; ASRM=13.7±5.7; PHQ-9=1.3±1.5), euthymic (EG; n=6; age=35.8±7.0 yrs; BMI=25.2±3.9; ASRM=2.7±1.8; PHQ-9=2.0±1.3) and depressed (DG; n=9; age=37.8±10.6 yrs; BMI=25.3±4.2; ASRM=2.2±1.6; PHQ-9=13.4±7.5) groups. Motion data were obtained using a 3D motion capture system (Motion Analysis, 120 Hz) and a force plate (AMTI, 1200 Hz), and joint moments and powers in the hip, knee and ankle were computed during stance using Visual 3D (C-Motion). We compared differences between groups using one-way ANOVA with Tukey correction. RESULTS: Gait speed (m/s) was greater for HG (1.59±0.16) than for EG (1.22±0.13), DG (1.18±0.28) and HC (1.23±0.11)($p<0.05$) at comfortable speed. Gait speed was similar among groups at slow (0.79±0.21) and fast (1.80±0.25) speeds. For comfortable speed, Peak knee extension moment (Nm/BW) was greater for HG (0.81±0.30) than for DG (0.43±0.22) and HC (0.45±0.14)($p<0.05$). Peak knee flexion moment was greater for HG (0.69±0.20) than for EG (0.42±0.07), DG (0.38±0.13) and HC (0.44±0.08)($p<0.05$). Maximum knee power (W/BW) for HG (2.42±0.86) was more than double that of EG (0.91±0.23), DG

(0.77±0.57) and HC (0.98±0.32)($p<0.05$). Maximum ankle power was greater for HG (5.26±0.88) than for EG (3.07±0.54), DG (3.17±1.33) and HC (3.52±0.53)($p<0.05$). For slow speed, peak knee flexion moment was greater for HG (0.50±0.11) than for DG (0.27±0.11)($p<0.05$). Maximum knee power was greater for HG (0.79±0.65) than for EG (0.29±0.09), DG (0.31±0.19) and HC (0.27±0.14)($p<0.05$). For fast speed, joint moments and powers were similar among groups. CONCLUSIONS: The results suggest that lower extremity gait kinetics may be mood-specific, particularly at the knee. The results also suggest that assessing knee moments and powers may provide information about changes in energy due to mood symptoms in BD, especially with regard to understanding body movement characteristics associated with hypomania, and further investigation of gait in BD with larger sample size is warranted.
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U Sensorimotor control

3-U-96 Action reprogramming in stepping movements: focal versus postural actions

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BACKGROUND AND AIM: The process of switching from an expected to an unexpected action is known as action reprogramming (AR). Previous work on upper limb movements has shown that reprogramming a focal movement exacts a temporal cost, possibly due to having to reprogram some part of a response prepared in advance. Lower limb movement is compounded by a greater challenge to postural control. Focusing on correctly made stepping movements, we investigated AR during stepping using a probabilistic reaction time stepping task (PRTS) to find out whether a similar temporal cost is seen at Step Onset, and whether anticipatory postural adjustment (APA) Onset is equally prolonged. Additionally, we sought to find out whether the APA was correctly suited to the new stepping movement when AR occurred. METHODS: Young participants (n=15; mean age:23.73±1.60) trained to make different steps in response to different visual stimuli, then performed the steps during a PRTS task which consisted of: 2 Unpredictable blocks where the likelihood of each stimulus appearing was random (Unpredictable trials,UT); and 2 Predictable blocks where the likelihood of each stimulus appearing was such that subjects experienced an implicit sequence (Probable trials,PT) which, at times, was violated (Improbable trials,IT) (Fig. 1). Step Onset, APA Onset, APA Duration were recorded. To quantify how correctly suited an APA was to the new stepping movement during AR, we looked at how closely the ensemble average of the initial part of the APA of Probable trials resembled the initial part of the APA during an IT for the stimulus that a) appeared(US) b) was expected to appear(ES); by calculating the sum of square residuals (SSR) between the two up to120ms after APA Onset. RESULTS: There was an overall effect of trial type on Step Onset, $p<0.0005$), APA Onset, $p < 0.0005$, and APA Duration, $p<0.0005$. Step Onset was faster during PT (828±26ms) than during UT (871±26ms), $p<0.0005$; and faster than during IT (8906±20ms), $p<0.0005$. There was no difference in Step Onset between IT and UT. For APA Onset, there was no difference between PT (364±15ms) and IT (361±13ms), but was slower during UT (387±16ms) than during PT, $p=0.001$, and IT, $p=0.002$. APA Duration was longer for IT (527±16ms) than for PT (465±18ms), $p<0.0005$, and than UT (485±18ms), $p<0.0005$; and was shorter for PT than for UT, $p=0.002$. The overall difference between the SSR for US and ES showed the initial part of the APA more closely resembled the presented than the expected stimulus, so the APA was correctly suited to the upcoming improbable stimulus. CONCLUSION: During AR preparing a correct stepping movement takes longer, but preparing an APA that is correctly suited to the new movement does not take longer, suggesting that the

mechanisms that govern postural movement and focal stepping movement during AR could be separate.
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3-U-97 The effects of foot cooling on muscle responses to a loss of balance

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BACKGROUND AND AIM: When the foot soles are cooled to reduce foot sole somatosensation, no consistent changes in quiet standing balance are observed [1]. Quiet standing may be too simple of a task, whereby reductions in foot sole somatosensation can be overcome by relying on the remaining sources of sensory information. However, when the balance task requirements become more difficult, such as recovering from an unexpected loss of balance, it is possible that the central nervous system becomes more reliant on foot sole somatosensation. With altered feedback from the foot soles, this may result in larger consequences to an individual's ability to maintain balance. Therefore, the purpose of this study was to examine the effects of reduced foot sole somatosensation, achieved through foot cooling, on postural muscle responses to a loss of balance. METHODS: Twenty healthy young adults (22±1 y) participated in this study. Baseline levels of skin sensitivity were assessed using Semmes-Weinstein monofilaments at three locations on the foot sole. Postural muscle responses were quantified in the form of surface electromyography (EMG) onset latencies and amplitudes from the soleus (SOL), medial gastrocnemius (MG) and tibialis anterior (TA) muscles while participants recovered their balance on a movable platform. They were instructed to recover their balance without taking a step to each of the 20 unexpected forward or backward surface translations (peak displacement of 0.2 m, peak acceleration of 2.0 m/s^2, and peak velocity of 0.6 m/s). Following the pre-cooling measures, the participant's foot soles were immersed no higher than the lateral malleolus in 0-2 °C ice-water for 15 min. Immediately after the foot cooling protocol, skin sensitivity and postural muscle responses to the platform perturbations were re-assessed. RESULTS: The foot cooling protocol decreased foot sole sensitivity (1.39 g to 3.93 g detection; $p<0.001$), which remained reduced for the duration of the experiment. Despite this significant decrease in foot sole sensitivity, postural muscle responses to the platform perturbations were minimally affected. In response to backward translations, the SOL EMG onset latency was delayed by 3-7 ms (p=0.041-0.048), and the SOL EMG amplitude increased by 18-23% (p=0.012-0.031). MG EMG amplitude also increased with foot cooling (14%; $p=0.036$), but its onset latency was not affected. Foot cooling had no effect on TA EMG activity in response to forward translations. CONCLUSIONS: A reduction in foot sole somatosensation resulted in minimal changes to lower limb EMG activity. Further, the magnitude of change was much lower than what is seen in individuals with balance deficits (e.g., older adults). This may suggest that foot sole somatosensation has a minor functional role in the activation of postural muscle responses following a loss of balance.
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3-U-98 The effects of multidirectional balance impairments on an aperture crossing task

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BACKGROUND: Dynamic stability is challenged by various balance impairments we face throughout the lifespan. It is the responsibility of the central nervous system (CNS) to integrate sensory information from the environment in order to make adaptive changes to maintain stability during locomotion. This is especially true when crossing doorways, or "apertures" in the environment. Warren and Whang (1987) found that the critical point (change in action) for aperture crossing of young adults was 1.3x their shoulder width. However, critical point was shown to increase to 1.6 in older adults (Hackney & Cinelli, 2011), as a result of age-related effects on dynamic balance control. Simulations of dynamic balance impairments can provide useful information about the role of balance on adaptive locomotion. Walking over compliant surfaces simulate dynamic balance challenges by creating a constant overcompensation and correction of the COM to control in the anterior-posterior direction resulting in changes in obstacle avoidance behaviours (MacLellan & Patla, 2006). Asymmetrical distance leg weights lead to A/P balance control changes during locomotion (Worton et al., 2016). The purpose of this study was to determine the effect of induced A/P balance instability on aperture crossing behaviours in young adults. It was hypothesized that any changes to balance control would lead to cautious behaviours resulting in increased critical points of young adults similar to that of older adults. METHODS: Twelve young adults were asked to walk towards a goal and safely pass through a door aperture located 5m along a 7.5m pathway. Aperture sizes varied between 0.8 and 1.8x's each participant's shoulder width. Participants performed three types of walking conditions: flat ground walking; walking on a high-density foam mat; and ground walking with asymmetrical weighting of the right ankle. Kinematic data (NDI Optotrak) of the head, trunk, and ankles was collected at 60Hz to measure shoulder rotation magnitude, walking speed, and trunk control during the trials. However, only the percentage of trials that resulted in shoulder rotations at the time of crossing the apertures will be reported. RESULTS: Findings of behaviours at the time of crossing revealed that apertures smaller than 1.4 times the participants' shoulder width elicited significant shoulder rotations (critical point) for all walking conditions. CONCLUSION: Although, perturbations in the A/P direction did not affect the gross measure of critical point as hypothesized, the manner in which individuals performed the task may have been affected. Further kinematic analysis, beyond the observational data, will determine the specific manner in which individuals controlled their actions during the three conditions. These findings will hopefully demonstrate the manner in which the CNS regulates acute balance impairments to successfully complete an aperture crossing task.

3-U-99 The effects of body tilt in the roll plane on upper limb pointing movements

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BACKGROUND AND AIM: Upper limb movements are finely tuned by the central nervous system (CNS) in order to achieve an intended action without requiring any special effort or attention. The CNS precisely controls for the effects of gravitational force acting on the upper limb, and seems to utilize these forces for executing the upper limb movements in the upright condition (e.g. Yamamoto and Kushiro, 2014). The question arises that if the egocentric coordinate of the body is dissociated from the gravitational coordinate by whole body tilt, how is pointing performance affected? To answer this question, we explored the relationship between body orientation in the roll plane and performance observed in pointing movements. METHODS: Fourteen right-handed, male subjects (aged 21¬–25 years) were secured to a seat mounted on a computer-driven tilt-table that could tilt the subjects to 5 positions (0°, ±8°, ±16° with positive, right side down) in the roll plane. As the chair reached the tilt position, the target was illuminated in front of the head for 500 ms. Two seconds after the target was extinguished, the subjects performed the pointing movement with their right index finger extended vertically toward the memorized target location under the instruction ?move as rapidly and accurately as possible.? No visual feedback was provided. Subjects successively repeated the pointing task 14 times under identical conditions. To evaluate the accuracy of the terminal location, final direction error (FDE) was calculated as the error angle between directions for start-to-termination and start-to-target and compared among the tilt conditions. RESULTS: The ANOVA revealed a significant main effect of body tilt [F (4, 52) =

7.69; $p < 0.001$] for the FDE. Post-hoc tests showed that FDE at -8° (-1.57°) was significantly smaller than those at 8° (1.51°, $p < 0.01$) and at 16° (-0.97°, $p < 0.05$), and FDE at -16° (1.84°) was significantly smaller than that at 16° ($p < 0.05$). Furthermore, we observed a significant positive correlation between the angle of body tilt and the magnitude of FDE [$F (1, 68) = 9.64$, $p < 0.01$, $r2 = 0.12$]. These results indicate that the terminal locations of the pointing movements shifted slightly, but steadily, toward the direction of the tilt as the magnitude of the tilt changed. CONCLUSION: We found a clear relationship between the orientation of the body in the roll plane and the performance of pointing movements, as seen in errors for terminal location. We suggest that dissociation of the coordinates due to whole body tilt attenuates spatial perception, even on the egocentric coordinate of the body, which, in turn, leads to errors in motor performance. The results of this study provide new insight into how motor control of the upper limb is achieved and organized through sensory-motor coordination by the CNS.

3-U-100 Can the older adult who over-or underestimate their gait ability be identified?

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BACKGROUND AND AIM. Successful execution of tasks requires an integration of the perception of one's action abilities and the perception of the task. If the abilities equal or exceed the task demands, the motor task can successfully be executed. Cognitive and physical decline in older adults may affect the perceptual judgment of the actual ability, which may lead to balance loss or falls. In the current study, we aimed to directly quantify the degree to which older adults misjudge their actual gait ability. METHODS. Twenty-seven older adults (74.4 ± 5.6 years) participated and were instructed to walk on a narrow path projected on a treadmill. The participants' misjudgment of gait ability was estimated using a path width manipulation. First, participants indicated the smallest path that they believed they would be able to walk on without stepping outside the path's boundaries. Thereafter, we determined the actual gait ability as the probability of stepping inside the path over a range of path widths. Comparing the perceived gait ability with the actual gait ability, enabled the computation of the degree of misjudgment. RESULTS. The path width paradigm seemed suitable for evaluating one's perceptual misjudgment of gait abilities. The degree of misjudgment revealed a range over participants towards either over-or underestimating their abilities (Figure. 1). Higher abilities did not significantly associate with better judgments ($\rho=-0.088$, $p=0.650$). CONCLUSIONS. From this study it seemed that older adults do not perfectly judge their gait ability. The direct quantification of the degree to which older adults (mis)judge their gait ability provides insight in the interplay between cognitive and physical abilities and can be of added value towards prevention of falls and promotion of healthy ageing.

3-U-101 An Investigation of the Relationship between Segmental Orientation, Dynamic Stability, and Hearing in Younger and Older Adults with Good Hearing

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BACKGROUND: Studies on orienting responses to auditory stimuli have typically been conducted in situations where the listeners were seated and usually involved characterization of movement of a single body segment, the head. The purpose of this study was to examine and compare the segmental orientation and dynamic stability of young and older adults when performing a listening task in which they were instructed to the sound source ("Directed Head Turn") while walking and when no instructions pertaining to head orientation were provided ("Undirected Head Turn"). METHODS: 11 younger (22.27 ±3.07 years) and 12 older adults (68.25 ±5.45 years) with self-reported normal hearing and no neurological or cognitive disorders took part in this study. Participants were outfitted with Optotrack (NDI) markers to track head, trunk, and heel movements at 60Hz and walked along a 7m path towards a goal. An optical trigger located half way along the path would, on some trials, initiate an auditory stimulus from one of two loudspeakers positioned 35-degrees to the left and right of the goal. Participants completed 30 trials in both the Directed Head Turn condition, where participants were instructed to orient their head in the direction of the source if an auditory stimulus was presented and the Undirected Head Turn condition, where no explicit instructions pertaining to head orientation were provided. Each condition included: 10 trials with no sound; 10 trials with a 1 kHz tone presented from left/right; and 10 trials with sentences from the left/right. 2 (Condition: Undirected/Directed Head Turn) x 2 (Direction: Left/Right) x 2 (Stimulus Type: Tone/Sentence) x 2 (Age Group: Younger/Older) mixed factorial ANOVAs were conducted for mean magnitude head yaw at 1m post-(auditory) trigger and mean SD trunk pitch at 1m post-trigger. RESULTS: Mean magnitude head yaw at 1m following the onset of the auditory stimulus revealed a main effect of Condition [$F(1,21)=55.816$, $p<.001$], such that rotations were greater in the Directed than in the Undirected condition. There was no significant effect of Age Group on heard rotation magnitude at 1m [$F(1,21)=1.211$, $p=.284$]. Trunk pitch variation (SD) from the trigger to 1m post-trigger was significantly greater in older adults (0.026 degrees) than younger adults (0.019 degrees) [$F(1,20)=10.751$, $p=.004$]. CONCLUSION: Similar head yaw rotations magnitudes in young and older adults during the Directed Head Turns appear to affect older adults' dynamic stability (i.e., greater trunk pitch variability), which could predispose them to falls. Since no participants fell or lost balance during the study, it is possible that older adults adopted strategies further along the path to prevent falls. Further analyses will be conducted to examine the relationship between head orientation and trunk control to determine if behaviours to auditory stimuli change further along the path.

3-U-102 Gaze and the visual control of foot placement when walking over real-world rough terrain

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BACKGROUND AND AIM: When walking over rough terrain, walkers gather information about the upcoming path to support stable and efficient locomotion. Specifically, humans must perform a rapid visual search to identify stable footholds in upcoming terrain in a manner that is temporal coupled to the ongoing gait cycle. In this way, walkers adapt their energetically optimized, biomechanically preferred gait cycle to account for the complexity of the terrain being traversed. METHODS: Using a novel experimental apparatus to record eye movements and full-body kinematics of subjects walking over real-world terrain, we recorded gaze and body movement data during natural behavior in unconstrained outdoor environments (Video demonstration available here - https://dx.doi.org/10.6084/m9.figshare.4003476.v3). Subjects walked over terrain of three levels of rough terrain - extremely rocky dry creek beds (Rough), moderately rocky trails (Medium), and flat packed-earth trails (Flat). RESULTS: In the Rough and Medium terrain conditions, gaze was tightly coupled to the locations of upcoming footholds, with the main locus of step planning appearing to occur around the third upcoming step (step N+3). In contrast, in the Flat terrain, subjects still occasionally looked at the region around Step N+3, but they did not fixate their footholds like they do in the Rough and Medium terrains. CONCLUSIONS: These results indicate that subjects utilize a step planning strategy organized around the 3rd step, with the degree of gaze/gait coupling varying with terrain complexity. This 3-s
tep planning strategy is consistent with lab-based findings that 2 steps of planning is the minimum for the efficient locomotion, but suggests a facet to human locomotor control that has not been observed in lab-based experiments. Future research will pursue the hypothesis that the 3-step planning window

constitutes the minimum requirements for planning steps in terrain that might require changes in locomotor heading.

3-U-103 The effects of peripheral visual information on an aperture crossing task in previously concussed, asymptomatic individuals

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BACKGROUND: Individuals acquire information about self-motion from the environment which specifies actions necessary to be successful (Fajen & Matthis, 2011). However, concussed individuals demonstrate residual disturbance in execution of postural movement at 30 days post injury, depicting an impaired ability to perceive self-motion in a visually conflicting environment (Slobounov et al. 2006). The current study investigated the extent to which one's behaviours were influenced by the amount and type of peripheral visual information during a collision avoidance task. It was hypothesized that individuals would perform best when the environment provided visual information regarding one's own self-motion. METHODS: Previously concussed (3-12months prior) asymptomatic young adults (N=5) walked along a 7m virtual path (via HTC Vive) towards a set of subway doors and instructed to safely board the train without colliding with the doors. When the participants were 2m from the doors, they began to close at a constant rate such that the final door aperture width at the time of crossing ranged from 35-85cm (in 10cm increments). Participants performed aperture crossing trials during one of four peripheral environments: 1) ground plane only; 2) ground plane plus stationary poles in the peripheral environment; 3) ground plane with stationary humanoids in the peripheral environment; or 4) randomly moving humanoids. Participants were exposed to three trials of each aperture width within each environment for a total of 72 walking trials (6 widths x 4 conditions x 3 trials). Kinematic data was collected using a 3D motion capture system (Optotrak, NDI). RESULTS: Preliminary data revealed that previously concussed, individuals demonstrated consistently cautious behaviours during each of the four environments. All participants executed significant shoulder rotations regardless of aperture width at time of crossing. It appears that each participant used a "one solution for all" such that shoulder rotation magnitudes at the time of crossing were not modulated to the different aperture widths or environments. The different environments had no effect on approach speed ($p>.05$) or medial-lateral stability during the approach phase ($p>.05$). CONCLUSION: These findings suggest that previously concussed individuals may not be in tune peripheral visual information (i.e., no change in approach behaviours) nor are they able couple their perceptions of self-motion and changes within the environment with appropriately tuned actions. Therefore, it is assumed that visuomotor deficits persist within a previously concussed population well beyond the resolution of symptoms (i.e., greater than three months) and these deficits result in cautious behaviours. To determine the timeline of the resolution of observed visuomotor deficits, further data collection will include more variability in time since symptom resolution along with aperture crossing behaviours of non-concussed individuals.

3-U-104 Phase-dependency of the balance response to Galvanic vestibular stimulation during walking

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BACKGROUND: To maintain upright posture of the body during locomotion in the frontal plane, the central nervous system has to modulate the muscle activity and the resulting ground reaction force to stabilize the position of the center of mass and the orientation of the body. Several studies have reported balance responses in the lower body that strongly depend upon the phase of the gait cycle, whereas responses in the upper body are usually only weakly phase-dependent. This is puzzling, because the upper and lower body are strongly coupled during walking, and the postural goal of keeping the upper body upright should not vary relative to the phase of the gait cycle. We hypothesize that there might be an underlying control mechanism for balance which is phase-independent. To test this hypothesis, we perturb the balance system during locomotion and observe the responses of the motor system in two previously established balance mechanisms. METHODS: Subjects walked on a self-paced, split-belt instrumented treadmill, surrounded by a 220 deg visual screen with 3D cubes distributed across the screen moving in the sagittal plane. Balance was perturbed by bipolar, binaural GVS that lasted for 600ms, every 6-9 strides, with an amplitude of 0.5mA. Polarity of the GVS was randomized to generate an equal number of right/left perceived falls. Stimulation was triggered by heelstrike of the right foot, and started after a randomized phase delay of 0, 150 or 450ms. We collected whole-body kinematic data, ground reaction forces and EMG data from five muscles on each leg. RESULTS: Preliminary results from four subjects indicate that in response to the stimulus, the center of pressure shifts in the direction of the perceived fall (the cathode) relative to the center of mass. The onset of this CoP shift occurs approximately 250-350ms after the stimulus onset. However, in the 450 ms GVS delay condition, the CoP response cannot be completed entirely in the current stance foot as it shifts to swing. Instead, the CoP shift transfers to the opposite foot as it enters stance, preserving the balance response. EMG results show that in the first post-stimulus step, the stance leg peroneus longus EMG (right) increased (decreased) for a perceived fall to the LEFT (RIGHT) in the 0 and 150ms delay conditions, but not in the 450ms condition. In the second post-stimulus step, the stance leg peroneus longus EMG (left) decreased (increased) for a perceived fall to the LEFT (RIGHT) in the 450ms, but not in the 0 or 150ms delay condition. CONCLUSIONS: These results indicate that there is a functional balance response to the GVS consisting of a shift of the CoP in the direction of the perceived fall. Modulation of the stance foot peroneal muscles appears to be a driving force in the generation of this CoP response. Although the activation of the underlying musculature is phase-dependent, the functional response of the CoP is phase-independent with respect to the gait cycle. FUNDING: Hendrik Reimann was supported by a Research Fellowship from the German Research Foundation (RE 3780/1-1)

3-U-105 Phase- and speed-dependent modulation of vestibular contributions to balance control during walking

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BACKGROUND AND AIM There is increasing evidence for a phase- and speed-dependent modulation of vestibular contributions to postural control during walking. Accordingly, vestibulospinal reflexes are phasically altered during the gait cycle (Dakin et al., J Neurophysiol, 2011) and the impact of vestibular disturbances decreases with increasing gait speed (Brandt et al., Lancet, 1999). Recently, this modulation was explained in terms of a selective suppression of sensory inputs by intrinsic locomotor efference copies observed during animal locomotion (Lambert et al., Curr Biol, 2012). The feasibility of such a feedforward mechanism should however critically depend on the predictability of the walking motion (Chagnaud et al., Biol Cybern, 2012). To test this hypothesis, we experimentally studied the impact of continuous stochastic vestibular stimulation (SVS) on balance control during walking and then examined whether the predictability of the walking motion can account for the differential weighting of vestibular cues during locomotion. METHODS Walking patterns of 7 healthy participants were recorded on a pressure-sensitive treadmill while walking for 10 min at 0.4 and 0.8 m/s. Continuous SVS (0-25 Hz; peak amplitude at ±4.5 mA) was delivered by a bipolar binaural electrode configuration over the mastoid processes that evokes postural responses in the roll plane. Time-dependent coherence between SVS and center-of-pressure (CoP) trajectories in the medio-lateral plane was analyzed to examine the dynamic impact of vestibular cues during locomotion. Predictability of the walking motion was quantified by calculating the coefficient of determination of the CoP-trajectory recorded during two separate no-stimulation gait trials. Weighting of vestibular cues was then estimated within the framework of a statistically optimal model in which the relative weights given to the efference copy and vestibular inputs depend on the predictability of the motion pattern. RESULTS SVS-CoP coherence showed a clear dependence on the gait cycle phase reaching maxima at 10±2 % and 60±3 % of the gait cycle (Fig A). Accordingly, SVS impact on balance control was primarily observed during phases of double support and largely suppressed during periods of single support ($p=0.011$). Moreover, SVS-CoP coupling decreased with increasing locomotion speed ($p=0.016$). Vestibular weightings estimated based on the predictability of the locomotion pattern closely predicted the phase- and speed-dependent impact of SVS on medio-lateral balance control during walking ($R=0.85$, $p<0.001$) (Fig B). DISCUSSION Complementing previous findings, our results demonstrate a phase- and speed-dependent modulation of vestibular contributions to balance control during locomotion. They further provide a compatible explanation for this modulation in terms of a selective suppression of sensory cues by an intrinsic feedforward mechanism that depends on the predictability of the locomotion pattern.

3-U-106 Influence of visual dependence on muscle synergy responses to visual and support surface perturbation in cerebral palsy

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Background and Aims: Simplified muscle synergies in individuals with cerebral palsy (CP) are thought to result from functional impairment due to brain injury. Visual dependence (VD), defined as disproportionate weighting of visual input as a compensatory strategy to acquire one's spatial orientation in the presence of deficits in other sensory systems, leads to different body segmental stabilization strategies in CP with VD that those without VD regardless of the existence of CP diagnosis. It is unclear whether VD as a perceptual choice would affect neuromuscular control strategies in adults with CP beyond the influence of functional impairment due to brain injury. We examined the muscle synergy of VD and visually independent (VI) adults with CP during upright stance when visual and supporting surface perturbations occurred. Methods: Twenty-four adults with CP (GMFCS level I & II) and 18 age-matched typical adults (TY) were tested for VD with Rod-and-Frame Test; 12 CP were identified with VD. Subjects from all three groups (TY, CPVI, CPVD) stood quietly on a force platform in the center of a 3-wall visual environment. The visual scene was either kept static or continuously rotated upward or downward in pitch at 30°/s. The support surface tilted 3° and thus generated ankle dorsiflexion, which remained tilted for 30s and returned to neutral position at 0.1°/s over another 30s. Surface EMG from the rectus femoris (RF), vastus lateralis (VL), biceps femoris (BF), medial gastrocnemius (MG), soleus (SO), and tibialis anterior (TA) were recorded, rectified, low-pass filtered at 20Hz, and calculated for muscle synergies using non-negative matrix factorization. Results: The number of muscle synergies required to describe variations in muscle activity was the smallest for CPVI, and the largest for TY. Adults with TY utilized more complex neuromuscular control strategies in response to perturbations from the visual and support surface. On the ventral side, both groups with CP tended to control knee extensors (RF&VL) and dorsiflexor (TA) together. Also, such coactivation was found higher in CPVI than CPVD. On the dorsal side, adults with CPVD were able to activate SO separately from the knee flexors (BF&MG), while adults with CPVI tended to control these muscles altogether. The activation of SO in CPVD, as compared to that in CPVI, was lower during pitch-up visual motion and higher during pitch-down visual motion. Conclusions: Muscle synergies, as an indicator of the complexity of neuromuscular control, are affected not only by functional impairment secondary to brain injury but also by perceptual choice (e.g., VD). Whether simplified muscle synergies due to the over-reliance on vision contribute to the early deterioration in functional mobility in CP awaits further investigation. Nevertheless, our results suggest that different interventional strategies may be needed with respect to the presence of VD for individuals with CP.

V Tools and methods for posture and gait analysis

3-V-107The Gait Variability Index is robust across differing over ground testing protocols in healthy young adults

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BACKGROUND AND AIM: Earlier work suggests that testing protocol affects gait variability measurement. Specifically, it is suggested that repeated walking protocols involving walking short distances with periodic interruptions in comparison to continuous walking protocols (walking longer distances without interruptions), may artificially inflate gait variability measures. Gait variability in these studies was quantified using the traditional measures of standard deviation and coefficient of variation. The Gait Variability Index (GVI) is a novel composite index for the calculation of gait variability and suggested to mitigate the limitations of the traditional gait variability measures. The objective of this study was to investigate if the GVI was similarly affected by differing testing protocols. METHODS: Fifteen healthy subjects (22 ± 2.5 years) without any history of injuries within the last 6 months participated. Participants completed two walking protocols (repeated and continuous) of 20 trials each at their self-selected walking speed. Walking procotols were presented in a random order. Spatiotemporal data were collected using the instrumented mat, GAITRite. The repeated walking protocol involved subjects walking back and forth over the GAITRite with individuals stopping after each pass on the GAITRite and starting again for the next trial. Whereas in the continuous walking protocols, subjects walked continuously for the 20 trials along a standardized curvilinear path. The GVI calculation was based on published guidelines by Gouelle et. al., 2013. Paired t-tests were used to investigate differences between the two walking protocols at 5, 10, 15, and 20 walking trials. Analyses were run in sequential sets of walking trials to systematically investigate the effect of walking trials on GVI. RESULTS: There was no difference in GVI between the repeated and continuous trials at 5 ($p = 0.08$), 10 ($p = 0.91$), 15 ($p = 0.98$), and 20 ($p = 0.92$) walking trials. CONCLUSIONS: GVI, a new composite measure is suggested to improve objective quantification of gait variability. Specifically, the GVI was developed to alleviate some of the methodological issues related to gait variability measures. Our findings suggest that the GVI did not change with differing over ground testing protocols, whether we compared 5 or 20 walking trials. Individuals with disabilities may lack the endurance required to walk the longer distances required by the continuous walking protocols. In such situations, repeated walking protocols may be the feasible approach to gait variability assessment. Using the GVI as the outcome measure for gait variability across differing testing protocols may ensure validity of gait variability measurement. Future work should further investigate effect of testing protocols in individuals with mobility deficits.

3-V-108Validity and Reliability of the Re-Step to measure stride time in healthy adults

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Background and aim: Spatial and temporal parameters of walking are used to evaluate outcomes following interventions. Re-Step (step of mind?, Israel) is a novel mechatronic shoe developed for training and rehabilitating walking. The system is equipped with four pistons that are able change the sole?s shape continuously in an unpredictable manner. Each piston is equipped with force sensors permitting continuous force measurements to obtain stride to stride time series. Beyond pure training, the sensors may be used to measure temporal parameters of gait. Thus, the aim of this study was to evaluate validity and reliability of stride time as measured with the system. Methods: thirteen healthy adults participated in this study. For validity we used data from three participants who walked in two conditions (with and without perturbation), at three velocities in each condition (preferred velocity, +10% and -10%). Each participant walked with the Re-Step on a split-belt treadmill (ForceLink, Clemborg, The Netherlands) equipped with a force plate sampling at 300 Hz, for six minutes in each condition (two minutes at each velocity). For reliability we used data from ten participants. Each walked three times on the outer line of a basketball court. To create a continuous walk, a curved line was marked on the floor near the corners. Each cycle was 50.5 meters long and the entire test was 151.5 meters long. After 15 minutes rest, the test was repeated. Duration of each cycle was measured with a stop-watch and velocity was calculated. Force from each sensor of the Re-Step was recorded at 100 Hz in both settings. The recorded data was analyzed using a custom, MATLAB based, software. Stride time was defined as the number of data points measured from one heel strike to the next on the same leg (result units are 1/100 of a second). Results and discussion: validity analysis was based on over 1400 strides for each condition and revealed a significant correlation for the unperturbed ($r=0.982$, $p<0.01$) and perturbed ($r=0.968$, $p<0.01$) conditions. When analyzed according to velocity, significant correlations were found for all velocities ($r=0.956$, $r=0.971$, $r=0.908$ for preferred speed, -10% and +10% respectively) with $p<0.01$. Additional analysis demonstrated Mean Absolute Percentage Error (MAPE) for the unperturbed condition of 0.03% and for the perturbed 0.04%. For the different velocities MAPE ranged between 0.01% and 0.03%. Reliability analysis was based on the average stride time measured for each cycle. Inter-class Correlation Coefficient (ICC) was calculated for measurement between legs (ICC=0.993, 95% CI 0.982-0.998). Preliminary analysis demonstrated no difference between left and right legs ($t=0.002$, $p=0.968$) and hence, left and right measuring devices were considered as two independent measurements. Originally we examined reliability for test-retest (average of the three cycles of the test). However, significant difference in velocity ($t=4$, $p<0.01$) between tests required a different approach. Conclusions: Re-Step produces valid and reliable results for stride time in healthy adults.

3-V-109Validation of Walking Episode Recognition in Supervised and Free-living Conditions Using Triaxial Accelerometers

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Validation of Walking Episode Recognition in Supervised and Free-living Conditions Using Triaxial Accelerometers Nethra Ganesh, Ngaire Kerse, Bruce MacDonald, Jochen Klenk Abstract BACKGROUND AND AIM: Specific gait parameters are associated with falls and injury but ascertainment is difficult in free living environments. Not all older people can come to the laboratory. The aim of this programme is to develop a real-world gait parameter assessment using body worn sensors. In this paper, we present the first step in this process, which is to establish the validity of a body-worn triaxial accelerometer for detection of walking episodes in older people above the age of 65 years. METHODS: Participants were 28 older people residing in independent-living retirement homes. Data was inertial sensor signals, attached to the L5 vertebral area using a belt, from scripted activities (a timed up and go, and sit to stand activities) and unscripted activities of daily living collected in a free-living environment. An algorithm designed to identify walking, standing/sitting and lying was applied to the uSense wearable accelerometer data which had been analysed by processing the raw data with two versions of a gait detection algorithm and the results were compared against annotated videos which served as the gold standard. Validity of gait assessment was based on the percentage of agreement between the analysed accelerometer data and the corresponding reference video with 100Hz sampling frequency and 0.01

frames/second. RESULTS: Comparison between the processed accelerometer data and the annotated video was a match of approximately 90% and 95% for walking episodes for unscripted and scripted activities respectively. Identification of sitting and standing was less precise. CONCLUSION: The triaxial accelerometer wearable device with a sampling frequency of 100Hz provides a valid measure of gait detection in older people aged above 65 years. Next step is to establish validity of a gait parameter algorithm. ACKNOWLEDGEMENTS AND FUNDING: Brain Research New Zealand

3-V-110Measurement Properties of the Community Balance and Mobility Scale in Young-Older Adults

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BACKGROUND and AIM: With the growing number of young-older adults, there is a need for balance and mobility assessment tools specifically validated in this population. This study aimed to evaluate the reliability, validity, re-sponsiveness, internal consistency, and ceiling effects of a challenging balance and mobility scale (Community Balance and Mobility Scale, CBMS) in young-older adults. METHODS: Fifty-one participants (66.4 ± 2.7 years) underwent CBMS assessment. The Fullerton Advanced Balance scale (FAB), Timed-Up-and-Go (TUG), 8-level balance scale, 3-meter tandem walk (3MTW), and gait speed were used for estimating concurrent validity. Reliability was calculated as Intra-class-correlations (ICC) and internal consistency by Cronbach alpha. Standardized response means (SRM) were used to assess responsiveness in detecting balance and mobility changes after a 4-weeks exercise intervention. RESULTS: The CBMS correlated high with the FAB ($\rho = 0.74$; $p < .001$); good with the 3MTW ($\rho = 0.61$; $p < .001$); and moderate with TUG, gait speed, and 8-level balance scale ($\rho = 0.31$-0.52, $p < .05$). Reliability (ICC > .95), internal consistency ($\alpha = .74$) and responsiveness (SRM = 0.75, $p < .001$) were good. In contrast to FAB and 8-level balance scale, the CBMS had no ceiling effects. Measurement properties of the CBMS are good to excellent in young-older adults. CONCLUSIONS: The scale can be recommended to identify balance and mobility deficits and intervention-related chang-es over time. Results suggest that the CBMS is particularly relevant for detecting and monitoring early age-related changes in balance and mobility, which might be masked by other balance scales used in the geriatric field.

3-V-111Validity of the Hilbert-Huang Method for Tremor Removal When Quantifying Sway in Patients with Parkinson's Disease

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BACKGROUND AND AIM: Loss of postural control is one of the most incapacitating symptoms of Parkinson's disease (PD). The gold standard for postural analysis is the force platform. Accelerometers offer a reliable alternative, but improper filtering of tremor or noise could lead to misleading results. Low pass filters are commonly used in the literature, but previous work demonstrated that the Hilbert-Huang transform may be a more appropriate method to filter tremor. Using the inverted pendulum model of sway, the present study aims at validating the Hilbert-Huang transform against measurements derived from a force platform. A second objective was to investigate differences in postural measures between healthy controls (CO) and PD patients using measures from the force platform, low pass filter, and Hilbert-Huang derived measures. METHODS: Sway during quiet standing was evaluated in 21 healthy controls and 25 people with PD. Subjects wore an accelerometer on the lower back while standing on a force platform. The Hilbert-Huang transform was applied to the acceleration data and the inverted pendulum model used to infer displacement of the center of mass from the force platform measure of center of pressure. Measures characterizing postural control and quantifying tremor were extracted. Processing was repeated using a low pass filter. RESULTS: The groups were similar with respect to age, height, weight, and cognitive function, as measured using the Mini Mental State Examination (p>0.1). There was a significant correlation between the difference of center of pressure and center of mass displacement and the acceleration of the center of mass (for Hilbert Huang and low pass filter, r>0.7). Skewness (CO: 0.03 ± 0.31; PD: -0.23 ± 0.33) and tremor (CO: 5.31 ± 0.12; PD: 5.07 ± 0.28) of the center of mass were significantly different between controls and PD (respectively, p = 0.034 and p = 0.038). A ROC analysis showed that the tremor measure calculated from the Hilbert-Huang signal yielded better discrimination than from the low pass filter (area under the curve, respectively 0.84 and 0.78). CONCLUSIONS: The present findings support the use of the Hilbert-Huang transform in analyzing sway data in the presence of tremor. Postural analysis using the Hilbert-Huang transform will yield meaningful estimates of balance control and enhance the ability to characterize sway using accelerometers. ACKNOWLEDGEMENTS AND FUNDING: The work leading to this invention has received funding from the European Community's Seventh Framework Programme FP7/2012 under grant agreement no. 316639

3-V-112Improved prediction of falls in community-dwelling older adults through phase-dependent irregularity of daily-life walking

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Background: Irregularity in human gait has been suggested to increase with aging and disease, and make older adults more susceptible to falls. Previous studies have shown that stability and variability metrics of daily-life trunk accelerations, based on either nonlinear analysis, spectral analysis, or phase-dependent analysis, can contribute to fall prediction [1], [2]. The main purposes of the present study were: 1) to develop a new concept of irregularity in walking, called phase-dependent generalized multiscale entropy (PGME), which combines nonlinear analysis, spectral decomposition, and phase-dependent analysis, and 2) to test the predictive ability of PGME for prospective falls. Methods: We re-analysed data of one week of daily-life activity originally described in [2]. The dataset contained accelerometry data from 52 single- and 46 multiple-time prospective fallers in a six month follow-up period, and an equal number of non-falling controls matched on age, weight, height, gender, and use of walking aids. PGME was estimated for trunk acceleration signals during walking epochs of at least 30 seconds. PGME was computed by: 1) reconstructing the gait dynamics [3], 2) decomposing the gait dynamics into multiple temporal scales by multivariate empirical mode decomposition [4], and 3) computing the generalized sample entropy for each temporal scale [5]. The predictive ability of PGME for falls was assessed using a partial least square discriminant analysis. We compared this predictive ability with that of other gait features used in [2] and six and twelve months fall history. The best performing model was identified using the Akaike information criterion and relative likelihood below 0.05. Results: PGME had a significantly better predictive ability of single-time fallers when compared to all other gait features combined and fall history (RL < 0.05, see bold numbers in Table 1). The single-time fallers had a higher PGME (p < 0.0001) at 60% of their step cycle compared to non-fallers. Although no significant differences were found between PGME of multiple-time fallers and non-fallers, PGME did improve the prediction model of multiple-time fallers when combined with other gait features (see all combined in Table below). Conclusion: PGME has the potential to improve fall prediction in older people, especially for single-time fallers. PGME further indicates that a fall-risk-related increase in the irregularity of the gait dynamics appears at 60% of the step-cycle, probably related to the heel-strikes and toe-offs. References: [1] Ihlen, E.A.F. et al., 2015. Biomed. Res. Int. doi: 10.1155/2015/402596 [2] van Schooten, K. S. et al., 2016. PLoS ONE. [3] Kantz, H., Schreiber, S., 2004. Cambridge University Press: Cambridge. [4] Rehman, N., Mandic, D.P., 2010. Proc. R. Soc. A 466, 1291-1302. [5] Silva, L.E.V., Murta, L.O., 2012. Chaos 22, 043105, 1-8.

3-V-113Clinically Usable System Identification Method for Human Standing Balance

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Background and Aim Assessment of postural balance is important in providing effective therapy and assistive technologies for individuals with postural disabilities and for elderly. While there are various clinically available quantitative measures, they are somewhat indirect. Parametric system identification may be a good candidate for the assessment to quantitatively understand the individual's postural control system. However, this requires laboratory-quality perturbation equipment, which is clinically unfeasible. Our lab has proposed a novel system identification method from the data acquired from unperturbed standing [1]. This method is clinically usable, though its accuracy can be compromised compared to the conventional parametric system identification method. Here we quantified its accuracy compared to the conventional method, to investigate its clinical usability. Methods In a simulation study, we modeled the body by a single-link inverted pendulum, pivoting around the ankle joint, controlling the body's center-of-mass. The postural control scheme was modeled using a closed-loop control system, representing the body's response to a continuous disturbances including gravity. We simulated unperturbed quiet standing with multiple internal noises driving the postural sway, and applied our method to identify the postural control system [1]. We also simulated perturbed standing with the same internal noises, and performed conventional, parametric system identification [2]. We set 10 gain-set combinations, and compared the outcomes of the two system identification methods. Results Figure shows the results of three key control parameters. The conventional methods accurately identified each parameter, while our method involved less accuracy (root-mean-squared error for Kp: 3.5+-2.4 and 16.3+-14.8 Nm/rad; $p = 0.040$, Kd: 3.4+-2.3 and 20.5+-17.4 Nm/rad"s; $p = 0.031$, K: 0.7+-0.8 and 25.9+-20.8 Nm/rad; $p = 0.012$, for conventional method and our method, respectively). However, Spearman correlation indicated both identified parameters were highly correlated (Kp: rho = 0.976, $p < 0.0001$, Kd: rho = 0.952, $p = 0.0003$, K: rho = 0.929, $p = 0.0003$). Conclusion The current results suggested that our method can quantitatively differentiate postural control systems, although it has larger errors compared to the conventional method. Since our method requires only an unperturbed quiet standing task with muscle activity recording, this method can indeed be implemented in clinical setting as an alternative measure to estimate balance control for each individuals. We will experimentally test this method in the next step. Reference [1] Vette AH, Masani K, Nakazawa K, Popovic MR. Neural-mechanical feedback control scheme generates physiological ankle torque fluctuation during quiet stance. IEEE Tran Neu Sys Rehab Eng 18: 86-95, 2010. [2] van der Kooij H, van Asseldonk E, van der Helm FCT. Comparison of different methods to identify and quantify balance control. J Neurosci Methods 145: 175-203, 2005.

3-V-114Quantitative gait measures during the 6 minutes walk test in lower limb amputees: preliminary results

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BACKGROUND AND AIM: Return to independence is one of the major targets of rehabilitation for people with a lower limb amputation (PLLAs). Independence is influenced by many factors such as walking ability (1). Over the long term, PLLAs are predisposed to osteoarthritis (OA), which also influences independence. The 6 minute walk test (6MWT) is recognized as a valid measure of walking ability for PLLAs (2). However, although it involves a large sample of strides, the main outcome of the 6MWT (i.e., maximal distance in 6 minutes) does not inform on gait strategies used by PLLAs. To our knowledge, the 6MWT was never instrumented in order to quantify gait parameters for PLLAs. Therefore, the aim of this study is to quantify spatio-temporal gait parameters during a 6MWT for PLLAs. METHODS: To date, three of the targeted fifteen PLLAs have been analysed at the Quebec Rehabilitation Institute. At the end of their rehabilitation, each PLLA performed a 6MWT, during which the person was instrumented with two inertial sensors (Gait Up, Lausanne, Switzerland), strapped on the top of each foot to measure spatio-temporal gait parameters. The following parameters were considered for gait cycle analysis: % of stance phase (StP), % of swing phase (SwP), % of loading response (LR), % of foot flat (FF), % of push (P). For each parameter, a comparison was performed between the two legs (i.e., amputee (AMP) vs. non-amputee (NAL)). RESULTS: Based on preliminary findings, we observed that the total distance reached during the 6MWT shows a large variation among the 3 PLLAs (400±241m). It appears also that if we only considered the %StP and the %SwP, both legs are symmetric (respectively, AMP: 63.9±2.2% vs. NAL: 64.2±2.5% and AMP: 36.1±2.2% vs. NAL: 35.8±2.5%). However, during the StP, the %LR appears to be longer for the AMP limb (22.5±4.1% vs 9.1±1.4%) while the %FF tends to be shorter (44.8±6.6% vs. 58.4±3.6%) (Figure 1). CONCLUSIONS: With these preliminary findings on PLLAs, it appears that gait during a 6MWT is symmetric if we only consider the %StP and the %SwP between both legs. However, when we look at sub-phases (%LR-%FF-%P), asymmetries are observed. The longer %LR on the AMP limb induces a shorter FF period. The %LR is recognized to be the sub-phase where the forces are maximal (3). Therefore, a diminution of the % LR can increase forces at lower limb joints. Over the long term, this alteration in the gait pattern might explain the predisposition of the NAL limb to develop OA. Recruitment is on going in order to confirm these preliminary observations. However, it is clear that the instrumentation of the 6MWT has the potential to bring additional information on gait parameters of PLLAs and can be easily integrated into clinical settings. ACKNOWLEDGEMENTS AND FUNDING: This study was funded by the Fonds de recherche Québec - Santé. REFERENCES 1. Potter JM et al. Arch Phys Med Rehabil. 1995 Nov;76(11):997-9. 2. Reid L et al. J Rehabil Med. 2015 Mar;47(3):256-61. 3. Perry J. J Sports Sci Med. 2010 Jun 1;9(2):353.

3-V-115Nonlinear analysis of postural stability in people with Parkinson's disease

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BACKGROUND AND AIMS: Postural instability is an early and common motor feature in people with Parkinson's disease (PD).Centre of pressure has been assessed to determine stability but more recently body worn monitors e.g accelerometers, have been used. Most postural stability studies employ linear methods of analysis that may miss important information on the temporal structure of the signals. Additionally, vertical acceleration is generally not assessed. The purpose of this study was to investigate postural stability by applying nonlinear methods to 3D accelerometer signals. This analysis may offer information about the underlying control mechanisms, use as an early biomarker and indicator of disease progression. METHODS: The study group consisted of 26 people (67 ±11 years, 23% female, UPDRS III: 26.1±10.3) recently diagnosed with PD and 31 healthy age-matched controls (CL) (68 ± 8 years, 45% female) who were recruited as part of an incident cohort study (ICICLE-GAIT). Participants stood still for 2 minutes, eyes open and arms by their side. A single tri-axial accelerometer (Axivity AX3, York, UK) on the lower back recorded acceleration. Recurrence quantification analysis (RQA), sample entropy and symbolic entropy were selected for analysis. RQA measures determinism, repeatability of data segments and flexibility of the control system [1]. Sample and symbolic entropy quantify predictability, with low values indicating high predictability [2]. Embedding dimension and time delay for

RQA were determined using false nearest neighbours and average mutual information respectively. For sample entropy, a vector length of 2 and tolerance of 0.2 were used. 19 surrogate signals were generated for each signal for sample and symbolic entropy. The threshold for symbolic entropy analysis was zero. RESULTS: An increase in several RQA parameters (mean line, maximum line and line entropy-see Fig 1) in the vertical direction was found for people with PD. Greater sample entropy was observed in the vertical direction for people with PD when compared to CL. No change in symbolic entropy was found between the two groups. CONCLUSIONS: People with early PD show changes in temporal patterns of acceleration in the vertical direction only. To maintain stability, centre of mass must be positioned over the area of support. Strict regulatory mechanisms are therefore essential in the horizontal plane, constraining movement. The vertical direction, however has more freedom as small changes in centre of mass height has less effect on balance. The lower predictability of vertical acceleration, as shown by increased entropy, may be related to increased reliance on goal directed postural control rather than habitual control which is often dysfunctional in PD. Increased RQA line parameters may result from increased rigidity. Further studies will determine how these nonlinear parameters relate to underlying neural correlates and clinical correlates.REFERENCES:[1]Schmit et al. 2006.Exp Brain Res,168;357-367.[2] Lamoth et al. 2012. Gait & Posture,35;489-493.ACKNOWLEDGMENTS:Financial support for this study came from the National Institute for Health Research (NIHR), Newcastle Biomedical Research Unit, Parkinson's UK and the NIHR Newcastle CRF Infrastructure funding.

W Vestibular function and disorders

3-W-116 Effects of Vestibular Training on Postural Control among Healthy Adults

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Background: Postural stability depends on the integration of the somatosensory, visual and vestibular inputs to produce motor outputs. When visual and somatosensory input is available and reliable, this reduces reliance on the vestibular system. Despite this, vestibular loss can still cause severe postural dysfunction. Training one or more of the three sensory systems can alter sensory weighting and change postural behavior. One form of sensory training is vestibular habituation, which involves head movement exercises that can desensitize the vestibular system and consequently help to resolve symptoms of vestibular impairment such as dizziness and vertigo. The purpose of this study was to assess sensory re-weighting of postural control processing after combined vestibular habituation with voluntary weight-shift training in healthy adults performed on NeuroCom SMART Balance Master. We hypothesized that the effect of this training protocol would significantly alter the pattern of sensory weighting by changing the ratio of visual, somatosensory, and vestibular dependence needed to maintain postural stability. Methods: Thirty healthy individuals (18-35 y.o.) were randomly assigned to one of three groups: No training, visual feedback weight shift training (WST) coupled with an active horizontal head-shake (HS) activity to elicit a vestibular perturbation, or the same WST without HS. Training was performed 2x/day, every other day, 3x/week. Pre- and post- assessments on the Sensory Organization Test (SOT) were performed. Separate repeated measures ANOVAs were used to analyze the six SOT equilibrium scores, composite scores, and sensory ratios by comparing baseline to post-training. Alpha level was set at $p<.05$. Results: There were significant training effects observed in the SOT composite ($p=.009$) and equilibrium scores ($p=.006$). The control and HS group both improved, whereas the no HS group did not. Among the sensory ratios, only the HS group showed improvement: somatosensory ($p=.025$), visual ($p=.042$), and a trend in the vestibular ratio ($p=.065$, n.s.). The training effect was related to surface condition ? stable vs. sway-reference ($p=.022$). Conclusion: Postural training can alter sensory organization after a relatively short training protocol. The benefits cannot be explained by a practice effect since the control group showed minimal improvement on the pre and post SOT. The effect is also not simply due to practice on the device, since the WST group with no HS, generally showed a decrease in post-training SOT scores, while the head shake group showed significant improvement. The sensory ratio changes suggest a possible reweighting of sensory dependencies induced by the provocative vestibular training. Next steps will require pre and post tests of VOR and VEMP and EMG of postural musculature to better isolate the source of these training-induced changes.

3-W-117 Does use of intratympanic gentamicin before vestibular schwannoma surgery improve compensation

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BACKGROUND: Unilateral vestibular deafferentation (uVD), as performed in vestibular schwannoma surgery, results in a chronic vestibular deficit affecting quality of life. It was shown that training with vestibular exercises and presurgery gentamicin ablation of vestibular function offers a possibility to speed up recovery process. Purpose of the study is to investigate whether only presurgical use of intratympanic gentamicin may speed compensation process compare to patients without gentamicin undergoing removal of vestibular schwannoma. METHOD: 32 patients undergoing retrosigmoid schwannoma surgery were divided into two groups. First group was treated with gentamicin with the aim to produce uVD before surgery (10 patients, mean age 47.8 years), second group was without gentamicin (22 patients, mean age 47.5 years). Patients in both groups were treated from 5th to 14th day after surgery by intensive vestibular rehabilitation and balance exercises using visual feedback. Data from both groups were compared before surgery, after 5 and 14 days after surgery. Outcome measures included static posturography under four different conditions (mCTSIB), evaluation of subjective visual vertical (SVV) and The Activities-specific Balance Confidence (ABC) Scale. ANOVA for repeated measurements was used for statistical analysis. RESULTS: There was no significant difference between groups. After 2 weeks of intensive vestibular rehabilitation and balance exercises using visual feedback we observed significant improvement in posturography parameters, ABC scores and SVV deviations. CONCLUSION: Our results show that presurgical use of intratympanic gentamicin did not speed up compensation process after vestibular schwannoma surgery. ACKNOWLEDGEMENTS: This work was supported by the Foundation ?Movement without help? and Grant TA030111175.

3-W-118 Vestibular modulation of phantom limb pain after supracondylar amputation. A pilot study.

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Aim: To assess the influence of vestibular stimulation (canals or otoliths) on the intensity of phantom limb pain in patients with unilateral supracondylar amputation of a lower limb, secondary to type 2 diabetes mellitus. Methods. Twenty five patients with phantom limb pain participated in the study (18 men/ 7 women, 23 right-handed). They were aged 59.8 ±11 years and they had no history of neurology, psychiatry, otology, or balance disorders, 18 of them were receiving insulin and 12 had retinopathy. After neuro-otology and pain assessments (Lahtinen & DN4 scores), they replied to anxiety, depression and dissociation questionnaires, and they were randomly assigned into 2 groups for unilateral vestibular stimulation: caloric stimulus (30°C or 44°C) or centrifugation (300°at 3.5 cm). Before and after vestibular stimulation, pain intensity and depersonalization/ derealization (Cox & Swinson 2002) questionnaires were administered, with a follow up of the pain intensity. Results. At the moment of unilateral vestibular stimulation 19 patients had pain. After caloric stimulus, pain decrease was reported by 8/8 patients and after centrifugation by 8/11 patients; while the 6 patients with no pain reported no sensation change. Depersonalization/ derealization symptoms decreased after any of the 2 stimuli. Pain intensity decrease persisted 1 and 7 days after stimuli in circa half and one third of the patients of each group; while patients who had no pain reported the usual pain intensity or no pain. Multivariate analysis showed no influence of the anxiety, depression or dissociation questionnaires on the effect of vestibular stimuli. However, just 4 patients had anxiety while 21 patients had depression and 13 reported dissociative experiences, with a similar distribution per group. Conclusion. In patients with supracondylar amputation of a lower limb secondary to type 2 diabetes mellitus, either unilateral caloric stimulus or centrifugation, may decrease the intensity of phantom limb pain with modulation of depersonalization/ derealization symptoms.

3-W-119 Effects of Monocular Visual Cues on the Vestibular Control of Standing Balance

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BACKGROUND AND AIM: The control of standing balance requires the integration and processing of diverse sensorimotor cues. With respect to the vestibular control of standing balance, the role of vision is primarily limited to binocular and no vision conditions. Thus, limited data exists on how monocular visual cues alter this standing balance control. The purpose of this study was to characterize how vestibular-evoked muscle and whole-body balance responses are modulated in response to visual cues provided by no, non-dominant eye, dominant eye, and binocular vision conditions. METHODS: Twelve healthy subjects (26 ± 5 years, 8 females) were exposed to a random, continuous electrical vestibular stimulation (EVS) signal over the mastoid processes (±3.5 mA, 0-20 Hz). Subjects stood quietly with their heads facing forward and eyes fixated on a visual array during four experimental (no vision, non-dominant eye, dominant eye, binocular) conditions. Eye dominance was determined using variations of the Miles and Porta tests. Whole body medial-lateral ground reaction force acting on the body, and muscle (surface electromyography) responses from the left (LMG) and right medial gastrocnemius (RMG) were calculated in time (cumulant density) and frequency (coherence) domains to characterize the vestibular control of standing balance. RESULTS: All subjects were categorized as right eye dominant. In the time domain, EVS-whole body balance responses, as represented by the medium-latency peak amplitude, increased progressively with a decrease in visual cues ($p < 0.05$). The EVS-whole body balance responses were increased 43, 23 and 10% for no vision, non-dominant eye, and dominant eye visual cues than binocular vision, respectively ($p < 0.05$). The EVS-LMG medium-latency peak amplitude increased progressively with decreases in visual cues ($p < 0.05$). There were no detectable differences in vestibular-evoked balance responses between monocular visual conditions. Surprisingly, the EVS-RMG medium-latency peak amplitude was 17% greater for the non-dominant than dominant eye ($p < 0.05$). In the frequency domain, EVS-whole body forces did not differ for any visual condition ($p > 0.05$). For EVS-LMG, peak coherence was 27 and 24% greater for no vision than dominant eye and binocular vision, respectively ($p < 0.05$). There were no differences in peak coherence between monocular visual conditions ($p > 0.05$). The EVS-RMG peak coherence was 23% greater for dominant eye than non-dominant ($p < 0.05$). CONCLUSIONS: Our results indicate that the vestibular control of standing balance is decreased when visual cues are progressively increased. Interestingly, as represented by the EVS-RMG vestibular-evoked balance responses, visual cues provided by the non-dominant eye may not be as reliable as the dominant. As such, the vestibular control of standing balance was greater when visual cues were provided by the non-dominant than dominant eye.

3-W-120 Balance Performance during Turning in Patients with Benign Paroxysmal Positional Vertigo

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Background and aim: Benign paroxysmal positional vertigo (BPPV) is a common cause of vertigo. Because of the symptoms, patients may experience postural instability when performing daily activities and adopt different movement strategies. Furthermore, patients may refrain from certain movement, such as head turning, to avoid triggering the symptom. The study aimed to investigate the balance performance during turning in BPPV patients compared to healthy young adults. Methods: Twenty-six healthy young adults (22.6±1.9 years) and 26 patients with BPPV (53.7±16.1 years) diagnosed with Dix-Hallpike test were recruited in the study. All participants were instructed to turn towards a target at the behind as quickly as possible when hearing an auditory cue from either side without moving their feet. A Kistler force plate was used to record postural sway during the turning task. Center of pressure (COP) data were analyzed from the force plate. The time to reach a stable position at the end turning position (turn duration), and displacement and velocity of the COP in anterior-posterior (AP) and medial-lateral (ML) direction during turning were measured. Independent t test was used to compare the difference of all the parameters between the two groups. Significance level was set at $p<0.05$. Results: The BPPV patients demonstrated a significantly longer time to reach a stable position at the end turning position than the healthy controls. A larger total sway path was noted in the BPPV patients than the healthy controls, although the difference was not statistically significant. There was no significant difference on all velocity parameters during turning, including maximum and averaged AP and ML velocity, between the two groups. Conclusions: BPPV patients required a longer time to reach a stable position than the healthy controls when turning. However, no group difference was found in the COP displacement and velocity during turning. It is possible that the turning task was not, as expected, challenging to the patients. BPPV patients might use different strategy, such as turning other body parts instead of turning the head to achieve the same goal. With this strategy it may take longer to complete the turning. Further study is required to investigate the influence of the turning movement to postural control strategy in patients with BPPV. Acknowledgements and funding: We thank Ministry of Science and Technology of Taiwan for supporting this study (MOST 104-2314-B-006-040- and MOST 105-2314-B-006 -017 -MY2).

3-W-121 Differential Effects of Vision Upon the Accuracy and Precision of Vestibular-Evoked Balance Responses

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Vestibular information must be transformed from head to foot-centred coordinates for balance control. This transformation process has been previously investigated using Electrical Vestibular Stimulation (EVS), which evokes a head-fixed sway response. Hitherto, the craniocentric nature of this response has been studied with respect to average sway traces. Such analysis will miss any trial-by-trial variations which might reflect changes in the efficacy of vestibular control of balance. Here we performed single-trial analysis to measure variation in the direction of the EVS-evoked sway response (i.e. precision), and compared this to the mean direction (i.e. accuracy). We determined the effect of vision upon both parameters. Volunteers adopted various head yaw positions (0, ±30 & ±60 deg) while EVS was applied, and sway response direction was determined by ground reaction force vectors. As previously reported, we found that mean sway direction was oriented towards the anodal ear, rotating in line with head yaw. Vision had no effect upon the directional accuracy of this response. However, when we analysed trial-

by-trial variations, we found that vision increased directional variability by ~20%. Further analysis revealed a strong inverse relationship between response magnitude and precision. Hence, when the EVS response was attenuated by opening the eyes, there was a simultaneous increase in variability. These results provide a novel method for analysing the efficacy of vestibular control of balance. The paradoxical observation that vision reduces the precision of the sway response can be explained by a multi-sensory integration process. As additional veridical sensory information becomes available, the relative contribution of vestibular input is reduced, causing a simultaneous reduction in both response magnitude and precision.

X Visual function and disorders

3-X-122 Comparison of traditional eye movement exercises with a novel oculomotor training paradigm using a head-mounted virtual reality device

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BACKGROUND AND AIM: In recent years, eye movement assessment and therapy in individuals with concussion has become increasingly important due to a high prevalence of oculomotor deficits. These therapeutic techniques include clinic and home-based programs where a patient either moves their eyes between two stationary targets or moving targets presented on either a computer or by a clinician directly. However, the efficacy of such programs has been called into question. The emergence of virtual reality (VR) as a rehabilitation tool allows for an interesting opportunity to develop new oculomotor training paradigms that could be more enjoyable for the patient, lead to higher compliance, and be more efficacious than traditional therapy. The aim of this study was to determine the feasibility of a novel VR eye movement training protocol by determining if it can improve oculomotor control in healthy individuals following training. This study will serve as a pilot study for development of oculomotor training protocols for individuals with concussion. METHODS: Seventeen participants (range: 19 to 30 years) volunteered for the study and were randomly placed into the control (CO), clinic (CL), or virtual reality (VR) group. All participants performed an initial (PRE) evaluation of saccadic eye movements, an evaluation three weeks later (MID), and a final evaluation after six weeks of training (POST). The CL group underwent training, which included pencil push-ups, metronome-guided voluntary saccades, and a convergence saccade task, while the VR group performed a novel training task using a head mounted display (Oculus VR, Menlo Park, CA), which consisted of saccades and smooth pursuit tasks. The CO group did not perform any training. RESULTS: A mixed-model ANOVA was performed from PRE-to-MID on the following: saccade number, initial saccadic latency, peak saccadic velocity, and mean absolute position error. There were no main effects due to session in either the saccade N or mean absolute position error. There was a main effect due to session in saccadic latency ($F(1,14) = 5.309$, $p<.05$) and peak velocity ($F(1,14) = 5.336$, $p<.05$; see Figure), which showed that both were higher in the MID session. There were no group differences at PRE or MID. CONCLUSION: There was a notable increase in the peak velocity for all groups; while there were not significant differences between the groups at the MID session, the raw data (see Figure) does suggest that saccadic velocity increased more in the CL and VR groups. An increased latency might be expected due to the speed-accuracy trade-off; however, there were no significant changes in mean positional error from PRE-to-MID, therefore it is not possible to make this determination. It will be necessary to analyze the POST session data as well as collect a retention evaluation to determine if the training protocols were successful in enhancing saccadic performance.

Oral Abstracts

Monday, June 26, 2017

O.1 – Aging

O.1.1 Depressive symptoms and executive function may be linked to different aspects of standing postural control in older adults.

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Background and Aim The ability to maintain posture when standing, especially while performing unrelated cognitive tasks like talking or reading a sign (i.e., dual tasking), is critical to safe completion of many daily activities for older adults. In the laboratory, dual task performance can be quantified by calculating the percent change in a given postural sway metric between single-task (ST) and dual-task (DT) conditions. Such dual task "costs" tend to increase with advancing age and executive dysfunction, and are linked to mobility decline and falls. Depressive symptoms are common in older adults and have also been linked to worse mobility and increased risk of falling. Yet, the effects of mood on standing postural control have not yet been fully established. We therefore examined the relationships between depressive symptoms, executive function, and postural control in older adults. Methods Sixteen older adults (8 women, mean±SD age = 81.24±10.41 years, range = 66-96 years) were recruited. Self-reported number of depressive symptoms was assessed by the 15-item Geriatric Depression Scale (GDS). Executive function was assessed by the Trail Making Test (TMT) parts A and B and defined as the difference in time needed to complete part B as compared to A. Postural control was assessed by a dual task paradigm in which participants completed trials of standing quietly (ST) and standing while performing serial subtractions (DT). Postural sway speed and elliptical area were derived from each condition. The dual task cost to each metric was calculated as the percent change from ST to DT conditions. Results GDS scores ranged from 0-9 (out of 15) and did not significantly correlate with the TMT test of executive function. Those with more depressive symptoms exhibited worse postural control; that is, greater sway area under ST ($R=0.85$, $p<0.0001$) and DT ($R=0.77$, $p=0.008$) conditions. Depressive symptoms did not, however, correlate with the dual task cost to any sway outcome. In contrast, executive function did not correlate with ST postural sway, but did correlate with DT sway area ($R=0.76$, $p=0.02$) and speed ($R=0.67$, $p=0.04$), as well as the DT cost to sway area ($R=0.71$, $p=0.001$) and speed ($R=0.73$, $p=0.03$). In all cases, better executive function was linked to better DT postural control and lower dual task cost. All significant correlations were independent of variance associated with age and gender. Conclusion Both depressive symptoms and executive function are linked to postural control, but in different ways. Whereas the number of depression symptoms appears to have a more global influence on the ability to maintain postural control within a given situation, executive function seems to more specifically relate to the ability to maintain postural control as cognitive demands on the system are increased (i.e., dual task costs). Both

mood and executive function should thus be considered as important factors contributing to standing posture in old age.

O.1.2 Texting while walking; effect of age and environment

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BACKGROUND AND AIM: In the past few years texting while walking (TeWW) have become a common daily dual-task performed by people from all ages. As with other dual tasks, TeWW requires a division of attentional resources between the two tasks; these may result in decrements of performance in one or both tasks (dual task cost; DTC). Unlike commonly-used dual tasks, TeWW involves a significant visual component, and generates DTCs even in young healthy adults and in both quiet and busy indoors environments. To date, the effect of age and environment on TeWW performance has been insufficiently studied and thus the aims of the current study were to examine differences in performance of TeWW between young and older adults as well as between two environments (indoors/outdoors). In addition, correlations between TeWW performance and executive functions and functional mobility were examined. METHODS: Thirty young (15 men; aged 27.8±4.4 years) and twenty older (7 men; aged 68.9±3.9 years) adults were asked to walk indoors and outdoors, with and without texting, as well as to text while standing. Each trial lasted for one minute. Gait parameters were obtained from accelerometers and texting performance was extracted from a custom-written Android application. DTCs were calculated for walking and texting. Participants also completed cognitive evaluations (Trail Making Tests; TMT A and B) and the timed up and go (TUG) test. RESULTS: Compared to single tasks, during TeWW both groups had decreased gait speed (i.e. shorter stride length and longer stride time) as well as decreased texting speed ($p<0.001$) indoors and outdoors. Only older adults had an increase in gait variability (stride length and time) in both environments ($p<0.001$). No age effect was found for DTC of gait and texting variables indoors. When outdoors, DTCs of gait speed ($U=156$, $p=0.004$), stride length ($U=158$, $p=0.005$) and stride time ($U=166$, $p=0.008$) were larger for older than for young adults. No main effects were found for environment (indoors/outdoors) in any of the gait or texting variables. In addition, no significant effect of environment was found for DTCs of gait or texting. Higher gait DTCs were associated with longer time to complete the TMT A and B ($r=0.52$ to $r=0.65$, $p<0.05$) but only for the young group. Longer time to perform the TUG was associated with larger stride time DTC indoors for both groups (young; $r=.47$; older; $r=.49$) and with higher stride time DTC outdoors for the older adults ($r=.47$). CONCLUSIONS: The results suggest that both healthy young and older adults possess the resources necessary to perform TeWW in both quiet and busy environments. Nevertheless, both groups had DTCs in both walking and texting. Higher gait variability during TeWW in the older group suggests that they may be more at risk for falls. The significant between group differences in DTCs found only outdoors suggest that older adults pay an additional "price" during outdoors TeWW. ACKNOWLEDGMENTS AND FUNDING: The Learning in a Networked Society (LINKS) Israeli Center of Research Excellence (I-CORE) and the University of Haifa.

O.1.3 The speed and variability of gait are associated with different functional brain networks in older adults

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BACKGROUND AND AIM: Walking is often assessed by measuring gait speed and/or the degree of variability in a given temporal-spatial parameter over time (e.g., stride time variability). Gait speed and variability are often only moderately correlated with one another and as such, suspected to be regulated in part by different control mechanisms. Resting-state functional magnetic resonance imaging (rs-fMRI) can be used to estimate functional connectivity both within and between brain networks. We evaluated the relationships between gait speed, gait variability and the functional connectivity of established large-scale brain networks, hypothesizing that these characteristics of gait are linked to the connectivity of different networks. METHODS: Twelve older adults (mean±SD age = 76±9.5 years) completed two study visits. On the first visit, multiple trials of over-ground walking at preferred speed were completed over a 14-foot GAITRite mat. Average gait speed (m/s) was computed, as well as gait variability defined as the coefficient of variation about the mean stride time. On the second visit, participants completed multiple, six-minute rs-fMRI BOLD sequences (3s TR, 3mm3). Functional connectivity was quantified by the correlation among spontaneous fluctuations in BOLD signals within and between seven pre-defined seed-based brain networks, such that greater positive or negative values reflected stronger connectivity. RESULTS: Gait speed and variability were not significantly correlated with each other ($r=-0.24$, $p=0.45$); however, they were associated with the strength of functional connectivity of different brain networks (Figure) and the associations remained significant even after adjusting for age, gender and BMI. Specifically, those with faster gait speed had stronger functional connectivity within the frontoparietal network ($r=0.61$, $p=0.04$). Those with less gait variability (i.e., steadier walking patterns) exhibited stronger negative functional connectivity between the dorsal attention network and the default mode network ($r=0.78$, $p<0.01$). In other words, lower gait variability was linked to a greater degree of anti-phase correlation in BOLD signals between these networks. No other significant relationships between walking characteristics and the strength of within- or between- network functional connectivity were observed. CONCLUSIONS: The observation that gait speed was associated with functional connectivity within the frontoparietal network suggests that this widely-assessed characteristic of walking depends upon the integrity of communication within a collection of brain regions linked to executive function. The link between gait variability and the degree of anti-correlated (resting) brain activity between the dorsal attention network and the default mode network suggests that one's steadiness of walking depends upon the capacity to dissociate the activity of these two networks from one another, which is critical to the ability to sustain one's attention.

O.1.4 Head sway restriction by older adults during precise manual motor imagery

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BACKGROUND AND AIM: Imagined movements share many similarities with physical ones. We have previously shown that manual motor imagery can evoke systematic changes in posture control. Unlike young, older adults restrict sway when making imagined arm movements, which could be interpreted as a postural threat response [1]. Here, healthy young and older adults imagined manual reaching movements under low, medium and high precision requirements. It is known that speed-accuracy tradeoffs affect both posture [2] and the timing of imagined movements [3, 4]. We predicted that older adults' sway restriction would be modulated by task precision. METHODS: Twenty-four young (18-26 yrs) and 23 older adults (67-80 yrs) with no history of balance impairment stood without vision in closed stance. Participants were asked to maintain upright stance while imagining making reaching movements of their right arm to an array of target locations presented at waist level either along the ML or AP direction. Precision of the arm movement was manipulated by varying target width (Fig., inset). Participants stood with arms relaxed by their sides with a computer mouse held in their left hand. Each trial commenced with a "get-ready" signal upon which participants imagined moving their right arm to the starting position (Fig., inset). This imagined posture was maintained until the "go-signal" was heard. Participants then imagined moving to the previously stated target location, and indicated arrival by clicking the mouse button. Target order was randomized, and precision counterbalanced. All factors except age and movement direction were within subjects. Sway was measured (at 60Hz) from Polhemus Fastrak sensors attached to the head and hip segments. The sway measure was RMS drift of hip and head position (across 1s time windows) [1]. RESULTS: Self-reported imagined MT increased approximately linearly with target distance. Young, but not older, participants' MT increased with required precision (Fig., top panels). Both groups' head sway was greater than hip sway at low precision. Older adults' head and hip sway did not differ in the higher precision conditions, whereas young adults' head sway remained greater than their hip sway as required precision increased (Fig., bottom panels). CONCLUSIONS: Older adults selectively curtailed head (or upper body) sway when the required precision of manual imagery increased. This sway restriction may reflect an attempt to stabilize the head and shoulder to allow better calibration of the imagined arm movement, especially as required precision increased. It could also be linked to the head stabilization strategy used by older people to improve sensory (e.g., vestibular) input quality during some difficult balance tasks [5]. ACKNOWLEDGEMENTS AND FUNDING: Supported by ESRC UK, and Warwick Postgraduate Research Fellowship. REFERENCES: 1. Mitra et al. (2016). Psychol Aging. http://dx.doi.org/10.1037/pag0000120 2. Bonnetblanc et al. (2004). Neurosci Lett, 358(3), 181-184. 3. Decety, J., & Jeannerod, M. (1995). Behav Brain Res, 72, 127-134. 4. Stevens, J. A., (2005). Cognition, 95, 329-350. 5. Di Fabio, R. P., & Emasithi, A. (1997). Phys Ther, 77(5), 458-475.

O.1.5 Combined exercise and cognitive training to improve dual-task balance in older adults

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Background and Aim: Researchers have demonstrated that with aging, higher level cognitive processes are increasingly recruited during balance and gait (Seidler et al., 2010). This view is supported by showing that cognitive dual-task training improved mobility and posture among older adults (Li et al., 2010). Other studies suggest that combined physical and cognitive training is more effective than single domain training in improving mobility among older adults (Silsupadol et al., 2007). However, the locus of combined training effects is not well understood. One possibility is that concurrent cognitive-motor performance trains general task coordination skills. Alternatively, combined training effects may be driven by improved cognition, in which case, concurrent training might detract from improvements in the cognitive domain. We therefore contrasted sequential and concurrent training conditions that delivered comparable amounts of exercise and cognitive training. Methods: We assigned 41 older adults to either Sequential or Concurrent training conditions consisting of 12 sessions of computerized divided attention training and recumbent cycling. All participants completed pre- and post-training assessments consisting of mobility (STS: Sit-to-Stand) and cognitive (n-back working memory) tasks performed singly and concurrently. Sound levels were individually adjusted as per hearing acuity. Auditory challenge was varied by lowering the sound intensity of the cognitive stimuli (15 dB lower than the ideal listening levels). Results: Pre-post comparisons on STS completion time revealed that both groups improved comparably, particularly under dual-task conditions. However, in the cognitive domain, participants in the Sequential training group demonstrated improved n-back performance accuracy under dual-task conditions. Within the Sequential training group, cognitive gains were more pronounced in the challenging auditory condition. These format-specific effects are corroborated by similar improvements to a second neuropsychological test of working memory, Letter-Number-Sequencing, again favoring the sequentially trained group. Conclusions: These results suggest that while both training protocols were successful in improving mobility under challenging dual-task conditions, Sequential training was more effective in improving dual-task cognitive performance. Therefore, focusing on one training intervention at a time appears to be more beneficial than dual-task training where participants are required to divide their attention between two tasks. The findings support the view that the locus of combined cognitive and aerobic training benefits on dual-task performance is through improvements to cognition, rather than through improvements to general task coordination ability.

O.1.6 Old adults drift while stepping in place: influence of ground optic flow and perceptual reference frame reliance on self-motion perception

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BACKGROUND AND AIM: The optic flow (OF) due to body motion provides a visual affordance to perceive the direction and speed of self-motion and thus control the body during locomotion. Artificial OF modulates gait while walking (Pailhous et al.,1990) and induces postural reactions in stationary individuals (Flückiger & Baumberger, 1988). Different frames of reference (FoR) are used in order to perceive and control one's spatial orientation (Isableu et al., 2010). Reliance on the visual FoR in young (Isableu et al., 2010) and old (Slaboda et al.,2011) adults has been linked to greater postural sway reactions and reduced reweighting ability under simultaneous visual and somatosensory perturbation. We wanted to examine how the increased reliance on the visual FoR with age (Agathos et al., 2015) may influence self-motion perception when the availability of podal information from the ground was intermittent due to stepping in place. This task should alter egocentric referencing with respect to the ground surface, and hence increase OF effects, especially in old adults. METHODS: 19 young (31.2 ± 6.3 years), 17 middle-aged (51.7 ± 5.8 years) and 20 old adults (74.1 ± 3.7 years) stepped in place (SIP) on a force plate during 30 s under static stimulation, approaching and receding OF projected on the ground in front of them and a control condition (no artificial stimulus). We calculated anteroposterior centre of pressure (COP) translation under the imposed visual stimulation conditions relative to the control condition. For the 2 OF conditions, OF sensitivity was defined as the ratio of COP translation velocity over absolute OF velocity: the visual self-motion quotient (VSQ). Reliance on the visual (assessed with the RFT and RDT) and egocentric (assessed with the rod-and-body test, RBT) FoR had been determined for all participants in a previous study (Agathos et al., 2015). RESULTS: Participants drifted forwards under the control condition. This natural drift was significantly greater for old adults ($p<0.05$). Middle-aged and old adults drifted further back under approaching flow compared to receding flow and static stimulation, while young adults did not drift significantly under any visual stimulation condition ($p<0.05$). VSQ values were significantly smaller under approaching, compared to receding flow. Old adults were more sensitive to OF compared to the other groups, revealed by larger VSQ values ($p<0.05$). We correlated FoR reliance with respect to the VSQ for approaching and receding flow. The correlations were positive for the RFT and RDT and negative for the RBT. A positive correlation was also found between the VSQ and the natural drift during the control condition. CONCLUSIONS: The VSQ appears to be a motor index of reliance on the visual FoR during SIP, revealing that drifting was limited by approaching flow and enhanced by receding flow, and is associated with greater reliance on the visual and reduced reliance on the egocentric FoR. Exploitation of the egocentric FoR for self-motion perception with respect to the ground surface is compromised by age and associated with greater sensitivity to OF.

O.1.7 Stepping over obstacles reveals gait changes in middle-aged adults not evident during steady state gait

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BACKGROUND AND AIM The ability to navigate challenging environments becomes compromised with age. Gait changes in older adults (OA) that relate to fall-risk include decreased speed and increased variability. Interestingly, these changes are observed in older (OA), but not middle aged (MA) adults during unobstructed walking (Hollman et al., 2007). It may be that steady state gait is not challenging enough to elicit changes in these temporal-spatial measures at MA. The purpose of this study was to identify the effect of advancing age on gait as a function of increasing task challenge. METHODS Three age groups included: 20-35 years (YA, N=20), 50-64 years (MA, N=15), 65-79 years (OA, N=19) (mean ages 23.8, 55.5, and 69.5, respectively). Participants walked along a 15 m walkway and stepped over a fixed, visible obstacle (3, 10, or 26 cm), or no obstacle was present. Four steps (step-2, step-1, step-obst, step 1) and five foot placements (fp-3, fp-2, fp-1, fp 1, fp 2) were examined for ten trials of each condition. Gait speed, foot placement variability (FPV), and step width variability (SWV) were measured. RESULTS There was a significant interaction of age by step number by obstacle

height for gait speed ($p=0.01$). Across all four steps and in all obstacle conditions, YA walked faster than OA. In step-2 and step-1, YA and MA speeds were not different. In step-obst and step 1 for the 10 and 26 cm obstacles, MA and OA speeds were not different (Fig. 1). Therefore, in easy tasks, MA speed was not different from YA; as task challenge increased, MA speed was not different from OA. There was a significant age by foot placement interaction for FPV ($p<0.01$). FPV was greater for MA and OA, compared to YA, but only for foot placements at least two steps before the obstacle (fp-3 and fp-2). Only a main effect of age was observed for SWV ($p=0.01$); SWV was progressively larger for each age group. The easier tasks, no and low obstacles, may be interpreted as insufficiently challenging by the MA as speed was not different from YA (Fig. 1). However, FPV (fp-2 and fp-3) and SWV were greater in the MA and OA compared to YA. Increased SWV is linked with increased fall rates in older adults, thus, MA may have an elevated risk of falls. Higher FPV reflects larger step-to-step changes in the two older groups. This may be detrimental to stability, as higher FPV may reflect reduced ability to gather and/or transform visual information. Conversely, higher FPV in the steps preceding the final foot placement (fp-2 and fp-3) may be functional, as the MA and OA groups may require more variability during obstacle approach to ensure that the final foot placement is achieved. CONCLUSIONS Gait changes were observed as early as middle-age, and these changes became more evident as task difficulty increased. The changes are related to decreased balance control and falls in older adults, and it is therefore imperative that this relation is investigated also in middle-aged individuals.

O.1.8 Activity Restriction, Balance Confidence, and History of Falls in Older Adults

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Background: Falls and fall-related injuries are a significant threat to health and well-being of older adults. A potential reason for the persistence of falls in the elderly is inadequate screening and identification of older adults at risk for falls. The aim of this cross-sectional analysis was to identify characteristics that distinguished individuals with a recent history of falls compared to individuals who had not fallen. In particular, this study evaluated associations of balance confidence and activity restriction with recent history of falls. Methods: Older adults from a rural community were invited to participate in a multidisciplinary falls screening and prevention program. One hundred twenty-nine community-dwelling men and women with mean age 75.4 years (SD = 9.8) participated in at least one event in the program. A variety of measures and demographic data were collected at each event. Measures pertinent to this analysis included history of falls (79 individuals reported at least one fall in the previous year), Activities-specific Balance Confidence Scale (ABC) scores (mean 62.4 ± 19.7), and a yes or no response to the question, "Do you limit your activities because you are afraid you might fall?" (72 individuals positive for activity restriction.) Estimates and p-values were calculated for parameters in a logistic regression model of the dichotomous history of falls (≥ 1 previous fall vs. no previous falls) with main effects of ABC score and self-reported activity restriction. Results: In this sample of 129 community-dwelling older adults, there was insufficient evidence to suggest an association between activity restriction and recent history of falls (Wald Chi-square estimate 2.0404, $p = 0.1532$). However, there is a significant ($p < 0.01$) effect of ABC score on recent history of falls such that the log odds of recent history of falls vs no recent falls decreases by 0.0375 for each one-point increase in ABC score. Conclusions: Balance confidence but not activity restriction was associated with recent history of falls compared to no recent falls in older adults in a rural community.

O.2 – Sensorimotor control

O.2.1 Sensory conflict stimuli as a window into emergence of posture control mechanisms in infants

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BACKGROUND AND AIM: During the first year of life, infants' posture control undergoes dramatic development. Within about two months, typically developing infants first begin to control their head with respect to gravity, followed by the upper trunk, then lower trunk, and then finally achieve independent sitting by ~8 months. During this period, infants explore the world, learn to regulate tone, interpret sensory cues from multiple systems, and generate muscle activations for posture control. All this is accomplished while infant's body mass more than doubles, significantly altering the biomechanics. This transition represents the most rapid learning of posture control in our lives. Understanding these developmental processes provides a paradigm for viewing motor learning of posture control, with long-term impact for people with posture impairments. METHODS: To investigate sensorimotor integration, we completed a longitudinal posture study with 6 infants tested ~2 times per month from ~2-8 months of age. Infants were positioned on a bench with trunk support at their segmental level of trunk control. Infants responded to sensory conflict stimuli that evoked frontal plane sway. Sway was measured with sensors placed at C7 and the head. Stimuli consisted of a continuous pseudorandom tilting bench at various amplitudes. The bench tilt stimuli create a sensory conflict where proprioception oriented the body away toward the tilting bench (away from upright) while vision and vestibular oriented the body upright. We characterized the stimulus-response behavior using frequency-response functions (FRF gains and phases). FRFs were interpreted using a feedback control systems model, based on Peterka (2003). The model controlled a single link body (that changed in mass and inertia with age and level of support) with time delayed sensory cues (visual/vestibular, proprioception, and torque feedback) and non-time delayed muscle tone (intrinsic stiffness and damping). RESULTS: At a young age and with high support, experimental gains and phases were relatively constant across frequency. At older ages and less support, infants had more phase leads and reduced gains at lower frequencies and phase lags at higher frequencies. Changes across stimulus amplitudes were most evident at the upper-lumbar support (~6 months). The model explained these changes primarily through increases in intrinsic stiffness and damping and torque feedback with increasing age. Torque feedback was consistently higher during the larger stimulus and was highest overall when infants were tested with upper lumbar support. CONCLUSIONS: Our study provides a window into the emergence of posture control and sensory reweighting in infants prior to independent sitting. The experimental results showed systematic changes across development and level of support which were explained through the model as infants increased muscle tone (stiffness and damping) and use of torque feedback. ACKNOWLEDGEMENTS AND FUNDING: We thank the parents and children who participated and the funding provided by NIH (R03 DC013858).

O.2.2 Acceleration feedback by muscle spindles contributes to trunk stabilization

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Background and aim Trunk stabilization can be defined as maintaining control over trunk posture and movement, in spite of the disturbing effects of gravity and external and internal perturbations. Trunk stabilization is required to control posture and movement during daily activities and it has been hypothesized that inadequate stabilization could contribute to low-back pain. However, the processes underlying trunk stabilization are incompletely understood at present. Various sensory modalities are likely to contribute, but the importance of each of these is unclear and it is unknown whether their contributions are based on encoding of position, velocity or acceleration of the trunk. The aim of the present study was to assess the contribution of different sensory modalities and the order of feedback of these modalities to trunk stabilization. Methods To assess trunk stabilization, we used a recently developed method in 35 healthy subjects. In short, upper-body sway was evoked by continuous unpredictable, multi-sine force-controlled perturbations to the trunk in the anterior direction, resulting in small fluctuations around a fixed working point. Subjects were instructed to either ?maximally resist the perturbation? (resist task) or to ?relax but remain upright? (natural task). Frequency response functions (FRFs) of the admittance (the amount of movement per unit of force applied) and reflexes (the increase in EMG amplitude per unit of trunk displacement) were obtained. To these FRFs, we fitted a physiological model, to estimate intrinsic stiffness and damping, as well as feedback gains and delays. Different model versions were compared to assess which feedback loops contribute significantly to trunk stabilization. Results Intrinsic stiffness and damping and muscle spindle (short-delay) feedback alone were sufficient to accurately describe trunk stabilization. Adding Golgi tendon organ, vestibular and visual feedback did not improve model fit. However, a model with feedback based on trunk movement and velocity alone yielded unrealistically low reflex delays. Addition of acceleration feedback yielded realistic delays and improved model fit. Conclusion Intrinsic trunk mechanical properties, which depend on muscle coactivation, and spindle feedback alone are sufficient to describe trunk stabilization in the sagittal plane under small mechanical perturbations. In line with this, we showed previously that closing the eyes does not affect trunk motion in these conditions. Although conventionally, only velocity and position information are assumed to be encoded by muscle spindles, feedback of acceleration has been shown to improve control and our data suggest that this mechanism is used in control of trunk posture.

O.2.3 Central not peripheral vestibular processing impairs gait coordination

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BACKGROUND AND AIMS: Healthy human gait is symmetric and exhibits anti-phased left-right stepping, ensuring an inter-limb coordination to maximize postural control and energy efficiency. This coordination is generated by neuronal inter-connections between central pattern generators in the spinal cord that are governed by cortical areas. Mal-function of central vestibular processing areas generates vestibular symptoms in the absence of an identifiable peripheral vestibular system lesion. For example, patients with vestibular migraine have a false perception of their body orientation in space. Walking in the dark enforces a coordinated afference primarily from the vestibular and somatosensory systems. This task, coupled with patients that have abnormal central vestibular processing information (vestibular migraine) or abnormal peripheral vestibular function (vestibular hypo-function or BPPV) enables a platform to tease out the relative sensory contribution and their integrated output responsible for this common task. We hypothesized that patients with aberrant central vestibular processing would demonstrate unique spatiotemporal gait characteristics, and have impaired accuracy and consistency of gait coordination compared with those patients with abnormal peripheral vestibular function and healthy controls. METHODS: One hundred and eighteen subjects were recruited. Peripheral vestibular function (n=61) was determined based on ocular and cervical vestibular evoked myogenic potential testing, video head impulse testing, and clinical examination. Patients with abnormal central vestibular processing (n=22) had normal vestibular function testing. Subjects were instructed to walk at a comfortable pace during three visual conditions; eyes open, eyes open and closed intermittently, and eyes closed. Subjects walked twice in each condition on a 6.7 meter GAITRite system. Spatio-temporal gait characteristics and variability (rhythmicity) for each subject were measured. Accuracy and consistency of gait coordination was calculated from step and stride times (known as phase coordination index, PCI), and asymmetry. RESULTS: Both patient groups showed a similar spatiotemporal gait pattern, which was significantly different than the pattern of the healthy controls. However, only the central vestibular patient group had an abnormal PCI. There were no significant interactions between the groups and walking conditions. CONCLUSIONS: Our data suggest: 1) Patients with abnormal perception despite a healthy peripheral vestibular end organ have impaired bilateral coordination of gait. This suggests the central processing of vestibular information affects the neuronal circuits mediating gait coordination. 2) The lack of interaction between groups and walking conditions suggests that humans react similarly to changes in visual conditions as long as somatosensation is preserved.

O.2.4 Effects of walking speed on spatiotemporal gait characteristics and their variability in patients with bilateral vestibulopathy: preliminary observations

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BACKGROUND AND AIM: Bilateral vestibular hypofunction (BVH) is a bilateral reduction or loss of vestibular function that results in severe balance deficits and an increased falls risk [1]. Given that the vestibular influence on locomotion appears to be suppressed with increased locomotor velocity [2,3], examining gait at different velocities may provide insight into the deficits experienced with BVH. As part of a larger study attempting to develop uniform BVH diagnosis

criteria, this study aimed to assess spatiotemporal gait characteristics and their variability across different walking speeds in patients with BVH. We present preliminary data from the first participants. METHODS: Nine patients (4 male, 5 female; Age: 55±15) with BVH have participated thus far. Experiments were conducted on the CAREN Extended system (Motekforce Link, Amsterdam, The Netherlands) using a reduced kinematic model (6 markers). The virtual reality display was fixed (no optical flow). Participants from the larger study who could walk without assistance were invited to participate. The participants first completed multiple 1.5 minute treadmill walking familiarisation trials, starting at 0.4m/s, followed by faster speeds (up to 1.6m/s) based on ability. Participants then completed five recorded bouts of walking, each lasting two minutes, at different speeds (0.6m/s, 0.8m/s, 1.0m/s, 1.2m/s and 1.4m/s). The final 60 strides at each walking speed were analysed and the means, standard deviations and coefficients of variation (CV) of stride length and time, step length and width, double support time and swing phase toe clearance were calculated. One way ANOVAs with walking speed as a factor were conducted. RESULTS: Stride length, step length and toe clearance all increased with increases in walking speed ($P<0.001$). Stride and double support time decreased with increased walking speed ($P<0.0001$). No walking speed effect was found for step width ($P=0.25$). Significant reductions in variability with increases in walking speed were found for stride length, stride time, step length, toe clearance ($P<0.01$) and double support time ($P<0.05$). A significant increase in step width variability was observed with increases in walking speed ($P=0.0033$). Variability was generally higher for toe clearance (CV range of 13.5% to 44.8%) and step width (CV range of 6% to 50%). CONCLUSIONS: These preliminary data suggest that while gait characteristics in the sagittal plane may improve with increases in walking speed in patients with BVH, at least in terms or variability, motions in the frontal plane may become more variable. This may have implications for mediolateral stability and falls risk in patients with BVH.
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O.2.5 The effect of compliant support surfaces on sensory reweighting in human balance control

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BACKGROUND AND AIM: Balance control involves the complex contribution of neural, muscular and sensory systems to maintain an upright posture and prevent falling. Information from sensory systems is combined based on their reliability according to a dynamically weighting process, i.e. sensory reweighting [1]. When balance is impaired, compliant foam mats are often used in training methods to improve balance control. However, the effect of the compliance of these foam mats on sensory reweighting remains unclear. In this study, we investigated the effect of compliant surfaces on sensory reweighting in balance control using system identification techniques. METHODS: Eleven healthy subjects (age 20-30 years, 8 women) were asked to maintain their balance while proprioceptive information was perturbed by continuous rotations of the support surface. Multisine torque disturbances containing frequencies in the range of 0.05-10 Hz were applied in 9 trials; three levels of support surface compliance,

combined with three levels of desired support surface rotation amplitude. Two additional trials were performed with eyes closed. With the use of system identification techniques, the dynamic response of the ankle torques to the support surface rotations was determined and represented by frequency response functions (FRFs). Lower frequency magnitudes (LFMs) were calculated by averaging the magnitudes in a lower frequency window (0.05-0.25 Hz), representative for sensory reweighting. RESULTS: Results showed that an increase in support surface rotation amplitude leads to a decrease in LFM (Figure 1). In addition, there was an interaction effect; the decrease in LFM by increasing the support surface rotation amplitude was less when the support surface was more compliant. Trials with eyes closed had a larger LFM compared to trials with eyes open. CONCLUSIONS: From the results, we can conclude that when balance control is trained using foam mats, two different effects should be kept in mind. An increase in support surface compliance results in larger support surface rotations and therefore down weighting of proprioceptive information. However, we also showed that support surface compliance itself also affects balance control resulting in less strong sensory reweighting for more compliant support surfaces. Therefore, therapists might perform more comprehensive exercising of the reweighting mechanism using a variety of foam mates with different compliances. ACKNOWLEDGEMENTS AND FUNDING This research is supported by the Dutch Technology Foundation STW (NeuroSIPE #10737 BalRoom) which is part of the Netherlands Organisation for Scientific Research (NWO), and which is partly funded by the Ministry of Economic Affairs. This research is also funded by The Netherlands Organisation for Health Research and Development, ZonMw (IMDI NeuroControl #104003014).

O.2.6 Correlations between multi-plane video head impulse test (vHIT) responses and balance control after an acute unilateral peripheral vestibular deficit.

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BACKGROUND AND AIM: Patients with an acute unilateral peripheral vestibular deficit (aUPVD) show profound stance and gait balance deficits. Clinically, it is assumed that the balance deficits in the pitch and roll planes are correlated with deficits in vestibular ocular reflex (VOR) responses in each canal plane. Usually, however, the lateral and anterior canal responses are affected following vestibular neuritis but not the posterior canal [1]. Previous studies have shown that deficits in lateral canal responses are weakly related to deficits in balance control [2,3]. However, it could be argued that a relationship would only be expected for anterior and posterior canal responses as these provide indicators of deficits in the roll (lateral) and pitch (anterior-posterior) directions. Given this background, we examined whether balance and vHIT VOR measures in roll and pitch planes are correlated. METHODS: 19 patients were examined at onset of aUPVD. To measure VOR function, vHIT was performed bilaterally in each of the canal planes. Vertical canal responses were converted to roll and pitch response asymmetries, assuming the canals are at 45 degs to the roll and pitch planes, and correlated with balance measures. Caloric tests with bithermal (44 and 30°C) water irrigation of the external auditory meatus confirmed the deficit side. To measure balance control and thereby assess aUVL influences during stance and gait, body-worn gyroscopes mounted at lumbar 1-3 recorded the angular velocity of the lower trunk in roll and pitch. RESULTS: vHIT lateral VOR response gain

asymmetries (mean 32.3±10.4) were greater than roll asymmetries (mean 14.2±9.9, $p<0.05$) but correlated ($p=0.04$). Pitch gain asymmetries were considerably less (mean 5.6±9.2). No significant correlations between VOR roll and pitch asymmetries were found for stance ($R<0.25$). In contrast several gait roll balance measures were significantly correlated with VOR roll asymmetries: roll amplitude walking 8 tandem steps ($R=0.51$), roll velocity walking while pitching the head up and down ($R=0.59$), roll velocity walking with eyes closed ($R=0.45$). No correlations were found with pitch asymmetries. CONCLUSIONS: This is the first report to directly link deficits in balance control with deficits in the roll plane of VOR control. The correlation was limited to roll responses. Gait and not stance correlations were found possibly because the magnitude of head roll during gait is similar to that imposed during vHIT responses. Previously reported correlations of VOR with pitch velocity during stance have been limited to low velocity lateral plane VOR responses [3]. Thus the sensory mechanisms leading to major pitch plane instability with aUVL during stance and gait despite a minor effect on posterior canal responses, and therefore on pitch plane asymmetry, remains unresolved. REFERENCES:
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O.2.7 Dynamic balance decrements last longer than 10 days following a concussion

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BACKGROUND AND AIM: Mild traumatic brain injury (mTBI), synonymous with concussion, has received considerable public and scientific attention in recent years. Balance decrements (e.g., more variable motion) is a cardinal symptom that is commonly screened for after a concussive event. Most concussion symptoms resolve within 7-10 days after the initial head trauma. However, there is emerging evidence that the effects of a previous concussion may linger longer than previously thought. The purpose of this study was to examine dynamic balance characteristics in participants who received a concussion within the last 40 days compared to a non-concussed population. It was hypothesized that the concussed participants would have more variable motion and a larger range of motion in the objectively measured dynamic balance task. METHODS: Concussed participants (N=10, 20.1 ± 1.1 yrs, 19.3 ± 11.4 days since the concussion) and non-concussed participants (N=69, 22.1 ± 2.6 yrs) participated in a large, multi-site concussion study. The dynamic balance portion of the study was assessed using a 70-second stepping-in-place task while characteristics of each stride were objectively measured using a custom Android app from a smartphone placed on the participants' thigh. After two practice trials, participants performed the stepping-in-place task in the following conditions three times each: (1) eyes open (EO), (2) eyes closed (EC), and (3) while shaking their head laterally (HS). Dynamic balance characteristics were quantified by examining the temporal variability of stride time [coefficient of variation (CV) of the duration between peak thigh flexion] and range of motion (ROM) of the thigh (difference between the mean thigh angle during the peak extension and flexion phases of the movement). A linear mixed model with group (concussion vs. healthy) and condition (EO, EC, and HS) factors was used, followed up

with simple effect comparisons if an interaction effect was significant. RESULTS: Participants with a concussion (M = 2.95%, SE = .20) showed greater stride time CV than non-concussed participants (M=2.48%, SE = .05) in the EC condition (p <.01). Concussed participants also showed a tendency to use smaller thigh ROM in the EC condition (M = 34.58°, SD = 2.44) compared to non-concussed participants (M = 39.66°, SD = 1.15), p = 0.09. CONCLUSIONS: The combination of a smaller ROM paired with more variable movement timing suggests altered neuromotor control for the concussed participants, even though they were well outside the window of time where balance symptoms are typically resolved. This suggests that more challenging dynamic balance tasks may be needed to more accurately identify neuromotor dysfunction after head trauma.

O.2.8 Dynamic single-leg balance control between athletes and previously concussed athletes during a visuomotor task.

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Title: Dynamic single-leg balance control between athletes and previously concussed athletes during a visuomotor task. Authors: Katelyn Mitchell, MScPT, CAT(C) and Michael Cinelli, PhD. Background: Objective measures currently utilized in the Return-to-Play (RTP) protocol do not accurately assess visuomotor integration to determine if athletes have recovered from a concussion. Baker et al. (2014), demonstrated that visuomotor deficits can persist in asymptomatic athletes up to 30 days after RTP. Furthermore, Cross et al. (2015) found that professional rugby players had a 60% increased risk of sustaining any injury following RTP, which may be attributed to sensorimotor deficits. The purpose of the current study was to assess dynamic balance control in concussed and non-concussed athletes during a visuomotor task. Methods: Eight previously concussed but recently asymptomatic (CONC), and eight sport and position-matched (CONT) male athletes were recruited from high risk sports (football, hockey, rugby). Participants stood in stable single support on a Nintendo Wii Balance board sampled at 100Hz while the Fitlight Trainer system administered a concurrent response time task. Five Fitlights were arranged on the floor anterior to the participant in a semicircle at 60°, 30°, and 0° about the midline. Each light illuminated 6 times in random either GREEN (70%) or RED (30%). Participants were instructed to quickly hover over the GREEN lights with their non-stance leg and withhold movements for RED lights. Participants completed a total of 6 trials (2 feet x 3 trials). Balance control between groups was assessed using both COP RMS displacement and Mean Power Frequency Analysis (MPF) of A/P COP. Results: No significant group differences in COP RMS displacement in either A/P (p=.22) or M/L (p=.34). However, MPF showed a significant group effect (p<.001) in the power of the frequencies in all bands (range= 0.1-1.0Hz) as well as differences in the frequency band with the highest power (i.e., CONC at 0.1Hz and CONT at 0.7Hz). These results suggest that CONC had greater reliability on the visual system to control movement and in turn, were utilizing a "slow" feedback mechanism at higher cortical areas. In comparison, CONT performed the task using higher frequencies and exhibited a "fast" feedforward mechanism of control. Conclusions: Athletes who have recently sustained a concussion exhibit poor neural control of their COP displacement in the A/P plane during a dynamic balance and visuomotor task. This may be attributed to deficits in sensorimotor integration of the visual, proprioceptive, and vestibular systems. The findings could help to improve current clinical practice guidelines with greater emphasis on objective assessment of the neural control of balance. As well, to inform practitioners with regards to appropriate concussion management during the RTP protocol to determine when an athlete is truly ready to return to sport.

O.3 – Neurological diseases

O.3.1 IMPAIRED ABILITY TO SUSTAIN BALANCE PERTURBATIONS IN PEOPLE WITH CHRONIC STROKE AND ITS ASSOCIATION WITH LEG AND TRUNK MOTOR FUNCTION

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BACKGROUND AND AIMS: Falls are a major health problem in stroke survivors. In daily life situations, the ability to recover balance after a perturbation is crucial to prevent a fall. Here, we investigated stroke-related impairments in the ability to sustain balance perturbations and the relation of these impairments with leg and trunk motor scores. METHODS: Eighty-one people after stroke (>6 months) and 46 healthy controls were included. To identify maximum balance capacity, participants were subjected to translational perturbations on a moveable platform in four directions (forward, backward, towards the paretic and towards the non-paretic leg). For each direction, we iteratively determined the highest perturbation intensity that could be sustained with a maximum of one step ('multiple stepping threshold'). For sagittal plane perturbations, we determined which leg was used for stepping (paretic/non-paretic). For sideways perturbations we determined the step strategy (side step/ crossover step). We assessed leg and trunk motor function with the Fugl-Meyer Assessment (FMA) and Trunk Impairment Scale (TIS). Multiple stepping thresholds were compared between groups with independent t-tests. In the stroke group, we used stepwise linear regression to determine the predictive value of motor scores and stepping leg for multiple stepping thresholds in each direction. Separate models were used for leg (FMA) and trunk motor scores (TIS). RESULTS: People with stroke demonstrated lower multiple stepping thresholds (24-47% lower) than controls ($p<0.05$ for all directions). Multiple stepping thresholds were 18% lower towards the paretic than towards the non-paretic side ($p=0.03$). In the sagittal plane, steps with the paretic leg were more common in individuals with better motor scores, however, paretic steps were associated with poorer multiple stepping thresholds. Together, motor scores and stepping leg explained 17-49% of the variance of forward and backward multiple stepping thresholds and 32 to 67% of the variance of sideways multiple stepping thresholds (Figure). Towards the paretic side, side steps were only used by individuals with good motor scores and resulted in better sideways multiple stepping thresholds than crossover steps. CONCLUSIONS: The ability to sustain balance perturbations with a reactive step is impaired after stroke. In the sagittal plane, paretic steps are more impaired than non-paretic steps. In the frontal plane, side steps are substantially more efficacious than crossover steps, but seem to be feasible only for individuals with high motor scores. Training programs to improve balance recovery responses after stroke should: 1) attempt to improve the quality of reactive steps, particularly with the paretic leg, and 2) specifically focus on practicing reactive side stepping.

O.3.2 Structural and functional connectivity underlying assistive device training-related mobility improvements in people with MS

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BACKGROUND AND AIM: A majority of people with multiple sclerosis (PwMS) have impaired functional mobility. To address this, PwMS often use devices, such as canes and walkers, to aid their mobility, however these individuals still experience impaired movement and fall frequently. Assistive devices may not be optimally effective because PwMS do not receive adequate training in their use. This study makes use of a randomized controlled trial to determine the impact of assistive device training on functional mobility and to identify neural descriptors and predictors of training efficacy in PwMS. METHODS: At baseline and following 6 weekly sessions of assistive device training or a wait-list control condition, functional mobility was assessed by the Activities-specific Balance Confidence Scale (ABC), the Multiple Sclerosis Impact Scale (MSIS-29), the Multiple Sclerosis Walking Scale-12 (MSWS-12), the Timed Up and Go (TUG), Timed 25 Foot Walk (T25FW), and 2 minute timed walk (2MTW). Data from 34 PwMS are presented, 14 of whom completed training and 20 from the wait-list control group. Differences in mean changes in mobility measures between active and control groups were assessed by Cohen's d effect sizes. Functional connectivity of the motor network was assessed by resting state functional MRI (fcMRI) in the intervention group as well as diffusion weighted images to evaluate white matter microstructural integrity. Associations between changes in mobility and changes in fcMRI were assessed by linear regression. RESULTS: There were significant differences between the active and control groups on a number of behavioral measures, with large effect sizes for the ABC ($p = 0.04$; $d = 0.69$), the MSIS-29 ($p = 0.01$; $d = 0.89$), and the MSWS-12 ($p = 0.005$; $d = 0.98$). No functional mobility improvements were observed between groups for the T25FW ($d = 0.22$), the TUG ($d = 0.15$), nor the 2MTW ($d = 0.02$). In the active group, functional connectivity between the left hemisphere's supplementary motor area (SMA) and the putamen was significantly increased following training, indicating increased communication along the striato-thalamo-cortical motor loop. It is interesting to note that greater increases in SMA-putamen connectivity following intervention was strongly correlated with poorer fiber tract microstructural integrity of white matter connecting the SMA and putamen ($r = 0.74$; $p = 0.003$). CONCLUSIONS: 6 weeks of assistive device training improves functional mobility more than a wait list control condition. These changes are associated with increases in functional connectivity of the striato-thalamo-cortical loop. Our results also indicate that the potential for functional changes in neural communication following rehabilitation are, at least in part, dependent upon quality of white matter microstructure suggesting that PwMS with more impaired neuroanatomy may achieve greater functional improvements with rehabilitation via neuroplasticity.

O.3.3 The impact of post-stroke spatial neglect on off- and on-line goal-directed locomotion tasks performed in virtual reality

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BACKGROUND AND AIM: Unilateral spatial neglect (USN), a highly prevalent and disabling post-stroke impairment, has been shown to affect the recovery of locomotion. However, our current understanding of goal-directed locomotion control in post-stroke USN is poor given the paucity of related literature and lack of consensus on the expression of the deficits. Upper-extremity research conveys that USN impacts mainly goal-directed off-line (e.g. reaching to remembered target location), as opposed to on-line movements (e.g. pointing to an actual target), suggesting the involvement of the ventral vs. dorsal stream in USN. Whether such distinctions hold for goal-directed locomotion remains to be explored. Moreover, higher-order visual perceptual abilities could be affected by USN and subsequently impact goal-directed locomotion; however, they have yet to be characterised in this population. The project aims to examine (1) goal-directed locomotion (end-point mediolateral displacement [MLD] and heading errors [HE]); (2) direction of walking trajectory deviation; and (3) perceptual abilities (contrast sensitivity, optic flow [OF] location and OF coherence, shape discrimination) and their relationship with goal-directed locomotion abilities in subjects with and without USN (USN and USN-) and healthy controls (HC). METHODS: Participants (n=45) performed (1) goal-directed walking trials to actual, remembered and shifting targets located 7 meters away at 0° and 15° right/left while immersed in 3D virtual reality scene; and (2) a set of controlled computerized visual-perceptual experiments. RESULTS: Within the USN group poorer performances (i.e. greater MLD and HE) were found for the remembered condition compared to the shifting condition for the left (neglected) target ($p<0.05$). USN participants showed altered walking performances compared to USN- (left target, $p<0.05$) and HC groups (left and right targets, $p<0.05$) for the actual and remembered conditions. USN participants demonstrated a rightward trajectory deviation for middle and left targets in all conditions. All visual-perceptual abilities were affected (i.e. higher thresholds) in the USN group compared to USN- and HC groups ($p<0.05$). Thresholds for OF location and coherence were significantly correlated with the MLD/HEs to left target in the remembered condition ($r= 0.23$ to 0.33, $p<0.05$). CONCLUSIONS: Although within-group analyses are in-line with the ventral stream hypothesis for USN, between-group results show that post-stroke USN affects goal-directed locomotion to left targets in both on-line/visually-guided behavior and off-line/recognition-identification conditions. Higher-order visual perceptual deficits may account for the difficulties experienced in both types of walking tasks. Goal-directed locomotion and visual-perceptual tasks can be explored in the design of future VR-based evaluation and training tools for USN to improve the currently used, conventional methods. ACKNOWLEDGEMENTS AND FUNDING: T.O. is supported by FRSQ PhD Fellowship and Richard & Edith Strauss Fellowship in Rehabilitation Sciences, A.L. is supported by the operating grant CIHR (MOP-77548).

O.3.4 How feasible and effective is it for physiotherapists to deliver a high intensity treadmill training and self-management program to stroke patients undergoing rehabilitation?

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BACKGROUND: The level of physical activity undertaken by stroke survivors in the community is low [1]. Cardiorespiratory fitness can be improved after stroke with training but few studies demonstrate sustained changes [2]. Discharging stroke survivors home with better walking and the ability to manage their own health could change this scenario. The aim of this study was to determine the feasibility and possible effect of a high-intensity treadmill and self-management program delivered to stroke survivors undergoing inpatient rehabilitation by clinical physiotherapists. METHODS: A pre-post trial was conducted across two hospital sites in Brisbane, Australia. Stroke survivors undergoing inpatient rehabilitation who could walk participated in a high-intensity treadmill and self-management program for up to 30 minutes, three times a week for 8 weeks with their usual physiotherapist. Feasibility outcomes included participation, compliance, adverse events and satisfaction. Clinical outcomes included physical activity (daily steps measured via ActivPAL over 4 days), walking ability (speed over 10 m and distance over 6 minutes), and cardiorespiratory fitness (VO2 Peak) collected pre training (Week 0), post training (Week 8) and at follow up (Week 26) as well as self-efficacy of walking, health-related quality of life, participation and self-reported physical activity were collected post training and follow up. RESULTS: Forty stroke survivors participated, completing 10 (SD 6) sessions, 94% at the specified training intensity, with high levels of satisfaction and no related adverse events. Following training there was a significant increase in physical activity (mean difference 2,709 steps/day, 95% CI 933 to 4564), walking speed (mean difference 0.24 m/s, 95% CI 0.05 to 0.42), endurance (mean difference 110 m, 95% CI 23 to 196), and cardiorespiratory fitness (mean difference VO2 Peak 0.29ml/kg/min, 95% CI 0.03 to 0.56) that was sustained at Week 26. At follow up, there was a significant increase in quality of life (mean difference 9.4/100 points, 95% CI 2 to 17). CONCLUSIONS: It is feasible for clinical physiotherapists to implement a high-intensity treadmill training program embedded within a self management approach during inpatient rehabilitation. Sustained clinical improvements suggest that a larger, randomized trial is warranted. [1] English C et al. Physical activity and sedentary behaviors in community-dwelling stroke survivors: A systematic review. Phys Ther. 94: 184-196. [2] Saunders DH et al. Physical fitness training for stroke survivors. Cochrane Database of Systematic Reviews 2016, Issue 3. Art. No.: CD003316.

O.3.6 Impaired step adjustment in patients with multiple sclerosis and its association with measures of inhibitory control

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Background and aim: Ability to adjust an ongoing step when encountering unexpected change in landing position is an essential skill in order to have flexible gait in ever changing environment. To effectively withdraw an ongoing movement, besides well-functioning sensory and motor systems, it is believed that inhibitory resources of cognitive function are also required. Given the pathophysiology of Multiple Sclerosis, this study aimed to assess step adjustment in response to a sudden stepping-target perturbation in persons with Mutiple

Sclerosis (pwMS) and to investigate whether measures of inhibitory control were related to this ability. Methods: 20 pwMS and 20 healthy participants performed stepping movements on to a visual target on the floor after its presentation. In some trials, target was unexpectedly shifted from its initial location to a new location [Fig 1]. Ground reaction forces under the supporting leg and kinematics of the stepping leg in baseline and target shift trials were measured. Outcome measures included execution time, step accuracy, time to adjust the stepping foot trajectory, time to adjust force under the supporting foot, peak and rate of force production. Stop-signal task was used to probe inhibitory control. This task required to make a motor response (pressing a key) to a Go stimulus (presentation of a sign in the center of a screen) and to stop responding on a No-Go stimulus. On No-Go trials (25% of the trials), the Go stimulus was followed by an auditory stop signal at various delay which instructed participants to withhold their response. Stop-Signal Reaction Time (SSRT), the time required to inhibit the ongoing response, provided an index of stopping ability. Using correlation analysis, relationship between measures of inhibitory control and step adjustment was assessed. Results: During target shift trials, patients demonstrated delayed onset of foot trajectory modification, prolonged execution time and less accurate positioning. Compared to healthy participants, modification of force production under supporting foot was also slowed and reduced in pwMS. (All $p<0.05$) Patients also had slower performance on stop-signal task ($p<0.05$). Moreover, significant correlations were observed between the measure of inhibitory task and stepping adjustment in individuals with PwMS. ($r= 0.66 - 0.73$). So that the patients with slower SSRT were more likely to spend more time to change the trajectory of stepping foot and to modify force under supporting foot in response to target shift. Conclusion: pwMS were not able to execute effective step adjustment when it was required. Efficiency of response inhibition was also declined in these patients. Association between measures of inhibitory control and impaired adjustment also point out the value of response inhibition in functional tasks like walking which should be considered in management strategies.

O.3.7 Altered plantarflexor muscle properties in stroke survivors - is there a connection between muscle and impaired gait?

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BACKGROUND AND AIM: Although impaired motor control contributes to limited mobility, changes in muscle properties such has architecture, size and material properties, specifically stiffness, will also influence force production and transmission, thereby affecting mobility. Using shear wave (SW) ultrasound elastography, SW velocity can be used as a surrogate for muscle stiffness, such that SW velocity is greater stiffer tissue. Knowing that SW velocity is greater in stroke-impaired muscle from previous work, we sought to gain insight into how changes in stiffness of lower extremity muscles contribute to gait. The aim of this study was to determine the relationship between SW velocity of paretic and non-paretic ankle plantarflexor (medial gastrocnemius, MG) and joint kinematics and kinetics during gait. METHODS: Fourteen stroke survivors participated in this study (age: 60.1±5.9yrs; Fugl-Meyer: 8-28, 19.1±6.1). Subjects were seated with their knee in maximum extension and their foot secured to a platform of a dynamometer (System3Pro, Biodex). B-mode and SW elastography ultrasound images (Aixplorer, SuperSonic Imagine) were captured, as well as joint angle and torque at different ankle angles (90°, 15° plantarflexion (PF), maximum dorsiflexion (DF), maximum PF, and two other intermediary angles) while the muscle was passive. Muscle architectural parameters (fascicle length, pennation angle, muscle thickness) were measured by digitizing the B-mode images. Gait analysis was conducted during over-ground gait at preferred gait velocity (motion capture system (Qualysis, Göteborg, Sweden), 30 reflective markers set, five force plates (AMTI, Watertown, MA). Regression analyses with leg as a categorical independent variable, in order to consider each limb, were performed to evaluate the relationship between SW velocity and joint kinematics and kinetics. RESULTS: All correlations occurred at multiple ankle angles, but we are only reporting at 90°. We found significant differences kinematics and kinetics, such as greater ankle moment and power on the non-paretic limb ($p < 0.01$). More importantly, as MG muscle thickness decreased, negative ankle work increased ($p=0.004$, $r2=0.52$), and as SW velocity increased, negative ankle work increased ($p=0.023$, $r2=0.40$). MG thickness increased as positive hip work decreased ($p=0.031$, $r2=0.37$). With decreasing MG muscle thickness, MG SW increased ($p=0.008$, $r2=0.48$). CONCLUSION: Our findings indicated that following a stroke, MG muscle appears to increase in passive stiffness if there is a loss of muscle mass. Additionally, increased dissipation of mechanical energy associated with increased passive stiffness would require adaptations from other joints in order to maintain gait, potentially at the hip. These results have strong implications that architecture and material properties of the MG affects the gait of stroke survivors. Patient-specific information on muscle properties would allow clinicians to refine and develop novel rehabilitation tools and treatments.

O.3.8 Antagonist muscle activity in postural responses to support-surface translations in exercise-study-eligible people with Parkinson's disease and neurotypical older adults

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BACKGROUND: A select group of individuals with diagnosed Parkinson's disease (PD) (Hoehn and Yahr stages [H&Y] 1-4, selected for postural difficulties and minimal tremor) have demonstrated abnormal antagonist muscle activation in automatic postural responses. Outcome measures derived from antagonist muscle activity may have more specificity than clinical tests in determining the effects of motor rehabilitation. However, it is unknown whether antagonist muscle activation is abnormal in individuals recruited into exercise trials, i.e. people with mild-moderate PD (H&Y 1-3), including those with tremor-dominant symptoms. AIM: We conducted a cross-sectional observational study in an exercise study-eligible cohort of individuals with PD, and non-PD controls to quantify abnormal antagonist muscle activity during postural responses to support-surface translations. METHODS: We examined 32 people with PD (H&Y 1 (n=1), 1.5 (3), 2 (13), 2.5 (5), 3 (10); UPDRS 33±12; age 67±9) and 9 non-PD controls (age 64±11), using baseline measures from a longitudinal study of exercise-based rehabilitation. Bilateral EMGs in tibialis anterior and medial gastrocnemius were recorded during reactive balance responses to multidirectional support-surface translations. EMGs during each trial were averaged over 2 time periods: APR1 (100-175-ms after perturbation onset, to examine EMG activity unaffected by stepping responses) and APRX (70-450 ms after perturbation onset, to examine EMG activity including medium- and long-latency responses). Average EMG values were assembled into "tuning curves" describing EMG activity as a function of perturbation direction and scaled to have a maximum value of 1. Decreased directional specificity of muscle activity was quantified by an increase in the number of perturbation directions in which the scaled EMG was greater than 0.5. Lower modulation of EMG amplitude across perturbation directions was indicated by a smaller "modulation index", which compared maximum and minimum EMG activation levels (100*[max-min]/[max+min]). RESULTS: No significant differences in directional specificity were seen in the PD versus non-PD cohorts across muscles and time bins ($0.06 \leq p \leq 0.96$). Similarly, directional modulation did not differ significantly between the PD and non-PD cohorts in the four muscles in either time bin ($0.08 \leq p \leq 0.80$). CONCLUSIONS: The PD cohort did not show abnormal antagonist activation patterns in automatic postural responses seen in previous PD cohorts with more severe PD symptoms, clinically assessed postural instability, and minimal tremor. Therefore, outcome measures derived from antagonist tuning curves may not be an appropriate rehabilitative outcome measure for the general PD population. However, subgroups of the exercise study-eligible population (i.e., patients with fall history, more severe symptoms, or the Postural Instability and Gait Difficulty subtype) may have abnormal antagonist muscle activity.

O.4 – Adaptation, learning, plasticity and compensation

O.4.1 Neural Correlates of Split-Belt Treadmill Gait Adaptation: A Systematic Review

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BACKGROUND AND AIM: Although there has been a recent drastic increase in the number of split-belt treadmill investigations, no consistent hypotheses have been suggested across studies for the underlying neural structures involved in this gait adaptation process. As such, the aim of this systematic review was to 1) provide an up-to-date consolidation of the major split-belt treadmill methodologies and 2) summarize the hypotheses of the neural correlates modulating gait adaptation in healthy individuals. METHODS: A systematic search strategy identified 213 unique articles published up to November 2016. After full text review, 45 original research articles fulfilled the inclusion criteria of a baseline period of tied-belt treadmill walking (both belts at the same speed) followed by a prolonged bout of split-belt treadmill walking (belts at different speeds) in healthy participants (18-38 years). Reported outcomes included spatiotemporal parameters (stance/swing, gait phasing, step length), kinetic measures (ground reaction forces) and/or lower limb muscle activation patterns. RESULTS: Methodologies: In addition to split-belt treadmill walking, a subset of studies (n=32) also provided further gait, environmental or physical manipulations. Studies manipulated feedback via the somatosensory system (n=11), motor output via neural stimulation (n=3) or locomotor mode (i.e. running, n=4), or environmental cues via changes to belt speed/direction (n=11) or secondary tasks (n=3). Neural Correlates: From this systematic review, we identified 6 key hypotheses for the underlying neural mechanisms of split-belt treadmill walking adaptation among young healthy adults: 1) the cerebellum; 2) proprioceptive feedback; 3) spinal circuitry; 4) cortical and sub-cortical structures; 5) sensory feedback reweighting and 6) energy expenditure and walking efficiency. A summary of rational for these hypotheses is provided in Table 1. CONCLUSIONS: There are currently six hypotheses for the neural correlates responsible for healthy split-belt treadmill gait adaptation. Peripheral manipulations, such as sensory feedback or treadmill velocity changes can aid in hypothesizing how the neural system implements context related information to update a locomotor plan. However, expansion of split-belt treadmill work to include neuroimaging would validate current hypotheses to the cortical and sub-cortical structures involved in gait symmetry adaptation. ACKNOWLEDGEMENTS & FUNDING: NSERC (DCH, CP), FRQS (DC), CFI (CP)

O.4.2 Age and dual task effects on gait adaptability during split-belt walking

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BACKGROUND AND AIM: Human gait is adaptive to environmental challenges. In laboratory settings, the use of a split-belt treadmill can simulate those challenges and elicit adaptations in gait. Because of age-related changes in neuromuscular and cognitive function, it is conceivable that aging affects gait adaptability, especially when locomotion is combined with a cognitive load. Since aging affects mechanical and control properties of the neuromuscular system, age could affect not only the magnitude of gait adaptations but also how such adaptations evolve during prolonged exposure to split-belt walking. This prolonged exposure provides insight into adaptation strategies. Although the effects of age and cognitive load on gait performance have been studied extensively, less is known about their effects on gait adaptability. Therefore, we examined the effects of age and cognitive load on gait adaptability and gait adaptation strategies during split-belt walking. METHODS: Young (21.7±2.1 y, n=14) and old adults (67.9±6.2 y, n=15) walked on a split-belt treadmill with and without a cognitive dual-task (Auditory Stroop task). Participants walked for 18 minutes on the split belt treadmill with embedded force plates: 6 minutes with belts tied at 1.0 m/s and 0.5 m/s (both 3 min; baseline phase), 6 minutes with split belts, with one belt moving fast (1.0 m/s) and the other belt moving slow (0.5 m/s; adaptation phase), and finally 6 minutes walking with belts tied (0.5 m/s; post-adaptation phase). Based on vertical forces, percentage swing time, swing speed, and symmetry of step length and limb excursion (stride length on split-belt treadmill) were calculated. Phase (baseline, early adaptation, late adaptation and post-adaptation) and task (single and dual task) differences were analyzed with a repeated measures ANOVA ($p < 0.05$). RESULTS: Old adults had an 18% larger limb excursion asymmetry at the late adaptation phase, with no difference at early adaptation. Gait strategies also differed between the two age groups: while young adults increased percentage swing time of the fast leg, old adults increased swing speed of the fast leg. In the dual-task condition, swing speed of the fast leg was higher for both age groups during late adaptation. Young adults performed better on the cognitive task during early adaptation, with 25 correct responses for young vs. 22 for old adults. CONCLUSIONS: The increase in limb excursion asymmetry in old adults suggests that gait adaptability decreases with age. Young and old adults use a different gait strategy to perform split-belt walking, and these strategies are not affected by a concurrent cognitive task. However, old adults' lower cognitive task performance during the early adaptation to split-belt walking suggests the prioritization of gait adaptation to the cognitive task. This prioritization of gait adaptation could indicate that old adults rely on cognitive function more than young adults to control gait adaptation.

O.4.3 Relation between Dynamic Balance Control and Metabolic Cost during Split Belt Adaptation

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BACKGROUND AND AIM: Studies using the split-belt paradigm have taught us a great deal about the changes in spatiotemporal step parameters during locomotor adaptation. However, metabolic cost and dynamic balance control are mostly neglected in these studies. It is generally believed that motor adaptation involves the optimization of metabolic cost. A recent study showed [1] that this applies to split-belt gait adaptation as well and that this reduction of metabolic cost during adaptation is related to changes in spatiotemporal parameters. While dynamic balance control is perturbed during split-belt gait due to the imposed step asymmetry, the relation between dynamic balance control and metabolic cost has not yet been studied. By studying metabolic cost and the fast and slow margins of support (MoS) between center of pressure and extrapolated center of mass [2], next to the conventional spatiotemporal parameters, we intended to gain insight in the factors that drive the reduction of metabolic cost during split-belt adaptation. We hypothesized that the reduction of metabolic cost relates to a decrease in the MoS during adaptation. METHODS: 15 healthy young adults were tested during 6-minute tied-belt (pre-adaptation, 2 minutes 0.7, 1.4, 0.7 ms-1 consecutively), 9-minute split-belt (adaptation, 0.7:1.4 ms-1), and 5-minute tied-belt (de-adaptation, 0.7 ms-1) gait. Kinematic data, ground reaction forces and spirometry were recorded to determine double support and step length symmetry, and the net energy cost. The extrapolated center of mass and center of pressure position were calculated from force plate data to define the MoS for the fast left leg (MoSFast) and the slow right leg (MoSSlow). Finally, the relation between changes in step symmetry, MoS and net energy cost over time were studied using correlational analysis. RESULTS: The results show an increase in spatiotemporal step symmetry and a decrease in net energy cost during adaptation. MoSFast was initially high and decreased during adaptation. MoSSlow was and remained lower than MoSFast, and showed a lower adaptation rate than MoSFast. Correlational analysis showed that the reduction in net energy cost during adaptation is more strongly related to changes in MoSFast than changes in MoSSlow. CONCLUSIONS: The results regarding metabolic cost and step symmetry were in line with previous studies. The difference in MoSFast and MoSSlow provides us with novel information regarding dynamic balance control during gait adaptation. The results show that the reduction of metabolic cost is partially driven by a decrease in the MoS. These findings indicate that split-belt gait adaptation not only involves changes in spatiotemporal step parameters, but also other elements of balance control, and give us insight in what humans learn during split-belt adaptation.
REFERENCES: [1] Finley et al. (2013) J Physiol [2] Hof et al. (2005) J Biomech.

O.4.4 Differentiated Gait Adaptation Patterns in Subjects with Parkinson's disease - a Split Belt Tread Mill Study

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Background and Aim: Physiotherapy interventions using split belt tread mills (SBTM) have been proposed in order to improve gait in subjects with neurological disorders, commonly accompanied by profound gait asymmetry (GA; e.g., Parkinson's disease - PD). Comparative effects in conjugated SBTM conditions (i.e., increased speed in one side as compared to decreased speed was on the other side) were not systematically reported. Aim: To methodologically compare the adaptation effects caused by SBTM walking with respect to the type (increased\decreased speed) and the side of the manipulated belt in PD patients. Methods: Eight participants with PD (age: 62.3 ± 9.95 yrs.) were tested. Baseline (BL) speed was individually determined based on over ground comfortable walking. In addition, the 'worst' and 'best' side (WS and BS, respectively) were defined for each participant based on the severity of the disease motor symptoms. The subjects performed four trials of SBTM walking presented in random order and separated by 5 min of seated rest periods. Each trial consisted of 2 min of walking with the two belts moving at the same speed (i.e., BL - tied belt [TB] configuration), followed by 5 min of SB setting - one belt's speed increased or decreased by 50% from BL speed value. Finally, the belts moved in TB configuration for additional 3 min. The differences between the trials were with respect to the modified belt side, and in whether the belt's speed was increased or decreased. Carried over after effects between consecutive trials were negligible according to post-hoc analysis. Results: Motor symptoms had asymmetric presentation, yet BS and WS step length values during BL did not differ significantly. The effect on step length and, in turn, induced GA in the early adaptation period (first 30 sec in the SB settings) is more pronounced in the 'speed decrease' conditions. The mean values (± SEM) of the percentile change in GA from BL were 34.0 ± 7.49 % and 11.3% ± 3.0 % when decreasing and increasing belt speed, respectively (nonparametric testing: $p=0.0078$; lumping both 'decrease' trials for comparison with both 'increase' trials). Further calculations showed that GA modification during the early adaptation period can be accounted for in part by the obvious differential leg excursion, and in addition by stance time alterations in the non-manipulated side. Conclusions: The present systematic analysis provided definitive proof regarding the stronger adaptation effects that can be obtained by decreasing one side belt's speed, rather than increasing the speed of the opposite belt. This can be established since, for the first time, all four conditions were compared within subjects with PD and in reference to their natural over ground gait speed. Further research is warranted to study post adaption effects among persons with PD with apparent GA in order to define optimal adaptation schemes to maximize the therapeutic effect of SBTM based interventions.

O.4.5 Disparate effects of motor-cognitive training and motor training alone on brain activation in patients with Parkinson's disease: an fMRI study

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BACKGROUND AND AIM: Recent studies have shown that deficits in executive function contribute to falls in older adults and patients with Parkinson's disease (PD). A recent randomized control trial (RCT) showed that a combined treadmill training with virtual reality (TT+VR) that targets motor and cognitive aspects of safe ambulation, led to fewer falls, compared to treadmill training alone (TT) (Mirelman et al, Lancet, 2016). Using fMRI, we aimed to explore the neural mechanisms that may explain the differences in fall rates after the intervention and provide insight into the motor-cognitive relationship. METHODS: Patients were randomly assigned to the TT arm (n=20, mean age: 71.5±1.5 yrs, disease duration: 11.6±1.6 yrs; 70% men) or TT+VR arm (n=20, mean age: 71.2±1.7 yrs, disease duration: 7.9±1.4 yrs; 65% men). Participants underwent an fMRI scan before and after the 6-weeks training program. The fMRI task included a motor-imagery task of walking in two virtual environments projected in the scanner: 1) walking in a virtual clear path and 2) walking while negotiating virtual obstacles placed along the virtual path. Whole brain and region of interest (ROI) analyses were used. RESULTS: No differences in neural activation were observed between training arms before the interventions. After training, participants in the two groups demonstrated different patterns of brain activation. After training, subjects in the TT+VR arm had lower activation than the TT arm in BA 10 and IFG (cluster level FWEcorr p<0.012), while the TT arm had lower activation than TT+VR arm in the cerebellum and middle temporal gyrus (MTG) (cluster level FWEcorr p<0.001). CONCLUSIONS: To our knowledge, this is the first study to demonstrate that specific exercises alter the pattern of brain activation differentially among patients with PD. These findings are in line with evidence from animal models demonstrating that exercise which focuses on task specific training affects frontal-striatal related circuits to a greater degree than non-task specific exercise. Lower activation in prefrontal cortex after training in the TT+VR participants, are consistent with the idea that training increases automaticity of gait while reducing compensation via the use of executive functions that are closely link to prefrontal cortex.

O.4.6 Gait initiation in people with corticospinal lesions: insights from StartReact

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BACKGROUND AND AIM: Corticospinal lesions cause impairments in voluntary motor control. Recent findings from StartReact paradigms suggest that some degree of voluntary control may be taken over by a compensatory pathway involving the reticulospinal tract. StartReact is the accelerated release of a preprogrammed motor program by a startling acoustic stimulus (SAS), presumably conveyed by the reticulospinal tract. Patients with corticospinal lesions have delayed simple reaction times, yet their SAS-induced reaction times are completely normal compared to healthy individuals[1]. As previous studies mainly focused on isolated single joint movements, the question remains whether the reticulospinal tract can also be utilized for controlling whole-body movements. To test this notion, we applied the StartReact effect during gait initiation in healthy controls and in patients with retrograde axonal degeneration of the corticospinal tract (Hereditary Spastic Paraplegia, HSP). METHODS: We included 12 patients with ´pure´ HSP and 12 healthy controls. They stood upright in front of a LED display with each foot on a separate force plate. As soon as the visual imperative stimulus was presented, the participants had to perform three consecutive steps. In 25% of the performed 16 trials, a SAS was presented simultaneously with the imperative stimulus. We determined latencies of tibialis anterior (TA), rectus femoris (RF), anticipatory postural adjustment (APA) and step onsets, as well as soleus (SO) offset. RESULTS: Without SAS, we observed an overall delay in HSP patients compared to controls, varying between 32 ms in SO offsets and 130 ms in step onsets. Administration of the SAS accelerated TA and RF onsets in both groups, but more so in HSP patients (SASxgroup, $p<0.05$), resulting in (near-)normalized onset latencies. In the healthy controls, the SAS also accelerated SO offsets, but an opposite effect was observed in HSP patients (64 ms delay in SAS-trials vs 32 ms in non-SAS trials; SASxgroup, $p<0.05$). The SAS also accelerated APA and step onsets in both groups, yet it did not normalize these onsets in the HSP patients (23 ms and 153 ms delays with SAS; SASxgroup, $p>0.115$). CONCLUSIONS: The (near-)normalization of TA and RF onset latencies with SAS that we observed in the HSP patients confirms previous findings. For SO deactivation, however, no such effect was found, which may underlie the persisting delays with SAS in APA and step initiation in these patients. This defective muscle deactivation may be due to the reticulospinal tract having indirect inhibitory (as opposed to direct excitatory) projections onto motoneurons[2], or by self-sustained firing of motoneurons overriding the inhibitory commands[3]. Our present finding may help explain the nature of voluntary motor control impairments in patients with corticospinal lesions. references 1 Nonnekes et al. (2014) 2 Peterson et al. (2010) 3 Heckmann et al. (2005)

O.4.7 Learning to balance on a slackline: Kinematic and spinal reflex adaptations

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BACKGROUND AND AIM: While training can improve balance performance, little is known about changes in joint coordination patterns and spinal reflexes that evolve with practice. Training balance on a narrow elastic line (slackline) improves postural control and depresses the soleus H-reflex (Keller et al 2012; Scand J Med Sci Sports 4: 471-7). This reflex depression may mediate the abolishment of a lower limb tremor that is prominent when individuals first attempt to maintain balance on an unfamiliar, unstable surface. We aimed to 1) study the emergence of coordinated upper body balance strategies and 2) examine the early and late reflex adaptations to balance practice on a slackline. METHODS: Twenty young adults naïve to balance sports were assigned to a learning (n=10) or control (n=10) group. Data were collected at 4 times: 1) baseline, 2) after 60min of practice, 3) after 1 week of practice (four 60-90min sessions) and 4) after 1 additional week of no practice. We recorded kinematics of the foot and thigh of the dominant leg, trunk, and upper and lower arms bilaterally (Optotrak, NDI) while participants stood in tandem stance on the slackline or on a narrow beam (transfer task). Continuous relative phase angles between joints (hip, elbows, shoulders) were examined to look for coordinated balance strategies. Additionally, we evoked T- and H-reflexes while participants stood on the ground and in tandem on the slackline. The time course of changes in reflex excitability was compared against the time course of tremor reductions. RESULTS: Increases in balance proficiency (time to fall) were accompanied by emergence of coordinated strategies involving anti-phase movement between the elbows (phase angles ~180°), along with in-phase and anti-phase movement between the hip and left elbow and hip and right elbow, respectively. The tremor subsided early in the first practice session; however, 1 week of practice was required to significantly depress reflex excitability. CONCLUSIONS: Improved trunk and foot stability (decreased velocity) and overall performance (reduced falls) appear to be accomplished by the progressive development of appropriately tuned and coordinated upper body strategies. Spinal reflexes likely do not mediate the tremor observed during initial exposure to this task since the longer time course of reflex changes did not correspond to the more rapid suppression of the tremor. Loops involving cortical and subcortical structures might be implicated, possibly driven by feedback error (mismatches between anticipated and actual sensory consequences of movements). A rapid development of a more accurate internal representation of the consequences of balance correcting movements would therefore correspond to tremor suppression. Our findings provide insight into the capability of healthy systems to implicitly learn complex balance strategies that are reliant on the upper limbs and require gaining an understanding of unfamiliar support surface properties.

O.4.8 Repeated exposure to height-related postural threat: how do humans adapt?
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BACKGROUND AND AIM: Postural threat, evoked through changes in surface height, influences standing postural control, with individuals leaning away from the threat and stiffening control of movement [1]. These changes in posture are associated with changes in psychological, physiological and cognitive state [1,2]. Repeated exposure to height reduces anxiety [3], however it is unclear how posture adapts to threat. This study examined how postural control adapts with repeated exposure to height-related threat and explored associations between changes in posture and changes in psychological, physiological and cognitive state. METHODS: Eighteen young adults stood on a force plate on a hydraulic lift and completed 5 consecutive 2-minute stance trials under conditions of low (0.8m above ground, away from edge) and high (3.2m above ground, at edge) postural threat. Stance trials at each threat condition were counterbalanced across participants. Participants reported confidence before each trial, and reported perceptions of fear, anxiety and attention processing (attention to: movement processes (Att-MP), task objectives (Att-TO), threat-relevant stimuli (Att-TS), self-regulatory strategies (Att-SRS), and task-irrelevant information (Att-TI) [2]) after each trial. Electrodermal activity (EDA) was recorded from the palm as an indicator of arousal. Centre of pressure (COP) measures included mean position (MP-COP), root mean square (RMS-COP) and mean power frequency (MPF-COP). Two-way repeated measures ANOVAs were conducted (THREAT: low vs high x TRIAL: 1 vs 5) for all measures. Correlations explored associations between changes in postural control and changes in confidence, fear, anxiety, arousal and attention across exposure to threat (high trials 1-5). RESULTS: Significant effects of THREAT were observed for all measures except RMS-COP, Att-TO and Att-TI. Significant TRIAL effects were observed for all psychological, physiological and cognitive measures except for confidence and Att-MP. Significant THREAT x TRIAL interactions were observed for EDA and fear, while a trend was observed for Att-TS, with greater reductions in all measures occurring over time in the high threat condition. Adaptations of a forward MP-COP shift were associated with increases in confidence and decreases in Att-MP, while decreases in MPF-COP were associated with decreases in EDA, fear and Att-MP. CONCLUSIONS: Threat-related postural changes persist with repeated exposure, although individual adaptations occur over time and can be predicted by changes in fear, arousal and attention to movement processes. This research improves our understanding of the psychological, physiological and cognitive processes underlying adaptation to threat and illustrates the impact of these adaptations on postural control. REFERENCES: [1] Hauck et al 2008 Gait Posture [2] Zaback et al 2016 Gait Posture [3] Emmelkamp et al 2002 Behav Res Ther ACKNOWLEDGEMENTS: Funded by NSERC to MZ, AA, MGC.

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O.5 – Brain imaging/activation

O.5.1 Quantifying the executive demand of walking with fNIRS neuroimaging

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BACKGROUND AND AIM: New insights into the executive control of walking are possible with the use of functional near infrared spectroscopy (fNIRS), which allows for cortical neuroimaging during natural movements. The control of walking involves a balance between "automatic" (primarily sub-cerebral) and "executive" (cerebral) control strategies. During typical steady state walking, automatic control predominates in well-functioning individuals. Under more complex walking conditions, executive resources are also recruited for controlling real-time deviations to the typical gait pattern. Executive control may also be recruited as a compensatory strategy for control of walking when automatic control is impaired, such as in elderly and neurologically injured individuals. Compensatory use of executive resources could compromise the safety of walking because executive control is attention demanding, slow, and susceptible to interference. We hypothesized that the executive control of walking, as measured by fNIRS prefrontal cortex activation, would be higher in individuals with mobility deficits and also during more complex walking tasks. METHODS: Participants included 14 adults post-stroke with moderate/severe mobility deficits, 15 elderly adults with mild mobility deficits, and 9 young healthy adults. fNIRS was used to measure prefrontal cortex activation during four walking tasks: typical walking, walking over obstacles, walking in dim lighting, and a dual-task condition of walking plus a verbal fluency task. Participants with stroke were also assessed with the Activities Specific Balance Confidence Scale and the Fugl-Meyer Assessment of lower extremity function. Main effects were examined using a three-way, repeated measures ANOVA (Group, Hemisphere, Task). Significant main effects were analyzed with a one-way ANOVA (effect of Group) or paired t-tests (effect of Task). RESULTS: Prefrontal activity during walking showed a main effect of group ($p<0.001$) and task ($p<0.001$), with stroke > elderly > young. Furthermore, lower functioning stroke participants exhibited greater prefrontal activity than higher functioning stroke participants when subgroups were defined by either the Fugl-Meyer score ($p=0.011$) or the balance confidence score ($p=0.006$). Prefrontal/executive reserve capacity, as quantified by the difference in prefrontal activity between dual-tasking and typical walking, was lower in the elderly and post-stroke participants ($p=0.003$). CONCLUSIONS: The primary finding from this study is that executive control of typical and complex walking is increased in individuals with mobility deficits, as indicated by greater prefrontal cortical activity. Assessing locomotor control strategies with fNIRS is a promising direction for objective assessment of impairment and recovery in humans with mobility deficits.

O.5.2 When is higher level cognitive control needed for locomotor tasks among patients with Parkinson's disease?

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BACKGROUND AND AIM: Turning has been implicated as a complex task that requires both motor and cognitive resources. Accumulating evidence shows that patients with Parkinson's disease (PD) require more steps and more time to complete a turn, however, the role of the prefrontal cortex during turning is not clear. We aimed to test whether prefrontal activation differs during turning and during walking in patients with PD. METHODS: 49 patients with PD (mean age 71.7±1.0 years; 67% men, disease duration 9.7±1.3 years) performed motor and cognitive tests. Prefrontal activation, specifically in Brodmann Area 10 (BA10), during turning and usual walking was measured using functional near infrared spectroscopy (fNIRS). The patients with PD were further divided into two subgroups with higher and lower functional status based on limitations in community ambulation. General Linear Model analysis adjusted for age, gender, disease duration and turn duration was used to assess differences between tasks and subgroups of patients with PD. In addition, Pearson's correlation was performed to assess for the associations between BA10 activation and motor and cognitive performance. RESULTS: Compared to quite standing, activation in BA10 increased during walking (0.24±0.04 µM/L; $p<0.001$), while it decreased during turning (-0.12±0.03 µM/L; $p=0.006$). Patients with relatively better ambulation had decreased ($p<0.001$) prefrontal activation during turning (-0.23±0.05 µM/L), as compared to patients with relatively worse ambulation (-0.01±0.02 µM/L). In addition, HbO2 levels during turning were associated with gait speed ($r=-0.441$, $p=0.002$). Patients with lower gait speed had higher levels of HbO2 during turning. In contrast, HbO2 concentration levels during turning were not associated with any cognitive indexes. CONCLUSIONS: These findings are the first to show that (1) BA10 plays a different role during turning and walking, at least among patients with PD, and (2) ambulation status may alter BA10 activation during turning. Higher prefrontal activation during turning in the subgroup of patients with relatively worse ambulation may reflect a compensatory attempt at improving mobility. The results of the present study highlight the interconnection between cognitive and motor abilities and the specificity of this reliance in different motor tasks in patients with PD.

O.5.3 Potential of non-invasive brain stimulation to ameliorate freezing of gait in Parkinson's disease: A deep repetitive TMS randomized, double-blinded, cross-over pilot study

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Background and aim: Freezing of gait (FOG) affects patients with advanced Parkinson's disease (PD) and is often unresponsive to medication therapy. FOG is frequently triggered in task switching processes (e.g., gait initiation, turns, doorways), which have been previously linked to the medial prefrontal cortex (mPFC), an area that is dysfunctional in PD patients with FOG. We aimed to investigate the impact of high-frequency deep, repetitive Transcranial Magnetic Stimulation (drTMS) of the mPFC on FOG. Methods: Nine patients with advanced PD participated in a randomized, double-blinded, cross-over pilot study. We applied real and sham drTMS using an H3 coil at 10 Hz, over the medial PFC. Each patient was assessed before and after 4 weeks of intensive stimulation (3 sessions per week) and 4 weeks of maintenance (1 session per week) of real and sham drTMS; the protocol lasted 16 weeks (8 weeks of real stimulation and 8 weeks of sham) for each study participant. The primary outcome was the score on a FOG-provoking test, repeated 3 times, under single task, dual task (motor) and dual task (motor and cognitive) conditions. The secondary outcomes consisted of parkinsonian motor symptoms as assessed with the Unified Parkinson's Disease Rating Scale (UPDRS-III) and the freezing of gait questionnaire (FOG-Q). We also quantified spatiotemporal gait parameters using a 7 meter sensorized mat. All testing were conducted in the "on" medication cycle, at the same time of the day. Results: Scores on the FOG-provoking test improved significantly (Δ= -4.14±3.98; p=0.027) after the intensive real drTMS treatment and the improvement persisted after the maintenance treatment (Δ= -6.00±6.66; p=0.046). Scores on the motor part of the UPDRS also improved after real-intensive treatment (Δ= -7.86±6.54; p=0.028), however this effect was not maintained. Conversely, scores on the FOG-provoking test and the motor part of the UPDRS were not significantly affected by the sham treatment. Gait speed variability was reduced from 8.37±3.59% at baseline to 5.25±1.05% after real treatment (p=0.028). Similarly, stride length variability decreased from 7.46±4.35% at baseline to 4.46±1.00% after real treatment (p=0.046); step time variability decreased from 6.20±1.92% to 4.69±1.25% after real treatment (p=0.028) and swing time variability decreased from 8.87±2.88% to 5.99±1.85% (p=0.028). In contrast, no significant differences were found after the sham stimulation, p>0.05. The scores on the self-report of FOG severity did not improve. Due to unexpected arm movement, discomfort, and pain during treatment, two patients dropped out at initial stage and eventually the study was halted. Conclusions: This study provides initial cause-and-effect evidence of the role of the PFC in FOG in PD using drTMS. Due to the small sample size and subject pain, the findings should be interpreted with caution. Future work and other non-invasive brain stimulation techniques are needed.

O.5.4 Activity of the subthalamic and pedonculopontine nuclei during initiation of gait: an electrophysiological approach in humans

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BACKGROUND AND AIM: In animals, modulations of the activity from the cortex, the basal ganglia or the brainstem can trigger locomotor behaviors and/or postural and balance modifications. The subthalamic nucleus (STN) may be a key structure in the associated network as it receives direct excitatory inputs from the cortex, indirect inhibitory inputs from the striatum, and direct excitatory inputs from mesencephalic locomotor structures. The latter likely include the pedonculopontine nucleus (PPN) and the cuneiform nucleus. They receive inhibitory afferents from the basal ganglia and projects excitatory descending inputs to the spinal cord. In patients with Parkinson's disease (PD), gait and balance disorders have been related to both the loss of dopaminergic neurons leading to STN dysfunction, and the loss of cholinergic neurons in the PPN. Deep brain stimulation (DBS) of the STN alleviates motor signs of PD. However, its effect on gait and balance disorders is controversial, with some patients being even aggravated. DBS of the PPN area have been also recently proposed to alleviate these disorders, but variable effects were reported. As the respective role of these two structures in the control of locomotion and posture in human is still poorly understood, we proposed to record their neuronal activity during gait initiation from patients recruited for DBS. METHODS: We recorded local field potentials during gait initiation from (1) the STN in 23 patients with PD both without and with dopaminergic drug treatment and in 3 patients with obsessive-compulsive disorder (OCD), and from (2) the PPN area in 4 patients with PD. Electrophysiological signals were acquired simultaneously with kinetic signals from a force platform covering at least the two first steps. A principal component analysis driven on kinetic parameters highlighted one main component corresponding to the locomotor performance. Then, we identified the correlations between the scores within this component and the activity from the STN. RESULTS: In the STN, the preparatory phase of the gait initiation process came along with a desynchronization in the beta band (13-25Hz) in all patients. It was significantly stronger in the absence of dopaminergic treatment for patient with PD. During gait execution, we observed bursts of synchronization in the theta band (4-8 Hz) arising in line with stepping events both in the STN and at the PPN level. Gait performance was positively correlated with these theta synchronizations in the STN in both dopamine state. Patients with OCD differed from patients with PD only in a stronger gamma synchronization during the movement. CONCLUSION: The STN contributes both to reduce movement inhibition to promote gait initiation and drive locomotor performance, two processes partly dependent upon the dopaminergic level. Mesencephalic structures also exhibit activities synchronized with stepping, and the similarities with the activity in the STN activity suggest that they might be involved together in the control of gait execution.

O.5.5 Vestibulocerebellar cholinergic loss is associated with turning characteristics during walking in mild-to-moderate Parkinson disease.

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Background and aim: Parkinson disease (PD) is characterized by progressive postural instability and gait difficulties. Particularly disabling is freezing of gait, often triggered by turning movements. This observation suggests vestibular system involvement. The pathophysiology of PD is characterized by nigrostriatal dopaminergic loss and, to a variable degree, more heterogeneous cholinergic losses. The novel vesicular acetylcholine transporter (VAChT) ligand [18F]FEOBV demonstrates distinct uptake by the vestibulocerebellum, including the flocculonodular lobules. The aim of this study was to examine the association between cholinergic innervation of the flocculonodular lobules and turning movements during walking in mild-to-moderate PD patients. Methods: 35 PD patients (9F, age=66.2±5.5 years, motor disease duration=6.3±4.6 years, median modified Hoehn and Yahr stage 2.5) underwent cholinergic brain PET imaging of the VAChT using [18F]FEOBV. MDS-UPDRS and wearable sensor (APDM) mobility assessments were performed in the dopaminergic "off" state. The ISAW (Instrumented Stand and Walk) module of APDM Mobility Lab assesses dynamic gait including a turn and return walk at the end of 7 meter straight walk. Vendor-provided spatiotemporal parameters were used for analysis of the straight walk and turning movement. [18F]FEOBV was synthesized following standard methods and a short (30 minutes) dynamic scan (every 5 minutes) was obtained 3 hours after bolus injection. Distribution volume ratio (DVR) was determined for MR based volumes of interest (using Freesurfer and SUIT segmentation software suites) with the supratentorial white matter as reference region. Results: Exploratory correlation analysis showed that increased DVR in the averaged bilateral cerebellar flocculonodular lobules was associated with shorter turn duration (r=-0.394, p=0.019) and especially with a shorter duration of the step preceding the turn (r=-0.519, p=0.001). There were no associations of thalamus, striatum, or cerebral cortex [18F]FEOBV DVR with these turning parameters. Significant linear regression (F=4.2, p=0.005) showed that the flocculonodular lobules DVR still independently predicted preceding step time duration (β=-0.409, t=-2.3, p =0.027) while correcting for motor disease duration (n.s.), age (n.s.), MDS-UPDRS part III score (n.s.), and stride velocity (β=-0.431, t=-2.0, p =0.051). Conclusions: These significant associations between the flocculonodular lobules and turning during gait may suggest, in part, a cholinergic vestibular role in postural instability and gait difficulties in PD. Further research is needed to investigate whether cholinergic vestibulocerebellar hypofunction is a determinant of turning-induced freezing of gait in PD. Acknowledgements and funding: NIH P50 NS091856

O.5.6 Does cortical activity evoked by postural perturbations scale with acceleration?

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BACKGROUND AND AIM: The relationship between cortical activity and corrective muscle responses evoked by balance perturbations is not well understood. Cortical activity evoked by support-surface perturbation during standing may be a sensory monitoring signal because its latency post-perturbation is too long to drive the initial muscle response. Perturbation acceleration has been shown affect cortical response amplitude in seated conditions, and muscle response amplitude in standing conditions. Here we tested whether both muscle and cortical response amplitude would scale with perturbation acceleration during perturbations to standing. METHODS: Forward support-surface translations during standing were delivered to six subjects (5 female, age 18-27). Five levels of acceleration (0.1g, 0.15g, 0.2g, 0.25g, and 0.3g; 20cm/s; 12cm) were presented in random order with 3 trials each. Scalp electroencephalography (EEG) and bilateral tibialis anterior muscle electromyography (EMG) was recorded at 1000 Hz. For each subject, onset latencies of EEG and EMG responses were calculated from averaged responses. Peak latency of a large negative peak (N1) occurring 100-200ms after perturbation onset was quantified in each subject based on the averaged EEG signal at the Cz electrode. For each trial, N1 amplitude was quantified as the largest negative value within 50ms of peak N1 latency. EMG amplitude was quantified as the mean activity in each of three consecutive 50ms time bins, beginning 50ms prior to N1 peak latency. We performed a 2-factor ANOVA (subject, perturbation level) on EEG and EMG metrics and linear correlations to measured peak acceleration values. RESULTS: EEG and EMG onset latencies were 78.8±5.2ms (mean±std) and 88.5±18.7ms, respectively. N1 peaks occurred at 151±5ms with amplitude 40±17uV. ANOVA revealed a trend towards significance of acceleration level on N1 amplitude ($p=0.073$), a significant effect of subject ($p<0.0001$), with no interaction ($p=0.17$). In grouped data, N1 amplitude was weakly correlated to peak acceleration ($p=0.040$; $r=0.22$). EMG amplitudes were weakly correlated with peak acceleration in the first two time bins (both $p<0.01$, $r=0.28$). On an individual basis, two of six individuals showed significant correlation between N1 amplitude and peak acceleration, whereas five of six individuals showed scaling of EMG to peak acceleration in at least one time bin ($p<0.01$). The individual that did not show significant scaling of EMG activity to acceleration ($p=0.23$) had the strongest correlation between N1 amplitude and perturbation acceleration ($p=0.0016$). CONCLUSIONS:Evoked cortical versus muscle activity to postural perturbation acceleration may arise from similar sensory inputs, but have independent scaling mechanisms. This study establishes a paradigm to further investigate the relationship between evoked muscle and cortical activity, which have been independently observed to change with threat, predictability, adaptation and impairment.

O.5.7 Association between Regional Cerebral Cholinergic Denervation and Gait and Postural Stability in Parkinson's Disease

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BACKGROUND AND AIM: Postural instability and gait difficulties (PIGD) present early in Parkinson's disease (PD), mark the onset of increased risk for severe disability in patients, and respond poorly to dopaminergic replacement therapy except in the early phase of the disease. The pathophysiology of PIGD motor features involves different neural systems. Evidence is emerging that cholinergic system degeneration is a significant contributor to PIGD features in PD. It is unclear, however, whether there are regional cerebral differences of cholinergic nerve terminal integrity involved in specific aspects of balance and gait disturbances in PD. The purpose of this study was to examine associations between regional cerebral cholinergic innervation and different components underlying dynamic balance and gait functions in PD. A total of 70 individuals with PD (sex: 52M/18F; age: 67.0 ± 6.6 yrs; modified Hoehn & Yahr stage: 2.4 ± 0.5; duration of disease: 6.9 ± 5.7 yrs) underwent balance and gait assessments in the dopaminergic "off" stage, as well as [18F]FEOBV brain PET imaging to quantify cholinergic innervation. Specifically, components of dynamic balance were assessed via the Mini-Balance Evaluation Systems Test (Mini-BESTest), which includes four sub-scores (transitions/anticipatory postural control, reactive postural control, sensory orientation, and stability in gait), with lower scores indicating worse performance. To assess level walking, participants performed an 8-meter normal-pace walk (GAITRite® mat), from which leg length-normalized speed, stride length, and stride length variability were extracted. To reveal which brain region's cholinergic innervation predicted each Mini-BESTest sub-scores and gait variables, stepwise regressions were performed. RESULTS: Results from the stepwise regressions are presented in the Table. Notably, a lower score for the dynamic gait subscale of the Mini-BESTest, slower gait speed, and a smaller stride length were significantly associated with lower cholinergic innervation in the parietal/occipital cortices. Also, poor anticipatory and reactive postural control was significantly associated with lower cholinergic innervation of the post-central cortex and brainstem, respectively. Finally, a lower sensory orientation score was significantly associated with lower cholinergic innervation in the hippocampus and cerebellar cortex, but greater innervation in the striatum. CONCLUSIONS: The cholinergic system appears to play regionally selective roles in locomotor functions. Clinically, these findings suggest heterogeneous cholinergic mechanisms underlying impaired mobility and falls in PD. Hypocholinergic innervation in the parietal and occipital cortices is robustly associated with gait difficulties; and hypocholinergic activity in the brainstem, motor cortex, hippocampus and cerebellum is significantly associated with reduced anticipatory and reactive postural control and sensory orientation. ACKNOWLEDGEMENTS AND FUNDING: NIH P50 NS091856

O.5.8 Neural representation of reactive balance control of slipping while walking: Differences in brain activation during action observation versus mental imagery

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Background: Perturbation training while walking is an effective method for reactive balance training and preventing falls. While neural correlates of walking have been extensively studied through mental imagery and/or task observation, neural mechanisms involved in reactive balance tasks such as recovery from slip-like perturbations are not clearly understood. Both mental imagery and observation assist in motor learning. While action observation functions by implicitly activating the mirror neuron system, mental imagery involves common neural substrates as those of movement preparation. With regards to experiencing slip while walking, our initial study examined neural correlates of mental imagery of slipping vs. walking4. Whether or not action observation or imagination of recovering from sudden slip-like perturbations would result in differential activation of brain areas is however unknown. Aim: The study aimed to evaluate the difference in activation patterns between imagined and observed conditions for slip using fMRI. Method: Eleven healthy young participants were exposed to one walking and one slip trial, followed by a MR scan with a paradigm of 30s block of each of the five conditions: rest with vision fixated on a white cross on a black screen, imagine walking on the treadmill (IW), imagine experiencing a slip on the treadmill (IS), observe walking (OW) and observe slip (OS). T2* weighted images with echo planer imaging to measure

BOLD signals and T1-weighted whole head structural images were obtained. After data pre-processing, to evaluate the hemodynamic response between conditions, level I analysis using General Liner Model was performed. OS vs IS, OW vs IW contrasts were analyzed. Significant differences were accepted at p-value < 0.005 and cluster threshold of 55. Result: Subjects received a median score of 4.5/5 on the vividness of visual imagery questionnaire. Comparing IS to OS, in addition to hippocampus, there was significant activation noticed in areas of the frontal cortex, inferior parietal lobule and cingulate gyral. Comparing IW and OW, in addition to precentral gyrus, no additional areas were activated. Conclusion: These findings suggest that motor imagery of an unexpected balance loss from a slip significantly activated substrates involved in motor planning, response selection and interpretation of sensory information. Greater activation during imagined slip condition as compared to observed slip condition suggests motor imagery might recruit more cortical neurons in critical movement correlates against passive action observation. Contrary to the results obtained for the slipping task, the similarity in activation seen between the observed and imagined conditions for the walking task (no difference in activation detected), could be as walking, being an overlearned activity is refined over time resulting in strengthened representations for both observed versus perceived actions. Thus, it may be concluded that motor imagery of a novel and threatening locomotor-balance task in its initial acquisition phase, may produce greater activation of neural substrates than action observation and benefit task learning.

O.6 – Cognitive, attentional, and emotional influences

O.6.1 Concurrent Phone Texting Alters Crossing Behavior and Induces Gait Imbalance during Obstacle Crossing

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BACKGROUND AND AIM: Texting on the phone while walking is commonly observed in pedestrians and could result in accidents or serious injuries, especially during a visual attention demanded locomotive task like obstacle crossing. The purpose of this study was to examine how a concurrent texting alters gait behavior and balance control during obstacle avoidance in college-age adults. METHODS: Ten healthy adults (5 females, 21.5±2.1 yrs) were recruited and performed the following two tasks in a random order: 1) walking and crossing an obstacle set at a 10% of the participant's height (OC) and 2) walking and crossing an obstacle while responding to text messages (OC+texting). Whole body motion data were collected from a set of 29 retro-reflective markers placed on bony landmarks and two additional markers affixed at both ends of obstacle with a 10-camera motion system. Dependent variables for obstacle crossing characteristics included the toe-obstacle clearance (TC) and foot placements (FP) of the leading and trailing feet. Gait balance control was examined using the peak forward velocity of the center-of-mass (vCoM) and the total medial-lateral CoM displacement (M-LCoM) during approaching and crossing strides. Paired-sample t-tests were applied to detect differences between two gait conditions. RESULTS: Participants demonstrated a significantly slower vCoM (1.4±0.1 vs. 1.3±0.1 m/s, p = .006) and greater TC for both trailing (18.7±4.5 vs. 25.0±6.6 cm, p = .014) and leading feet (15.7±3.5 vs. 19.1±4.4 cm, p = .001) in OC+texting. In addition, when texting concurrently, subjects demonstrated a significantly greater M-LCoM (4.5±0.8 vs. 6.2±1.6 cm, p = .013) with a significantly reduced leading foot FP (25.4±5.8 vs. 21.2±3.7 cm, p = .036). CONCLUSION: Although a conservative gait strategy was employed to reduce tripping risk while performing texting during obstacle crossing, it results in a greater frontal plane body sway and a closer leading foot placement to the obstacle. This may increase the risk of gait imbalance or stepping onto the obstacle.

O.6.2 No association between depressive symptoms and gait or balance in patients with cognitive impairments and Alzheimer?s disease

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Background and aims: Depressive symptoms are common at any stage of cognitive impairment and Alzheimer?s disease (AD). Both depression and cognitive impairment are associated with reduced gait speed and balance. In this study we examined the associations between depressive symptoms and gait and balance performances in a sample of memory clinic patients. Methods: 109 patients were recruited consecutively from a memory clinic; 10 had subjective cognitive impairment (SCI), 12 had mild cognitive impairment (MCI), 68 had a mild degree of AD and 19 had a moderate degree of AD. Mini Mental Status Examination (MMSE) was used to assess global cognitive function. Gait function was assessed using regular gait speed (m/s) from the 10 m walk test and balance was assessed using Balance Evaluation Systems Test (BESTest). Depressive symptoms were assessed using the Cornell Scale for Depression in Dementia (CSDD). Scores ranges from 0-38 where higher score indicates higher level of depression. The CSDD score had a skewed distribution, so we used the cut off established for similar population of 6/7 points to categorize patients as having depression or not. Patient characteristics, balance and gait performance was compared between patients with and without depression, using t-tests, Mann-Whitney U-test or chi square tests where appropriate. To examine the influence of depressive symptoms on gait and balance, we conducted two multiple linear regression analyses with balance and gait speed as dependent variables. Patients characteristics (age, sex, education, comorbidity (yes/no) and MMSE) and depression were added as independent variables. Results: The patients? mean (SD) age was 71.8 (9.2) years, 50 (45.9 %) were men, mean (SD) years of education was 13.2 (3.5), 37 (33.9 %) had comorbidities. Their median (IQR) MMSE was 25.0 (6). Mean (SD) gait velocity was 1.11 (0.25) m/s and their mean (SD) score on BESTest was 80.0 (13.6) per cent. 32 (29.4 %) of our sample had depression. In the bivariate analyses, more women than men had depression. There were no significant differences between patients with and without depression regarding age, education, comorbidity, scores on BESTest or gait speed. In the two separate multiple linear regression analyses models, depression was not significantly associated with neither scores on BESTest nor gait speed. Conclusion: In this sample of memory clinic patients, we found no significant association between balance and depression, or between gait speed and depression.

O.6.3 Re-conceptualising anxiety-related reinvestment in older adults

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BACKGROUND AND AIM: Falls by older adults represent a major social and economic problem. After a fall many older adults become anxious about falling again, which in turn can cause significant changes in the way older adults control posture and gait. Anxious older adults are also more likely to consciously control movements that would otherwise be largely automatic, such as walking (Huffman et al., 2009; Young & Williams, 2015). As a result, cognitive resources are diverted away from environmental factors and the automaticity of movements can be compromised. In the context of performing sporting 'ontogenetic' skills it is suggested that anxious individuals will 'reinvest' cognitive effort into controlling their actions by reverting to explicit (declarative) cues used in earlier stages of skill learning (Masters & Maxwell, 2008). However, gait is a largely implicit and phylogenetic skill (learned in the relative absence of declarative/verbal movement rules). Therefore, it may be inappropriate to conceptualise anxiety-related tendencies to consciously control posture and gait as 'reinvestment'. Instead, it is likely that older adults with falls-related anxiety will start to 'over-think' their movements and new explicit cues for movement are formed. METHODS: We aimed to examine the nature of conscious movement control in 40 older adults and sought to identify if relationships exist between state anxiety, self-reported 'reinvestment' and self-generated explicit movement cues. We asked participants to complete 20 repetitions of an obstacle avoidance gait task over a 7 meter walkway. Gait velocity and double support time were measured using a GaitRite walkway. Directly after the walking trials participants were shown a video of themselves walking during one of the trials and asked to describe what they were thinking about during that trial. RESULTS: We found clear associations between state anxiety, 'reinvestment' (scores on the Movement Specific Reinvestment Scale) and self-reported use of explicit movement rules. The declaration of movement cues corresponded to gait parameters that might be considered as conservative or 'stiffening', such as increased double support time. CONCLUSIONS: We suggest that the increased conscious control of walking actions often observed in older adults should not be characterised as 'reinvestment', but rather 'investment' in to newly generated movement rules. We further suggest that such rules will predicate conservative movement strategies or stiffening behaviours. It is possible that recently founded cognitive strategies are relatively more susceptible to intervention; thereby presenting an opportunity for novel therapeutic strategies aimed promoting automatic/implicit movement control processes in older adults. Masters R, Maxwell J. The theory of reinvestment. International Review of Sport and Exercise Psychology, 2008;1(2), 160-183. Huffman JL, Horslen BC, Carpenter MG, Adkin AL. Does increased postural threat lead to more conscious control of posture? Gait & posture, 2009;30(4), 528-532. Young WR, Williams AM. How fear of falling can increase fall-risk in older adults: Applying psychological theory to practical observations. Gait and Posture, 2015; 41, 7-12.

O.6.4 Sympathetic nervous system activity as an assessment of perceived challenge of walking after stroke

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BACKGROUND AND AIM: Following stroke, the perceived challenge of walking is associated with increased fall risk and reduced participation in community mobility and life role activities. Current assessments of perceived challenge involve self-report (e.g., balance confidence and self-efficacy) which are susceptible to measurement bias. The development of an objective, physiologically-based assessment of the perceived challenge of walking would enhance evaluation of stroke recovery. The objective of this study is to investigate measurement of sympathetic nervous system (SNS) activity as a physiological probe of the perceived challenge of walking. SNS activity, which can be robustly measured by skin conductance, is well known to be increased under challenging conditions that invoke stress, anxiety, or fear. We hypothesize: 1) skin conductance will be increased during walking tasks that are more complex/challenging; 2) skin conductance will be associated with preferred gait speed and balance confidence. METHODS: Participants included 33 adults with chronic post-stroke hemiparesis. A battery of 18 challenging walking tasks were performed, such as walking in dim lighting, over obstacles, up stairs, on foam, or while performing a cognitive task. Participants were instructed to perform each task at their preferred speed. SNS activity was measured using skin conductance recorded from electrodes on the palmar surface of the first and third fingers of each hand. Skin conductance signals were acquired at 32 Hz and analyzed with commercially available software. The primary outcome was the percent difference in skin conductance level (ΔSCL) between the resting/baseline and active phases of each task. RESULTS: The group average ΔSCL for all tasks ranged from 4% to 15%, with easier tasks having a smaller ΔSCL (e.g., walking in dim lighting) and harder tasks having a larger ΔSCL (e.g., walking up stairs). Across tasks, there was a strong negative association between group mean task performance speed and ΔSCL ($p<0.01$) such that ΔSCL was highest for the tasks in which people slowed down the most. Across participants, there was a strong negative association between ΔSCL and preferred walking speed ($p=0.003$) and a moderate negative association between ΔSCL and balance confidence ($p=0.05$). When participants were divided into subgroups with lower and higher balance self-efficacy, the low self-efficacy subgroup demonstrated considerably higher ΔSCL values during the most challenging walking tasks (10.4% versus 15.8%, $p=0.003$). CONCLUSIONS: Increased SNS activity (skin conductance) during walking is associated with worse mobility performance and lower self-efficacy. This provides preliminary validation of SNS activity as a measure of perceived challenge. Future research should test whether objectively measured SNS activity or subjectively measured self-report is more strongly associated with participation in community ambulation and life role activities.

O.6.5 Visual scanning behavior during attention-demanding tasks while walking in healthy young adults

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BACKGROUND AND AIM: Walking while texting has been recognized as a pedestrian safety risk, and this risk is likely to increase with the expanding use and popularity of mobile devices. Dual-task related changes in gait characteristics and texting performance have been identified, however, visual scanning behavior during distracted walking is unknown. The aim of this study was to determine the effects of attention-demanding tasks while walking on visual scanning behavior in healthy young adults. METHODS: Twenty young adults (age 25 years, SD 2.7; female 55%) completed 3 walking tasks: (1) single-task walking, (2) walking while texting, and (3) walking while simultaneously performing a letter fluency cognitive task. All tasks were performed continuously for 30 meters in a busy hospital lobby. Texting and letter fluency were also performed in single-task (sitting). The order of testing was randomized. Visual scanning behavior (percentage dwell time and total number of visual fixations) was recorded using Eye Tracking Glasses. We identified "walking path" and "non-walking path" as areas of interest for visual scanning. A Walking Condition (single-task, dual-task letter fluency, and dual-task texting) x Visual Area of Interest (walking path or non-walking path) repeated measures ANOVA examined interaction effects on the total number of visual fixations and percentage of dwell time, with Tukey's HSD post hoc tests. RESULTS: There was a significant interaction between the walking condition and visual area of interest for both dwell time ($p<.001$; partial eta squared=.94) and number of visual fixations ($p<.001$; partial eta squared=.85). Dwell time (%) and fixation count were significantly greater for the walking path than for non-walking path for both single-task walking and dual-task letter fluency, but not for dual-task texting. Although there was no significant difference in dwell time on walking path between single-task walking (72.6%) and dual-task letter fluency (72.4%), there was a significantly greater number of fixations on walking path in the dual-task letter fluency (135) than single-task walking (69, $p<.01$), indicating more frequent eye movement within the walking path area during dual-task letter fluency. During dual-task texting, average dwell time and fixation count were considerably low for both walking path (3%, 5 fixations) and non-walking path (0.5%, <1 fixation); rather, the participants mostly kept their visual focus on the phone (83%, 109 fixations). CONCLUSIONS: Texting while walking is associated with a considerable reduction in overt visual attention to the walking path and the surrounding environment. Although there was no difference in attention to the non-path areas between the 3 conditions, the high dwell times on the walking path for single-task and dual-task letter fluency imply greater situational awareness via covert attention relative to texting. ACKNOWLEDGEMENTS AND FUNDING: This work was supported in part by a Promotion of Doctoral Studies (PODS) - Level I Scholarship from the Foundation of Physical Therapy and by the University of North Carolina at Chapel Hill.

O.6.6 How do anxiety, falls efficacy, and movement specific reinvestment influence segmental control of older adults during adaptive turning?

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BACKGROUND AND AIM: Everyday ambulation requires us to turn effectively and safely to alter travel direction. It has been suggested that strategies such as greater 'coupling' between body segments during turns are used by older adults to increase balance control, however, they may also be indicative of future fall-risk. Currently, the psychological determinants of such turning characteristics are not well understood. Furthermore, there have been limited attempts to apply the propositions of existing psychological theories to fall-risk-related behaviours in older adult populations. The aim of this study was to investigate whether trait anxiety, falls efficacy, and movement specific reinvestment influenced segmental control of older adults during adaptive turning and whether support could be offered for hypotheses related to existing theoretical frameworks: Processing Efficiency Theory (PET) and Reinvestment Theory (RT). METHODS: Twenty one older adults (¡Ý 65 years of age) were separated by median splits into 'high' and 'low' groups for each respective measure (trait anxiety, falls efficacy, and reinvestment). Participants were asked to traverse a novel adaptive walkway presented in two differing patterns. Sections of each pattern denoting a turn in either the left or right direction were selected for analysis. Changes in gait velocity prior to turn onset and several measures indicative of head, trunk, and pelvis bodily segment axial rotation were analysed, alongside mental effort ratings. RESULTS: The results offer moderate support for the hypotheses of PET, as the high trait anxiety group were found to produce higher mental effort ratings and later turn onsets than the low trait anxiety group. Additionally, both the high trait anxious and low falls efficacy groups displayed greater 'coupling' of the head and trunk during rotation in comparison with their opposing groups. Furthermore, low falls efficacy was associated with lower peak angular velocity and peak angular rotation, as well as longer turn durations when compared to the high falls efficacy group. In contrast, levels of support for the hypotheses of RT were less forthcoming, as high 'reinvestors' producing a significantly lower peak angular rotation than their low reinvesting counterparts was the only difference observed between the two groups. No between-group differences were found for changes in gait velocity before turn initiation. CONCLUSIONS: The findings indicate that trait anxiety may lead to processing and motoric inefficiencies during turning. Also, low falls efficacy is associated with more 'cautious' segmental control and 'en bloc' turning strategies. However, contrary to the hypotheses made in relation to RT, higher levels of dispositional reinvestment do not appear to influence the turning characteristics of older adults to the same degree as trait anxiety or falls efficacy.

O.6.7 Gait Disturbances In Older Individuals With Mild Cognitive Impairment: Are They Caused By A Motor Planning Problem?

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Background: Motor planning is the cognitive stage prior movement execution (i.e. thinking how to perform a movement). Hence cognitive impairments may profoundly affect motor planning capabilities. Walking difficulties, including instability, are common in older individuals with Mild Cognitive Impairment (MCI) and may be worsened while performing a concurrent cognitive task (dual-task). Thus, planning an action that is about to happen while walking could overload cognitive resources in people with MCI provoking gait disturbances. We postulate that planning an obstacle avoidance while walking would affect gait stability of individuals with MCI due to cognitive overloading. Methods: Forty four participants from the Gait & Brain Study were enrolled in this sub-study (MCI = 22; Controls = 22). Gait performance was assessed in four conditions: single-task gait (STG); single-task gait+obstacle (STG+O); Dual-task gait (DTG); Dual-task gait+obstacle (DTG+O). During the obstacle conditions, participants had to walk and step over a vertical obstacle (~23 cm) placed transversely on the 6 m electronic carpet (PKMass®) at 70 cm from the end of the carpet. This carpet quantified measures of gait stability including step velocity and step-to-step fluctuations in time and distance (variability) prior obstacle crossing (planning phase). During dual-task conditions participants walked performing a serial sevens subtraction task. The total number of subtractions and errors while sitting and while walking were used to estimate cognitive load and task prioritization. The dual-task gait cost (DTC) was calculated for conditions with and without obstacle using the following formula: DTC= (DTG - STG)/STG; DTC=(DTG+O - STG+O)/STG+O. ANOVAs were used to compare groups in each walking condition controlling for age, sex, and physical status (Short Physical Performance Battery). Results: Individuals with MCI walked significantly slower than Controls during STG (p=0.04). Unexpectedly groups had similar DTC during DTG condition. The presence of an obstacle affected gait velocity and its variability in both groups similarly. An interaction between group and obstacle conditions (p=0.04) revealed that DTC for gait velocity increased from DTG to DTG+O in individuals with MCI; whereas the DTC decreased from DTG to DTG+O in Controls (see figures). Velocity variability was similar in both groups irrespective of obstacle and dual-task conditions. Importantly, individuals with MCI made more errors in the serial sevens subtractions than Controls in both DTG (p=0.004) and DTG+O (p=0.05); but similar performance was observed during the sitting condition (no walking). Overall, both groups performed the same number of subtractions in all conditions. Conclusions: Our results suggest that older individuals with MCI may not be able to plan long stepping sequences. These individuals may need to generate shorter and more frequent stepping sequences to overcome this planning deficit. This planning strategy can overload their precarious cognition causing more gait instability. ACKNOWLEDGEMENTS: Lawson Research Foundation; Our gratitude to Korbin Blue and Alanna Black and all members from the Gait & Brain Lab.

O.6.8 Motor switching benefits rather than costs during gait-related tasks

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Background and aims: Motor switching, the ability to flexible switch motor actions in response to changes in the environment, typically comes at a cost of slower action initiation. We have recently shown that motor switching costs during forward and backward stepping are related to freezing of gait (FoG) in Parkinson's disease (PD). Here, we evaluated motor switching in two different gait-related tasks in PD with and without FoG and healthy subjects. Methods: Two motor switch tasks were conducted: 1) forward stepping with left or right leg and 2) turning in place clock- or counterclockwise. The motor action was triggered by an auditory cue 'same' or 'switch', cueing a turn in the same direction or a step with the same leg as in the previous trial (repeat trials) or a turn in the opposite direction or to step with contralateral leg (switch trials). Fourteen PD subjects and 5 healthy subjects completed the turn protocol and 18 PD (9 with FoG) completed the step protocol. Angular velocity signals from inertial sensors placed at the shins were used to detect the instant of foot-off. Reaction time (RT) was calculated as the difference between onset of the auditory cue and the instant of foot-off. Results: During turning, motor switch trials were faster than motor repeat trials ($F(1,16) = 21.58$, $p <.001$) in PD and in healthy subjects. This motor switch benefit was also observed when subjects were stepping forward instead of turning ($F(1,16) = 12.09$, $p = .003$). No differences in motor switch effects were observed between PD with and without FoG ($F(1,16) = 0.02$, $p = .884$). Switch effects were also not different between most and least affected leg to step with (no interaction effects). Conclusions: In sharp contrast to consistently reported delays in reaction time when switching between cognitive sets using upper limb responses, we observed faster responses when switching leg than when stepping with the same leg. Our results were very consistent across groups, and across the two types of motor actions. Biomechanical and locomotor mechanisms related to balance control potentially underlie this discrepancy. For example, asymmetry in weight-bearing when returning from a step may be more advantageous to execute a next step with the contralateral leg, thereby masking central set effects. Alternatively, reciprocal pattern generators for locomotion may speed gait-related set switching. Acknowledgements and Funding: Funding through MRF Early Clinical Investigator Award (KS), NIH K99 HD078492 01A1 (MM), NIH 2R01 AG006457-29, VA Merit I01 RX001075-01 (FBH).

O.7 – Falls and fall prevention

O.7.1 Similarity of repeated falls in older people: do past falls predict the circumstances of future events?

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BACKGROUND AND AIM: Over 60% of older people in long-term residential care (LTC) will fall at least once per year, and many will fall repeatedly (Rubenstein et al., 1994). For patients who present with a fall, clinicians seek to understand how and why the fall occurred to guide approaches to prevention. Underlying physiological and behavioural risk factors may cause repeated falls to be similar in nature, or conversely, create a risk for falling during any activity. To test the hypothesis that falls within individuals are similar, we investigated the consistency of repeated falls captured on video in two LTC facilities. METHODS: We obtained video footage of 905 falls in 223 individuals. The number of falls per individual ranged from 1 to 46. For each fall, we used a structured questionnaire (Yang et al., 2013) to identify the cause of imbalance (slip, trip, hit/bump, collapse, incorrect weight transfer or loss of support with an external object) and the activity at time of falling (sitting, standing, walking, sit-to-stand transfer or stand-to-sit transfer). We used generalized variance, a measure of diversity, to determine whether falls within individuals are more similar than falls between individuals. Since the accuracy of the estimated variance will depend on the number of falls in a given individual, we compared within-subject variance to 95% confidence intervals in between-subject variance for 2 to 46 falls randomly sampled from the entire dataset via a bootstrap procedure. RESULTS: The generalized variance for the cause of imbalance was lower than the 95% confidence interval of the between-subject generalized variance in 11 of 16 individuals with 10 or more falls. For these individuals, the probability that the cause of imbalance was different in two random falls ranged from 25 to 55%. Incorrect weight transfer accounted for 52 to 85% of falls in eight individuals, loss of support with an external object accounted for 45 to 57% of falls in two individuals, and hit/bump accounted for 59% of falls in one individual. Generalized variance for activity at the time of falling was similar within and between subjects, except for one individual who fell 12 out of 16 times during walking. CONCLUSIONS: Our results indicate that repeated falls within LTC residents are more similar than between subjects in terms of the cause of imbalance, but not for activity at the time of falling. However, the probability that the cause of imbalance was the same in two falls in a given individual was, at best, 75%. These results suggest that, in designing interventions, one cannot rely on the circumstances of a specific fall to accurately predict the circumstances of future falls. Rather, repeated fallers are likely to fall for a variety of causes and while undertaking a range of activities.

O.7.2 Successful landing during a fall: Video evidence of the strategies used by older adults in long-term care to avoid head impact during real-life falls

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Background and Aim. Falls are common across the lifespan, and any fall can cause serious head injury. Falls in young adults rarely cause head impact and injury, presumably due to the protective role of "safe landing strategies" (Hsiao et al., 1998; Feldman et al., 2007). We recently analyzed video footage of real-life falls by older adults in long-term care (LTC), and described that over 30% of falls in this population result in head impact (Schonnop et al., 2013). In the current analysis, we focus on the landing strategies used by older adults to successfully avoid head impact during falls, examining the roles of upper limb impact, avoidance of torso impact, and flexion/ extension of the upper torso and neck. Methods. We started with a database of 1532 falls experienced by 438 LTC residents. We excluded falls where the head impacted an object other than the floor (n=206), and falls where the landing configuration was not strictly forward, sideways or backward (n=525). The remaining 801 falls in 315 individuals included 85 forward landings (FL), 406 backward landings (BL), and 310 sideways landings (SL). The mean age at time of fall was 82.1 yrs (SD 9.4). Each fall was analyzed with a structured questionnaire (Yang et al., 2013). We use the terms "failed" to represent falls involving ground contact to the head, "successful" for falls not involving head impact, "hand impact" for ground contact to one or both hand(s) and/or elbow(s), and "torso impact" for ground contact to the torso and/or shoulder(s). Results. The portion of falls that were successful was 51% for FL, and 78% for both BL and SL (see Figure). When compared to failed falls, successful falls were less likely to involve torso impact (19% versus 69% for FL, $p<0.0001$ by Chi-Square; 63% versus 100% for BL, $p<0.0001$; 73% versus 100% for SL, $p<0.0001$). Hand impact was less common in successful than failed falls for FL (79% versus 98%, $p<0.0001$) and BL (63% versus 79% for BL, $p=0.02$), but not SL (97% versus 100%; $p=0.08$). The most common successful landing strategy in FL was impact to only the hand(s) and knee(s). In BL and SL, most common successful landing strategy involved impact to the lower torso and hands and flexion of the upper torso/ neck to maintain the head off the ground. Conclusions. As expected, in all three landing configurations, successful falls were less likely than failed falls to involve torso impact. Surprisingly, hand impact was at least as common in failed falls as in successful falls. However, in each direction, the most common successful landing strategies involved hand impact. Furthermore, most successful BL and SL falls involved torso impact. We conclude that for older adults in LTC, torso impact is common during falls, and avoiding head impact often requires muscle action to stabilize the upper torso and neck off the ground as a supplement to upper limb fall arrest - targets that may be amenable to improvement through resistance training.

O.7.3 Charting falls over 54 months in newly diagnosed Parkinsons disease: which early features discriminate fallers and falls type?

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Background and Aim Falls in Parkinson's disease (PD) occur in response to a broad range of factors such as disease severity, self-efficacy, and age. Understanding the impact of these features over time is limited because early falls-naïve cohorts are rarely examined, with cohorts routinely including established rather than emergent fallers. Examining falls evolution from diagnosis is important to help characterise fallers and to identify features that mitigate against falls. Methods A comprehensive battery of clinical tests including cognitive, motor, behavioural, and gait measures were carried out on 99 newly diagnosed participants from the ICICLE-GAIT (Incidence of Cognitive Impairment in Cohorts with Longitudinal Evaluation) incident cohort study. Falls were documented monthly over 54 months using a falls diary with follow-up. Baseline characteristics were described and between-group differences examined for 5 groups of fallers according to falls status at baseline and 54 months and falls occurrence at 18 month intervals. Outcomes were compared for single and recurrent fallers, and for all groups including and excluding retrospective fallers. Results By 54 months 79 (79.7%) of the total cohort had fallen which included 26 (26.2%) retrospective fallers. New fallers emerged as follows: baseline to 18 months n = 30 (30.3%); 18 to 36 months n = 17(17.1%); 36 to 54 months n = 6 (6.0%). Twenty participants (20.3%) remained falls-naive. Over 54 months disease severity and gait outcomes were the strongest baseline discriminative features for new fallers. Median PIGD score was .60 for fallers at baseline through to 36 months, reducing to .40 for fallers at 54 months and non-fallers. Pace and variability domains of gait discriminated across the 5 groups (P = .023 and P = .034 respectively) in contrast to the other domains which were not significant (P =.252, .344, .509 for rhythm, asymmetry and postural control respectively). Subjective cognitive complaint was the only discriminative cognitive variable with 92% of baseline fallers reporting subjective complaint, gradually reducing to 40% for 56 month fallers. Without exception, outcomes were better for the 20 non-fallers compared with fallers at any time point. Balance self-efficacy and fatigue were discriminative only when retrospective fallers were included. Single fallers (n = 7) were significantly younger than recurrent fallers (n = 58) by 15 years, with significantly higher MoCA visuospatial scores. Conclusions Baseline performance discriminates new fallers over 54 months in PD, with motor function dominating. Different types of fallers can be characterized by clinical features at diagnosis. These findings help guide clinical decision-making and emphasize the need for early intervention. Acknowledgements and funding Thanks to Rosie Morris, Heather Hunter and Dadirayi Miriphiri for assistance with falls data collection. Funding bodies include the National Institute for Health Research Biomedical Research Unit, AND Parkinsons UK

O.7.4 Influence of initial limb load and hip abductor-adductor muscle performance on lateral protective stepping in younger and older adults.

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Background. Aging brings about challenges in the ability to recover from balance perturbations through protective stepping, especially in the lateral direction. For example, younger adults mainly recover balance with a single lateral step, while older individuals often rely on alternative stepping strategies that increase their fall risk. Previous work has suggested that lateral protective stepping may be affected by intramuscular adipose tissue infiltration and diminished performance of the hip abductors (AB) in older adults. These impairments have been linked with increased fall risk, as it compromises center-of-mass (CoM) control during stepping and especially during lateral weight transfers preceding first step onset. Aim. This study investigated the influence of hip abductor-adductor (AB-AD) muscle performance on the weight transfer phase of protective stepping using a single lateral step under different initial limb-load condition s in younger and older adults. Methods. 15 younger adults (29.1±1.1 yrs) and 13 older adults (71.8±1.1 yrs) performed hip AB-AD isometric maximal voluntary contractions (IMVC) at 30° of hip AB. Motorized lateral waist-pull perturbations were applied during three different initial step-side limb-loading conditions, 50% body weight (bw), 65% bw, and 80% bw. Participants were instructed to recover their balance using a single lateral step. Kinetic (two AMTI force plates) and kinematic (VICON) data analyses were performed only on the successful single lateral step trials. Between-group comparisons were performed with an independent samples t-test, with significance set at $p<0.05$. Results, Older adults had significantly lower peak IMVC AB (26%)-AD (36%) torque ($p<0.05$), and lower AB rate of torque development (RTD) (64%, $p<0.05$). In all limb-load conditions, older individuals had a lower incidence of successful single lateral steps (by 22-50%), initiated pre-step weight transfer postural adjustments later (27-35ms, $p<0.05$) and lifted the stepping foot later (43-78ms, $p<0.05$) than younger adults. Consequently, lateral and downward CoM momentum at step lift-off were about ten-fold greater ($p<0.05$), and step-side peak rate of vertical force development (RFD) (79-190%), hip AB net joint torque (97-200%) and power (111-352%) were larger ($p<0.05$) in the old versus young. Conclusions. Although older individuals showed reduced maximal isometric hip muscle performance, they were also able to often execute single lateral recovery steps independent of initial limb loading condition, though less often than younger adults. In order to perform a lateral recovery step, older adults exerted much greater net joint/muscular output that approached their maximum capacity. This may ultimately affect their ability to effectively use a lateral step to recover lateral balance and prevent falling. Acknowledgements. We thank the Claude D. Pepper Older American Independence Center, University of Maryland, Baltimore and the National Institute on Aging at the National Institutes of Health (R01AG033607).

O.7.5 Intervention to Enhance Lateral Balance Function and Prevent Falls in Aging: First Results from the LIFT Study

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Intervention to Enhance Lateral Balance Function and Prevent Falls in Aging: First Results from the LIFT Study. Mark W. Rogers1, Vicki L. Gray1, Rob Creath1, Sandy McCombe Waller1, Brock Beamer1, 2, Janice Abarro1, Mario Inacio1, Ozell Sanders1, Chieh-ling Yang1. INSTITUTIONS

(ALL): 1. University of Maryland School of Medicine, Baltimore, MD, United States. 2. Baltimore VA Medical Center, Baltimore, MD, United States. BACKGROUND AND AIMS: Impaired standing balance contributes to falls and loss of functional mobility with aging. Protective stepping to maintain balance deteriorates with aging especially sideways resulting in lateral instability. Hip abductor (AB) muscle performance with altered muscle composition related to lateral balance function and abnormal lateral stepping and diminished mobility predict falls and may be reversible through rehabilitation training. The aims of this study were to conduct a single blind RCT to assess the comparative effectiveness of induced- step training and/or hip AB strengthening on balance, mobility, strength, and falls. METHODS: 106 community living adults aged >65 years were randomly assigned to receive either progressive lateral waist-pull perturbation-induced step training with or without AB muscle strengthening, AB strengthening alone, or seated stretching exercises (Control) for 3 x/week x 12 weeks. Kinematic, kinetic, and clinical outcomes were assessed at baseline, immediately post-training and at 3 months post-training. Primary outcomes included % trials with multiple recovery steps, first step length, peak isokinetic (60 deg/s) peak AB-AD joint torques. Secondary outcomes included additional stepping parameters and clinical tests of balance and mobility. Prospective fall frequency for each group was monitored during 12 months of follow-up post-training. Repeated measures ANOVAs and adjusted post-hoc analyses were used to analyze primary outcomes. RESULTS: Significant improvements ($p<0.05$) in balance and mobility occurred especially for step training groups, and AB torque increased ($p<0.05$) with strengthening. Prospective falls were least with step training and greatest among Controls. CONCLUSIONS: Perturbation-based step training appears to be feasible, safe, and effective for improving lateral balance control to prevent falls, and can be reinforced with hip AB muscle strengthening in community living older adults.
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O.7.6 Circumstances leading to inadvertent trips in the lab for young, middle-aged and older adults

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BACKGROUND AND AIM Trips and falls occur in all ages. Examining the circumstances of inadvertent trips throughout adulthood will identify gait behavior associated with trips. Although inadvertent obstacle contacts with a stationary, visible obstacle occur only 1% of the time in a laboratory setting, insight can be gained by examining these failures. The purpose of this study is to gain insight into the causes of inadvertent trips across the lifespan. METHODS Three age groups included: 20-35 years (YA, N=20), 50-64 years (MA, N=15), 65-79 years (OA, N=19). Participants walked along a 15 m walkway and stepped over a fixed, visible, 26 cm obstacle ten times. Head angle and limb trajectory are reported. Trip trials were compared to no trip trials for each age group. RESULTS Twelve participants tripped, seven trips in YA (3.5% of trials), two in MA (1.3%), and three in OA (1.6%). The percentage of trips in YA in the laboratory is consistent with the high rate of trips and falls in YA in everyday life (Heijnen & Rietdyk, 2016). This may be because YA are less concerned about trips, since they are likely to recover from a trip more easily. The head angle was higher in the trip trials versus non-trip trials (-15 deg. vs -21 deg., where 0 deg. is looking straight ahead), suggesting that participants looked down at the obstacle less in the trip trials. This may reduce the ability to gather visual information to guide the limb. The three age groups tripped for different reasons. YA tripped with the trail limb due to insufficient toe elevation (Fig 1A), consistent with Heijnen et al. (2012). MA tripped with the trail limb because the trail limb was placed too close to the obstacle (Fig 1B). Closer placement decreases the time and space available to modify the trail limb. OA tripped with the lead limb because of its placement too far from the obstacle (Fig 1C). This may be a conservative strategy to provide a larger margin of safety around the obstacle. However, the lead limb crosses the obstacle in the latter phase of swing, and OA have a shorter step length, so they must place the lead limb closer to the obstacle to ensure adequate clearance both before and after crossing the obstacle (Muir et al., 2015). While there are limited observations in this data set, they indicate that OA did not trip more than YA or MA. However, trips with the lead limb, as observed in the older adults, are harder to recover from, as the center of mass is closer to the front of the base of support, reducing the time available to recover from the trip. CONCLUSIONS In the limited number of observations, head angle may be related to successful crossing, the young adults tripped due to inadequate limb elevation, and the older groups tripped due to inappropriate foot placement. Young and middle-aged adults tripped with the trail limb, while older adults tripped with the lead limb, which is more difficult to recover from. A larger study to further examine these failures is warranted.

O.7.7 Neuromuscular, cognitive, and behavioral factors contributing to falls

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BACKGROUND AND AIM: Neuromuscular, cognitive and behavioral factors are major contributors to falls among older adults. We aim to characterize the relationships between these factors and how they contribute to falls, which is critical for evaluating fall risk and designing fall prevention efforts. METHODS: Within a prospective cohort study of older primary care patients (n=362, age=76.6±6.9, 67.4% female, 18.3% non-white), we evaluated the following fall risk factors at baseline using factor analysis: mobility-related neuromuscular impairments (leg strength, limb velocity, trunk extensor muscle endurance, leg range of motion), executive function (Trail Making Test, Digit Symbol Substitution Test), memory (Hopkins Verbal Learning Test), Physical Activity Scale for the Elderly, Activity Specific Balance Confidence [ABC] Scale, pain, vision, sensory loss, depressive symptoms and comorbidity score. Results from the factor analysis were used to create negative binomial regression models predicting fall rates over 4 years of follow-up. All models were adjusted for age, sex and race. The additional variables were tested for inclusion in all models. RESULTS: We identified 3 factors: (1) neuromuscular impairment/self-efficacy (leg strength, limb velocity, trunk extensor muscle endurance, the ABC Scale); (2) executive function (Trail Making Test, Digit Symbol Substitution Test); and (3) memory (Hopkins Verbal Learning Test). The following variables were created for inclusion in the negative binomial regression models: (1) severity of neuromuscular impairments (leg strength, velocity, and trunk extensor muscle endurance), scaled 0-3, signifying the number of impairments with values within the lowest tertile; (2) poor memory

and (3) poor executive function, scaled 0/1, signifying performance 1.5 standard deviations below the population norm on cognitive tests within the memory and executive function domains, respectively. Poor executive function was associated with a fall incidence rate ratio (IRR [95% CI]) of 1.57, [1.11-2.21], adjusting for age, sex, race, and comorbidity score. Poor memory did not significantly predict fall incidence rate when adjusting for executive function. Having the most severe neuromuscular impairment (score=3) compared with having the least severe (score=0) was associated with a fall IRR of 2.34 [1.32-4.17] and attenuated poor executive function by 14% to nonsignificant. Other levels of neuromuscular impairment severity were not predictive of fall incidence rate. The ABC Scale [0-100] was associated with a fall IRR of 0.98 [0.98-0.99] and attenuated the relationship between neuromuscular impairment severity and fall incidence rate by 27% to nonsignificant. CONCLUSIONS: Poor executive function, neuromuscular impairment severity, and balance self-efficacy contribute to falls among older adults and likely share some mechanistic factors. Poor self-efficacy may have an important effect on the evaluation of mobility-related neuromuscular impairments. This study highlights important factors that should be considered together when assessing risk and designing treatment for those vulnerable to falls. ACKNOWLEDGEMENTS AND FUNDING: NIA (R01 AG032052-03); NICHD (1K24HD070966-01); NCRR to the Harvard CTSC (1 UL1 RR025758-01)

O.7.8 VIP2UK feasibility randomised controlled trial: A feasibility study of Home-Exercise vs Home-Exercise & Home-Safety vs Control to prevent falls in older people who are visually impaired.

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[1]University of Manchester, [2]University of Southampton, [3]Glasgow Caledonian University, [4]University of Surrey, [5]Central Manchester University Hospital NHS Foundation Trust, [6]Manchester Academic Health Sciences Centre, [7]University of Loughborough, [8]Universi

VIP2UK feasibility randomised controlled trial: A feasibility study of Home-Exercise vs Home-Exercise & Home-Safety vs Control to prevent falls in older people who are visually impaired. Todd C, Ballinger C, Brundle C, Chastin S, Gage H, Harper R, Henson D, Laventure B, McEvoy L, Pilling M, Olleveant N, Skelton DA, Stanford P, Waterman H. Background & Aims: There is limited evidence for preventing falls in people with visual impairment. We conducted a feasibility study to optimise design and interventions for a definitive RCT of Home-Safety and Home-Exercise programmes to prevent falls in older visually impaired people, including exploring the use of sensors and self-report for activity monitoring. Methods: Mixed methods community-based feasibility RCT, following UK-MRC guidance, comprising random allocation of participants to (1) control group receiving usual care and social visits, (2) experimental group receiving Home-Safety programme (3) experimental group receiving Home-Safety & Home-Exercise programme. Participants: community-dwelling, ≥65 years and visually impaired. Primary outcome: falls rates. Secondary outcomes: physical activity (self-report and instrumented using activPAL sensors) and Home-Safely adherence. Research assistant and statistician were blinded to group allocation. Programme delivery costs were calculated. Qualitative interviews explored acceptability of interventions. Results: 575 low vision clinic patients and 44 community group members had to be screened to recruit and randomise 49 people (16 control; 16 Home-Safety, 17 Home-Safety & Home-Exercise). Interventions implemented over 6 months by an occupational therapist. 43/49 completed trial and 6-month follow-up. At 6-months, 100 % reported at least partial adherence to Home-Safety recommendations, but adherence to Home-Exercise was equivocal. Although self-reported physical activity increased, activPAL sensor data showed decreases in activity. There were no statistically significant differences between groups in falls; but this feasibility study was not powered to detect any difference. Costs per person (2011) were, Home-Safety =£249; Home-Safety & Home-Exercise =£674. Qualitative data revealed the acceptability of interventions, but also how these could be improved. Conclusion: It is feasible and acceptable for occupational therapist to deliver low cost Home-Safety and Home-Exercise based falls prevention programmes to visually impaired people living independently in the community. Full study needs to change recruitment procedures to improve recruitment rates. We need to identify how to improve adherence to Home-Exercise. We also need to reconcile the differences between sensor and self-report measures of changes in activity before a definitive RCT can be undertaken.

O.8 – Rehabilitation

O.8.1 Effectiveness of additional trunk exercises on gait performance: A randomized controlled trial

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BACKGROUND AND AIM: Little is known concerning the effect of additional trunk rehabilitation on gait performance. Previous studies have demonstrated the beneficial effect of trunk exercises on trunk performance, sitting and standing balance. However, further confirmation is necessary with respect to gait performance. Investigating gait performance by both clinical and biomechanical outcome measures might lead to new scientific insights in the importance of the trunk during gait rehabilitation in people suffering from stroke. Our aim is to examine the effects of additional trunk exercises on gait performance via clinical and biomechanical assessments in patients receiving inpatient rehabilitation after stroke. METHODS: An assessor-blinded randomized controlled trial was conducted in patients after stroke with impaired trunk control. A total of 16 patients were randomly allocated. Patients received either 16 hours of additional trunk exercises (experimental) or cognitive exercises (control) during one hour a day, four days a week for four weeks. Trunk exercises were performed on both stable and unstable surfaces and consisted of seated reaching activities and weight shifting exercises, and core stability training, such as bridging exercises and crunches. Gait performance was assessed clinically by the Tinetti Test and biomechanically by spatiotemporal parameters measured by means of 3D motion capture (Plug-In-Gait model, Vicon). In addition, the treatment effect on the trunk itself was assessed by the total Trunk Impairment Scale (TIS) and its subscales. A t-test was performed to determine significant differences in the patient's baseline characteristics. The treatment effect was analysed by a repeated measures ANOVA. Level of significance was set at

$p<0.05$. RESULTS: No significant differences were found between the two groups at baseline. The majority of the gait parameters improved in both groups over time, only stride length, TISstat and TIScoo failed to reach significant results. Additionally, a treatment effect was found for the experimental group on the Tinetti Gait subscale (p=0.001), total Tinetti Test (p=0.007), walking speed (p=0.010), stride length (p=0.026), TISdyn (p=0.001), TIScoo (p=0.037) and total TIS (p=0.0001). No significant effect was found for Tinetti Balance subscale (p=0.139), cadence (p=0.121), step length (p=0.071) and TISstat (p=0.201). An overview of the results can be found in table 1. CONCLUSIONS: Results showed that additional trunk rehabilitation is beneficial in improving gait performance in sub-acute stroke patients. Therefore, we recommend to incorporate these exercises as early as possible in a stroke rehabilitation program. The high functional ability of the included patients at baseline might result in a ceiling effect of some gait parameters. However, this criteria was necessary to ensure that gait analysis could be executed safely and without external support.

O.8.2 The effect of a combined motor-cognitive training, Thinking in Motion, versus a cognitive training on gait and cognition in older adults: a randomized clinical trial

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Background and Aim: The association between cognition and gait has been widely shown; there is evidence that cognitive training can improve gait, and vice versa. However, whether a combined training can improve both gait and cognition more than a specific training is yet to be explored. The Thinking in Motion program is inspired by Eshkol-Wachman Movement Notation, originally developed for dancers. The program translates motions into writing signs and, as such, it is inherently cognitive-motor training. The aim of this study is to compare the effect of a Thinking in Motion intervention with a control group, computer-based cognitive training, CogniFit, on cognitive function and gait under single- and dual-task conditions. Methods: Using a randomized single-blind control design, 48 sedentary older adults recruited to the study (mean age= 81.2 SD=2.2, Montreal Cognitive evaluation = 16.2 SD=3.1) and randomly assigned to 8-week, thrice weekly Thinking in Motion intervention (n=28) or CogniFit© training (n=19). Primary outcome was gait speed under single- and dual-task conditions and cognitive function as measured by CogniFit© battery. Gait parameters were measured by Mcroberts© motion analysis laboratory. Due to abnormal distributions of the outcomes, a Mann-Whitney test was conducted and intent-to-treat was implemented. Results: Of 48 participants, 2 did not complete the study (one in each group). Both groups improved in gait and cognition. No significant differences in age, sex, cognitive function, use of walking aids, or gait speed were found between groups at baseline. After 8 weeks the intervention group demonstrated improved significantly in cadence (mean difference intervention = 26.5, SD=2.8, control = 16.72 SD=1.9, p=0.0013) only during single-task condition and cognitive performance as measured by CogniFit evaluation (mean difference intervention 26.39, control-17.92 p=0.03). Sub-group analysis revealed that these differences were even greater among those with walking aids in the intervention group compared to the control group. Conclusion: Thinking in Motion is a promising strategy to improve gait and cognition. Future studies should address the effect of longer intervention as well as its effect on different patient sub-groups.

O.8.3 Implanted functional electrical stimulation for post-stroke drop foot: an analysis of kinematic and kinetic benefits at push-off and initial swing.

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Background and aim Contralesional 'drop foot' is a major problem for many stroke survivors, which is usually treated with an ankle-foot orthosis (AFO). However, AFOs hamper normal ankle mobility during many activities. Functional electrical stimulation (FES) of the common peroneal nerve is an alternative treatment that provides active dorsiflexion and allows normal ankle motion. Although evidence for a surplus value of peroneal FES over AFO based on clinical gait measures is scarce, patient preference has consistently found to be higher for FES than for AFO(1). Recently, we have shown that paretic ankle plantarflexion power was higher with FES compared to AFO(2). Plantarflexion power is a key element in gait propulsion and swing initiation, which are both often affected on the paretic side after stroke. Thus, we further compared the effects of peroneal FES to AFO regarding the kinematics and kinetics of the late stance phase of gait and the kinematics of the initial swing phase in an extended patient sample. Methods A 4-channel peroneal nerve stimulator (ActiGait®) was implanted in 22 chronic stroke patients. Their gait pattern was studied across 26 weeks (n=11) or 52 weeks (n=18) after first activation. Instrumented gait analyses were performed while subjects walked at a comfortable walking speed on a 10m walkway at baseline (AFO only) and 2, 8, 26, and 52 weeks after activation (both FES and AFO), see fig 1. Ankle kinematics and kinetics of the late stance of gait and kinematics of initial swing were calculated, besides basic spatiotemporal variables. Effects were statistically tested using GEE modelling with time, device (AFO vs. FES) and 'room for improvement' (RFI, difference between paretic and nonparetic side at baseline) as independent factors. Results With FES, ankle plantarflexion angle (β=3.0 °, p=0.03), velocity (β=32 °/s, p=0.02) and power (β=0.4 W/kg, p=0.05) were increased compared to AFO. Consequently, with FES, the vector of the ground reaction force (GRF) at peak ankle power (i.e. 'propulsion') was more oriented towards the direction of gait (β=1.7 °, p=0.02), while the horizontal GRF (β=1.1 % body mass, p=0.07) and gait speed (β=0.08 m/s, p=0.11) tended to be higher with FES. Gait speed improved significantly over time (β=0.002 m/s, p=0.001) for both devices. Step length asymmetry improved with FES only for the subjects with a high asymmetry at baseline (RFI*device interaction: β=0.1% , p=0.02). FES did not result in improved knee or hip flexion during (pre)swing. Conclusions The results of this study confirm that with peroneal FES more residual ankle plantarflexion power is utilized during late stance than with AFO. This improved ankle power results in better paretic propulsion and better step-length symmetry, but not in better swing phase kinematics. Perhaps the perceived subjective benefits of FES are related to improved paretic propulsion and gait symmetry, but more studies are needed of walking in complex, challenging environments. 1.van Swigchem et al. J Rehabil Med 2010; 42: 117-121 2.Schiemanck et al. Restorative Neurology and Neuroscience, vol. 33, no. 6, pp. 795-807, 2015

O.8.4 Continuous versus intelligent cueing and feedback for gait in people with Parkinson's disease: One size does not fit all

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BACKGROUND AND AIM: Most previous studies on external cueing in people with Parkinson's disease (PD) have investigated the effects of continuous auditory cueing, which may promote cue-dependency and limit transfer of learning. A potential alternative, reducing this risk, is to support performance with 'intelligent' cues or feedback. This involves the temporary provision of external input only at moments that performance significantly deviates from a predefined goal. So far, it is unknown how these methods benefit patients with different disease profiles, such as people with (FOG+) and without freezing of gait (FOG-), who are known to respond differently to continuous cueing. METHODS: 15 FOG+ and 13 FOG- participants, matched for age and disease severity, performed four 30 minute walk tests, with a one week interval between tests. They were exposed to either 1) continuous cueing (ConCue), 2) intelligent cueing (IntCue), 3) intelligent feedback (IntFB) or 4) no information (NoInfo). A bout of intelligent input was provided via headphones each time five consecutive strides deviated from their baseline cadence. Corrective input involved 10 beats (IntCue) or a verbal instruction to adapt speed (IntFB) per deviation. ConCues consisted of continuous rhythmic beats matching the participant's baseline comfortable cadence. The number of deviations was assessed using foot-mounted sensors. Participants' preference for each of the conditions was evaluated using a questionnaire. RESULTS: A significant group by condition interaction was found for the number of gait deviations ($F(3,9)=4.53$; $p=0.015$). FOG+ showed significantly more deviations than FOG- during IntCue (mean [95%CI]; FOG+: 4.45 [2.50 - 7.92], FOG-: 1.43 [0.58 - 3.49]; $p=0.04$) and IntFB (FOG+: 6.09 [3.36 - 11.04], FOG-: 1.67 [0.49 - 5.66]; $p=0.03$). In FOG+, the number of deviations during ConCue (1.83 [0.78 - 4.31]) was significantly lower than during NoInfo (21.39 [9.80 - 46.72]; $p=0.02$) and IntFB (6.09 [3.36 - 11.04]; $p=0.01$) and it was lower during IntCue and IntFB compared to NoInfo ($p=0.04$ and $p<0.05$ respectively). Despite the fact that ConCues had the most positive effect on cadence deviations in FOG+, the majority favored IntFB (60%; $p=0.02$). In FOG-, no differences in gait characteristics were found between conditions, but most of the FOG- (62%; $p=0.02$) subjectively preferred IntCue. CONCLUSION: Despite a subjective preference for an intelligent system, objective gait parameters show that people with FOG are highly dependent on continuous temporal guidance to produce a stable gait pattern during a 30 minute walk. Technological systems providing cueing or feedback should take into account these differences between people with and without FOG in order to provide optimal guidance according to disease profile.

O.8.5 C-Gait: automatized, standardized and patient-tailored walking adaptability training

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BACKGROUND AND AIM: Safe community ambulation requires the ability to adapt walking to environmental properties and hazards. This walking adaptability is often impaired in elderly with a high risk of falling and in persons after stroke. Walking adaptability may be improved by treadmill training augmented with visual context projected on the walking surface, such as provided by the C-Mill. The C-Mill allows therapists to attune training to specific needs and abilities of individual patients; however, this requires specialized knowledge from therapists, which precludes large-scale implementation and can be a source of uncontrolled variation in multicenter comparisons. Therefore, automatization and standardization of such patient-tailored training is needed. The aim of this study was to evaluate the validity, test-retest reliability, and feasibility of automatized and standardized patient-tailored C-Mill walking adaptability training (C-Gait). METHODS: The first C-Gait training session serves as an initial assessment to evaluate the baseline level of several walking adaptability constructs (Figure 1a). The objective and subjective information from this initial assessment forms the input for a decision algorithm aimed at defining patient-tailored training content and difficulty of the second C-Gait training. Output of the second training defines the third training, and so forth. Twenty-four healthy individuals (12 elderly and 12 young) performed the C-Gait initial assessment twice to assess the face validity (young vs. elderly) and test-retest reliability. A group of 30 persons with gait and/or balance deficits due to high risk of falling or stroke performed 5 weeks of C-Gait training after the initial assessment to assess the feasibility of the employed decision algorithm. The primary outcome measures were training progress (e.g. belt speed, C-Gait walking adaptability scores) and user experience using an evaluation questionnaire. Secondary outcome measures were walking-related clinical measures (10MWT, TUG, SPPB & ABC) and walking quantity and quality (MoveMonitors) measured before and after the training period. RESULTS: Figure 1a illustrates representative C-Gait initial assessment data, showing that for most constructs the healthy young performed better than the older persons. The preliminary feasibility results are shown in Figure 1b, which illustrates the C-Gait training progress of belt speed as an expected rising trend with overall high mean C-Gait walking adaptability scores, suggesting progressive training at a challenging but doable level. CONCLUSIONS: We expect that the further development of C-Gait, if reliable, valid and feasible, allows for standardization, automatization and thereby optimization of patient-tailored walking adaptability training. This will contribute to optimal training in terms of content (attuned to the walking construct identified as impaired) and difficulty level (ensuring a challenging but doable therapy, which is expected to enhance patient motivation and therapy adherence).

O.8.6 Internal model of verticality: neuromodulation through body-weight support in a tilted virtual environment

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Background - The development of rehabilitation techniques modulating the sense of verticality is a major challenge in balance disorders related to lateropulsion or retropulsion (stroke, Parkinson, etc.). Through this pilot study in healthy participants, we tested two techniques that are likely to modulate verticality perception: immersion in tilted virtual environment (visual cues) and walking with body weight support (somesthesic cues). Methods - Among 20 recruited healthy participants, 12 (53.3±7 years old) were studied using visual vertical evaluation (VV, 8 trials) in 3 postural conditions (in sitting, treadmill walking and treadmill walking with 30% of body weight suspended by a vertical rope (BWSW) combined with 2 visual conditions (darkness and immersive virtual tilted room (VTR), 18° clockwise tilt with Oculus Rift® head mounted display (HMD)). The study design aimed at introducing a VV bias through the VTR, then testing

BWSW immediate and after effect to reduce the error in degrees. Head orientation was monitored. Results - In VTR the mean VV error was of 11.0±4.4° ($p<0.001$) toward the room tilt side with an after effect of several minutes recorded in darkness. BWSW redressed the VV in all visual conditions: VV bias decrease in VTR and so does the after affect (-0.6°; $p<0.05$). VTR induced a head tilt (4.3±0.6°) toward the VV tilt, higher in BWSW condition. In darkness, head axis conversely remained vertical BWSW condition. Conclusions - We conclude BWSW induces a modulation in the construction of internal model of verticality through the reweighting of somesthesic input. These findings make it necessary to explore the optimum BWSW terms of use in rehabilitation program specifically dedicated to patients with a pusher syndrom. We have reason to expect a BWSW program could enhance their sense of verticality and thus decrease postural disorder interfering with functional abilities.

O.8.7 Recalibration of perceived postural capabilities mediates post-intervention improvements in older-adult functional balance

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Background and Aim Recent technological developments have led to "exergames" (portmanteau of exercise and videogames) becoming a common platform for balance-based exercise interventions in older adults. However, these interventions often use commercially available exergames that are too physically demanding for older adults and which are not designed to train areas of balance that decline with age. Furthermore, while research indicates the positive impact bespoke exergame interventions can have on balance confidence (Young et al., 2012), little is known about how such enhanced confidence could mediate frequently observed post-intervention improvements in balance (i.e., Fu et al., 2015; Maillot et al., 2012). Therefore, the aims of the study were to investigate (1) whether playing a custom-designed exergame could improve movement-specific aspects of functional balance in older adults, and (2) the psychological mechanisms underpinning any observed improvements in balance. Methods Twenty-six older adults completed an 8-session, 4-week balance intervention, in which they played a novel, replica version of one of the first videogames commercially available: PONG. In this simple game, players move a paddle to intercept a ball by manually rotating a handle. However, by intercepting the signal from a WBB and linking it to virtual reality software it became possible to design a novel, replica of PONG where players used their balance, moving along the anterior-posterior plane, to control the paddle. The game involved participants intercepting the ball in a range of positions up to, including, and beyond their anterior-posterior limits of stability. Our exergame utilised a novel handicapping system whereby participants' paddle sizes were directly representative of their functional balance abilities, ensuring a suitable level of challenge for all participants regardless of their balance ability. Measures of functional balance were recorded periodically throughout the intervention (functional reach and limits of stability). Structured focus groups were used to assess psychological functioning, with these analysed through inductive thematic analysis. Results Results showed significant improvements in balance performance (both functional reach and anterior-posterior limits of stability). Focus group data revealed that these improvements may be explained by a change in perceived action capabilities, with participants stating that they were more "aware" of their balance abilities and limitations. Conclusions Previous research has demonstrated the age-related increases in discrepancies between perceived and actual postural capabilities. As the observed improvements were greater than physiologically feasible considering the training dosage and duration, we propose that post-intervention improvements in functional balance may have been the result of a recalibration of the participants' perception of their balance capabilities. When interpreted with reference to literature documenting the efficacy of current commercially available games, our findings support the application of custom-designed exergames in a clinical setting and highlight the importance of psychological factors in explaining any observed improvements.

O.8.8 Long-term balance training with vibrotactile sensory augmentation in community dwelling older adults

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BACKGROUND AND AIM: Balance rehabilitation training reinforces the development of sensorimotor strategies to improve postural control and functional mobility for healthy community dwelling older adults (OA). Sensory augmentation (SA) provides cues about body motion to complement and/or replace native sensory information. Vibrotactile SA has been shown to improve real-time balance performance of individuals with vestibular disorders and OA. However, limited controlled studies have investigated the effects of balance rehabilitation training supplemented with SA. A recent study by Lim et al. demonstrated that training with SA resulted in minimal improvements over training alone. However, the training period was short (i.e., two weeks). The aim of this study was to determine the effects of longer-term training with SA versus training alone in OA. METHODS: Twelve OA (4 M, 8 F, 75.6±1.43 yrs.) with mild balance concerns were recruited to participate in this study. Pre- and post-training functional tests conducted by a blinded assessor included the Activity Balance Confidence Scale (ABC), Sensory Organization Test (SOT), Mini Balance Evaluations Systems Test (MiniBESTest), Five Times Sit to Stand Test (5xSST), and 10 Meter Walk Test. Participants were randomly assigned to one of two groups: control (CG; n=6) or experimental (EG; n=6). Participants performed balance training in their homes three times per week for eight weeks exercising for approximately 40 min per session (six 30 s repetitions of six selected exercises from five balance rehabilitation exercise categories). Both CG and EG participants used a novel smartphone balance trainer for exercise instructions, and to record step-outs and perceived difficulty ratings (visual analog scale). The smartphone balance trainer also provided vibrotactile SA based on body sway to the EG participants. A physical therapist used these data along with clinical expertise and an exercise progression framework to prescribe suitable exercises on a weekly basis. Paired-sample t-tests were performed using the functional test scores ($p<0.05$). RESULTS: No significant differences were found between the two groups for the pre-training tests. SOT composite scores improved for both groups (EG: 69 to 81 ($p=0.06$); CG: 67 to 71), with significant improvements observed for the EG. Likewise, MiniBESTest scores and duration of 5xSST significantly improved for the EG (22.2 to 25.7 ($p<0.05$); 13.6s to 10.7s ($p<0.05$)), but not for the CG (23.8 to 24.2; 11.4s to 10.8s). Improvements for the ABC Scale and gait speed were

comparable for the two groups. CONCLUSIONS: Sensory augmented balance training, supported remotely by a physical therapist, yielded greater functional changes in a subset of the metrics evaluated following an eight-week home-based balance training program compared to training alone. These results suggest that SA may be a useful tool for improving short-term balance training in OA. ACKNOWLEDGEMENTS AND FUNDING: NSF (GARDE 1159635), University of Michigan Claude D. Pepper Older Americans Independence Center (NIH RCDC/KL2 2P30AG024824-11), and Michigan Brain Initiative Working Group.

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O.9 – Parkinson's disease

O.9.1 Progression of dopa-resistant gait impairment in early Parkinson?s disease

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BACKGROUND AND AIM: Gait impairments are significant in the early stages of Parkinson's disease (PD) and increase falls risk. While some aspects of gait are well controlled by dopaminergic therapies, resistance to levodopa makes clinical management challenging. The aim of this study was to identify which characteristics of gait are dopa-resistant in early PD. METHODS: Sixteen gait characteristics were assessed longitudinally (Baseline assessment, 18 months and 36 months) in 108 PD (Age: mean±sd 69.5±10.5yr; 72♀; Unified PD rating scale motor assessment: 25.4±10.4) recruited a median of five months from diagnosis and in 130 age-matched controls (Age: 66.9±7.7yr; 36♀). People with PD were tested 'on' medication. Participants walked at their "comfortable walking pace" for two minutes around a 25m oval circuit. Gait was repeatedly sampled with an instrumented walkway (Gaitrite). We defined dopa-resistant gait characteristics as those which: i) progressed significantly over the 36 months despite optimal medication; ii) progressed more in PD than controls; and iii) were not associated with increased levodopa equivalent daily dose (LEDD). Change in gait was assessed with a linear mixed-effects model. Participants and time from baseline assessment were included as random effects, and age at baseline, gender and group as fixed effects. We examined Pearson's correlations between change in LEDD and change in gait. RESULTS: Gait characteristics which progressed in PD more than controls (and % yearly progression rate) included variability of step time (4.5%/yr), step length (5.7%/yr) and step width (3.4%/yr). LEDD increased significantly from the baseline (176±144mg/day) to 36 month (517±257mg/day) assessment. Within person change in LEDD was not related to progression of variability of step time (r = .015, p=.877) or step length (r=-.039, p=.687), corroborating that these variables represented dopa-resistant progression. However, increased in LEDD was related to increased step width variability (r=.218, p=.023) and so was not considered dopa-resistant. CONCLUSIONS: Variability of step length and step time increase in the early clinical stages of PD, despite optimal levodopa medication. Increased gait variability may predispose people with PD to trips and falls, and so identifying the underlying neural substrates responsible for their progression will help better target interventions to manage gait impairment in the early stages of PD. ACKNOWLEDGEMENTS AND FUNDING: ICICLE-GAIT is supported by the National Institute

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O.9.2 Impaired perception of gait asymmetry during split-belt walking in patients with Parkinson's disease with and without freezing of gait

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BACKGROUND AND AIM: Normal walking requires constant adaptation to varying circumstances to ascertain stable gait. Patients with Parkinson's disease (PD) and freezing of gait (FoG) are known to experience impairments in gait rhythmicity, symmetry, and bilateral coordination within and between both legs. In particular, freezers (FRs) were found to have increased difficulties with gait adaptation during prolonged split-belt walking and re-adaptation to tied-belt walking, resulting in gait asymmetry. In the current study, it was investigated whether these gait problems are related to perceptual deficits of gait asymmetry in FRs. METHODS: Thirteen FRs, 12 non-freezers (NFs) and 12 healthy controls (HC), matched for age and disease severity, were investigated during walking on a split-belt treadmill. Both belts started at an equal speed of 3.0 km/h and after a random time interval, the speed of one of the belts was gradually increased with 0.01 km/h per second. Participants had to indicate by pressing a response button at which moment they perceived belt speeds to be different. We calculated the perception accuracy (the percentage of correct responses) and the perception threshold of locomotor asymmetry (the difference between split-belt speeds at the moment of detection). In addition, spatio-temporal gait characteristics during both split- and tied-belt walking were determined. Each patient performed 8 trials, including 3 practice trials, 5 test trials in which the left or the right belt accelerated, and a sham trial in which none of the belts accelerated. Trials were presented in random order. A one-minute walk with belts at equal speed was provided between all trials to wash out potential adaptation effects. RESULTS: Perception accuracy significantly differed between groups ($p=0.029$). Post-hoc tests revealed that FRs had poorer perception accuracy than NF ($p=0.024$) and HC ($p=0.020$). Impaired perception was mostly present for trials in which belt speed on the disease non-dominant side increased ($p=0.007$). Remarkably, FRs tended to have more incorrect responses in the sham trial ($\div^2=0.059$), although no actual change in belt speeds occurred. Average perception threshold did not differ between groups ($p=0.328$). During tied-belt walking, post-hoc tests revealed that FR exhibited more asymmetrical step lengths than HC ($p=0.034$). Step length asymmetry was significantly correlated with the total number of incorrect trials ($p=0.008$, $r=0.407$). CONCLUSIONS: The results of the present study support the hypothesis that FRs have more impaired perception of locomotor asymmetry than NFs. In addition, FRs seemed to have an exaggerated response in anticipation of salient stimuli, which may signify a compensatory mechanism. The perceptional deficit may lead to altered gait adaptation abilities. Our findings

give rise to developing novel rehabilitation methods, addressing perceptual abilities in patients with FoG.

O.9.3 Visual exploration during gait in Parkinson's disease: response to visual cues

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Background and aim: Gait impairment is a core feature of Parkinson's disease (PD) with implications for falls risk. Visual cues improve gait in PD but the underlying mechanisms are unclear. Attentional or visual processes may underpin response to visual cues, and can be studied by measuring visual exploration (saccades and fixations) when walking. For example; visual cues may prompt greater visual exploration to task-relevant locations (e.g. floor) during gait rather than irrelevant locations (e.g. ceiling). Understanding how cueing influences visual exploration will help develop effective therapeutics. This study examined visual exploration in response to a visual cue during gait in PD. We studied; 1) visual exploration under cued and dual-task conditions; and 2) relationship between visual function, attention, visual exploration and gait in PD. Methods: Visual exploration (saccade frequency (SF), fixation number (FN)) was measured using a mobile eye-tracker in 55 PD and 32 age-matched control participants while walking. Fixation location was examined in a sub-group of 20 PD and 21 controls. Participants walked with and without a visual cue under single and dual-task (forward digit-span). Visual function and attention were also assessed. Changes in visual exploration in response to cues and dual-task were compared with ANOVA or Friedman analysis. Relationships between exploration, visual function, attention and gait were explored using bivariate and structural equation modelling (SEM) analysis. Results: Attention and visual function were significantly impaired in PD. Visual exploration was impaired in people with PD who had greater fixations on unrelated locations during non-cued gait compared to controls. Visual exploration increased with a cue (SF and FN $p<.001$) and the increase was maintained under dual-task (SF $p=.008$, FN $p=.022$) irrespective of group, with greater increase in PD. Both groups increased fixations to task-relevant locations with a cue ($p<.001$) and people with PD reduced fixations to unrelated locations. Attention rather than vision played a central role in cue response in PD. SEM analysis showed that attention directly related to SF, visual function and cued-gait velocity (ß=-.37, $p=.036$) in PD, whereas visual function only related indirectly to SF (ß=-.12, $p=.008$) and cued-gait velocity (ß=-.17, $p=.031$) with relationships underpinned by attention. Attention also underpinned an indirect relationship between SF (ß=.10, $p=.031$) and cued-gait velocity in PD. Conclusions: Visual cues elicit greater visual exploration of task-relevant locations during gait in PD, with response facilitated through attentional mechanisms. However the specific attentional aspects involved in cue response require further examination. Acknowledgments and funding Financial support for this study came from the National Institute for Health Research (NIHR) Newcastle Biomedical Research Unit and the NIHR Newcastle CRF Infrastructure funding.

O.9.4 Accuracy of commercially available activity monitors in people with Parkinson's disease

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BACKGROUND: Despite the known benefits, physical activity (PA) is low in many people with Parkinson's disease (PD). Achieving and maintaining optimal volume and intensity of physical activity is a challenge. Activity prescription is typically based on that for healthy adults, however energy expenditure during walking may be higher in people with PD due to gait impairments. Commercially-available activity monitors may aid in motivating people to increase PA levels, but it is not clear whether they are accurate in people with PD. The aims were: 1) To investigate the relationship between activity intensity and walking cadence, walking environment and characteristics of PD. 2) To determine the concurrent validity of two commercially-available activity monitors (the Fitbit Charge HR and Garmin Vívosmart® HR) in people with PD. METHODS: 33 people with mild-moderate PD participated in this cross-sectional study. Participants performed six, two-minute walks along a 44m corridor at their usual walking pace, then at target cadences of 60, 80, 100, 120 and 140 steps/minute. A 500m outdoor walk was also performed. Measures of activity intensity (e.g. oxygen consumption, heart rate) were compared across the seven walking conditions. Step count was recorded by the Garmin and Fitbit devices worn on both wrists, and the ActivPAL3. Spatiotemporal parameters of participant?s normal and fast gait were recorded using the GAITRite. RESULTS: There was a significant increase in oxygen consumption and heart rate for each increase in cadence from 60 to 140 steps/minute. Measures of oxygen consumption and heart rate were significantly higher during outdoor walking. Oxygen consumption when walking outdoors was positively correlated with self-reported activity levels, step length and gait speed. Compared to the ActivPAL3, both commercial activity monitors had low error (1-7%) and moderate to high consistency at self-selected pace both in (ICCs>0.51; p<0.05) and outdoors (ICCs>0.78; p<0.05). The Garmin recorded low error (<5%) and high agreement (ICCs >0.70; p<0.001) for all cadences >80 steps/minute. The Fitbit had high error (>10%) and low consistency for all cadences except 100-120steps/minute. Both recorded high error at 60steps/min. CONCLUSIONS: Cadence can be used to define physical activity intensity in people with PD, regardless of walking location. Participant characteristics associated with oxygen consumption are modifiable, thus could be addressed to reduce energy costs of walking. The Fitbit Charge HR and Garmin vívosmart® HR are accurate in counting steps compared to the ActivPAL3 at self-selected walking speed both in and outdoors, but not at low speed. The Garmin vívosmart® HR was consistently accurate at reflecting cadence at a variety of gait speeds, whereas the Fitbit Charge HR showed high error. Investigations should be undertaken to confirm the accuracy of commercially available devices prior to use in patient populations.

O.9.5 Maximum step length test as an objective marker of motor disease symptom severity in Parkinson disease

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Background and aim: The MDS-UPDRS scale is often used by clinicians to subjectively assess motor disease symptom severity (Part III) in Parkinson disease (PD). Easy to assess and objective measures of motor disease symptom severity may provide more reliable outcome biomarkers for PD clinical trials. The maximum step length (MSL) test has shown to be a good predictor of mobility performance in older adults. The aim of this study was to examine the association of MSL with motor disease symptom severity in PD as assessed with MDS-UPDRS. Associations of MSL with potential covariates, such as muscle strength, muscle mass, and vibrational sensation were also examined. Methods: 37 PD patients (8F, age=67.8±5.3 years, motor disease duration=6.8±4.2 years, median modified Hoehn and Yahr stage 2.5) underwent MSL assessment on a Zeno Walkway pressure sensor mat (Protokinetics) in the forward and backward directions in the dopaminergic "on" state. Subjects stood with their arms crossed and were instructed to step forward (or backward) as far as they could and then immediately return to their initial position. PKMAS software was used to identify the foot falls and the height-normalized MSL distance was calculated as "stride length" between the two foot falls. MDS-UPDRS was performed in the dopaminergic "off state". Strength of different dominant leg muscle groups was assessed with the microFET2 handheld dynamometer (Hogan Scientific). Lean appendicular muscle mass was obtained with DXA bone densitometry (Hologic). Lateral malleoli vibration perception was assessed with a 12 Hz tuning fork. Results: Preliminary analysis showed strong correlation of MSL with age in PD patients (r= -0.560, p=<0.001), but not with disease duration. To examine the disease-specific associations of maximum step length, subsequent (partial) correlations were performed while correcting for age. Backward rather than forward MSL had best correlation with MDS-UPDRS motor sub-scores. Backward MSL correlated with MDS-UPDRS Part III score (r=-0.556, p<0.001), postural instability and gait difficulty (r=-0.456, p=0.005), bradykinesia (r=-0.596, p<0.001), and rigidity sub-scores (r=-0.574, p<0.001); however, not with MDS-UPDRS Part I or Part III tremor sub-scores. There was no correlation of MSL with lateral malleoli vibration perception. Measures of lean appendicular mass did not correlate with MSL. However, MSL did correlate with knee extension (r=0.473, p=0.005) and hip- extension (r=0.338, p=0.054), abduction (r=0.469, p=0.006), and adduction (r=0.396, p=0.023) strength in PD patients. Conclusions: The age-corrected correlation between backward MSL and non-tremor motor scores of the MDS-UPDRS PART III motor scores suggests that this measure may serve as an objective biomarker of PD motor symptom severity. Further studies are needed to examine the progression of MSL with disease progression. MSL may possibly serve as an objective outcome biomarker of motor disease symptom severity in PD in clinical trials. Acknowledgements and funding: NIH P50 NS091856

O.9.6 Dynamic stability limits during walking turns in Parkinson's disease

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BACKGROUND AND AIM: Medio-lateral stability during walking turns relies on the interaction between precise weight shifts of the body and changes in base of support by regulation of step width. Although impairments of these postural features are believed to cause falls in individuals with Parkinson's disease (PD), little is known about how they interact during walking turns in PD. Therefore, we aimed to investigate dynamic stability limits during pre- and unplanned walking turns in individuals with PD (OFF and ON medication) compared to their healthy counterparts. METHODS: 19 older adults with mild to moderate PD (7 females, mean age and disease duration of 72 and 5 years, respectively) and 17 healthy controls performed the

following tasks: walking straight, or walking and turning 180° to the right or left during pre- and unplanned condition. The preplanned condition was visually cued before starting to walk and the unplanned was cued 0.6 m before reaching the turning point. Participants with PD were assessed OFF and ON medication. Two turning strategies were identified: step strategy (i.e. the turning step was performed in the direction of turning) and spin strategy (i.e. the turning step was in the opposite direction of turning). As a proxy for center of mass, the center of the pelvis segment was calculated as the average position between right and left posterior superior iliac spine. Step width and pelvis medio-lateral shift were calculated in relation to the line of progression for the first turning stride (see Figure). Stability limits were calculated as the absolute difference between step width and pelvis shift (positive values: step width > pelvis shift). ANOVAs were used to evaluate the effects of medication (PD OFF vs PD ON) and differences between groups (PD ON vs controls). RESULTS: Differences in stability limits between PD and controls only occurred during turning and not straight walking (see Figure 1a-c). Specifically, while using the step strategy during pre- and unplanned turns, individuals with PD reduced their stability limits by 33% compared to controls (p=.001), caused by a 22% narrower step width in the PD group. For the spin strategy during unplanned turns, individuals with PD reduced their stability limits by 108% compared to controls who used 72% greater negative step width, i.e. external foot crossed over and landed medial to the line of progression of the internal leg. Medication only increased stability limits for the step strategy during unplanned turns (p=.001) owing to an 8% greater step width in the ON-state (p=.006), while the pelvis shift was unchanged. CONCLUSIONS: We found that individuals with PD compared to healthy controls positioned the pelvis segment closer to the margins of their medio-lateral base of support while turning. Our findings suggest that problems regulating step width is a key contributing factor for dynamic stability in PD. As dopaminergic medication has little effect on stability limits, rehabilitation plays a crucial role in targeting medio-lateral stability in PD.
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O.9.7 Peripheral Neuropathy Contributes to Impaired Gait in Parkinson's Disease

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BACKGROUND AND AIM: In individuals with Parkinson's disease (PD), postural imbalance and gait difficulties represent significant causes of disability, and are thus important contributors to the loss of independence in performing activities of daily living and to a reduced quality of life. Although these difficulties stem, in part, from the nature of this neurological disease, disease-independent contributing factors may also exist. In fact, neuromuscular factors such as decreased peripheral sensation, hip strength, and ankle proprioception have been linked to gait and balance difficulties in healthy older adults. The purpose of this study, therefore, was to investigate the contribution of peripheral neuropathy to gait performance in PD. METHODS: From a total of 143 individuals (106 males) with PD, 14 males met the criteria for peripheral neuropathy (age: 67.9 ± 7.2 yrs; modified Hoehn & Yahr stage: 2.4 ± 0.6; duration of disease: 6.4 ± 4.9 yrs) and were matched 1:1 for sex, Hoehn & Yahr stage, and duration of disease with

14 controls (no peripheral neuropathy; age: 64.8 ± 8.1 yrs; modified Hoehn & Yahr stage: 2.3 ± 0.5; duration of disease: 6.9 ± 3.7 yrs). Peripheral neuropathy was defined as the presence of three criteria: (1) high vibration perception threshold at the medial malleoli via biothesiometry (> age-specific 95th percentile); (2) decrease cold temperature sensation at distal shanks; and (3) absence of ankle jerk reflexes. All participants underwent a gait assessment (8-meter normal pace walk on a GAITRite® mat) and [11C]dihydrotetrabenazine dopaminergic PET imaging in the dopaminergic "off" state. Three stepwise regressions were performed to determine whether the presence of neuropathy predicted gait performance (height-normalized gait speed, stride length, and stride length variability) while accounting for striatal dopaminergic innervation. RESULTS: The presence of peripheral neuropathy was significantly associated with a shorter stride length and greater stride length variability (Table), while accounting for striatal dopaminergic innervation. Although the overall model did not reach significance (p = 0.057), the presence of peripheral neuropathy was also significantly associated with a slower gait speed, controlling for striatal dopaminergic innervation (Table). Although levodopa use is known to be associated with neuropathy in PD, levodopa equivalent doses were not found to differ between groups (cases: 757.6 ± 509.5 mg/day; control: 852.1 ± 828.7 mg/day; p = 0.719). CONCLUSIONS: Lower-limb peripheral neuropathy is a significant contributor to gait difficulties in individuals with PD, independent from age, Hoehn & Yahr stage, duration of disease, and striatal dopaminergic denervation. Hence, this important contributing factor to gait performance should be considered by clinicians and scientists when assessing gait, as well as when determining and developing effective therapies aimed at alleviating these debilitating symptoms of PD.

O.9.8 Increased Gait Asymmetry During Single and Dual Task Walking Predicts One-Year Conversion to Freezing of Gait in Patients with Parkinson's Disease

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BACKGROUND AND AIM: Freezing of Gait (FoG) is considered one of the most disabling symptoms of Parkinson's disease, leading to an increased risk of falls and loss of independence. As therapeutic options might, at least partly, relieve this symptom, it is of high importance to predict the moment when a patient first develops FoG or "converts to being a Freezer". However, evidence pointing to specific disrupted gait mechanisms that precede and could potentially predict conversion to FoG is lacking and therefore this prospective study set out to investigate these factors and explain the occurrence of FoG. METHODS: Sixty non-demented(MMSE≥24) PD patients (UKPDS - BB Criteria) without FoG were consecutively recruited from the Movement Disorders Clinic of the University Hospital Leuven. Self-paced normal walking (ST Gait) and walking with an auditory Stroop task (DT Gait) were assessed using a 10-camera VICON 3D Motion Analysis system at three time points with one year intervals when OFF-medication. Patients were classified as converters with the New Freezing of Gait Questionnaire (NFOG-Q) and spatiotemporal gait outcomes in the year prior to conversion were compared with the outcomes of the patients who did not convert. ROC analyses and Youden's Index were used to identify potential predictors and thresholds of conversion while single predictor Logistic Regression with one-year conversion as a binary outcome was used for prediction. RESULTS: Nine out of the 60 patients (15%) dropped out of the study over the total study duration of two years, while 12 patients (20%) converted to displaying FoG. Out of 110 ST and DT gait variables, Gait Asymmetry (GA) was the most indicative of conversion, based on significant p-values. Area Under Curve (AUC) for Gait Asymmetry (GA) was between excellent for ST Gait (AUC = 0.833; $p<0.001$; 95%CI: 0.697 - 0.969) and good for DT Gait (AUC = 0.795; $p = 0.002$; 95%CI: 0.623 - 0.967). Threshold values for GA based on the Youden's Index showed a Sensitivity and Specificity of 75% and 87% for ST Gait and 75% and 78% for DT Gait, respectively. Logistic regression models yielded significant results for both ST GA (OR: 5.70; $p = 0.001$; 95%CI: 2.01 - 16.20) and DT GA (OR:2.66; $p = 0.004$; 95%CI: 1.37 - 5.17) in predicting one-year conversion and the models predicted 40% and 45% of variance(Nagelkerke R^2) in conversion, respectively. CONCLUSIONS: Although disruption in rhythmicity of movement has been implicated in FoG, this is the first study that objectively describes a link between gait asymmetry and conversion to freezing. The finding that movement symmetry is more affected in converters in both normal gait as well as in dual-task gait suggests the presence of a non-task specific underlying deficit in automaticity and synchronisation in locomotor circuits. Future research should explore whether interventions targeted at improving gait symmetry might delay conversion to FoG in Parkinson's Disease.

O.10 – Tools and methods for posture and gait analysis

O.10.1 Age-Related differences in compensatory stepping thresholds following unexpected balance loss.

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Background and aims: Trips and slips account for about 60% of falls during walking in older adults. Unexpected loss of balance due to sadden surface translation may be ecologically valid to evaluate the necessary balance avoidance strategies to recover from slips and trips. Evaluating age-related differences in stepping threshold to unexpected loss of balance have the potential to assess fall risk in older adults. Past studies show that older adults perform more steps to recover balance, less able to perform cross-over stepping, and show more leg collisions. Step threshold is less investigated. We aimed to explore age-related differences in balance avoidance strategies, specifically the compensatory stepping thresholds. Compensatory stepping threshold at individual level is defined as the minimum disturbance magnitude that elicits a compensatory stepping response and compensatory stepping threshold at a group level is defined as the minimum disturbance magnitude that more than 40% of the group subjects responded performing stepping. Methods: Twenty-three young and 71 older adults were exposed to 18 right and 18 left surface translations. They instructed to respond in a "natural" manner (no instructional constraints). During the examinations the surface translations perturbation magnitude was systematically increased in steps, from low magnitude (i.e., low displacement, velocity and acceleration) to high magnitude (i.e., high displacement, velocity and acceleration). Stepping threshold at individual and group levels were explore, balance response strategies, step reaction times, step length and center of mass movement, evaluated as well. Results: Eight avoidance strategies were performed by both age group subjects: 1) Arms abduction; 2) Upper Body Balance response; 3) Unloaded leg lateral step; 4) Loaded leg lateral step; 5) Crossover step; 6) Multiple steps; 7) Leg collisions; 8) leg abduction; and also 9) falls into harness. In general, young's were able to avoid fall performing arm and upper body responses. There was significant difference in step threshold at individual level between older adults and young's (6.9cm±3.0cm vs. 15.3cm±2.7cm, respectively). At a group level a compensatory stepping response was the most prominent response in a perturbation magnitude of 7cm and higher, compare with 17cm in young's. Regarding stepping strategies, older adults performed multiple steps in 13% of trails compare with only 1% in young's. Both old and young adults performed unloaded leg step in low magnitude perturbation (1-7cm in older adults and 1-9 in young's) and cross-over stepping in a higher magnitudes. Leg collisions and falls into harness were seen in older adults only. Conclusions: The dramatic differences in step threshold and inefficient step strategies (i.e., multiple steps, leg collisions and falls) between young and older during balance perturbation, support the view that even independent and relatively healthy older adults have a problem controlling their lateral balance. The compensatory stepping thresholds, is a relatively easy parameter to identify, it does not require motion capture systems and can be performed in clinical and research-related assessments to identify risk of fall and effectiveness of a balance training programs

O.10.2 Gait adaptation to conflictive visual flow in virtual environments
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BACKGROUND AND AIM: Visual-proprioceptive interaction plays a key role in gait performance. The manipulation of optic flow and surface inclination facilitates the investigation of the mechanisms underlying this sensorimotor interaction. There is evidence that optic flow may modulate walking speed (WS) and promote postural adjustments on inclined surfaces. This concept is clinically relevant and represents a challenge for gait rehabilitation programs. The aim of this study is to examine gait adaptation of young adults exposed to a conflicting visual scene depicting an inclined surface during level walking. METHODS: Fifteen healthy participants (7 male; age: 29±4 yo; BMI: 23.4±3.3) walked on a level treadmill (at self-paced mode) synchronized to a motion capture system (Vicon, Oxford, UK). Concurrently, a fully immersive virtual reality system (CAREN High End, Motek Medical, The Netherlands), projected a virtual environment (VE) simulating a one-lane road on a full-room dome-shaped screen. Here we report on 3 walking conditions (out of nine randomly presented): [1]: level VE, [2]: VE switches to uphill (+10°), and [3]: VE switches to downhill (-10°). In conditions 2 & 3, the VE changed when the participant reached steady-state velocity, and the new VE lasted for 70 seconds. We compared WS for level VE with the other conditions and characterized the temporal pattern of the visual conflict effect (Figure 1A). Then we evaluated changes in spatiotemporal parameters (step and stride length) as well as joint angles (knee, elbow and pelvis) during the course of the effect. RESULTS: Conflictive visual flow significantly influenced gait. WS: increased in VE uphill ($p=0.02$) and decreased in VE downhill condition ($p=0.056$), as compared to level condition. Further, WS differed between VE uphill and VE downhill conditions ($p=0.0094$, Figure 1B). An early-stage effect peaked at 14.3 and 10.8 seconds, respectively, after the onset of visual conflict. Joint angles: range of motion increased during the effect ($p<0.05$) for both conflicting conditions (Figure 1C). Spatiotemporal: conflictive uphill scenery led to an increase in step length (0.73±0.15m vs. 0.88±0.09m, p=0.0018). Additionally, step and stride length were significantly larger during VE uphill versus VE downhill condition ($p<0.05$, Figure 1C). CONCLUSIONS: Our results suggest that young adults show gait adaptations under conflictive sensory conditions. A key finding is that these adaptations appear to differ depending upon the type of incongruence in visual flow. Presentation of visual scenes depicting uphill and downhill surfaces differentially affected walking speed, range of joint motion, and walking pattern. Our study contributes to current understanding of how visual-proprioceptive interaction affects gait in the context of visual conflict. Future research might explore how this type of manipulation of sensorimotor integration may enhance gait rehabilitation programs. ACKNOWLEDGEMENTS: 1. PACE Horizon 2020 Project. Marie-Curie agreement No 642961, and 2. Israeli Ministry of Science and Technology, Grant # 3-12072.

O.10.3 Experimental vs. model-based comparison of stepping threshold in response to external force-controlled perturbation.

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BACKGROUND AND AIM: Stepping is a common protective strategy for dynamic balance recovery following external perturbations of stance. The present study investigated the force at which a step is triggered during force-controlled forward perturbations of different durations delivered at waist level. Experimental results were compared with the stepping predictions of a simple biomechanical model. METHODS: Twenty-two healthy young adults (5 women; 19-37 years old) were asked to try not to step in response to 86 different force/time combinations of forward waist-pulls (Fig A). Each trial perturbation was characterized by its force F (or Fn when normalized according to the subject body weight), its duration (T), and its consequence (binary: 1 step or 0 no-step). The probability of a step as a function of perturbation characteristics was then calculated for the entire group and the forces at which 50% of subjects stepped (F50) were identified for each tested perturbation duration (Fig B). Experimental results were compared to a numerical criterion used to estimate if a recovery step was necessary for a given square force perturbation. It was obtained from the dynamics of a linear inverted pendulum + foot model and considering the maximal balance recovery reactions. These were an instantaneous shift of the center of pressure at the anterior edge of the functional base of support (CoPmax = 15,3 cm) that arises after the perturbation (at a delay representing the reaction time RT = 116 ms). Values of CoPmax and RT were obtained from the experimental data. RESULST: The experimental stepping boundary was well described by a simple hyperbolic function with a positive horizontal asymptote: $F50 = a/T + C$, in which a defines the radius of curvature of the function and C the asymptote of the smallest force that can trigger a step (i.e. a force less than C can be resisted indefinitely without stepping). The result of this fitting (Gauss-Newton, nonlinear, least-mean-squares) is represented on Fig C (red line) and the mean squared error was very small (MSE 0.12). The threshold function (i.e. values of Fmax) computed using the biomechanical model (Fig C solid blue line) correctly predicted the force-time threshold determined experimentally (red curve). CONCLUSIONS: The stepping boundary describes the maximal force that has to be applied for a specific time to trigger a step. Experimentally, this boundary corresponds to a constant impulse (i.e. constant perturbation force-duration product), a model that can be easily implemented in clinical applications. When compared with the biomechanical model, the stepping boundary is largely explained by the RT and the CoP displacement within the functional BoS (CoPmax). Future work could investigate clinical population to test further the validity of these stepping boundary methods and their predictive capabilities. ACKNOWLEDGEMENTS AND FUNDING: This work was supported by NHMRC Australia.

O.10.4 Minimal Number of Strides for Reliable Estimation of Temporal Gait Parameters - Implementation of a Novel Algorithm on the Phase Coordination Index

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BACKGROUND AND AIM: Gait research is progressing in novel ways as new technologies become available (e.g., wearable sensors, self-paced treadmills (SPTMs), etc.). Gait analysis of data from wearable sensors has been found an effective clinical tool for diagnosis and treatment [1,2]. The Phase coordination index (PCI), a temporal gait measure that quantifies consistency and accuracy in generating the anti-phased left-right stepping pattern [3], can assess bilateral coordination of gait in various cohorts (e.g., Parkinson's disease, post stroke). As PCI, like gait variability, is based on mean values calculated across series of gait cycles, participants are required to perform lengthy walking trials, prolonging gait assessments and causing discomfort to some participants. This study introduces a generic algorithm to identify the minimal number of strides needed to obtain a reliable, representative PCI. METHODS: Historical data from 16 healthy participants (age: 32.9 ± 5.5 y, 8 women) in a previous study [4] were analyzed. Participants walked on a SPTM instrumented with force plates at his/her comfortable speed. Heel strike detection data were extracted from an interval characterized by steady state velocity. A series of N-1 PCI values was calculated for i= 2,3,4...N gait cycles for each subject. There is a value i=k, termed point of stabilization (POS), representing a certain number of gait cycles, for which no significant change in PCI occurs as additional gait cycles are added. The algorithm presented here uses a 2-stage iterative process to determine POS. Stage 1 searches for the gross interval of PCI values location of the region containing the POS. In stage 2, the algorithm performs a high-resolution recursive, iterative process within this interval to find the exact point. The criterion for defining stability within a window of PCI values is a coefficient of variation (CV) of ≤ 5%. Figure 1 depicts the output of the algorithm. To cross-validate the algorithm, we implemented the same algorithm to calculate 'when' stride-to-stride-time variability (stride-CV) stabilizes. RESULTS: Our recursive, iterative algorithm indicates that 21.3 ± 4.9 (SD) strides should be captured to attain a representative PCI. Similar results (i.e., 20.7 ± 7.8 strides) were obtained for stride-CV. CONCLUSIONS: Gait trials conducted on a SPTM with at least 22 strides at a steady state velocity should suffice to obtain reliable estimation of PCI and stride-CV in healthy young adults. While this methodology may be considered generic, future studies should determine whether POS values are similar for

elderly and/or disabled participants, and for data obtained during over ground walking.
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O.10.5 Local Dynamic Gait Stability in Parkinsonism

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BACKGROUND AND AIM: Falls are a leading cause of injury, disability, and death in elderly adults and measures of gait quality, such as local dynamic stability (LDS), are sensitive predictors of fall risk in elderly adults. LDS is often described as a reflection of the ability of the neuromuscular control system to attenuate local perturbations, but the effects of neurodegenerative diseases on LDS are still unclear. Despite the high rate of falls and common gait disorders in individuals with idiopathic Parkinson's Disease (iPD) or parkinsonism, also called frontal gait disorders (FGD) or vascular parkinsonism, the complex dynamics of gait such as local dynamic stability (LDS) have not yet been explored. Differences in LDS between healthy elderly, individuals with iPD and individuals with FGD may contribute to a better understanding of the neurological correlates of LDS. We hypothesized that LDS will differ between controls, individuals with iPD, and individuals with FGD and be indicative of basal ganglia and frontal lobe contributions to LDS. METHODS: Sixty-five individuals with iPD (mean, SD = 68.5, 9.9 years), 10 individuals with FGD (72.1, 6.4 years), and 29 healthy controls (69.9, 7.2 years) were studied. Twenty-three of the 65 subjects (68.2, 6.6 years) with iPD reported freezing of gait (FoG). Subjects with iPD or FGD were tested >12 hours after withholding anti-PD medication. Each participant walked at their self-selected comfortable walking pace for two minutes between lines spaces 7.62 m apart. Inertial sensors on the sternum, lumbar, and bilaterally on the wrists and feet collected tri-axial accelerations and angular velocities at 128 Hz. After removing turns and transitions steps, bouts of 5 steady state strides were extracted to calculate LDS. The length of each bout was normalized to 5*130 data points to maintain equal data length. A 9D state space was constructed using the tri-axial accelerations of the trunk and their twice-time-delayed copies using a delay of 0.25*average stride time across all participants. LDS was calculated using the maximum finite-time Lyapunov exponent of the mean log divergence curve from 0 - 0.5 strides. Linear regression models compared LDS across groups. Post-hoc pairwise comparisons were performed using independent two-sample t-tests. RESULTS: Subjects with FGD had significantly worse LDS compared to subjects with iPD and controls ($p < 0.01$). LDS did not differ between controls and subjects with iPD. However, LDS was worse in subjects with iPD who reported FoG compared to those without FoG and compared to controls ($p < 0.01$). CONCLUSIONS: These results support our hypothesis that neurological dysfunction produces less stable dynamic control of the upper body during gait. However, similar LDS between controls and subjects with iPD without FoG suggests that frontal lobe dysfunction, rather than basal ganglia dysfunction, may be more critical to LDS. ACKNOWLEDGEMENTS AND FUNDING: Funding from NIH R37AG006457.

O.10.6 Fractional stability of human gait: Towards a unified concept of gait stability

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Background: Over the last decades, various stability measures have been introduced to detect instability during walking. All of these measures assume that gait stability may be equated with exponential stability, where stability is quantified with Floquet multipliers or Lyapunov exponents. These specific constructs of gait stability assume that gait dynamics are time independent and do not exhibit phase transitions. However, results from walking models and empirical studies show that the assumption of exponential stability breaks down in the presence of phase transitions, which occur in each step cycle. The aim of the present study was to investigate whether a general non-exponential mathematical construct of stability, coined fractional stability, is an improved concept of gait stability. Method: Gait dynamics for 42431 epochs of 30 sec of daily-life walking from 172 community-dwelling older persons (data from [1]) were reconstructed and divergence curves d(t) were computed [2]. Exponential stability was computed by the mathematical expression $d(t) = d(0)*\exp(\lambda s*t)$, where d(0) is the size of the initial perturbation, t is time and λs is the Lyapunov exponent. Fractional stability was computed by a mathematical expression, $d(t) = C*t^{(\beta-1)}E(\alpha,\beta)(\lambda*t^\alpha)$,based on fractional calculus where fractional derivatives á and â is an extension of integer Newtonian derivatives, $\alpha = 1,2,..$ and $\beta = 1,2,..$[3]. Surrogate data series were created through multivariate empirical mode decomposition (MEMD) and used to assess the influence of phase dependent changes in the gait dynamics on the parameters of fractional stability (i.e., α, β, and λ). The goodness-of-fit of exponential and fractional stability to d(t) was compared by Akaike Information Criterion where a relative likelihood (RL) below 0.05 was considered as a better fit. Results: Fractional stability resulted in a better fit compared to exponential stability for d(t) of all 42431 epochs ($p < 0.00001$) and allowed modeling of the characteristically nonlinearities in d(t) found in previous studies (Figure 1A). None of the epochs had $\alpha = 1$ and $\beta = 1$, which would have indicated the presence of exponential stability. There was also no significant correlation between the parameters of exponential and fractional stability ($R < 0.17$, $p >0.05$). The surrogate tests indicated that the nonlinearities in d(t) were created by phase transitions within the step cycle which led to a decrease in β and increase in λ. In contrast to the positive λs values of exponential stability, all λ values of fractional stability were negative, indicating that the gait dynamics were stable and not unstable as concluded by previous studies on exponential stability. Conclusion: Fractional stability seems to be an improved concept of gait stability when compared to exponential stability and allows for modeling the influence of phase transitions as occurs in each step cycle. References: [1] van Schooten, K. S., Pijnappels, et al., 2016. PLoS ONE. [2] Rosenstein, M.T., Collins, J.J., Deluca, C.J., 1993. Physica D 65, 117?134. [3] Yu, J., Hu, H., Zhou, S., Lin, X., 2013. Automatica 49, 1798-1803.

O.10.7 Validation of foot placement locations and step lengths on the Interactive Walkway

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BACKGROUND AND AIM: The Interactive Walkway was developed for an overground assessment of walking and walking adaptability. The Interactive Walkway is a 10-meter

walkway equipped with multiple integrated Kinect v2 sensors for markerless 3D motion registration, a set-up which has recently been validated for quantitative gait assessments against a gold standard [1]. In order to assess walking adaptability, the Interactive Walkway uses a projector to present gait-dependent visual context on the walkway, such as obstacles and stepping targets, based on real-time processed Kinect data. Estimates of foot placement locations are then used to calculate outcome measures of walking (e.g., step length) and walking adaptability (e.g., margins to an obstacle or stepping accuracy). Foot placements are estimated based on the median ankle position during the single-support phase [1]. However, the ankle position seems to change gradually during the single-support phase compared to a gold-standard (Fig 1). The aim of this study is to validate estimates of foot placement locations on the Interactive Walkway against a gold-standard motion-registration system. METHODS: In total, 12 healthy subjects performed multiple stepping trials, in which they were asked to repeatedly step at several fixed positions on the walkway with either the left or right foot using various step lengths. The required foot placement locations and step lengths were imposed by projected stepping stones. Body points' time series of the lower extremities were recorded with the Interactive Walkway and the gold-standard Optotrak system. Foot placement locations were estimated using the median anterior-posterior ankle position during the single-support phase (i.e., between foot off and foot contact of the contralateral foot). Performed step lengths were determined on the basis of estimated foot placement locations. A repeated measures ANOVA was conducted to determine the effect of system, left or right step, imposed step length and repetitions on foot placement locations and step lengths. RESULTS: There was a significant main effect of system ($F(1,11)=21.27$, $p=0.001$) on foot placement locations. The Interactive Walkway estimated foot placement locations 1.4±0.3 cm posterior compared to the Optotrak system. A significant main effect was found for imposed step length ($F(3.0,32.5)=55104.17$, $p<0.001$) on performed step lengths; step lengths increased with increasing imposed step lengths. No main effect of system was found on step lengths ($p=0.712$). CONCLUSIONS: The results of this study demonstrate that there was a small but significant difference between the two systems for foot placement locations, which may be taken into account as a correction factor. No significant difference was found for step lengths, indicating that the bias between the two systems for foot placement locations only affected outcome measures based on absolute foot placement locations, such as margins to an obstacle, and not outcome measures based on relative foot placement locations, such as step length and stepping accuracy. REFERENCES: [1] Geerse DJ, Coolen BH, Roerdink M. Kinematic Validation of a Multi-Kinect v2 Instrumented 10-Meter Walkway for Quantitative Gait Assessments. PLoS One. 2015; 10(10):e0139913.

O.10.8 Estimation of gait temporal and spatial parameters in individuals post-stroke by inertial sensors: first steps of the validation process

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1) Background and aim: There is currently a trend to transfer rehabilitation research from gait lab environments to more ecological situations in the community. In healthy subjects, models

that estimate gait parameters, using shank angular velocity data as measured by inertial sensors, assumed generally symmetry between left and right sides. However, the former estimate is still difficult in pathological subjects, such as post-stroke individuals due to a large asymmetry. The aim of this study was to validate a new method to estimate spatio-temporal gait parameters in post-stroke individuals using inertial sensors. 2) Methods: Chronic hemiparetic individuals, who were independent walkers with residual lower-limb motor deficits, were included. During a walking circuit, they walked 20 times on an instrumented mat used to measure spatio-temporal parameters (GAITRite, 23 ft. long, considered as reference). Walking speed was assessed on the first 20-m of the circuit. Participants wore 6 wearable inertial sensors (OPAL, APDM inc.) fixed at the shanks, thighs, pelvis and chest levels. Data from the inertial sensors were only analyzed for the steps taken on the GAITRite. A 10-Hz Butterworth filter was applied on gyroscopic data recorded by shank sensors, and minimal angular velocity peaks (in sagittal plane) were used to define heel-strike (HS) and toe-off (TO) instants of both limbs. Cadence, and cycle, stance and swing times were estimated for paretic and non-paretic sides, based on HS and TO instants. Stride and step lengths were estimated based on thighs and shanks orientation as determined from accelerometric data. Mean parameters for each trial with more than 3 steps were calculated. Correlations (Pearson's test) and difference (paired t-test) were assessed between mean parameters estimated from inertial data and measured by the instrumented mat. 3) Results: Eight hemiparetic individuals were included, with walking speed ranging from 0.47 to 1.12 m/s; all but one walking with a stick. All temporal and spatial parameters (calculated from 131 trials analyzed) were highly correlated between inertial data and the instrumented mat ($r > 0.8$, $p < 0.05$), except for paretic swing and paretic stride length which showed moderate correlations ($0.6 < r < 0.8$). Paretic step length was poorly correlated ($r < 0.5$). The paired t-tests revealed that cadence and cycle times were similar between inertial data and the instrumented mat ($p > 0.1$) while all other parameters were different ($p < 0.05$). Stance time and swing time were respectively underestimated (mean difference: -0.13 (0.07) sec) and overestimated (+0.14 (0.06) sec) by inertial data when compared to GAITRite system. 4) Conclusions: Work is ongoing to further develop the method, in particular to improve stance and swing time estimations, and paretic step length estimation. This method based on inertial sensors could be now used independently of GAITRite system for temporal parameters, in spite of a systematic bias.

O.11 – Coordination of posture and gait

O.11.1 When two become one: on spontaneous pattern formation in side-by-side and hand-in-hand walking

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BACKGROUND AND AIM: When two persons are walking together, their footsteps sometimes spontaneously adjust to one another. Such episodes of entrainment may enhance when holding hands; the mechanical coupling affects arm-leg coordination of each walker and hence between-walker stepping. The aim of this study was to examine the effects of detuning (couples with similar or dissimilar cadences) and coupling (hand-in-hand or side-by-side walking) on spontaneous stepping pattern formation during slow treadmill walking. Because the arm-to-leg frequency relation is typically 2:1 for slow walking, two interpersonal coordination patterns are expected to occur, namely synchronizing left and right legs (ipsilateral phase-locking) and synchronizing inner and outer legs (contralateral phase-locking). METHODS: In total, 32 young healthy adults participated in the experiment. We first determined their self-selected cadence on a multi-Kinect-v2-based 10meter overground Interactive Walkway, for a range of imposed walking speeds as set by a speed cue. This allowed us to select 8 pairs with similar self-selected cadences and 8 pairs with different self-selected cadences. Coupling was manipulated by having the pairs walk hand in hand or side by side on a huge treadmill (1.3 km/h; Figure 1a). Full-body 3D kinematics was captured with Kinect v2. Pairs walked 10 minutes alternately hand in hand (strong coupling) and side by side (weaker coupling). RESULTS: We observed a greater occurrence of phase locking for hand-in-hand walking than for side-by-side walking. Phase locking further occurred more often in the low-detuning group with similar self-selected cadences than in the high-detuning group with dissimilar cadences. The effects of coupling and detuning were additive (Figure 1b). For both groups, two phase-locking patterns prevailed: ipsilateral phase-locking and contralateral phase-locking, with a preference for the former. CONCLUSIONS: Coupling strength and detuning independently affected the occurrence of spontaneous phase locking in paired walking. Ipsilateral phase locking occurred more often than contralateral phase locking, presumably because the distance between the two walkers was then kept constant. A limitation of the study was that couples were not familiar with each other, and hence hand-in-hand walking was somewhat awkward, yielding a variety of unanticipated inter-personal coordination patterns such as a total absence of swing in the coupled hands. We conclude that coupling and detuning had strong and predictable effects on spontaneous phase locking in paired walking, but also that hand-in-hand walking is a task affording a rich repertoire of within-person and between-person arm-leg coordination patterns, which may require an 'octopodal' level of analyses.

O.11.2 Upper body motion provides additional unique information about gait in people with Parkinson's disease

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BACKGROUND AND AIM: Upper body motion during gait may be a biomarker of incipient pathology, intervention response and disease progression in Parkinson's disease (PD). Studies of upper body motion in PD have typically focussed on few variables, single sensor locations, have recruited small samples and have not compared their utility to lower body movements. Therefore, relative to traditional spatiotemporal variables, it is unclear if measuring upper body motion provides additional useful information about PD gait. The aim of this study was to determine if upper body motion during gait provides additional useful information when combined with traditional spatiotemporal gait characteristics. To achieve this aim, we investigated the univariate and multivariate discriminatory ability of upper and lower body variables. METHODS: 70 people with PD (69.2 ± 9.9 yr, Male: 47, Female: 23, UPDRS III: 38.3 ±

11.9) and 64 age-matched controls (71.6 ± 6.8 yr, Male: 35, Female: 29) walked for 2 minutes round a 25m circuit. Upper body variables proposed in the literature (Acceleration RMS, RMS Ratio, Jerk RMS, Jerk ratio, Harmonic ratio, Coefficients of attenuation and Autocorrelations) were calculated in three directions from three inertial sensors (128 Hz, APDM) located at the head, neck and pelvis, creating a total of 78 upper body variables. Sixteen spatiotemporal variables were measured using a 7m meter Gaitrite mat, and were selected a priori according a five-domain (pace, rhythm, variability, asymmetry and postural control) validated model of gait. Univariate (receiver operator characteristic (ROC) curve) analysis was used to identify characteristics which best discriminate PD and control participants. Binary logistic regression analysis was then performed to determine whether the upper body variables contribute unique and beneficial discriminative information. RESULTS: Forty-four of the 78 upper body variables discriminated PD from control participants better than chance (p<.05). Variables derived from autocorrelations of upper body acceleration discriminated best (greatest area under the curve = 0.81). When the 16 spatiotemporal characteristics were entered (forward stepwise) into a binary logistic regression, the model was able to classify group membership with 74% accuracy. Upper body variables resulted in a model with 83% accuracy. Finally, when spatiotemporal characteristics were force entered into the model first (Block 1, 74% accuracy), upper body variables significantly contributed (p<.001) an additional 16% accuracy when subsequently entered into the model (Block 2, 90% accuracy). CONCLUSIONS: Upper body variables are able to distinguish people with PD from age-matched controls more accurately than traditional spatiotemporal characteristics. They provide additional information about gait in PD. Therefore, we recommend that upper body motion is assessed in conjunction with traditional spatiotemporal variables for a holistic characterisation of PD gait. ACKNOWLEDGEMENTS AND FUNDING: MRC-Arthritis research UK Centre for Integrated Research into Musculoskeletal Ageing (CIMA). National Institute for Health Research (NIHR) Newcastle Biomedical Research Unit, Parkinson's UK and the NIHR. INSIGNEO - institute of in silico medicine.

O.11.3 Stepping to a target in a novel balance environment

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BACKGROUND AND AIM: High stepping reaction time is a predictor of future falling [1], possibly due to inadequate weight shifts preceding foot lift-off [2,3]. These can occur due to external balance perturbations [4] or incorrect planning [2,3]. Thus, incorrect weight shift planning might be linked to falls [5]. To investigate the effect of incorrectly scaled weight shifts on stepping, we developed a novel robotic platform able to amplify subjects' weight shifts in real-time. METHODS: Eleven young adults (23.7±4.6 years) stepped as fast and accurate as possible to a target suddenly illuminated in front of one of their legs. On 1/3 of the steps the target jumped shortly before foot liftoff, forcing quick and potentially destabilizing adjustments. This task was performed on a moveable platform in three conditions: platform still (baseline, 60 steps and post-adaptation, 30 steps) or moving (adaptation, 90 steps). When moving, the platform doubled subjects' mediolateral center of mass movement (COM) in real time. Thus, subjects had to plan a smaller COM movement to generate an appropriate weight shift. Stepping errors (distance between the target and the foot at landing), step onset (time between target onset and foot liftoff) and step execution times (time between liftoff and landing) were analyzed using rANOVA (target jump x condition). The first and last five steps of each condition were compared using paired samples t-tests. RESULTS: Target jumps increased step execution times and stepping errors (by 50 ms and 49.5 mm, both $p<0.01$). Step onsets were delayed in adaptation (by 7 ms), but faster in post-adaptation (by 24 ms). Target jumps delayed step onset by 10 ms in baseline and adaptation (condition x jump interaction, $p=0.03$). Step onsets were faster in the first steps of post-adaptation, compared to last adaptation steps (by 37 ms, $p = 0.01$, jump). Stepping errors increased at the start of adaptation (by 19.5 mm, $p = 0.02$, no jump), but decreased over time, within adaptation (by 21.8 mm, $p = 0.03$, target jump) and post- adaptation (by 7.5 mm, $p = 0.047$, no jump). CONCLUSIONS: When targets jumped, stepping errors increased, but manipulating balance by platform movements had no effect on stepping accuracy. However, manipulating balance delayed step onsets, in line with the need to adjust weight shifts in this novel environment, and was accompanied by increased stepping errors in the first five steps. Although initially significantly perturbed, subjects quickly adapted to stepping on a moving platform. Analyses of weight shifting and adaptation rates of weight shifting and stepping to clarify the underlying mechanisms are pending. ACKNOWLEDGEMENTS AND FUNDING: European Community FP7 project CoDyCo (no. 600716). REFERENCES: [1] Lord et al., J Gerontol A Biol Sci Med Sci, 2001 [2] Sparto et al., J Neurophysiol, 2013 [3] Cohen et al., J Gerontol A Biol Sci Med Sci, 2011 [4] Mille et al., J Neurophysiol, 2014 [5] Robinovitch et al., Lancet, 2013

O.11.4 Intersegmental coordination during walking on gradients

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1)BACKGROUND AND AIM: Previous studies on human locomotion have suggested that the coordination of the lower limb segments is intended to reduce the complexity of the motor control. During walking, the angles of the thigh, the shank and the foot relative to vertical (elevation angle) co-vary along a characteristic loop constrained on a plane. The change in the orientation of this plane provides information about the adaptation of the inter-segmental coordination to a particular situation. Here we investigate how this coordination is tuned to adapt to a change in the slope of the terrain at different speeds of progression. 2)METHODS: Ten subjects walked on an inclined treadmill at different slopes (0, ±3, ±6 and ±9°) and seven speeds (from 2 to 8 km/h). Thigh, shank and foot elevation angles were recorded at 100 frame/s, by means of reflective markers glued on anatomic landmarks. A principal component analysis was performed using the eigenvectors of the covariance matrix of these angles. The orientation of the principal plane (u3t) was quantified by the direction cosine between the third eigenvector and the positive axis of the thigh segment. 3)RESULTS: At each slope and speed, planar co-variation is maintained as the variance accounted for by the two first eigenvectors equals 99.45± 0.24%. Fig. 1 presents u3t as a function of slope at low, intermediate and high walking speeds: u3t is affected by both slope and speed (ANOVA, $p<0.001$). At low speeds, u3t decreases with slope from ?9° to +9°. As speed increases, the effect of slope is reduced and almost disappears at the highest speed. The change in orientation of the plane is thought to be related to the ability of the subject to adapt to the different walking conditions [1]. Among others, this adaptation is necessary to maintain stability [2]. Furthermore, a reduction of u3t has been associated with a decrease of mechanical power output [3]. At low speeds, on a steep descent, u3t is high, most likely to ensure stability rather than to reduce the muscular power. Indeed, Hunter et al. [4] has shown that when walking downhill, the energy expenditure can be reduced using a more relaxed gait, compromising stability. When slope changes from ?9° to +9°, u3t is progressively reduced, which suggests that the inter-segmental coordination is more and more tuned to reduce muscular power. At all slopes, the muscular power becomes more and more important as speed increases. Our results show that at high speeds the inter-segmental coordination is almost independent of slope. In this case, u3t is maintained low, most likely to contain the power increase due to speed. 4)CONCLUSION: Our results suggest that at low speeds the inter-segmental coordination is tuned to increase stability, especially on steep descent. When speed increases, the inter-segmental coordination is adapted to reduce the mechanical power output at all slopes. 5) REFERENCES: [1] Noble, J.W. & Prentice, S.D. (2008). Exp Brain Res 189:249-255. [2] Cheron, G., Bouillot, E. Dan, B., Bengoetxea, A., Draye, J.P. & Lacquaniti, F. (2001). Exp Brain Res 137:455-466 [3] Bianchi, L., Angelini, D. & Lacquaniti, F. (1998). Eur J Physio 436:343-356 [4] Hunter, L.C., Hendrix, E.C. & Dean, J.C. (2010). J Biomech 43:1910-1915

O.11.5 Shoulder muscle activity acts to dampen, not drive arm swing motion when altering upper limb mass characteristics

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BACKGROUND AND AIM: There is currently no consensus on whether arm swing during locomotion arises from active neural control or passive mechanical mechanisms. Past work has shown that walking with weights added to the arms leads to an increase in shoulder muscle activity. However, it is unknown if this increased muscle activity is used to drive arm swing or if it assists in the damping of arm movements when the sensory and mechanical characteristics of the arm are altered. METHODS: Eight healthy young adults walked on a treadmill at speeds of 2, 3, and 4 mph with arm mass being manipulated using Velcro ankle weights attached around the forearm. The masses added to the forearm were normalized for each individual participant (as a percent of total body mass) and included the following conditions: 1) 2.5% on both arms; 2) 2.5% on the right arm; 3) 5% on both arms; 4) 5% on the right arm; and 5) unloaded. Full body 3-dimensional kinematics and electromyography from 15 muscles (bilaterally) were recorded for a minimum of 10 strides in each condition. RESULTS: Anterior-posterior arm swing excursion increased with treadmill speed on the right ($p < 0.002$) and left ($p < 0.001$) sides during all arm weight conditions. On the right side, arm swing excursion was decreased when the 5% mass was added to the arm unilaterally and bilaterally ($p < 0.001$). Arm swing excursion only decreased on the left side when the 5% weight was added bilaterally ($p < 0.001$). Right anterior ($p < 0.001$) and posterior ($p < 0.001$) deltoid mean muscle activity increased when the right arm was loaded. The left anterior deltoid mean muscle activity was greater when the arms were loaded bilaterally ($p < 0.001$) and the left posterior deltoid presented higher mean activity when the 5% mass was added bilaterally ($p < 0.001$). Determination of mean anterior and posterior deltoid activity at selected phases of the gait cycle suggested these muscles primarily acted eccentrically, with the anterior deltoid being most active during the deceleration phase of posterior arm movement ($p < 0.001$) and the posterior deltoid being most active during the deceleration phase of anterior arm movement ($p < 0.001$). CONCLUSIONS: As shown previously, the addition of mass to the arms leads to a decrease of sagittal arm swing motion and an increase in shoulder muscle activity. The results showing the anterior and posterior deltoids primarily acting eccentrically suggests the function of these muscles is to dampen arm swing movement as opposed to accelerating the arm into swing. These results correspond to the argument that upper limb swing during human locomotion arises largely from passive mechanical mechanisms.

O.11.6 Rhythmic wrist movements facilitate lower limb rhythmogenesis and the soleus H-reflex

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BACKGROUND AND AIM: Neural coupling between the upper and lower limbs during human walking is supported by modulation of cross-limb reflexes, the facilitatory effect of arm movements on rhythmic leg movements and the presence of rhythmic activity in the proximal arm muscles. Nevertheless, the involvement of distal arm muscles in cyclic movements is also suggested given their step-synchronized activation in many locomotor-related tasks (e.g., swimming, skiing, climbing, cycling, crawling, etc.). Here we tested the hypothesis that rhythmic movements of the distal parts of the upper limbs (hands) may potentiate rhythmogenesis of the lower limbs and reflex excitability. METHODS: Participants were 22 healthy volunteers (17 men, 5 women). We investigated the effect of rhythmic wrist movements, separately and in conjunction with arm swinging, on the characteristics of non-voluntary cyclic leg movements evoked by muscle vibration in a gravity neutral position and on the soleus H-reflex of the stationary legs. For the H-reflex modulation, five conditions were compared: stationary arms, voluntary alternating upper limb swinging, combined upper limb and wrist motion, wrist movements only and motion of the upper limbs with addition of load. RESULTS: The results showed that both lower limb rhythmic movement generation and the soleus H-reflex were potentiated by rhythmic wrist movements. Interestingly, flexion-extension wrist motion facilitated movement of the legs and also involved the foot, suggesting neural interaction between the distal segments of the upper and lower limbs. The H-reflex potentiation was related to rhythmicity of wrist motion rather than to a simple extra tension in the upper limb muscles (a kind of the Jendrassik manoeuvre) since adding resistance to arm oscillations (without flexion-extension in the wrist joint) had an opposite inhibitory effect on the H-reflex. CONCLUSIONS: The current findings extend the existing findings demonstrating the conditioning effects of upper limb movements on the lumbosacral motor pool's excitation. Yet, the extent to which rhythmic hand movements per se can influence spinal excitability has not previously been reported. Our results further support the existence of connections between the distal parts of the upper and lower extremities at the neural level, suggesting that wrist joint movements can be an important component of motor neurorehabilitation.

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O.11.7 Head orientation and stabilisation strategies across age, tasks and optic flow conditions: dynamic stimuli improve head stabilisation even in old age

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BACKGROUND & AIM: Visual dependence for spatial orientation increases with age (Agathos et al., 2015). A more rigid, en bloc, head stabilisation strategy has been observed in more visually dependent populations (Assaiante & Amblard, 1993; Isableu et al., 2010; Mesure et al., 1999) in order to limit the relative degrees of freedom between the head and the trunk. However, the head stabilisation in space (HSS) strategy is the most appropriate for dynamic equilibrium control (Berthoz & Pozzo, 1988). We examined whether old adults' greater visual dependence would also translate to a more rigid head stabilisation strategy across different postural and locomotor tasks and visual conditions, whereby sensory incongruence is introduced. The inclusion of middle-aged adults in our study allows the investigation of the evolution in head stabilisation strategies with age as well. In addition, we considered whether optic flow would lead to differential head reorientations, given the established effects on posture (Flückiger & Baumberger, 1988) and locomotion (Pailhous et al., 1990). METHODS: 19 young (31.2 ± 6.3 y.o.), 17 middle-aged (51.7 ± 5.8 y.o.) and 20 old adults (74.1 ± 3.7 y.o.) stood quietly (QS) or stepped in place (SIP) during 30 s and proceeded to walk along a 5 m walkway onto which a cobblestone pattern was projected. They were instructed to look straight ahead for every task. The initial gait cycle (IGC) and steady state gait (SSG) where examined separately. Head and trunk orientation in pitch were measured under 4 visual stimulation conditions: a control condition (no artificial stimulus), static stimulation (no pattern motion), optic flow (moving pattern). Five trials were recorded per visual condition. Head stabilisation strategy was determined according to the anchoring index (AI) between the head and trunk segments (Amblard et al., 1997). RESULTS: During the walking tasks, under the control condition, old adults had a lower mean head pitch orientation compared to the younger participants, especially during the IGC ($p<0.05$). An optic flow effect, common to all age groups and tasks, was observed for head pitch orientation. A backward head tilt was observed under approaching and receding flow, compared to the other conditions ($p<0.05$). During QS, all participants mainly used the en bloc strategy. The HSS or no specific strategy were found as the body moved during SIP, the IGC and SSG. Old adults rarely adopted the optimal HSS strategy, most frequently showing no specific strategy. Young and middle-aged adults were more influenced by optic flow, adopting the HSS strategy more often. This optic flow effect was less pronounced in old adults, only appearing during the walking tasks. CONCLUSION: Optic flow influenced head orientation and stabilisation strategy in pitch. Dynamic stimuli, i.e. artificial optic flow and/or stimuli generated by body motion, improved head stabilisation. Old adults seem to lose the ability to consistently adopt the HSS strategy and show a cautious negotiation of gait initiation. The improvement in head stabilisation while walking and the backward head tilt (a strategy to

diminish sensory incongruence) observed under optic flow are, however, indicators of adaptability maintenance in old age.

O.11.8 Dynamic multisegmental postural control in patients with chronic non-specific low back pain: A cross-sectional study

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Background and Aim: To quantify functional instability in patients with chronic non-specific low back pain (CNLBP), summary scores, e.g. centre of pressure (CP), are frequently reported. However, such scores may not reflect the true postural status. Methods: In this cross-sectional study, summary scores and multi-segmental postural outcomes were compared during a dynamic postural control task in patients with CNLBP (n=24, 24-75 years, 9 females) and symptom-free controls (n=34, 22-67 years, 11 females). Anticipatory postural adjustment was analysed 1 second prior to perturbation. Compensatory postural adjustment was analysed during the first second and from 1 to 3 seconds after perturbation. Primary outcomes were variance of multi-segmental joint configuration (uncontrolled manifold index, UI) and centre of mass (CM) excursion. In a sub-analysis, 95% confidence- and standard-ellipse surface areas and approximate entropy of CP dispersion, as well as individual joint excursions (ankle, knee, hip, lumbar, and neck) were compared between the groups. Postural scores were correlated with health related outcome measures (pain and function). Non-parametric tests for group comparison followed up with P-adjustment for multiple comparisons were conducted. Principal component analysis was applied to reduce dimensionality for kinematic analysis of multiple joints. Results: Both groups, on average, performed similarly with respect to the summary outcomes (UI, CM, and CP). Comparison of multi-segmental joint kinematics demonstrated significant differences of hip angle excursion ($P<0.001$) during the response phases, representing medium-sized group effects (r's=0.3-0.4). Significant (P's<0.05), but moderate correlation of CP ($r=0.41$) and centre of mass trajectory ($r=0.42$) with the health related outcomes were observed during the anticipatory phase. Conclusions: These findings lend further support to the notion that summary outcomes do not suffice to describe subtle postural differences in CNLBP patients with low to moderate pain status. During kinematic postural assessments, excessive motion of hip and neck segments should be monitored.

O.12 – Cognitive Impairment

O.12.1 Discriminating geriatric patients with and without cognitive impairment: What's in someone's gait?

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BACKGROUND AND AIMS: There is a parallel increase in life expectancy and the number of old adults with cognitive impairment. Evidence suggests that changes in gait speed and stride-

related measures can predict future cognitive impairment. However, cognitive impairment is often accompanied by other geriatric syndromes that also affect gait speed and stride-related outcomes. Therefore, it is conceivable that a more detailed gait analysis could increase the accuracy of the relationship between gait and cognition in the prediction of cognitive impairment. Against this background, gait can be evaluated in terms of its dynamic properties, reflecting for example gait stability, smoothness, and regularity. Gait dynamics quantify temporal variations in the gait pattern derived from trunk or limb accelerations that may be masked when the data is averaged over strides. Although dynamic outcomes are interdependent, they are also complementary to each other and reflect unique gait properties. We studied what characterized the gait pattern of geriatric patients with and without cognitive impairment compared to healthy old controls, and determined if these measures in turn could discriminate patient groups. METHODS: 95 old adults were included: 25 healthy old adults (age 65±5.5), 31 cognitive intact (age 79±5.3; MMSE 27.4±2.3) and 39 cognitive impaired (age 82±7.2; MMSE 23.5±6.2) geriatric patients. Accelerations of the lower back were registered in anterior-posterior (AP), medio-lateral (ML) and vertical (V) direction, from which 23 gait measures were computed. We used a multivariate Partial-Least-Square Discriminant Analysis (PLS-DA) to reduce dimensionality and build a classification model. VIP-values indicated the importance of each gait outcome. RESULTS: The PLS-DA model with 3 latent variables explained 59% and 50% of the variance in respectively gait and patient group. Higher V step and stride regularity (VIP=1.3; VIP=1.3), and AP stride regularity (VIP=1.3) particularly characterized healthy old adults, while higher AP, ML, and V Root Mean Square (VIP=2.8; VIP=3.4; VIP=3.2) and lower V and ML Multiscale Entropy (VIP=1.2; VIP=1.1) were related to geriatric patients, and lower V Lyapunov Exponent (VIP=1.3), and less V symmetry (VIP=1.7) to cognitive impaired geriatric patients. 100% of the healthy old adults were correctly classified. Geriatric patients with and without cognitive impairment were correctly classified for 48% and 51%, respectively. CONCLUSIONS: The patient groups revealed unique gait characteristics. Therefore, gait analysis that examines the dynamics of gait could aid motor and cognitive diagnoses and help develop intervention strategies that target specific gait functions. However, discrimination between geriatric patients with and without cognitive impairment was poor. Clinicians and researchers should be aware that gait impairments may not only be predictive of cognitive impairment, but may reflect other geriatric syndromes as well.

O.12.2 Gait disorders in the elderly and du task gait analysis: a new approach for identifying motor phenotypes

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Background: Gait disorders and gait analysis under single and dual-task conditions are topics of great interest, but very few studies have looked for the relevance of gait analysis under dual-task conditions in elderly people on the basis of a clinical approach. Methods: An observational study including 103 patients (mean age 76.3 ±7.2, women 56%) suffering from gait disorders or memory impairment was conducted. Gait analysis under dual-task conditions was carried out for all patients. Brain MRI was performed in the absence of contra-indications. Three main gait variables were measured: walking speed, stride frequency, and stride regularity. For each gait variable, the dual task cost was computed and a quartile analysis was obtained. Nonparametric tests were used for all the comparisons (Wilcoxon, Kruskal-Wallis, Fisher or Chi² tests). Results: Four clinical subgroups were identified: gait instability (45%), recurrent falls (29%), memory impairment (18%), and cautious gait (8%). The biomechanical severity of these subgroups was ordered according to walking speed and stride regularity under both conditions, from least to most serious as follows: memory impairment, gait instability, recurrent falls, cautious gait ($p<0.01$ for walking speed, $p=0.05$ for stride regularity). According to the established diagnoses of gait disorders, 5 main pathological subgroups were identified (musculoskeletal diseases (n=11), vestibular diseases (n=6), Mild Cognitive Impairment (n=24), central nervous system pathologies, (n=51), and without diagnosis (n=8)). The dual task cost for walking speed, stride frequency and stride regularity were different among these subgroups ($p<0.01$). The subgroups Mild Cognitive Impairment and Central Nervous System pathologies both showed together a higher dual task cost for each variable compared to the other subgroups combined ($p=0.01$). The quartile analysis of dual task cost for stride frequency and stride regularity allowed the identification of 3 motor phenotypes ($p<0.01$), without any difference for white matter hyperintensities, but with an increased Scheltens score from the first to the third motor phenotype ($p=0.05$). Conclusions: Gait analysis under dual-task conditions in elderly people suffering from gait disorders or memory impairment is of great value in assessing the severity of gait disorders, differentiating between peripheral pathologies and central nervous system pathologies, and identifying motor phenotypes. Correlations between motor phenotypes and brain imaging require furthers studies. Keywords: Gait disorders, Elderly, Gait analysis, Dual task paradigm, Motor phenotypes

O.12.3 Depression Increases The Risk Of Injurious Falls In Older Individuals With Mild Cognitive Impairment. Results From The Gait & Brain Study

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Background - Falls are highly prevalent in older individuals with Mild Cognitive Impairment (MCI) and also in older individuals with depression. However, it is currently unknown whether the risk of falls in individuals with MCI would increase in the presence of depression. Aim: The aim of this study was to evaluate the impact of depression on risk of falls and their outcomes in individuals with MCI. Methods - Ninety seven participants (74 ±8 years of age) from the Gait & Brain Study were (from 2007 to 2016). Participants were asked to report fall occurrence every 6 months during their visits to our lab, within 36 months (mean 30 months; range 24-36). A standardized falls questionnaire was used to record the number of falls and their outcomes. Time to an event (fall) was characterized according with three outcomes: fall, multiple falls (≥2) and injurious fall. Cox-Regression analysis was used to estimate the Hazard Ratios (HR) for each fall outcome. Regression models were adjusted for age, general cognitive status, executive functions, sex, anti-depressant medication, total number of medications, physical activity levels and number of falls within the last 12 months at baseline visit. Cognitively preserved individuals without depression (Controls; n=25) were set as reference for the MCI with depression group (MCI_D; n=22) and for the MCI without depression group (MCI; n=50). Participants were included in the MCI_D group if receiving treatment for depression or if having a score ≥ 5 in the

Geriatric Depression Scale (GDS-15; 5 points cutoff for significant depressive symptoms). Results - Cox-Regression analysis revealed that individuals with MCI with depression are at increased risk to suffer an injurious fall (HR: 4.3; 95%-CI 1.306 - 15.113, p=0.017) compared to individuals with MCI without depression (HR: 1.7; 95%-CI 0.565-5.143, p=0.344); however individuals in both MCI groups had similar risk to become faller or multiple faller. Conclusions - Depression may undermine the precarious cognitive resources of individuals with MCI which can affect an individual's ability to negotiate challenging balance situations. Finally, the presence of depression in older adults with MCI can be a risk factor for injurious falls.
ACKNOWLEDGEMENTS: Lawson Research Foundation; Our gratitude to Korbin Blue and Alanna Black.

O.12.4 The impact of the Ronnie Gardner Method on physical performance in people with mild cognitive impairment: A pilot randomized controlled trial

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Authors: Kristina Zawaly, Ngaire Kerse, Lynette Tippett, Suzanne Purdy Abstract BACKGROUND AND AIM: People with Mild Cognitive Impairment (MCI) have an increased fall risk due to the interaction of risk factors related to balance, gait and cognitive deficits. The aim of this programme of research is to improve gait and reduce falls in people with MCI. Novel interventions that stimulate cognition and deliver upright exercise may improve balance and gait. Ronnie Gardner Method (RGM) provides both cognitive stimulation and upright cross brain coordinated activity set to music. The aim of this investigation was to study the feasibility of a pilot randomized controlled trial to inform a definitive randomized controlled trial. METHODS: Participants were 30 people with MCI based on a cognitive assessment (neuropsychological and functional) living independently. Participants were randomized to one of three groups: RGM; free movement dance sessions; seated dance? /music appreciation classes (control). Each group met for one hour weekly for 12 weeks. Measures included the Short Physical Performance Battery (SPPB), measuring sit to stand time, gait speed and balance. The data was not distributed normally and as a result, non-parametric analysis was used for interpreting the data. RESULTS: The mean age was 80.5 (SD=6.12) years and 83% were female. 30 people began the trial (Intention to treat, last observation carried forward group), 26 completed baseline and follow up assessments (Complete case group); six people in each group (n=18) completed 6 or more sessions [Pre-protocol (PP) group]. The results for gait speed [SPPB score (0-12)] change over time for the PP group was statistically significant (p=0.02). The difference of each groups performance between pre-and post-assessment was assessed using the Mann-Whitney U test, which revealed that there was a statistically significant difference between RGM and seated music appreciation class (control) (p=0.02), however there was no statistically significant difference between RGM and free movement dance (p=0.50) and free movement dance and the seated music appreciation class (control) (p=0.12). The interventions were enjoyed by the participants and the study measures were acceptable and useable. There were no adverse events during the activities. CONCLUSION: This is to our knowledge, the first report demonstrating that RGM participation for people with MCI is a safe, acceptable and feasible programme and is associated with improvements in mobility. Our data suggests that RGM may

be beneficial in improving mobility which warrants additional research. ACKNOWLEDGEMENTS AND FUNDING: Brain Research New Zealand

O.13 – Developmental disorders

O.12.5 Spinal locomotor output in children with cerebral palsy

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BACKGROUND AND AIM: Normal development of human locomotion from the neonate to the adult involves a gradual functional reorganization of the spinal locomotor output (Dominici et al 2011; Ivanenko et al 2013). The first years of life represent an extremely important phase of maturation. Detailed descriptions of gait impairments have been reported in children with cerebral palsy (CP), but it is still unclear how maturation of the spinal pattern generation circuitry is affected. While the general hypothesis of delayed maturation in CP has been previously put forward (Forssberg 1999), our study is the first demonstration of the spinal segmental output, characteristics of these patterns and their progression with age. METHODS: We analyzed gait kinematics and EMG activity of 11 pairs of bilateral muscles with lumbosacral innervation in 35 children with CP (19 diplegic, 16 hemiplegic, 2-12 yrs) and 33 typically developing (TD) children (1-12 yrs). Spatiotemporal alpha-motoneuron (MN) activation was assessed by mapping the EMG activity profiles from several, simultaneously recorded muscles onto the anatomical rostrocaudal location of the MN pools in the spinal cord, and by means of factor analysis of the muscle activity profiles. RESULTS: TD children showed a progressive reduction of EMG burst durations and a gradual reorganization of the spatiotemporal MN output with increasing age. By contrast, children with CP showed very limited age-related changes of EMG durations and MN output, as well as of limb intersegmental coordination and foot trajectory control. Factorization of the EMG signals revealed a comparable structure of the motor output in children with CP and TD children, but significantly wider temporal activation patterns in children with CP, resembling the patterns of much younger TD infants. A similar picture emerged when considering the spatiotemporal maps of MN activation. Children with hemiplegic CP showed differential maturation of these features on the affected and less affected lower limbs. CONCLUSIONS: Early injuries to developing motor regions of the brain substantially affect the maturation of the spinal locomotor output and consequently the future locomotor behavior. The lack of maturation of the spatiotemporal spinal locomotor output between 2 and 12 yrs in children with CP may be consistent with the idea of critical developmental windows (Hadders-Algra 2004; Yang et al 2013; Friel et al 2014).
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O.12.6 Dynamic postural control in typical development, Autism Spectrum Disorder and Developmental Coordination Disorder

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BACKGROUND AND AIM: Few studies directly compare postural control in Developmental Coordination Disorder (DCD) and Autism Spectrum Disorder (ASD), despite documented overlap in motor symptoms. Visuomotor integration-the use of visual information to guide motor behavior-may have a different impact on postural stability in ASD vs. DCD. Monitoring eye movements during motor tasks may aid in identifying key differences in visuomotor integration between these two clinical populations. This potential difference between ASD and DCD, and even perhaps within subgroups of these two disorders, has important implications for intervention. This study aimed to examine the accuracy and speed profile of postural control in individuals with ASD, DCD, and typical development during a dynamic task. METHODS: We administered a dynamic postural control task to 9 children with DCD (M.Age = 8.40, SD = 1.14), 7 children with ASD (M.Age = 12.54, SD = 2.90), and 4 typically-developing children (M.Age = 9.75, SD = 0.96). Participants stood on an instrumented treadmill with embedded force plates (V-Gait CAREN; MotekorceLink) and wore mobile binocular eye-tracking glasses (ETG 2.0; SMI) while performing a dynamic postural control task in a virtual environment. Children displaced their center of pressure (CoP) medial-laterally to match a user-controlled object to a virtual target oscillating horizontally at 8 frequencies (0.1-0.8 Hz). RESULTS: Group differences were evident in accuracy, calculated as CoP deviation from target (Figure 1). DCD group accuracy was lower overall than the ASD or TD groups; notable separation between all groups occurred at 0.4, 0.5, and 0.7 Hz. The DCD group also had faster, more jerky movements (M.Velocity = 0.37; M.Accel = 70.14) than the ASD (M.Velocity = 0.26; M.Accel = 47.50) or TD (M.Velocity = 0.26; M.Accel = 46.79) groups. CONCLUSIONS: Key differences are evident between ASD, DCD, and typical development in the postural control accuracy during a task requiring integration of visual and motor information to support online adjustments to CoP. Postural control variables (e.g., CoP deviation from target, CoP velocity and acceleration) may serve to differentiate between those with fundamental motor impairments (e.g., DCD) versus those who may have motor symptoms driven by atypical visuomotor integration (e.g., ASD) in a way that would inform diagnosis and development of new interventions. Preliminary eye-movement data also suggests that the ASD group had less efficient eye movements than TD or DCD groups when tracking the dynamic target, using large over- and under-shooting saccades more than smooth pursuit. This likely led to impoverished or inaccurate visuospatial information, and complicated attempts to use visual feedback to guide planning and execution of CoP adjustments. FUNDING: National Science Foundation (NRI-1208623, SMA-1514495); National Institutes of Health (NCATS, KL2-TR001103); UNTHSC Seed Grant (RI-6095).

O.12.7 The effect of ankle foot orthosis stiffness on the Margins of Stability during gait in Cerebral Palsy

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BACKGROUND AND AIM: Ankle-foot orthoses (AFOs) are prescribed to normalise lower limb kinematics during walking in children with cerebral palsy (CP). Tuning the stiffness of the AFO can lead to changes in lower limb kinematics in children with Cerebral Palsy (CP)[1]. However, varying AFO stiffness can also change trunk movements[2]. The cause of altered trunk movements when wearing AFO's is unclear. As increased trunk movements were related to decreased gait stability[3,4], we examined the effect of varying AFO stiffness on gait stability in CP. METHODS: 15 children with spastic CP (11 boys / 4 girls, 10±2 years, GMFCS level I-III), all walking with excessive knee flexion, were prescribed with a spring-hinged AFO (Neuro Swing®, Fior & Gentz). Stiffness was varied into a rigid (3.8 Nm·deg-1), stiff (1.6 Nm·deg-1) and flexible (0.7 Nm·deg-1) configuration. At baseline (shoes-only) and for each AFO stiffness a 3D-gait analysis was performed. Margins of Stability (MoS) in the mediolateral and anteroposterior directions were calculated as measures of gait stability. Center of mass (CoM) was estimated from the center of the pelvis and trunk based on the weight ratio of the lower body and upper body[5]. The extrapolated centre of mass (XCoM), was defined as the CoM plus its velocity times a factor √('maximal height of CoM'/ 'acceleration of gravity')[6]. MoS were calculated as the position of the XCoM relative to the lateral malleolus of the ankle of the leading foot for the sideward MoS and relative to the heel marker of the leading foot for the backward MoS[7]. For each step sideward and backward MoS were calculated for the moment at which the MoS reached its minimum value within each step. Generalized Estimation Equation analyses were used to analyze the effects of different AFO stiffness conditions ($\alpha = 0.05$). RESULTS: Mediolateral MoS leg differed depending on AFO stiffness condition (Table 1). Mediolateral MoS decreased gradually with increasing AFO stiffness, but only reached significance on the most affected side. Varying AFO stiffness did not significantly affect anteroposterior MoS of the least or most affected leg. CONCLUSIONS: AFO stiffness had a significant impact on gait stability in children with CP. Increasing the AFO stiffness resulted in gradually decreasing mediolateral MoS (i.e. decreasing gait stability). It appears that increasing AFO stiffness might impede the control over the degrees of freedom around the ankle joint, coinciding with increases of the translation of the CoM, at the cost of a lower MoS. When tuning a patient's AFO stiffness one should consider the patient's gait stability in addition to the lower limb and trunk kinematics. REFERENCES: [1] Kerkum et al. PLoS One 2015;10(11):e0142878. [2] Meyns et al. Gait Posture 2016;49S:2. [3] Romkes et al. J Pediatr Orthop B 2007;16(3):175-80. [4] Delabastita et al. Front Hum Neurosci 2016;10:354. [5] Zatsiorsky, Human Kinetics, 672 p. [6] Hof et al. J Biomech. 2005;38(1):1-8. [7] Hak et al. PLoS One. 2013; 8(12): e82842. ACKNOWLEDGEMENTS AND FUNDING: PM is supported by the EC as a Marie Skłodowska-Curie fellow (proposal 660458). This project was supported by Phelps stichting, Kinderrevalidatie Fonds Adriaanstichting & Johanna Kinderfonds.

O.12.8 Postural Control Deficits in Autism Spectrum Disorder: dissociating sensory acuity and sensory integration

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Background and aim: Autism Spectrum Disorder is a developmental disorder affecting social interaction, communication but also sensory and motor behavior. One of the key aspects of sensory and motor behavior that is impaired in individuals with ASD is postural control, however the nature and mechanisms of this impairment are not well understood. Recent studies suggest that these deficits are most evident when one or more of the sensory channels (visual, vestibular and proprioceptive) involved in this task is compromised. Thus, this impairment is likely to be either due to impaired sensory acuity, due to impaired sensory integration or both. The main aim of this study was to assess the contribution of sensory acuity and sensory integration deficits to the postural control deficits observed in individuals with ASD. Based on previous findings in the literature we hypothesized that these deficits will be due to sensory integration rather than sensory acuity. 2. Methods: Fifteen high functioning (IQ>80) young adults with ASD (2 female, age range 18-35 years) and 15 age- and gender-matched controls first performed an ankle joint-position matching task measuring proprioceptive acuity. Then, they performed a postural control task, without vision, thus involving only proprioceptive and vestibular information. Participants were asked to stand on a fixed surface (baseline, 2 minutes), immediately followed by standing on a sway referenced surface (adaptation, 3 minutes) which induced inaccurate proprioceptive information about body sway, and then again on a fixed surface (reintegration, 3 minutes). Results: ASD participants and controls were not different in absolute and variable error in the joint position-matching task, and in the balance task no group differences in AP (Anterior-Posterior) and ML (Medio-Lateral) path length were shown during baseline. However, when sway referencing was introduced AP and ML path length increased in both groups as expected, but over the course of the 3 minutes of adaptation to this environment, control participants were able to adapt to the sway referenced environment as shown by a gradual reduction in AP sway. In contrast, ASD participants did not exhibit an ability to adapt to this environment as shown by their large levels of sway throughout the adaptation phase. This result reflects an inability to reweight proprioceptive and vestibular information during postural control. Finally, when the fixed surface was restored both groups were able to return to their baseline levels of sway at the same rate. Conclusions: These results confirm the hypothesis that the postural control deficit observed in individuals with ASD is primarily due to central, sensory integration deficits rather than peripheral, sensory noise. Future research is needed to identify ways to moderate this deficit in order to improve motor skill performance and quality of life in children and adults with ASD.

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