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ABSTRACT BOOK

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Keynote Abstracts

K.1: Unravelling the relationship between pain and the control of posture and movement

Paul Hodges, University of Queensland

One thing is clear – there is inherent variation in how individuals with pain control posture and movement – variation in how this differs from those without pain, variation between individuals, variation within individuals, and variation within individuals over time. Pain might cause changes in posture and movement, be the consequence of such changes, or be unrelated. Although many treatments for musculoskeletal pain that address control of posture and movement have been shown to be effective, effect sizes are generally more modest than were predicted. Early research generally compared participant groups with and without pain. Some showed changes that were somewhat systematic, perhaps by luck, perhaps because the inclusion criteria narrowed the variation of the presentation of the group. To make progress in this field it is critical to unravel the mechanisms and explanation for the variation, so that we can begin to understand their relevance for progression or recovery of the condition, and if and how interventions should proceed. This knowledge is fundamental to address the hypothesis that effectiveness of any treatment for pain (including interventions that target motor control of posture and movement) is likely to be more effective if it targeted to the right patients at the right time. To begin to unravel the variation in posture and movement in pain it is necessary to understand what pain is; to acknowledge that not all pain is the same; to interrogate mechanisms using a whole system view; and to accept that posture and movement will not change uniformly across all presentations. Recognition that pain is not in the tissues, but an output of the nervous system in response to multiple inputs (that can include nociceptive input) and processes is a valuable starting point. Three key clinical descriptors of pain suggest maintenance of pain by different mechanisms. Nociceptive pain is caused by actual or threatened damage to non-neural tissue and is due to the activation of nociceptors, including sub-optimal tissue loading from biomechanical features; neuropathic pain is caused by a lesion or disease of the somatosensory nervous system; and nociplastic pain arises from altered processing of nociceptive information and can include involvement of diverse mechanisms related to central sensitisation as well as psychological factors including cognitions about pain. Features of these mechanisms can co-exist and change over time. Posture and movement have different relevance and relationships to these mechanisms. Recent work investigating aspects of motor control from the function of sensory and motor cortices (including function of glial cells), to motor strategies and sensory function has begun to reconcile how pain mechanisms and motor changes interact. Other work has unravelled novel mechanisms that involve interaction between immune and neuromuscular symptoms that that are beginning to explain some of the link between body and mind and its variation across individuals. Ultimately this work and new understanding could help identify the patients for whom rehabilitation of posture and movement is likely to have greatest relevance and effect.

K.2: Falls: risky business

Ngaire Kerse, University of Auckland

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This presentation will talk about falls in ARC and the community and contrast aged residential care and community setting introducing the idea of risk being dynamic. Implications for practice and research will be emphasised.

K.3: Intermittent control during human quiet stance: A greedy strategy for postural stabilization

Taishin Nomura, Osaka University

In my keynote lecture at the ISPGR 2023, we will delve into the complex phenomenon of postural sway during quiet standing. Traditionally, it has been believed that ankle joint stiffness plays a key role in stabilizing bipedal stance, but recent scientific evidence challenges this notion. Our study takes a data-driven and model-based approach, using the intermittent control model to explore the causes of postural variability and connect human postural control aspects.

The intermittent control model proposes an alternative strategy to stiffness control, suggesting that upright posture is stabilized by exploiting inertia-force-driven passive recovery dynamics when active control is switched off during micro recoveries. This model is supported by evidence indicating that the recovery movement is not actively controlled by calf muscle contraction but instead by inertia force in the absence of active control. Furthermore, we will discuss how postural instability in patients with Parkinson's disease tends to lose the intermittency of the control.

The keynote lecture aims to logically connect these findings with the intermittent control model and discuss the possibility of acquiring the intermittent control strategy through reinforcement learning. This approach resolves trade-offs between stability, flexibility, postural error, and energy consumption. Additionally, we will present recent findings on the neural correlates of intermittent postural control during quiet standing.

Overall, the keynote lecture provides a comprehensive overview of the causes of postural variability during quiet standing and offers new insights into the intermittent control model. The presentation highlights the potential for acquiring this strategy through reinforcement learning and provides valuable information on the neural correlates of intermittent postural control. Attendees will leave with a deeper understanding of the complex mechanisms underlying postural control and the potential for innovative interventions to improve postural stability in both healthy individuals and those with neurological diseases.

K.4: A tale of three studies: Exploring different approaches to enhance walking in Parkinson disease

Gammon Earhart, Washington University

Parkinson disease (PD) is associated with declines in both the quality and quantity of walking and gait dysfunction is considered a red flag for emerging disability. Moreover, people living with PD report that difficulty walking is one of the most problematic symptoms they experience, and one that they would most like to improve with treatment. This presentation will cover three ongoing studies that aim to enhance quality and/or quantity of walking in PD through different, novel approaches. The first study, being conducted with co-PI Terry Ellis, targets quality and

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quantity of real-world walking behavior. This study uses a "connected behavioral approach" linking physiotherapists to people with PD using a mobile health (mHealth) platform to deliver strategies to increase self-efficacy and provide goal-oriented, dynamic walking routines and walking enhancing exercises over one year. The second study, being conducted with co-PI Kerri Rawson, targets freezing of gait through a newly developed mindfulness-based walking program intended to reduce anxiety. The third study compares the use of music and singing to enhance walking quality, employing neuroimaging to explore the neural mechanisms underlying movement to external vs. self-generated rhythmic cues. Collectively, these studies provide new insights that may inform future delivery of individualized treatment approaches to improve walking in PD.

K.5: Biomechanical analysis of gait imbalance: A view from the center of mass

Li-Shan Chou, Iowa State University

Gait and balance impairments are common in older persons and patients with neurological or musculoskeletal disorders. These mobility impairments contribute measurably to the risk of falls and accidental injuries, and loss of ambulation often is the marker of a downward spiral in health and functional status. Therefore, accurate assessment of individual-specific mobility impairment is critical to reducing the incidence of falls and developing treatment interventions. Toward to this front, movement analysis plays a contributing role in the enhancement of our ability to achieve these goals. This presentation will discuss findings from our biomechanical studies assessing the center of mass (COM) motion during walking, utilizing COM motion makers to detect gait imbalance in different clinical populations, and discuss their potential clinical applications.

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Symposium Abstracts

Symposium 1: What's next for concerns about falling research in older people? Applying what we know to advance practice

S1.1: Applying the health literacy lens to manage concerns about falling in older people: a theoretical framework

Mei Ling (Mae) Lim[1], Kimberley S van Schooten[1], Kylie A Radford[1], Thomas Hadjistavropoulos[2], Bronwyn Everett, Rixt Zijlstra[1], Kim Delbaere[1]

[1]Neuroscience Research Australia, [2]University of Regina

BACKGROUND AND AIM: Adherence, uptake and long-term participation can be improved in health programs for older people with concerns about falling. While health literacy empowers older people to have greater control over their health, little is known about the extent to which health literacy influences health behaviours associated with concerns about falling in older people. This study aimed to synthesise current findings on health literacy, concerns about falling and falls to propose a multicomponent theoretical model on health literacy and concerns about falling. METHODS: A literature search for models and frameworks related to concerns about falling and health literacy was conducted. Using our literature review findings, we propose a health literacy and concerns about falling model, based on the theoretical framework on concerns about falling model by Hadjistavropoulos et al. (2010) and the framework of health literacy and health action by von Wagner et al. (2008). RESULTS: Existing evidence on the relationship between health literacy and concerns about falling in older people is limited. Evidence from other research areas, however, shows that health literacy is closely related to many of the determinants of concerns about falling. Our model proposes that health literacy can affect health actions in relation to concerns about falling by acting on the determinants of health behaviour during the motivational (decision-making about health action) and volitional (translating thoughts to actions) phases of health behaviour. CONCLUSION: Our model offers a novel perspective on the role of health literacy on health behaviours associated with concerns about falling; providing insights for researchers and clinicians to consider health literacy when managing older patients with concerns about falling. More research is also needed to clarify health literacy's impact on older people's adherence and decision-making processes to health programs for managing concerns about falling.

S1.2: The Perceived Control Model of Falling: Developing a unified framework to understand and assess maladaptive fear of falling

Toby Ellmers[1]

[1]Imperial College London

BACKGROUND AND AIM: Concerns about falling are common in older adults. High levels of concern increases the likelihood that an individual will experience fear of falling (an emotional and physiological response) when they perceive their balance to be threatened. Fear of falling can have a profound influence on a variety of behaviours that increase fall risk. However, fear

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of falling can also have potentially positive outcomes for certain individuals. Without progressing our understanding of mechanisms underlying these contrasting outcomes, it is difficult to clinically manage fear of falling. METHODS: This presentation first summarises recent findings on the topic of fear of falling, balance and fall risk - including work highlighting the protective effects of fear of falling. Specific focus is placed on describing how fear of falling influences sensory, perceptual, cognitive and motor process in ways that might either increase or reduce fall risk. Finally, it reports the development and validation of a new clinical tool that can be used to assess the maladaptive components of fear of falling. RESULTS: We present a new conceptual framework - the Perceived Control Model of Falling - that describes specific mechanisms through which fear of falling can influence fall risk. This model argues that we need to 'look beyond' fear of falling and consider the cognitive processes that it triggers. The model specifically identifies perceived control over situations that threaten one's balance as the crucial factor mediating the relationship between fear and increased fall risk. The new 4-item scale that we develop - the Updated Perceived Control over Falling Scale (UP-COF) - is a valid and reliable tool to clinically assess perceived control. CONCLUSIONS: This new conceptualisation and tool (UP-COF) allows clinicians to identify individuals for whom fear of falling is likely to increase fall risk, and target specific underlying maladaptive processes such as low perceived control.

S1.3: What factors influence self-reported concerns about falling?

William Young[1], Sarah Almakoshi[1]

[1]University of Exeter

Background and Aim: Concerns about falling are common in older adults. Many report disproportionately low or high concern about falling relative to their actual physical balance abilities and current evidence indicates that this error is associated with risk of future falls. The recent World Guidelines for Fall Prevention and Management in Older Adults recommends the 'Falls-Efficacy Scale - International' (FES-I) to measure concerns about falling. The current work aimed to evaluate factors that potentially influence subjective reporting of Concern about Falling. Methods: Eighty four older adults were recruited from community groups, supported living accommodation and hospital settings in the UK and Saudi Arabia (note: participant recruitment is ongoing). Participants completed the Timed Up and Go in addition to questionnaires that included evaluation of: i) Concern about Falling (FES-I), and ii) anxiety and depression (Hospital Anxiety and Depression Scale). After completing the FES-I under Baseline conditions (usual instructions), participants were asked about the level of support they typically receive to perform the tasks listed in the FES-I and to imagine how concerned they would feel in two hypothetical scenarios: that this support/care either was or was not readily available. Participants repeated the FES-I according to both of these scenarios. We determined 'perceptual extremes' by calculating the difference between FES-I scores between hypothetical conditions. We determined the 'reporting tendency' of each participant by calculating the relative position of Baseline FES-I score within the perceptual extremes. We then evaluated whether there was an association between reporting tendency and HADS. Results: Initial (ongoing) analyses indicate that the magnitude of perceptual extremes varied greatly across the pilot sample (range = 0 - 43 points). Mean reporting tendency was approximately equidistant between perceptual extremes, but this also varied greatly. Current results indicate that reporting tendency is negatively associated with HADS outcomes; a relationship likely to contribute towards observed discrepancies between Baseline FES-I and actual balance performance (TUG). Conclusions: The current results indicate that a combined


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self-reported outcome of anxiety and depression is associated with a negative bias in reporting tendency (i.e., under Baseline conditions, people with higher HADS scores are more likely to intuitively imagine performing FES-I tasks in more challenging circumstances/without support, leading to higher FES-I scores). Such tendencies are highly likely to be inherent in other self-reported measures of Concern/Fear of falling. As such, these initial findings should not be interpreted as negative criticism of the FES-I. On the contrary, we suggest that there could be additional value in measuring and utilising potential anxiety-related reporting bias both within the FES-I and across a range of patient-reported outcomes.

S1.4: Assessing and Managing Concerns about Falling: Clinical Recommendations

Kim Delbaere[1], Toby Ellmers[2], Christopher Todd[3], David Hogan[4], Mae Lim[1], Lisa McGarrigle[3], Ellen Freiberger[5], Klaus Hauer[6]

[1]Neuroscience Research Australia, University of New South Wales, [2]NeaCentre for Vestibular Neurology, Department of Brain Sciences, Imperial College London, [3]School of Health Sciences, Faculty of Biology, Medicine and Health, The University of Manchester, [4]Brenda Strafford Centre on Aging, O?Brien Institute for Public Health, Cumming School of Medicine, U, [5]FAU Erlangen-Nürnberg Germany Institute for Biomedicine of Aging, [6]Department of Geriatric Research, Geriatric Centre of the University of Heidelberg

BACKGROUND and AIM: Concerns about falling (CaF) are common, with an estimated prevalence of 21-85% reported in community-living older people. Our review of clinical guidelines showed that CaF are not consistently recognised or recommended as an essential component of a multifactorial fall risk assessment of older people. The aims were to make evidence-based recommendations on CaF assessments and interventions [1]. METHODS: We conducted a critical appraisal of existing evidence through narrative reviews, expert consensus and several systematic reviews and meta-analyses. RESULTS: There is inconsistent evidence that CaF is predictive of future falls. CaF should be part of a comprehensive fall risk assessment, combined with balance and/or gait assessment to assess older people in the community. CaF is a measure of an older person's perceptions about the falls they have experienced, the impact falls have had on their quality of life, their openness to various interventions, and as a treatment outcome in a subset of older people. The Falls Efficacy Scale International (FES-I) and Short Falls Efficacy Scale International (Short FES-I) have a strong to moderate level of evidence for their use in older people living in the community. A recent systematic review and meta-analysis of 59 studies showed that both FES-I and Short FES-I are reliable and valid tools when used with both healthy older people and those with conditions that put them at a greater risk of a fall. Both instruments demonstrate good internal consistency, test-retest reliability, inter-rater reliability and construct validity in these populations. Preliminary research from a systematic review suggest that the Short FES-I may be more suitable for use with inpatients and in residential care settings due to its brevity (7 items). CaF in older people can be managed by a variety of intervention strategies. Exercise interventions, cognitive behavioural therapy and occupational therapy can be recommended based on a series of systematic reviews and meta-analyses that looked at the effect of these individual interventions on CaF. However, these interventions only reach small to moderate effect sizes in trials. Two recent systematic reviews looked at the individual components of intervention strategies that might be more effective and highlighted that supervised holistic exercise interventions in community settings, such as Pilates or yoga, were significantly associated with a greater reduction in CaF. There is insufficient evidence to make a recommendation on the best combination of interventions to reduce CaF in older people. CONCLUSIONS: FES-I is a

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suitable test of CaF that can easily be implemented in clinical practice. Older adults with CaF should be offered an exercise program ideally as part of a multidisciplinary approach. [1] Montero-Odasso, van der Velde, Martin, et al. World guidelines for falls prevention and management for older adults: a global initiative. Age Ageing 2022; 51: 1-36.

Symposium 2: Neuroimaging investigations of reactive balance: where we are now and where we are going

S2.1: Neural correlates of reactive balance

Tanvi Bhatt[1], Lakshmi Kannan[2], Olusola Ajilore[2], Prakruti Patel[3], Rudri Purohit[2]

[1]University of Illinois at Chicago, [2]University of Illinois in Chicago, [3]Colarado State University

Dr. Bhatt will present her work from functional neuroimaging on imagined and observed slipping and how they related with reactive stability during treadmill gait-slips. She will also present data from training-induced changes in brain activations during imagined slipping. Lastly she will present data regarding the impact of cognitive impairment on structural and functional connectivity within the cortical-subcortical regions and how it relates to deficits in reactive balance using a sample of people diagnosed with mild cognitive impairment. She will present data on how these findings helped design a dual-task reactive balance training clinical trial in this population.

S2.2: Subcortical contributions to reactive postural control: Evidence from neurological populations

Daniel Peterson[1]

[1]Arizona State University

BACKGROUND AND AIM: In this presentation, Dr. Peterson will provide data on our current understanding of subcortical contributions to reactive balance. Specifically, he will discuss recent work from his and other labs describing reactive balance deficits (and ability to improve these deficits) in populations with pronounced subcortical degeneration such as Parkinson's disease (PD) and multiple sclerosis (MS). Then, he will discuss data linking these subcortical and behavioral deficits. METHODS: The presentation will include emerging and recently published data on 1) deficits in reactive balance in people with PD and MS (and their ability to improve reactive balance), 2) structural brain connectivity and white matter integrity of subcortical regions in the abovementioned neurological populations, and 3) the relationship between subcortical structure/function and reactive stepping performance (and its improvement). RESULTS: Reactive balance deficits are distinct across PD and MS populations, with people with PD typically exhibiting smaller (hypokinetic) reactive balance responses, and people with MS exhibiting delayed reactive balance responses. Emerging evidence indicates that the hypokinetic reactive balance deficits observed in people with PD may be related to cerebellar and brainstem changes. Alternatively, the delayed reactive balance onset in people with MS may be linked to spinal and supraspinal changes in white matter quality. Finally, improvements in reactive balance in people with PD may also be linked to cerebellar integrity, particularly in lobules 1-4. CONCLUSIONS: These data improve our understanding of relationships between subcortical structures and reactive balance outcomes in the context of


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neurological populations. Generally, they outline the differential deficits in reactive balance across two neurological populations, and provide information on potential subcortical neural contributions of these deficits.

S2.3: Neuroimaging investigations of reactive balance: where we are now and where we are going

Kelly Westlake[1]

[1]University of Maryland School of Medicine

Dr. Westlake will present her research involving the influence of cognitive and psychological factors, including anxiety and fear of falling, on reactive balance control. She will include results from her recent functional and structural neuroimaging investigations in older adults that shed light on the differences in neural mechanisms related to reactive balance control in those with and without psychological impairments. Based on these results, she will highlight the potential need to differentially diagnose and treat those with psychological impairments along with her preliminary results of an integrated cognitive-psychologically driven reactive balance training intervention.

S2.4: Frontocentral EEG response to compensatory stepping to regain balance in healthy individuals and people with stroke

Joris van der Cruijsen[1], Wouter Staring[1], Digna de Kam[1], Lotte van de Venis[1], Teodoro Solis Escalante[1], Vivian Weerdesteyn[1]

[1]Radboudumc

BACKGROUND AND AIM: A loss of balance initiates several cortical responses (as measured with electro-encephalography, EEG), of which the most apparent is the frontocentral N1/theta response, peaking at about 100 ms after the loss of balance. The magnitude of the N1/theta response has been linked to various factors related to the threat of losing balance, such as the perturbation intensity and the compensatory action required to recover from the loss of balance. In addition, a second, yet smaller peak in theta activity is seen around the foot strike of the compensatory step, which may be related to performance monitoring. Here, we compared the frontocentral EEG dynamics during whole-body balance perturbations of people in the chronic phase after stroke, age-matched healthy controls, and healthy young subjects following perturbation onset and upon the foot strike of the compensatory step to regain balance. In addition, we investigated whether balance training (either perturbation-based training or conventional physiotherapy) affected the N1/theta response for patients with stroke. METHODS: We recorded 126-channel EEG, EMG, and motion tracking during whole-body balance perturbations in different directions in people with stroke, age-matched controls, and healthy young subjects. The people with stroke were measured before and after ten sessions of training. Perturbation intensity was fixed for all participants at an intensity that required a compensatory step to regain balance. We compared the frontocentral EEG response in the time-domain and time-frequency domain for the different groups, perturbation directions and stepping legs around the N1-peak and the foot strike of the compensatory step. RESULTS: The preliminary time-frequency results suggest that the different perturbation directions induce different dynamics between groups, primarily upon the foot strike of the compensatory step and less pronounced around the N1 latency. Between groups, event-related synchronization occurred upon foot strike for all perturbation directions in people with stroke and the age-matched controls. However, in the healthy young subjects, this only occurred prominently in

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the backward direction, suggesting a relationship with the perceived postural threat. Within subjects, distinct EEG activations were found between perturbation directions in the theta, alpha, beta and gamma range around the N1-latency and upon foot strike. CONCLUSIONS: Additional analyses of EEG dynamics between stepping legs, perturbation directions and before and after the ten sessions of training will be presented in the symposium. In addition, we will discuss the interpretations and potential implications of these findings concerning healthy and impaired human balance control.

Symposium 3: Understanding neural excitability in balance and mobility

S3.1: New insight into the potential role of neuroimmune mechanisms in sensorimotor adaptations in pain

Paul Hodges[1]

[1]University of Queensland

BACKGROUND AND AIM: Many aspects of posture and movement differ between individuals with and without pain and these are often targeted with interventions to address pain, with variable success. A major barrier is the incomplete understanding of the underlying mechanisms. Advances in methods to study brain function are providing new opportunities. This presentation will discuss new observations from investigation of brain glial activation as a possible novel mechanism.

METHODS: Simultaneous PET-fMRI was used to measure glial activation in functionally defined regions of S1/M1 in individuals with and without chronic back pain (sub-grouped using clinical criteria into primary nociceptive and nociplastic pain mechanism groups). Somatotopic regions of M1 and S1 related to the low back, leg and arm were identified using fMRI during standardized motor tasks and thermal stimuli. Sensorimotor measures included single and paired-pulse transcranial magnetic stimulation and quantitative sensory testing. Questionnaires measured sleep, depression, disability, and pain.

RESULTS: Glial activation was greater in the lower back cortical representation of S1/M1 for individuals with nociplastic back pain than both nociceptive back pain and painfree groups. Corticospinal excitability was lower in this group. Glial activation in S1/M1 positively correlated with sensitivity to hot and cold pain, poor sleep, depression, functional disability and BMI, and negatively correlated with intra-cortical facilitation.

CONCLUSIONS: Neuroinflammation in S1/M1 of the brain of individuals with nociplastic pain highlight a novel mechanism to explain not only enhanced sensitivity and motor features. Whether this can be modified with rehabilitation requires further investigation. Mechanisms likely differ based on pain type.

S3.2: The potential of functional near-infrared spectroscopy for predicting gait performance after stroke

Sue Peters[1]

[1]Western University

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BACKGROUND AND AIM: Predicting gait outcomes or guiding therapy interventions is a target of neuroimaging research after stroke. Experimental designs using surrogate gait-like movements, such as knee or ankle range of motion during functional magnetic resonance imaging (MRI), cannot fully capture the cortical activation associated with overground gait. Consequently, to truly understand the cortical mechanisms of gait dysfunction, neuroimaging devices like functional near-infrared spectroscopy (fNIRS) hold promise because it is untethered and can be used during gait in real-world settings like in stroke inpatient units. Thus, the aim of this talk is to explore whether fNIRS data holds promise for informing clinical practice. METHODS: fNIRS is an imaging tool that can evaluate multiple contiguous cortical regions during walking without physical constraints to uncover the cortical mechanisms of gait. Thus, in my lab, we use fNIRS during gait in various experimental paradigms like robotic exoskeleton overground gait, during various phases of gait (acceleration and steady state), and during various dual tasks (easy and difficult). RESULTS: Using fNIRS during a robotic exoskeleton gait task, we found the posterior parietal cortex is active during passive gait which may be related to the planning of limb coordination while maintaining postural control. Also, in people with stroke, we have shown phase-dependent differences in activation between frontal and parietal cortices during gait. Specifically, we show the sensorimotor cortex has increased activation during acceleration only, with the posterior parietal cortex increasing in activation during steady state gait only. Yet, the prefrontal cortex is active during both acceleration and steady state gait, and there is a relationship between the level of activation and gait speed (higher activation associated with faster gait speed). When another task is performed during walking (i.e., dual task gait), we show larger activation in prefrontal, premotor, and posterior parietal cortices with no differences between an 'easy' dual task and a 'hard' dual task. Taken together, these findings indicate a relationship between cortical activation and performance that fNIRS can quantify after stroke. CONCLUSIONS: fNIRS holds promise for informing clinical practice. Further, data derived from fNIRS may identify subgroups of patients who will benefit from certain therapies; however, the field is in its infancy and will benefit from future research with larger sample sizes. Thus, fNIRS has current research applicability with ample clinical application potential.

S3.3: Individual-specific cortical signatures during perception of standing balance perturbations in health, aging, and after stroke

Jasmine Mirdamadi[1], Scott Boebinger[2], Kennedy Kerr[1], Clara Beth LaFollette[1], Lena Ting[2], Michael Borich[1]

[1]Emory University, [2]Emory University and Georgia Institute of Technology

BACKGROUND AND AIM: Somatosensory perceptual function may play a critical role in maintaining upright balance but is often difficult to assess clinically and remains understudied. Here, I will discuss how quantifying cortical activity using electroencephalography (EEG) during balance perturbations may provide mechanistic insight into relationships between perceptual and balance function in health, aging, and after stroke. The central hypothesis is that balance becomes less automatic and more cognitively demanding in individuals with lower balance function, which impacts how the brain integrates multisensory information to perceive whole-body motion during balance perturbations. METHODS: Cortical activity was measured with 64-channel EEG during support surface translations to standing balance in younger adults (YA), older adults (OA) without stroke, and older adults with chronic ischemic stroke. Whole body motion (WBM) perception was assessed with a 2-alternative forced choice paradigm in which participants reported whether pairs of support-surface perturbations were in the "same"

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or "different" direction. The first perturbation was delivered in the backward direction, while the second perturbation was in the backward direction but deviated laterally at an angle that preferentially loaded one of the legs. Responses were fit to a psychometric curve to quantify perceptual threshold. Balance ability was quantified via the distance traversed on a narrowing beam and the miniBEST Test. Two metrics of cortical sensory processing overlying sensorimotor cortex were analyzed: 1) the balance "N1", the most robust perturbation-evoked potential, thought to represent a sensory-driven error signal; 2) pre-perturbation beta power, thought to represent intrinsic sensorimotor processing. We compared cortical activity across groups, and also tested associations between cortical activity, perceptual ability, and balance ability. RESULTS: Perceptual thresholds were higher (i.e., worse) in stroke, particularly when loading the paretic leg, compared to OA and YA, and associated with lower balance function. In both OA and stroke, the N1 was smaller and delayed, while pre-perturbation beta power was higher, compared to YA. In YA, higher pre-perturbation beta power, but not the N1, was associated with worse whole-body motion perception. In stroke, slower N1 responses, but not pre-perturbation beta power, were associated with worse WBM perception. DISCUSSION: The similar patterns of cortical activity in both OA and stroke suggests that changes in cortical sensory processing may be more tied to aging-related neurodegeneration rather than due to stroke. Given distinct associations between different aspects of cortical sensory processing and perceptual ability in YA and after stroke, EEG may serve a useful tool to guide mechanistically-based interventions to prevent and reduce falls.

S3.4: Challenges with using EMG as an outcome measure for stroke rehabilitation

Jayne Garland[1]

[1]Western University

BACKGROUND AND AIM: More often than not, randomized controlled trials testing the effectiveness of interventions for balance and mobility after stroke render non-significant results; this happens not because the interventions fail to produce improvements but typically because the "control" group improves. One possible explanation is that the functional outcome measures lack the sensitivity to detect change. The aim of this talk is to explore whether more sensitive laboratory measures, like EMG responses to postural perturbations, might be a useful outcome measure. METHODS: I have been performing clinical studies on standing balance and postural perturbations with people following stroke for decades using two basic paradigms: efficacy studies of a single session of an intervention to determine its physiological effects as measured by EMG, kinematics, and/or force platform data; and randomized controlled trials to examine the effectiveness of an intervention over time with pre/post measurements taken at least one month apart. I will present data from these studies to address the aim of this talk. RESULTS: In efficacy studies that involve a single session of an intervention, EMG measures can detect change. However, in an effectiveness study using a randomized controlled trial design, EMG measures did not detect change any better than functional measures and were not correlated with the change in functional outcome measures. Several explanations for these findings will be discussed. CONCLUSIONS: EMG has been proven useful for understanding mechanisms associated with functional change but may not be useful as an outcome measure in effectiveness studies.

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Symposium 4: Stepping forward with immersive technology to study, assess, and intervene on locomotor behaviour

S4.1: Fundamental research on healthy locomotor behaviour across the life span using VR

Michael Cinelli[1], Anne-Hélène Olivier[2]

[1]Wilfrid Laurier University, [2]Univ Rennes 2

Our research examines safe human navigation in cluttered environments, which is affected by the dynamics between the person and the environment, such that changes to the person and/or the environment should result in a change in actions. Fortunately, collisions between pedestrians or other objects rarely occur because vision plays a key role in safely and efficiently guiding routes away from collisions and towards open spaces. Initially, the focus of our research considered collision avoidance behaviours in real-world paradigms to determine the visual information used to initiate and control actions. We later expanded our studies to better understand the development of (research with kids) and the effects of aging on visuomotor control, as well as the contributions of training on collision avoidance performance. However, the behaviours observed in real-world laboratory studies may not fully translate to those performed in real life situations. The laboratory is not a real-life situation, it is contrived and the complexity of environmental elements and their behaviours are limited. We believe that the key to fully understanding collision avoidance behaviours across populations is to make the laboratory "life-like", while preserving experimental control. With the advancement of technology, we have been able to use virtual reality (VR) to create immersive situations to test human behaviours. VR allows us to make our testing environments more realistic to real life. Also, virtual environments allow participants to interact with objects and people in an environment whose features can be fully manipulated (sometimes physically impossible), from appearance to behaviour. Our presentation will discuss how we validated the use of VR to study human behaviour in populated environments, both at the trajectory and gaze levels. Building on these results, we will present new research paradigms that were impossible to design in real-life settings. Finally, we will discuss elements that must be taken with caution when using VR as well as the future challenges. One important take home message will be related to the co-development of real and virtual studies for cross-fertilization of research results.

S4.2: Research on alterations to locomotor behaviour using virtual reality

Anouk Lamontagne[1], Bradford McFadyen[2]

[1]McGill University, [2]Université Laval

Combined we have published over 130 peer-review articles advancing our knowledge about neuro-mechanical control underlying locomotor navigation in young and older adults as well as in populations with acquired brain injuries. Amongst these we have published 17 papers together, the majority involving the virtual reality (VR) technology which we have used since the early 2000s. Increasingly over the past two decades, our research has focused on more complex locomotor tasks required within everyday life for safe and independent community ambulation. The evolution of the VR technology in terms of the quality, affordability and characteristics of VR displays and associated technology (e.g., integrated eye tracking,

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omnidirectional treadmills, etc.) has facilitated this focus, allowing a further understanding of control mechanisms as well as the design of assessment and training tools for the rehabilitation of locomotor disorders. In this presentation, we will use the circumvention of dynamic obstacles or pedestrians as an example of a complex locomotor task, and present evidence on how VR has allowed a better understanding of healthy and altered (due to ageing and acquired brain injury) mechanisms of adaptive locomotor control. The influence of cognitive and psychosocial factors on pedestrian interactions will also be discussed from recent experiments involving manipulations of cognitive load, and personal factors on the avoidance of collision with another pedestrian (emotions; wearing of surgical mask within the new reality of public health measures). The second part of our talk will discuss the processes involved in the development of two specific VR platforms/toolkits co-developed between our laboratories that target the assessment and training of complex locomotor tasks in individuals with locomotor disorders. The development of these platforms/toolkits and their continuing evolution provide concrete examples of both the opportunities and challenges associated with the co-construction process with different stakeholders (e.g., patients, clinicians), cross-laboratory collaboration, resource sharing, co-supervision of research trainees, and more. Lastly, we will discuss the barriers, facilitators and future perspectives related to the application of VR in fundamental and applied locomotor research. We look forward to opening this talk to detailed discussion with the audience.

S4.3: Applying evidence for rehab with AR

Melvyn Roerdink[1], Jorgen Ellis[2]

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Leading augmented-reality (AR) glasses, like Microsoft HoloLens and Magic Leap, are rapidly progressing towards consumer-readiness, with profound improvements in wearer comfort, form factor, data quality and AR field of view. One of the strengths of AR compared to VR is that the visible real world can be augmented with meaningful and environment-aware digital content, bringing AR locomotor navigation a step closer towards real-world applications. Since the launch of HoloLens 1, we have been exploring the use of AR cues for real-world gait assistance, modification and navigation for people living with Parkinson's disease. In this presentation, we will address recent scientific findings as well as technological and commercial developments towards real-world gait assistance and navigation. First, we will discuss the influence of expanding AR fields of view on gait-modifying effects of AR cues as well as the required head orientations and point-of-gaze to pick up task-relevant AR information. Then we will discuss the concurrent validity of gait parameters derived from AR glasses against 3D motion capture in the lab, as well as real-time motor-state classification (e.g., sitting, standing, freezing, turning, walking) from AR glasses data against gold-standard video-annotations. The combined findings suggest that it is technologically feasible to personalize and activate AR cues (e.g. intercue distance) based on real-time monitored gait characteristics (e.g. step length) and motor states (e.g. present a gait-initiation cue when standing or freezing). We will follow the discussion with exciting new developments in digital therapeutics by Strolll.co for home-based remotely monitored and prescribed AR gait-and-balance exergames for people with Parkinson's, and address its clinical feasibility in terms of safety, adherence, usability and effect for improving gait and balance. Finally, we will introduce NavigAlt, an intelligent navigational AR cueing application to assist gait in unknown environments for people with Parkinson's disease. This requires real-time processing of the movement and environment data to generate safe assistive walking paths (avoiding obstacles) towards intended

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destinations, a challenging task requiring partnerships between academia and industry as will be exemplified and discussed by the speakers.

Symposium 5: Digital gait monitoring: time for implementation?

S5.1: Digital gait monitoring with wearable sensors: where are we and where should we go?

Kimberley van Schooten[1]

[1]University of New South Wales

Digital gait monitoring with wearable sensors is an emerging technology that shows great promise in providing insights into fall risk and mobility during daily life activities. This innovative technique can provide a continuous and objective estimation of gait characteristics during daily life that can be used to monitor fall risk. Several studies have demonstrated that gait characteristics are closely associated with fall risk in various populations such as ageing individuals, stroke survivors, people with MS, Parkinson's disease, and dementia. However, our recent research findings indicate that the predictive models developed in previous studies may not generalise well to new populations, which suggests that there may be limitations to the current approach. Furthermore, although our recent research links gait characteristics to physiological fall risk, it also shows that they may not be responsive to experiencing a fall or undergoing a fall prevention intervention. Additionally, the current approach of trunk worn sensors and the requirement for advanced processing skills may limit the clinical uptake of this technology. With this presentation, I will provide an overview of the research and evidence to date, highlighting research gaps and the caveats of using this technology in clinical settings. Despite these limitations, the potential benefits of digital gait monitoring with wearable sensors are clear. This technology has the potential to provide clinicians and researchers with objective, continuous measures of gait characteristics that can be used to assess fall risk and mobility. Moving forward, it will be crucial to continue refining and validating these methods in diverse populations and explore new applications of wearable sensor technology in fall prevention and mobility assessment.

S5.2: The Potential of Wrist-worn Accelerometry in Predicting Injurious Falls and Depressive Episodes in Older Adults

Lloyd Chan[1], Tiffany Choi[2], Stephen Lord[1], Matthew Brodie[1]

[1]NeuRA, [2]Caritas Institute of Higher Education

Background and aim: Wrist-worn accelerometry, widely incorporated into smartwatches, offers a convenient long-term gait monitoring approach. However, their potential to predict injurious falls and incident depressive episodes in older adults is unknown. This study investigated the potential of wrist-worn sensors in predicting these outcomes, informing the development of prevention strategies. Methods: A population-based longitudinal cohort study was conducted with 72,359 participants aged 65 and older recruited from the UK Biobank study. At baseline, participants were assessed on daily-life walking speed, quality, quantity, intensity, distribution, and walk-related arm movement proportions using wrist-worn accelerometers for up to seven days. Univariable and multivariable Cox proportional hazard regression models were used to

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analyse the associations between these parameters and injurious falls and diagnosed incident depressive episodes for up to nine years. Results: Of the participants, 5% (n=1627) experienced at least one injurious fall requiring medical attention, and 1.8% (n=1332) had incident depressive episodes over a mean of 7.2 ± 1.1 years. All gait variables, except for some walk-related arm movement proportions, were significantly associated with the incidence of both injurious falls and depressive episodes ($p<0.05$). After adjusting for covariates, daily running duration, steps per day, and usual walking speed were predictive of injurious falls; Daily running duration, steps per day, and step regularity were identified as independent and significant predictors ($p<0.01$) of depressive episodes. Conclusions: These results suggest that digital gait biomarkers, captured by wrist-worn sensors, can be integrated into screening programs for falls and depression. In the subsequent phase, it is imperative to recognise the challenges and corresponding solutions to the clinical implementation of digital biomarkers.

S5.3: Activity and older people; utility of accelerometry from a clinical

Ngaire Kerse, Khalid Abdul Jabber, Lynne Taylor, Ri McArdle, Lyn Rochester, Sue Iord, Anna Rolleston, Ruth The

Activity is essential to function and wellbeing for older people. Accelerometery is an exact technique to measure activity. For people in aged residential care, activity levels are very low, and walking patterns include shuffling, low speed mobility and lots of inactivity. The LiFECURVE tool is a hierarchical ordering of functions and is suggested for health promotion activation and reablement for community dwellers. Activity patterns of Māori are largely unknown in Aotearoa/New Zealand. This presentation will outline the use of accelerometery in three studies; uptake of accelerometery varied across settings: about 2/3 of 500 people in aged residential care and about half of a small sample of 90 community-dwelling older people (aged 75+) were able to wear an accelerometer for seven days, whereas most of a group of community-dwelling Māori (n=18) reported that the accelerometer attachment, which used surgical tape, caused undue skin irritation and were unable to continue wearing the device. Utility of the accelerometery data was good once obtained. Accelerometery was able to differentiate between people in dementia care compared to those in high level dependency care, by showing higher volumes and different patterns of walking activity in the former group; and in the community, the utility of the LiFECURVE tool was able to be assessed and found to not reflect actual activity level closely. Day to day utility of accelerometery in clinical practice will require further development of the technology and associated algorithms to improve utility for clinicians in practice.

S5.4: The role of wearable technology in healthcare: Health professionals? consensus on clinical utility and roadmap to actual use

Meghan Ambrens[1], Kim Delbaere[1], Ken Butcher[2], Jaqueline Close[1], Peter Gonski[3], Friedbert Kohler[3], Nigel Lovell[1], Daniel Treacy[4], Kimberley van Schooten[1]

[1]Neuroscience Research Australia, [2]University of New South Wales (UNSW), [3]UNSW, [4]NSW Health

Background: Falls and mobility disability are common with advancing years. While wearable technology may allow for timely identification, assessment, and evaluation of clinical interventions, it is not routinely used in clinical practice. Objective: To establish expert consensus on how wearable technology can be applied to support clinical care for people experiencing changes to mobility and/or who are at increased risk of falling. Methods: A Delphi

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study was conducted among 17 hospital-based health professionals. Over three-rounds, experts were asked about fall prevention, mobility assessment, the role of wearable sensors to assess fall risk and mobility, and clinical considerations for implementing wearable technology into clinical practice. Consensus was defined as 75% agreement. Data were analysed using qualitative and quantitative methods. Results: Fall prevention and physical activity promotion are key considerations for people experiencing changes to mobility and/or who are at increased risk of falling. Experts agreed wearable technology has short and long-term clinical utility, data should be shared with general practitioners to improve long-term health outcomes and devices would need to fit all individuals with a preference for wrist or pendant-worn locations. Technological literacy was not a perceived barrier. However, cost and data accuracy were important for successful implementation. Conclusion: This study provides a consensus statement and guidance on the clinical implementation of wearable technology for the assessment of fall risk and mobility in older people. Health professionals are receptive to using wearable technologies to advance fall risk and mobility assessment and believe wearable technology has a role in clinical practice.

Symposium 6: Tonic neuromuscular processes: How much of postural control do they explain and what is this the origin of tone

S6.1: Tonic muscle activity modifies muscle mechanics for sensorimotor control of balance

Lena Ting[1]

[1]Emory University & Georgia Tech

INTRODUCTION: Postural muscle tone increases transiently in threatening balance conditions, as well as chronically in aging and neurological disorders such as cerebral palsy and Parkinson's disease. Muscle tone modulates a special "postural property" of muscle called short-range stiffness: attached cross bridges formed when the muscle is stationary cause high, transient resistive force to stretch; this resistance much lower if a moving muscle is stretched. But because it is difficult to measure muscle tone, the role of short-range stiffness in postural control is still poorly understood. Further, the same short-range stiffness property drive bursts of muscle spindle sensory signals that are critical for signaling a postural perturbation. We hypothesize that the neural regulation of postural tone enables healthy individuals to take advantage of muscle's postural property, but that elevated postural tone typical of neurological disorders increases postural stiffness at the expense of balance capacity. METHODS: As it is prohibitive to measure muscle tone and muscle force directly in humans, we use a combination of human, animal, experimental and computational approaches to quantify the role of muscle tone in balance control. These include inverse dynamics during postural perturbations to standing balance control in children with spastic cerebral palsy and adults with Parkinsonian rigidity. We also use in vitro single muscle fiber experiments characterize how muscle tone and movement modulate short-range stiffness in postural-relevant conditions. In silico simulations of muscle cross-bridge biophysics can then be used to predict muscle force and muscle spindle sensory signals elicited in balance perturbations, and how they change in health and disease. RESULTS: In healthy young adults, hip and knee joint torques in support-surface perturbations are predominated by short-range stiffness response, precluding the need for

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sensorimotor response. Short-range stiffness were higher in older adults with and without Parkinson's disease, and accompanied by reactive sensorimotor responses. Corroborating these findings, in vivo experiments show that muscle short-range stiffness persists at low muscle activation levels and muscle stretches on the order of postural sway (<1% stretch), but may be reduced if postural sway increases (<3% stretch). In silico muscle models further demonstrate the nonlinear stiffness of muscle and muscle spindle responses to discrete and continuous muscle stretch. SIGNIFICANCE: Low levels of postural tone are critical for taking advantage of muscle short-range stiffness properties that stabilize posture and send sensory signals for balance control. Elevated levels of postural tone may be detrimental in making the body overly stiff and more difficult to control.

S6.2: Assessing motoneuron persistent inward currents in postural control

Martin Zaback[1], Matt Topley[1], Christopher Thompson[1]

[1]Temple University

BACKGROUND AND AIM: Synaptic input to motoneurons (MNs) comes from multiple descending and afferent sources. However, a critical, and often overlooked source of excitation comes from MNs themselves in the form of persistent inward currents (PICs). PICs can cause MNs to continuously discharge when there is little or no synaptic input. Since their first description in the 1980s, PICs have been hypothesized to play an essential role in the maintenance of postural muscle tone. However, due to the difficulty assessing PICs during normal motor behaviour, our understanding of how these are regulated during postural control is limited. In humans, PICs are typically assessed by having individuals slowly increase and decrease a muscle contraction to a submaximal target over tens of seconds, during which motor units are progressively recruited and derecruited. A paired-motor unit technique is then used to estimate the magnitude of PICs. Recent work has adapted these methods to estimate PICs in lower limb muscles during standing. However, since standing is a largely unconscious task, estimates of PICs derived from highly controlled, voluntary contractions may not be representative of the neuromodulatory state of MNs during postural control. Thus, there is a need for methods that can be used to unobtrusively extract estimates of PICs during natural postural behaviours. METHODS: Since quiet standing is predominated by low-frequency postural sway, it is possible that individuals naturally generate time-varying muscle contractions suitable for paired-motor unit analyses. We explored this possibility by having young adults complete a series of standing trials on independent force platforms while high-density surface electromyography (HD-EMG) was recorded from muscles of the triceps surae. HD-EMG data were decomposed into motor unit spike trains and a semi-automated algorithm searched for large (>1 cm) anteroposterior centre of pressure (AP-COP) excursions that fit triangular profiles. Since these events are unpredictable and may be infrequent, a separate group of participants were presented with discrete optic flow to evoke similar postural events. RESULTS: Triangular profiles could be identified from COP time-series during quiet standing, but they were relatively small and infrequent (3.5 events / 10 minutes standing). However, progressive recruitment and derecruitment of triceps surae motor units was often observed during these events. Presentation of discrete optic flow significantly increased the amplitude of triangular COP excursions that could be evoked (>60% incidence). CONCLUSIONS: Estimates of PICs can be extracted from natural postural sway. Since PICs play a critical role in shaping motor output and may be modulated in a state-dependent manner, developing practical methods for their assessment is necessary to understand how these MN properties affect balance in health and disease.

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S6.3: Early manifestation and development of muscle tone in infants

Yury Ivanenko[1]

[1]IRCCS Fondazione Santa Lucia

INTRODUCTION. In this presentation, various findings, ideas and approaches will be considered that represent important conceptual frameworks for characterizing manifestation and development of muscle tone in infants. The postnatal development of sensorimotor networks is characterized by maturation of the musculoskeletal system, sensory feedback, as well as by the proper formation of muscle tone, which is an integral part of all movements. METHODS. Several methods were used to characterize manifestations of muscle tone and its development during the first years of life, such as assessing muscle responses during passive joint movements of lower and upper limbs, spontaneous activity and stepping movements. RESULTS. Muscle tone can be manifested in both resistive and 'compliant' posture behavior and both types of reactions are frequently present in infants, especially during the first months of life. A functional reorganization of the loading component during stepping was also observed, related to both maturation of the spatiotemporal patterns of muscle activity and learning the 'rules' of walking in the gravitational field during early development. This time period represents one of the important epochs for characterizing changes in the state of the developing nervous system in infants. The data will also be presented on how early injuries to developing motor regions of the brain in children with cerebral palsy affect maturation of the spinal motor output. CONCLUSIONS. Various concepts for evaluating muscle tone will be discussed. A reorganization of the spatiotemporal muscle activity patterns and a substantial reduction of sensorimotor responses to muscle length changes with age suggest a reduction in excitability and learning the functionally appropriate muscle tone throughout the first year of life. The precursor of the mature antigravity loading pattern in infants will be discussed also in comparison with other animals.

S6.4: Tonic neuromuscular processes affect postural control differently across age and tonic disease

W. Geoffrey Wright[1]

[1]Temple University

BACKGROUND AND AIM: Tonic neuromuscular processes combine with phasic outputs to help control posture and locomotion. Clinically, tonic neuromuscular processing has long been recognized as being essential to healthy motor functioning. It helps with balance by providing anti-gravity background forces and torques via sustained fatigue-resistant muscle activity that allows for unconscious control of numerous body segments. While disease can affect tonic processing, healthy aging can change tone as well. METHODS: 45 subjects (N=23, healthy young, N=13 healthy older; N=9 Parkinson's Disease) were tested in a protocol involving a series of quiet standing postural tasks with eyes-closed. The tasks involved maintaining upright posture while standing on an inclined ramp for an extended period of time, then continuing to stand upright after the surface was returned to horizontal. This method is known to induce lean after-effects, which is a method for separately measuring slowly adapting tonic changes in muscle set-point and fast, phasic muscle responses. The outcome measures were change in center of pressure (COP) and EMG pre and post surface ramp tilt. RESULTS: All groups showed postural some adaptation in postural tone, in that lean after-effects were evident, but healthy young showed larger shifts in COP than healthy older adults, and PD shift in COP was

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only trending towards significance (p=0.06). In both healthy populations after-effects developed more quickly than in PD. EMG activity was altered dependent on whether it was flexor or extensor muscle. CONCLUSIONS: In these populations, the differences in size and decay constant of after-effects during lean adaptation suggest tonic neuromuscular processes play a role in how adaptable postural control is to changing surface conditions but this is affected by aging and basal ganglia function. In an ongoing study using high-density surface EMG, we are applying a novel analysis to estimate persistent inward currents (PICs) in spinal motoneurons, which can cause sustained discharge in the absence of synaptic input. Muscle tone is thought to come from multiple descending and afferent sources and while results are preliminary, PICs could provide some insight as to one of the sources of tonic processing.

Symposium 7: Beyond straight walking: Turning is a sensitive and highly relevant performance marker in different movement disorders

S7.1: Changes in dynamic balance in real-life turning movements are sensitive to cerebellar ataxia

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BACKGROUND AND AIM:. Analysis of real-life walking movements adds ecological validity to natural history and intervention studies. Turning movements represent a highly relevant component of everyday walking behaviour, as 35%-45% of steps occur within turns. Compared to straight walking, turning movements are suggested to be more challenging in terms of dynamic balance, as they involve a stronger demand of anticipatory postural adjustments and trunk-limb coordination strategies. Existing work in Parkinson's disease, multiple sclerosis, cerebellar ataxia, or ageing focused on assessing general turning parameters such as turn angle, mean velocity, duration or the number of steps within the turn. However, these measures do not reflect specific dysfunctional mechanisms such as dynamic balance control. This longitudinal study aimed to unravel quantitative motor biomarkers in degenerative ataxias in real-life turning movements which are sensitive for changes both longitudinally and at the premanisfest stage of degenerative cerebellar ataxia. METHODS: Combined cross-sectional (n=30) and longitudinal (n=14, 1-year interval) study in degenerative cerebellar disease (including 8 pre-ataxic mutation carriers) compared to 23 controls. Turning movements were assessed by three body-worn inertial sensors in three conditions: (1) instructed laboratory assessment, (2) supervised free walking (SFW), and (3) unsupervised real-life walking (RLW) (4-6 hours at patients' homes). In addition to general turning parameters, we focused on measures which allow quantifying impaired dynamic balance control while turning, in particular lateral sway pattern. This was operationalized by the measure Lateral Velocity Change (LVC) characterizing the lateral acceleration patters of the lumbar sensor during continuation steps of turning movements. RESULTS: We analysed 16.8 ± 6.71 turns in the SFT and 78±18 turns (between 50° and 120°) in the RLT condition per participant with no difference between groups. Measures which quantified dynamic balance during turning - lateral velocity change (LVC) and outward acceleration -, but not general turning measures such as e.g. speed, allowed differentiating ataxic against healthy subjects in real life (effect size δ=0.68), with LVC also differentiating preataxic against healthy subjects (δ=0.53). LVC was highly correlated with

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clinical ataxia severity (SARA score, effect size ρ=0.79) and patient-reported balance confidence (ABC score, ρ=0.66). Moreover, LVC in real life - but not general turning measures or the SARA score - allowed detecting significant longitudinal change in one-year follow-up with high effect size (rprb=0.66). CONCLUSIONS: Measures of turning allow to capture specific changes of dynamic balance in degenerative ataxia clinical assessment as well as in real life, with high sensitivity to longitudinal differences in ataxia severity and to the premanifest stage.

S7.2: Clinical application of turning in Parkinson's disease: classification, falls and disease progression

Lisa Alcock[1], Rana Rehman[1], Lynn Rochester[1], Silvia Del Din[1]

[1]Newcastle University

Background and aim: The ability to navigate complex environments is necessary for maintaining an independent and active lifestyle. To achieve this, we must be able to ambulate from one location to another (walking) and modify/ change our walking direction (turning). Turning is a highly challenging movement, particularly for patients with movement disorders as the task requires multisensory integration and multi-segment co-ordination. Cardinal motor symptoms (i.e. bradykinesia, rigidity, postural instability etc.) affect turning in people with Parkinson's disease (PD), but non-motor symptoms (i.e. visual dysfunction, attention) also play a role. A reduced quality of turning (slower, less variable, more cautious turning strategy) has been observed in older adults who fall and people with PD. The aim of this talk is to demonstrate the clinical utility of turning outcomes in patients with PD: exploring disease classification; fall typology; and disease progression. Methods: A group of PD participants were recruited as part of the longitudinal cohort study; ICICLE-GAIT. Participants were assessed every 18 months for up to six years with turning data available at 36-, 54- and 72-month time points. Three 180 degree turns were extracted from four 10-m intermittent walks during a laboratory gait assessment. A tri-axial inertial measurement unit was worn on the lower back (Opal, 128Hz). Turning outcomes were extracted using a validated algorithm: 11 spatiotemporal (i.e. turn duration, angular velocity) and 88 signal-based (44 from the acceleration signal (i.e. RMS, Jerk RMS) and 44 from the gyroscope signal (i.e. RMS, angular acceleration)). Results: For the classification of PD, turning outcomes derived from a single sensor on the lower back resulted in a classification accuracy of 85%. Turning outcomes across all movement planes were equally important to fall typology with an emphasis on the start phase of the turn. Our findings indicate that turning performance is sensitive to PD disease progression over 36 months. Nine turning outcomes (1 spatiotemporal, 8 signal-based) significantly progressed over time, with changes predominantly observed in signal-based features across anterior-posterior and mediolateral planes. Conclusions: Our findings demonstrate that discrete turning outcomes are informative in PD. Outcome selection is important and varies depending on the clinical application. Signal based features (accelerometer and gyroscope) were particularly influential, as were features extracted from the different phases (start, mid and end) of the turn. Important turning features have been identified and may be used for feature reduction. Acknowledgements: ICICLE-GAIT (PI: Professor Rochester) is supported by the NIHR Newcastle Biomedical Research Unit and NIHR Newcastle CRF Infrastructure funding.

S7.3: Capturing turning behaviours in dementia subtypes using wearable technology: considering validity of an algorithm and clinical utility for supporting diagnosis

Riona Mc Ardle[1], Lisa Alcock[1]

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[1]Newcastle University

Background: Digital mobility outcomes can be feasibly captured in people with different dementia subtypes using wearable technology, such as body-worn inertial measurement units, in lab-based and real-world environments. Based on findings from digital mobility assessment, different dementia subtypes (i.e. Alzheimer's disease and Lewy body dementia) show unique signatures of gait impairment which may act as a supportive differential diagnostic marker. The assessment of gait often includes other complementary features of mobility, such as turning behaviours, which may provide additional support for distinguishing dementia subtypes. Growing evidence suggests that discrete turning impairments may occur in neurodegenerative conditions, such as Parkinson's disease, and may be related to cognitive decline. Therefore, the aim of this talk will be to describe ongoing work to validate an algorithm to accurately capture turning behaviours in dementia and its subtypes, and to present novel preliminary findings which will characterise turning impairments in people with Alzheimer's disease and Lewy body dementias. Methods: Ninety-eight participants from the GaitDem study were included in this analysis, composed of 35 people with Alzheimer's disease, 35 with Lewy body dementia and 28 older adult controls. Participants wore an Opal inertial measurement unit (128 Hz) on their lower backs while carrying out an intermittent 10-m walking task six times, which included five 180 degree turns. A 2D colour video camera videoed the assessment area and used for data verification purposes. Videos of participants were reviewed by two independent blinded raters to detect turn start and end. Turn start and end times were used to extract spatiotemporal (e.g. total turn time, turn angle) and signal-based turning characteristics (e.g. angular velocity, angular acceleration in each axis). Limit of agreement and Bland Altman plots were used to assess agreement between raters and between raters and algorithm for each group separately. Group differences were assessed using parametric (i.e. one-way ANOVA) and non-parametric tests (e.g. Kruskal Wallis). Results: Results regarding the validation of the turning algorithm will be presented in this talk. Preliminary findings suggest that people with Lewy body dementia have significant spatiotemporal and signal-based turning impairments, while people with AD have significant signal-based based turning impairments compared to controls. No significant differences were found between dementia subtypes for turning behaviours. Conclusions: This talk will demonstrate the validity of an algorithm to detect turning behaviours in dementia subtypes, building on prior work in older adult fallers and people with Parkinson's disease. Preliminary findings suggest that turning assessment may be a useful tool to distinguish dementia from normal ageing, but may have limited value as a differential marker for dementia diagnosis.

S7.4: Prefrontal correlates of turning in people with neurological diseases

Martina Mancini[1], Carla Silva-Batista[1], Anjanibhargavi Ragothaman[1], Fay Horak[1], Christopher Gomez[2]

[1]Oregon Health & Science University, [2]University of Chicago

Background and aim: Turning impairments are common in people with neurological diseases, such as Parkinson's disease (PD) and spinocerebellar ataxia (SCAs), and lead to reduced mobility and quality of life. Compared to straight ahead gait, turning requires more neural resources to properly plan and execute the movement. Specifically, turning is thought to be associated with increased executive function demands, stemming from the prefrontal cortex (PFC). Turning, particularly 360 degrees turning in place, is a trigger for freezing of gait (FoG) in PD. It has been reported that people with SCA also have difficulties in performing large turns

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and adopt a series of compensatory strategy aimed at reducing the instability associated with turning. It is possible to monitor PFC activity during mobility tasks using methods such as mobile functional near infrared spectroscopy (fNIRS). The aim of this talk is to explore changes in PFC activity during turning in place, measured with fNIRS, in PD and SCAs. Methods and Results: People with PD (N=47) were asked to turn in place, 360 degrees, alternating right and left, continuously for 80s, preceded and followed by 20s of standing still as baselines. Six wearable inertial sensors were used to characterize turning characteristics. An 8-channel mobile functional near infrared spectroscopy (fNIRS), with two reference channels, was used to record changes in oxygenated hemoglobin (HbO2) and deoxygenated hemoglobin (HHb) within the PFC. Our findings showed increased PFC activity (HbO2) while turning in place in people with PD and FoG compared people with PD without FoG. In addition, higher PFC activity was related to higher FoG severity, as characterized by wearable sensors. Individuals with genetically determined SCA (N=16) were also studied as a second population with turning impairments. PFC activity (HbO2) while turning was increased in people with SCAs compared to healthy controls of similar age (N=15). However, pilot findings showed that such increased in PFC activity is present in the early manifest stage and not in the pre-manifest stage of SCA. Conclusions: These preliminary studies suggest the involvement of the PFC in people with PD and FoG while performing a challenging task such as turning-in-place. The increased activation of the PFC in people with PD and FoG compared to those with PD without FoG and the association between that increased PFC activity and poorer turning performance highlights the loss of automaticity in people with PD, particularly in those who experience FoG. In SCAs, our pilot data suggest that PFC activity is increased only in early SCA and not in pre-manifest SCA, when clinical scores are normal, suggesting prefrontal activity is compensating for cerebellar deficits. fNIRS techniques could be used to improve understanding of brain mechanisms associated with walking automaticity in multiple neurological disease sand might be employed as an outcome measure in clinical trials.

Symposium 8: Understanding mobility in the visually impaired: Progress, pitfalls, and possibilities

S8.1: Vision Loss affects Street-Crossing Decision Making

Shirin Hassan[1]

[1]Indiana University

Crossing the street is a complex and dangerous task that we do daily. When crossing a non-signalized intersection, pedestrians must judge gaps in vehicular traffic to allow them enough time to reach the other side of the street before an approaching vehicle reaches them. The visual system plays an important role when making street-crossing judgements. However, what happens to a person's ability to make safe and accurate crossing decisions when there is vision loss? Most previous street-crossing studies have evaluated only the effects of aging in normally-sighted people. Furthermore, these studies have been conducted predominately in the laboratory where there is reduced ecological validity. In this presentation, I will explain my laboratory's research findings of our street-crossing study conducted in people with actual visual impairment in a real-world street environment. In our experiment, crossing decisions along a non-signalized street with two lanes of one-way traffic were collected from 129 visually

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impaired subjects. The subjects were classified as either having only visual acuity loss (VA Loss) or, both VA and visual field (VF) loss (VA + VF Loss) and self-reporting either "having" or "not having" difficulties crossing the street. After observing traffic for two seconds using their habitual vision and hearing, subjects were required to decide whether they thought it was safe to cross the street for different vehicular gap times. The percentage of unsafe decisions (%Unsafe), computed as the percentage of times subjects indicated that they would cross a measured vehicular gap time that was shorter in duration than their actual crossing time, was computed for every subject. The percentage of correct decisions (%Correct) was also calculated for each subject by computing the percentage of times subjects indicated that they would cross a measured vehicular gap time that was longer in duration than their actual crossing time. Generalized linear mixed models with repeated measures for subject were used to determine if the %Unsafe and %Correct decisions changed as a function of age, subject group (with and without self-reported difficulties) and type of vision loss (VA Loss and VA + VF Loss). Based on our study's results, I will discuss how street-crossing decision making performance is highly variable among visually impaired pedestrians in real-world street environments. I will also talk about how a subject's performance is affected by age, the type of vision loss and if a visually impaired person's own perception of their street-crossing ability correlates with their actual performance. Additionally, I will cover the clinical implications of these results on pedestrian safety in visually impaired people including how clinicians and rehabilitation specialists can best identify and train those visually impaired pedestrians who are at risk for making unsafe street-crossing decisions.

S8.2: Obstacle avoidance in visual impairments

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[1]Research Scientist

Background and Aim: When walking through the environment, we often take a path that circumvents obstacles on the way to our designated goal. This process is hampered by the reduction in sensory input, cognitive resources, and neuro-motor mechanisms due to aging and/or loss of vision, making it more challenging to effectively avoid obstacles while walking. A recent EEG study has shown that when unexpected obstacles appear, certain areas of the brain (frontal and parietal) are involved in decision-making in young, healthy subjects. However, the cognitive processing involved in obstacle avoidance for individuals with visual impairments is still unclear. This study examined how people with visual impairment and age-matched controls choose their path to a target, and the visual information they use for path planning. It is the first study to combine mobile eye tracking and elecrtoencephalography (EEG) in individuals with visual impairment. Methods: Three individuals with central field loss, 2 individuals with peripheral field loss, and 3 age-matched control participants, between 58 and 75 years old were asked to avoid stepping outside an avoidance margin between a stationary obstacle and the edge of a walkway as they walked to a bookcase and picked up a target from different locations on a shelf. Eye movements were measured using a mobile eye tracker and participants' dynamic brain activity was monitored by a mobile dry EEG headset. Results: Our results showed that those with visual impairments did not pay much attention to the target position and instead relied on the avoidance margins to make path planning decisions. Unlike control participants, those with visual impairment would always select the path side with the largest avoidance margin and directed their gaze more to the avoidance margin area and less to the target area for path planning during obstacle avoidance. Our EEG data showed that older adults with visual impairment had a greater cognitive load than the healthy-sighted controls

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during obstacle avoidance, as indicated by an increase in power of the frontal theta and a decrease in power of the parietal alpha brain oscillations. Our results also showed that the greater cognitive loads are not just related to obstacle negotiation, as found previously, but also to obstacle detection when one is visually impaired. Conclusions: The significance of our findings is that the weights assigned to environmental factors (target and obstacle location) when choosing a path differed between those with visual impairment and healthy sighted age-matched control subjects. Thus, when planning their path, the primary concern of older adults with visual impairment is their safety while the primary concern for older healthy sighted subjects is the target location. These findings further suggest that for an obstacle avoidance task, visual impairment elicits a higher level of mental processing, as compared to healthy vision in older adults.

S8.3: The effect of peripheral field loss in retinitis pigmentosa: from gaze adaptations to measures of mobility performance to assess therapeutic benefit

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BACKGROUND AND AIM. Peripheral visual loss impairs both visual perception and motor control. It damages spatial localization, affects postural control, could lead to unintentional bumps and orientation errors. Subsequently, patients suffering from severe peripheral field loss walk slowly and limit their independent travel. However, they should adapt their behavior to compensate for their deficit, and develop new sensorimotor strategies. METHODS. In a first series of experiments, we explored this hypothesis with 10 retinitis pigmentosa (RP) patients performing goal directed locomotion and trajectory reproduction. In a second series of experiments, we developed a new mobility test in real-life (RL) and virtual reality (VR) conditions and performed a prospective, longitudinal study (test-retest) to compare the performance of RP patients and healthy participants in both conditions. 30 RP patients and 30 age-matched healthy participants had to walk through a maze either physically presented (RL) or displayed in a virtual reality headset. In multiple light level conditions, participants were instructed to step over two steps, pass under two flags, avoid a cone and two high obstacles, avoid a dead-end, and finally reach an end goal. We designed a performance score taking into account trial duration and mobility errors. RESULTS. The loss of peripheral vision did not alter gaze anticipation behavior. However, we identified several changes in gaze strategies, including more extensive exploration, mostly on the ground. Results of the mobility test indicated a good construct validity (>90% discrimination between groups) and a very good agreement of the performance score between sessions (ICCs>.9) and between VR and RL conditions (r=.98). Importantly, the vast majority of patients (RL: 73%; VR: 80%) thought the difficulties encountered in the test were representative of those encountered in daily life, and 97% suggested using this activity to assess their functional vision abilities. Moreover, up to 78% of RP participants felt that the VR test was representative of their difficulties in daily life. CONCLUSIONS. Currently, there is no cure for RP. However, recent advances in gene therapy and optogenetics have shown promising results in restoring visual function in animal models. The effectiveness of these therapies in humans is still being evaluated, and measures of mobility performance may provide valuable insights into their therapeutic benefits.

S8.4: The influence of spatial cues on navigation with visual impairment

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BACKGROUND AND AIM: The goal of visual accessibility--the design of environments that support safe and efficient navigation for people with visual impairment--can be facilitated by an understanding of how conditions of low vision influence space perception on both local (e.g., environmental features) and global (e.g., cognitive maps) scales. People with low vision have uncorrectable vision loss, but have some remaining functional vision and it is important to recognize that they use their residual visual capabilities for many components of navigation. Our work aims to define how simulated central and peripheral vision loss influences the use of visual cues that inform perception of distance and memory for locations when navigating in real world spaces. METHODS: In one approach, we identify several visual cues that are important to distance perception with low vision and describe experiments that demonstrate their use. These include a salient floor-wall boundary and cues for object ground contact. In a second approach, we use a sensory cue integration paradigm in immersive virtual reality (VR) that allows for a more precise evaluation of how visual and non-visual cues used are used in spatial updating, or the ability to keep track of one's location during navigation. We use a homing task where participants physically walk towards a target via multiple waypoints with visual landmarks to help them encode their spatial location. Participants then walk back to the target with only one cue available (such as visual landmarks or self-motion), or both cues. We have tested both young and older normally sighted adults. RESULTS: The distance perception studies show that when boundaries or ground contact are not visible or perceived, then errors in perceived distance occur. The cue-integration studies show that older adults have higher error and variability in all conditions compared to younger adults but receive greater relative multisensory benefit. CONCLUSIONS: I will discuss how the VR paradigm can be adapted for real or simulated visual impairment to test how use and combination of cues may be influenced by experience with reduced-cue contexts. These research findings have the potential to inform architectural design guidelines for large-scale spaces and multisensory strategies that take into account basic perception of spatial cues.

Symposium 9: Effects of perception of motion on postural control in health and disease

S9.1: Incorporating Perception of Motion and Spatial Orientation into Models of Posture and Gait Control: A Conceptual Framework

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Background: Most models of posture and gait control rest on the notion that vestibular, visual, and somatosensory inputs are detected by the peripheral nervous system and transmitted to the central nervous system for processing into percepts of spatial orientation and commands for controlling locomotion. In these models, spatial disorientation, abnormalities of posture and gait, and symptoms and signs of vestibular and balance disorders are thought to arise from disruptions in the detection and transmission of data due to structural defects in peripheral organs or central pathways, or mismatches among sensory inputs. This bottom-up conceptualization of the vestibular and balance system cannot account for the growing body of evidence about motion perception and spatial orientation such as the effects of innate and

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previously learned interpretations of peripheral inputs (priors and past states), predictions of self and object motion (future states), and assessments of threats and priorities for controlling posture and movement (present and future states) in health and disease. They also offer no cogent explanations for the existence of common vestibular disorders such as persistent postural-perceptual dizziness that have presumed pathophysiologic mechanisms centered on changes in functioning rather than defects in structure of vestibular and balance systems. To explain these experimental observations and clinical disorders, models of postural and gait control must be dynamic in nature to account for past, present and future states and encompass the top-down influences of perceived motion and spatial orientation as well as compromises of priorities and costs inherent in executing movements. Methods: Computational neuroscience, neurophysiology, psychophysics, control theory, and clinical neurosciences offered key elements for constructing a more advanced model of posture and gait control. Results: A model of posture and gait control was created that coherently incorporated temporal elements, predictive information processing, and previously underrepresented effects of perception and priorities as top-down drivers that exert considerable control over human locomotion at all levels of the sensorimotor system. Conclusions: This updated model offers a more advanced conceptual framework for understanding experimental data on posture and gait control from healthy individuals and patients with structural and functional vestibular and balance disorders.

S9.2: Postural threat affects perceptions of balance-related sensory information and postural stability

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BACKGROUND AND AIM: Emotions such as fear and anxiety are strongly related to balance instability and falls, and have a high co-morbidity with dizziness, vertigo and vestibular-balance disorders. While traditionally fear and anxiety are considered a negative consequence of balance impairments, recent evidence suggests these factors may also directly contribute to altered balance performance and balance perceptions in both healthy and clinical populations. METHODS: Increasing postural threat through changes in support-surface height has been used experimentally to induce state-changes in fear and anxiety, and assess parallel changes in postural control. Studies have shown anxiety-related changes across a broad range of dynamic balance behaviours including anticipatory postural adjustments, postural reactions, stepping and landing strategies, and commonly used clinical balance measures. In addition, anxiety and fear significantly influence sensori-motor reflex gain during stance including increases in Ia and Ib spinal reflexes, vestibulo-spinal and vestibulo-ocular reflexes, and to a lesser extent for visual and cutaneous reflex pathways. Anxiety-related sensory changes are accompanied by cortical changes assessed through sensory-evoked cortical responses and cortico-muscular coupling. These changes may underlie our recent observations of changes in perceived movement during balance tasks, and conscious perceptions of balance-related sensory information. RESULTS: During static balance, threat increased the gain between actual and perceived movement; actual sway amplitude decreased while perceived movement amplitude measured with a real-time tracking task remained unchanged in the HIGH (3.2 m, at the edge) compared to LOW (1.1 m, away from edge) height condition. When participants performed whole-body voluntary leaning to different positions relative to their stability limits, they perceived a larger amplitude of whole-body leaning under conditions of increased threat. During continuous mediolateral pseudorandom support surface tilts, perceived trunk


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movement measured with a real-time tracking task was larger in the HIGH compared to LOW height condition. A similar increase in perceived amplitude was observed in an isolated ankle rotation task measured independent from whole-body sway. These changes in gain were not accompanied by any significant decreases in detection thresholds of ankle rotation or cutaneous sensation of the foot sole. CONCLUSIONS: Taken together, our results suggest postural threat can affect emotional state and conscious perceptions of balance-related movement likely through changes in response gain of somatosensory and other balance-relevant sensory stimuli including vestibular inputs. These results provide important insights into the potential mechanisms contributing the threat-related changes in postural control in healthy individuals and those with functional balance deficits and vestibular disorders.

S9.3: Perception of motion in patients with persistent postural-perceptual dizziness (PPPD)

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BACKGROUND AND AIM: Persistent postural perceptual dizziness (PPPD) describes a persistent sensation of dizziness and/or unsteadiness (without vertigo) aggravated by upright posture that generates increased postural sway. METHODS: I will introduce a novel measure of perceived instability to investigate the relationship between observed sway and perceived instability in patients with PPPD, as compared with patients with persistent observed instability due to bilateral vestibulopathy (BV). RESULTS: Generally, patients with bilateral vestibulopathy can faithfully reproduce their objective sway, but PPPD patients over-reproduce observed sway. The abnormal relationship between observed and perceived sway in PPPD represent an average twofold increase in sway misperception. Such errors of magnitude estimation are coherent with abnormal threat assessment and bodily hypervigilance displayed by patients with PPPD and related disorders, following an acute episode of postural instability or threat to balance. CONCLUSIONS: In PPPD, central alterations in magnitude estimates of self-motion signals are responsible for abnormal perception of sway and instability. This may ensue secondary to a shift in perceptual processing of self-stability, with heightened and permanent state of postural anxiety due to an internal awareness of altered balance function. Such a shift to cortical-based control of posture may involve abnormal frontoparietal interactions, supported by evidence implicating the prefrontal cortex in fear conditioning and extinction, decision confidence, and executive behaviour planning. Diagnostic formulations, pathophysiological exploration, and treatment design should perhaps then shift away from the 'inner ear' and focus instead on postural perception, motor predictions, and threat assessment as part of the cortical control of balance.

Symposium 10: Brain-muscle cross talk: bridging basic and clinical research to explain mobility resilience and discover novel interventions

S10.1: Molecular mediators of muscle-brain cross-talk in older age

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In older age, some persons move and function better than others, even for similar levels of locomotor risk factors. The source of such mobility resilience is currently unexplained. We propose the unique modulatory and adaptive capacity of central nervous and muscle skeletal systems may provide clues to understand the sources of such mobility resilience. We contend that the previously unrecognized relationship between the central nervous and skeletal muscle systems is one of the factors enabling adaptation/ compensation and thus resilience. This working model has the potential to generate discovery of new multi-systemic interventions to promote mobility resilience, not only for older adults, but also for other types of mobility impairments. There is strong biological plausibility supporting a cross-talk between the central nervous and skeletal muscle systems. Recent emerging evidence has offered insights into shared biological processes and molecular mediators of such cross-talk (e.g. mitochondrial function, myokines). However, evidence is primarily for animal models and selected patient populations with muscle degeneration. It is controversial how or whether such cross-talk occurs in older adults or persons with other conditions. I will discuss the biological plausibility of muscle-brain cross-talk as a driver of mobility resilience, based on existing literature and our own work. Specifically, I will summarize evidence that: a) greater muscle activity releases neuroprotective cytokines (e.g. exerkines); b) lower muscle health (e.g. lower mass and greater adiposity infiltration) drives release of harmful proinflammatory cytokines, with neurodegenerative effects. She will discuss a novel working model whereby lower muscle health may harm cognition via altered homeostasis of exerkines and proinflammatory cytokines, resulting in a neurodegenerative profile.

S10.2: Transcranial electrical stimulation to improve mobility and resilience in older adults

Brad Manor[1]

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BACKGROUND AND AIM: Standing and walking are controlled by complex systems that rely upon effective cross-talk between the peripheral neuromuscular system, spinal circuits, and numerous subcortical and cortical brain networks. Importantly, these systems are dynamic, meaning that they continually adapt in order to maximize output in response to recent activity, as well as to longer-term changes in structure or function due to lifestyle factors, aging, and/or disease. This adaptive capacity, therefore, is one important contributing factor to the maintenance of mobility over time. Transcranial electrical stimulation (tES) is a form of non-invasive brain stimulation that can safely and selectively modulate cortical excitability. A single exposure to tES alters excitability, and therefore activity, within the targeted brain region and its connected neural networks for an hour or more following stimulation. Mounting evidence further suggests that regular exposure to tES can induce lasting neural plasticity in younger adults, older adults, and in those individuals suffering from age-related disease. METHODS: This talk will first highlight the fundamentals of tES and describe its application within clinical research studies. RESULTS: Evidence will then be reviewed suggesting that tES is capable of inducing meaningful changes to numerous supraspinal elements of the motor control system--from the cortical drive to muscles, to fatigue, to the executive control of movement--that may augment adaptive capacity and therefore, the ability to maintain mobility even in the presence of locomotor risk factors. CONCLUSIONS: Finally, the limitations of tES, the key gaps in our understanding of tES mechanisms as they relate to the brain-muscle cross talk framework, and avenues for future research using tES to enhance mobility resilience will be discussed.

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S10.3: Individual differences in response to mobility intervention in older adults: what's known and what's next?

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[1]Hebrew SeniorLife / Harvard Medical School

In older adults, interventions to improve physical activity and/or mobility are often effective when analyzed at the group level. However, responsiveness to intervention often varies considerably from individual to individual, even if the number and severity of baseline risk factors are relatively similar. There are numerous interconnected physiological factors that drive this inter-individual variance in adaptive capacity. These factors appear to include, among others, the individual's motivation, their baseline functional level and aspects of their physiology including muscle-brain cross-talk, and their readiness for physical activity and behavioral change. The purposes of this presentation are to 1) describe factors contributing to inter-individual variance in the responsiveness to physical activity and/or mobility interventions in older adults, and 2) encourage collaborative efforts to better understand and exploit these factors in order to optimize interventions for each individual older adult. The speaker will first review available evidence suggestive of potentially modifiable factors that influence an individual's ability to adapt and benefit from intervention. The speaker will then review results and provide tangible examples from a pilot clinical trial designed to improve goal-directed physical activity within relatively inactive older adults through the use of a personalized behavioral intervention combined with noninvasive brain stimulation. The talk will end with a discussion of how to utilize this information to inform the design of patient-centered approaches aimed at improving physical activity and mobility in vulnerable older adults.

S10.4: Dopaminergic vulnerability and motor impairments in the elderly: Need for targeted pharmacotherapy

Nicolaas Bohnen[1]

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Motor impairments, including slow walking, are common in the elderly in the absence of prototypical Parkinson's disease (PD). The etiology of such disturbances is heterogeneous and multi-system in nature. Dopamine is a key neurotransmitter involving motor, cognitive and behavioral circuitry. Normal aging is associated with substantial dopaminergic losses in the brain. However, some older adults have an accelerated decline with age resulting in mild Parkinson-like motor changes Recent dopamine-replacing treatment effects on gait and balance in older adults will be reviewed. Brain and muscle energetics that may play a role in selective benefits will also be discussed. Prior dopaminergic therapy studies have shown overall limited effects in non-PD elderly. A major limitation of these studies is the non-targeted selection of the elderly study population calling for personalized medicine approaches. More recent dopaminergic treatment studies targeting specific sub-groups of non-PD elderly will be discussed.

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Oral Abstracts:

Oral 1: Brain activity

O.1.1: Application of permutation entropy to detect motivational changes in fNIRS signals during gait

Sarah Schwab[1], Nicole Carver[1], Dalton Cooper[1], Sarah Doren[1], Pierce Boyne[1]

[1]University of Cincinnati

BACKGROUND AND AIM: Motivational environments are known to positively contribute to physical performance and motor skill acquisition. Recent research suggests that when under "extra motivational" conditions during gait, non-disabled adults show increased gait speed and increased magnitude of brain activation across most of the cortex using functional near-infrared spectroscopy (fNIRS). Brain activity is typically indexed by analyzing fNIRS signals in terms of the mean (eg, mean oxygenated hemoglobin, deoxyhemoglobin). Entropy approaches have also been proposed as useful complementary methods for analyzing fNIRS signals. Entropy methods consider the predictability or regularity of a time series, and in doing so, may provide additional insights into the underlying dynamics of brain activity. The aim of this study was to apply permutation entropy (PE) to fNIRS signals during gait to determine if different motivational environments influence regularity. METHODS: Twenty-six non-disabled adults (age: 24.8 ± 3.9 years) participated. Participants performed a single-visit gait experiment, which included 20 trials of maximal speed overground walking (12m x 4/trial). Ten trials were randomized to include "extra" extrinsic motivation (eg, lap timer, verbal encouragement). The other 10 trials did not include such motivators ("standard" trials). Oxygenated hemoglobin (HbO) response was measured using a portable fNIRS system (NIRSport2) from six regions of interest: superior frontal gyrus medial area 9 (SFG9m), primary motor cortex lower limb region (M1-LL), supplemental motor area, dorsal premotor cortex, anterior prefrontal cortex (aPFC), and dorsolateral prefrontal cortex. HbO data were analyzed using PE to characterize the regularity of HbO signals. Mixed effects models compared PE between the different motivational conditions and brain regions. RESULTS: There was a significant effect of motivational condition on PE in the aPFC, $F(1, 435.12) = 4.22$, $p = .04$, $d = -0.29$, such that PE was higher in the standard motivation condition ($M = 0.927$, $SE = 0.006$) compared to the extra motivation condition ($M = 0.918$, $SE = 0.006$). PE was higher in M1-LL compared to all other brain regions of interest regardless of motivational condition. A moderate, positive association was found between the PE difference (standard vs. extra motivation) and self-determination in the aPFC, $r(24) = 0.47$, $p = .01$, such that a greater difference in PE between motivational conditions was associated with greater self-determination. CONCLUSIONS: This study provides early evidence to suggest that different motivational environments during gait influence not only the magnitude of fNIRS signals, but also the regularity of signals in the aPFC. Importantly, these PE differences found in the aPFC were positively associated with individuals' self-determination, suggesting a possible role of the aPFC in motivation for gait activity.

O.1.2: When freezing causes a shutdown! An fNIRS study on complex stepping in people with Parkinson's disease

Paulo Pelicioni[1], Stephen Lord[1], Yoshiro Okubo[1], Jasmine Menant[1]

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[1]University of New South Wales

Background and aim: People with Parkinson's disease (PD) who experience freezing of gait (FoG) are at increased risk of falls, particularly in situations relying on anticipatory postural adjustments (e.g., turning) [1]. Previous research has shown increased prefrontal cortex activity in people with PD during FoG [2]; however, other cortical areas, such as the supplementary motor area and premotor cortex, involved in movement preparation and sequencing of movement, are understudied. Thus, we investigated cognitive and motor cortical activity during simple and complex stepping tests [3] using fNIRS (functional near-infrared spectroscopy) in people with PD experiencing FoG (PD+FoG) or not (PD-FoG) and healthy older adults. Methods: Fifty-two people with PD (PD+FoG, n=17; PD-FoG, n=35) and 95 healthy older adults participated in the study. All participants performed a simple choice stepping reaction time test (CSRT) and two cognitively-demanding stepping tests (inhibitory CSRT and Stroop stepping task) on a computerised step mat. Cortical activity was determined as relative changes in oxygenated (HbO), and deoxygenated (HbR) haemoglobin concentrations in the prefrontal cortex, supplementary motor area and premotor cortex using fNIRS. The stepping outcomes were: (i) decision time: the time from stimulus onset to foot lift-off; (ii) movement time: the time between lift-off and touchdown onto the correct step panel. Results: Overall, the healthy older adults group had faster decision and movement stepping times than the PD groups ($p<0.05$). Compared with the PD-FoG, the PD+FoG showed slower decision times in all tests ($p<0.05$) but not movement times. There were no between-group differences in cortical activity during the CSRT and inhibitory CSRT; however, in the Stroop Stepping task, the PD+FoG exhibited reduced cortical activity in prefrontal cortex (HbO, $p=0.009$/ HbR, $p=0.003$), premotor cortex (HbO, $p=0.007$/ HbR, $p=0.012$) and supplementary motor area (HbO, $p=0.018$/ HbR, $p=0.043$) compared with the healthy older adults group. Conclusions: People with PD with FoG have a reduced ability to compensate for their motor deficits during a complex stepping test as suggested by reduced cognitive (prefrontal cortex) and motor (premotor cortex and supplementary motor area) cortices activity, a "shutdown" phenomenon. Strategies to overcome this neural inefficiency are needed for PD+FoG to reduce their risk of falling [1] and improve their quality of life. Reference 1. Pelicioni et al., 2019. Doi: 10.3390/ijerph16122216 2. Belluscio et al., 2019. Doi: 10.16/j.neuroscience.2019.07.024 3. Pelicioni et al., 2019. Doi: 10.1177/1545968320969943 Acknowledgements and funding: Dr Pelicioni was a recipient of a Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) PhD scholarship [Grant number: BEX 2194/15-5]. Stephen Lord is supported by an NHMRC Research Fellowship. Parkinson's NSW funded the research project.

O.1.3: Effects of an exercise intervention on balance, gait, brainplasticity and exercise responsiveness in Parkinson's disease

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BACKGROUND AND AIM: Parkinson's disease (PD) has a detrimental impact on balance, gait, and cognition. Evidence suggests that exercise can improve balance and gait performance and induces changes in the neural system. The EXPANd trial investigated the effects and responders to a highly challenging balance and gait training (HiBalance) program on gait and balance as well as corresponding changes in brain structure and activity in people with PD. METHODS: This double-blinded randomized controlled trial (RCT) included 95 mild to moderate PD (mean age 71 years) that were assigned to either the HiBalance (n = 48) or an

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active control speech training program (n = 47). The group-based interventions were performed twice weekly over a 10-week period with the addition of a weekly home exercise program. Participants underwent balance (Mini-BESTest) and gait (GAITRite) as well as functional (fMRI) and structural (sMRI) magnetic resonance imaging (3T Phillips Ingenia) assessments before and after the intervention. We used multilevel models to assess intervention effects. To explore responders to the HiBalance intervention (n=39), we defined responders according to change in Mini-BESTest and gait velocity as high, low or non-responders (Mini-BESTest: high=increased ≥3points, low=increased 1-2 points, non= no response or decreased; gait velocity: high=increased ≥0.14m/s, low=increased ≥0.04m/s and non=≤0.04 m/s). RESULTS: We found no significant group-by-time effect on balance performance (b = 0.4 95% CI [−1, 1.9], p = 0.57) nor on gait velocity (b = 0.05 95% CI [−0.03, 0.12], p = 0.25). A preliminary explorative responders analysis showed, that in the HiBalance group, 10 participants were high responders, 13 were low responders, and 16 showed no response or decreased in balance performance after the intervention. This pattern was similar with regards to gait velocity, 11 participants were high responders, 11 were low responders and 17 were non-responders. Regarding the brain alterations, there were no significant group-by-time interaction effects in the fMRI data in the striatum, the frontal areas, or elsewhere in the brain. sMRI data showed no group-by-time interaction between the groups in balance, gait, or brain volume. Within-HiBalance group analysis showed higher left putamen volumes post-training. We also found community structure changes and stronger thalamic-cerebellar connectivity in the HiBalance group and not in the active control group. CONCLUSION: The findings contrast previous studies of the HiBalance program but are congruent with other double-blinded RCTs of exercise in PD. The divergent results and the mix of responders and non-responders also raise important questions on who benefits from exercise interventions and how to optimize exercise for people with PD. The subtle structural brain changes that were seen after the HiBalance program need further research but are in line with a recent meta-analysis of exercise effects revealing that structural changes are easier to confirm than functional. ACKNOWLEDGEMENT AND FUNDING: We express our gratitude to the participants and funders (the Swedish Research Council, the Swedish Parkinson Foundation as well as Karolinska Institutet and Region Stockholm).

O.1.4: Post-perturbation sensorimotor beta power could be a cortical biomarker of falling

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Background: Previous studies have indicated that cortical beta frequency (13-30Hz) oscillations might be related to sensorimotor information processing and changes in ongoing motor behavior. A recent study indicated that sensorimotor beta power is increased with increasing perturbation magnitude and is higher in young adults with lower balance ability. However, most of previous studies delivered stance perturbations and with perturbation magnitudes which might not be large enough to elicit laboratory falls. Hence, it is still not established whether there is a cortical basis of falling. In our recent pilot study, healthy young fallers demonstrated larger perturbation-evoked N1 potential compared to non-fallers following large-magnitude gait-slips. The present study is the first to examine differences in sensorimotor beta power before and after unpredicted overground gait-slips between healthy young fallers and non-fallers. Methods: Twenty healthy young adults (12 female/8 male; ages 18-35) were exposed to a single, novel, large-size (slip distance=65cm) right-sided slip during

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walking. Brain activity was recorded using 32-channel wireless electroencephalography (EEG) device with an in-built low pass filter of 500Hz. Using single-trial EEG analysis, beta power was extracted during two time-bins and baseline corrected: pre-perturbation (300 ms before slip onset) and post-perturbation (0-300 ms i.e., from slip onset to recovery limb touchdown) focused over motor cortical areas (Cz electrode). A fall was detected if the peak load cell force following a slip exceeded 30% of the participant's body-weight for at least 1 second after slip-onset. For statistical analysis, a 2×2 ANOVA was conducted to assess the main effect of time (pre/post perturbation), group (fallers/non-fallers) and their interaction on beta power at Cz. Results: All participants experienced a backward loss of balance upon a novel slip exposure. 35% (8/20) of participants experienced a fall. The 2×2 ANOVA showed time* group interaction on beta power. There were no group differences in beta power during pre-perturbation time bin ($p>0.05$). Although both groups demonstrated increase in beta power post-perturbation ($p<0.01$), fallers showed higher beta power post-perturbation compared to non-fallers ($p<0.001$). Conclusion: Sensorimotor beta power might be a neurobiomarker of falls. Healthy young fallers exhibit higher beta power post-perturbation, which could suggest the need for greater recruitment of cortical resources for sensorimotor processing and balance recovery. However, the greater spatial modulation of beta power post-perturbation might have been temporally inefficient to impede a fall. Thus, higher post-perturbation beta power might be related to impaired reactive balance control in healthy young adults. The results suggest cortical governance possibly to modulate reactive balance control and slip fall/recovery outcomes.

O.1.5: Effect of directional deep brain stimulation on action inhibition during gait initiation in patients with Parkinson's disease

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BACKGROUND AND AIM: Gait disorders especially freezing of gait (FOG) are the most disabling symptoms in Parkinson's disease (PD) patients. FOG has been reported to be partly related to dysfunction of the supplementary motor area (SMA)-basal ganglia-brainstem pathways, with possible exaggerated inhibitory processes. Subthalamic deep Brain Stimulation (STN-DBS) is highly efficient to treat motor and non-motor signs of PD but its therapeutic efficiency on gait disorders and falls is variable among patients with an aggravation reported in about 1/3 of cases after surgery. Here, we aimed to assess the effects of directional STN DBS applied in sensorimotor (SM) and more anterior part of the STN, i.e. within the "hotspot FOG" determined in a previous retrospective study, on gait initiation performances during a modified GO/NOGO task that includes inhibitory processes and in a double-blind randomized controlled study. METHODS: We assessed gait and balance disorders using validated clinical scales and gait recordings in PD patients candidate for STN-DBS, before surgery OFF and ON Dopa, and 6 months after surgery with single-ring and directional STN-DBS. Gait recordings was done using a force plate and a motion capture system. The gait initiation task consisted of initiating gait following a visual cue: 1) at each Go signal without uncertainty (Go certain), or 2) with uncertainty in a Go/No Go task (Go uncertain and NoGo) depending the shape of the visual cue. We measured the reaction time (RT) and spatiotemporal parameters of gait initiation, and compared the results obtained in the different DBS conditions. RESULTS : Up to now, 9 PD patients (7M/2F, age= 60.7 ± 5.7 years, disease duration=11.7 ± 3.3 years) with FOG (FOG-Q = 25 ± 4.8) and severe parkinsonian disability (Movement Disorders Society-Unified

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Parkinson's Disease Rating Scale part III [MDS-UPDRSIII] OFF = 42.6 ± 12.7) were operated and assessed at 6 months. We found a significant lower RT during Go certain vs Go uncertain gait initiation in both SM and hotspot FOG conditions, and a significant lower RT with hotspot FOG relative to before surgery (ON Dopa, p<10-4). With Hotspot FOG relative to sensorimotor STN-DBS, we found a significant higher step length (p=0.02), medio-lateral center of pressure (CoP) displacement during postural adjustments (p<10-4), and vertical dynamic postural adjustments (p=0.03), in the Go certain condition. We found no significant difference between directional Hotspot FOG and SM STN-DBS for the Go uncertain condition. CONCLUSIONS: These preliminary results suggest that STN-DBS applied in a more anterior position within the hotspot FOG has better effects on gait initiation relative to sensorimotor STN-DBS, with less proactive inhibition. This could be related to the preferential modulation of the hyperdirect SMA-STN pathway with hotspot FOG relative to SM STN-DBS. ACKNOWLEDGEMENTS AND FUNDING: This study was supported by Boston Scientific, Agence Nationale de la Recherche

O.1.6: Associations between gait impairments and regional cerebral glucose metabolism in patients with isolated REM sleep behaviour disorder

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BACKGROUND AND AIM: Individuals with isolated rapid eye movement sleep behaviour disorder (iRBD) are at risk of developing synucleinopathies such as Parkinson's disease (PD) and dementia with Lewy bodies (DLB). Although iRBD is the prodromal stage of α-synucleinopathy, individuals may still display subtle gait impairments that are indicative of early neurodegeneration. Fluorodeoxyglucose-positron emission tomography (FDG-PET) is a neuroimaging method that can detect early-stage neuronal changes by measuring cerebral glucose metabolism. Previous research using FDG-PET has shown abnormal metabolic activity in iRBD. However, it is not yet understood whether this abnormal activity is associated with gait. Therefore, the main aim of this study was to assess the associations between FDG-PET and gait among iRBD patients. METHODS: 12 individuals with iRBD (Age: 66.43 ± 8.75 years, 5 females) and 12 healthy older adults (HC) (Age: 66.35 ± 8.68 years, 5 females) were selected from the Mayo Clinic Study of Aging. The HC group was matched on age, sex, and education level. Participants underwent gait assessment using a GAITRite carpet and resting state FDG-PET imaging. Gait and FDG-PET variables were compared between the iRBD and HC groups using independent t tests. To assess the relationship between glucose uptake and gait, Pearson's partial correlations were performed between FDG-PET standardized uptake value ratios (SUVR) for the regions of interest (ROIs) and gait measures, controlling for age. ROIs were selected based on covariance patterns previously characterized in iRBD, PD, and DLB: the thalamus, precentral gyrus, temporal, parietal, occipital, precuneus, and pallidum regions. The gait measures of interest were velocity, cadence, double support time (DST), and swing time variability. RESULTS: Only thalamus SUVR [95% CI, 0.015, 0.14, t(22) = 2.565, p= .018] and cadence [95% CI, 0.92, 13.2, t(22)= 2.385, p = .026] were significantly different between groups. In the iRBD group, greater swing time variability was significantly correlated with occipital (r= −.739, p = .009), parietal (r= −.625, p= .04) and precuneus (r= −.745, p= .008) hypometabolism. Higher DST was significantly correlated with thalamus hypermetabolism (r= .645, p= .032). No significant correlations were observed between any gait variables and FDG-PET in any ROIs in the HC group. CONCLUSIONS: This study shows that cerebral glucose metabolism is associated with gait function in iRBD, specifically in areas that also show

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abnormal glucose metabolism in DLB and PD. Given that swing time variability is higher in PD than HC and DST is higher in PD and DLB than HC, the associations in this study provide evidence that subtle gait impairments reflect early neurodegeneration in iRBD. These results also suggest that these unique associations may be used to predict who is at risk for developing synucleinopathies since hypometabolism in the occipital and precuneus regions have been shown to be associated with higher phenoconversion rate to PD and/or DLB. Additionally, predicting whether an individual with iRBD will develop PD or DLB may also be possible. Understanding the relationship between cerebral metabolic function and gait in iRBD may contribute to early diagnosis and treatment.

Oral 2: Lifespan

O.2.1: Trunk postural control and adaptability in children with modest and severe brain injury

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BACKGROUND AND AIM: Moderate-to-severe cerebral palsy (CP) is associated with postural impairments in trunk control. However, this population is typically excluded from research due to their complex clinical features (eg, lack of verbal communication and wheelchair dependence). We begin with a summary of our first-ever systems identification quantification of the postural control system in children with moderate-to-severe CP [1]. Then, we present more recent work examining how neural control changes when external trunk support is provided. Specifically, external support simplifies the balance task (fewer degrees of freedom needed to control) and improves daily function. However, does external support also catalyze the use of more mature reactive postural control or do abnormal neural processes continue regardless of external support? METHODS: An external surface tilt stimulus, containing a wide bandwidth of frequencies, evoked trunk responses in eight sitting children with CP (ages 2.5 to 13 yr) across several test sessions. Postural sway was described through root-mean-square sway and frequency response functions (magnitude and phase/timing). Further quantification of the postural control system used a feedback control model that included an inverted pendulum stabilized by corrective torque mechanisms based on body sway (stiffness), sway velocity (damping), and summation of sway over time (integral control). Experimental sway metrics and model parameters were compared between CP and healthy subjects and between two levels of external support. RESULTS: Compared to healthy subjects, results for children with CP showed large RMS sway, FRF gains, and increased variability. Modeling showed that subjects with CP adopted "simple" control with major contributions from a passive and reflexive mechanism and only a small contribution from active sensory integration. Relative to their body size, subjects with CP had higher stiffness, significantly lower damping, 3-5 times larger corrective torque, and much higher sensorimotor noise compared with a healthy mature system. When additional support was provided, children with CP improved postural control in some ways: increased damping and decreased sway. However, other features indicated less mature control: significantly heightened stiffness, significantly less integral control, less adaptability, and further evidence for simple control with minimal visual and vestibular integration. CONCLUSIONS: Children with moderate-to-severe CP may use a simple control

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system with significant sensorimotor noise. Providing trunk support may aid subjects in daily activities by lowering postural sway via increased stiffness and damping. However, additional support does not spontaneously enable the nervous system to demonstrate mature postural control. [1] Goodworth A.D. & Saavedra S. (2021). Postural mechanisms in moderate-to-severe cerebral palsy, J Neurophysiology, 125(5):1698-1719 ACKNOWLEDGEMENTS AND FUNDING: NSF Award: 2015660 (PI: Goodworth)

O.2.2: Coordination during running and walking in children with Developmental Coordination Disorder and typically developing children when synchronization with metronomes

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Background and aim Developmental Coordination Disorder (DCD) is characterized by deficits in motor coordination, planning and automatisation. These deficits rely on timing and temporal prediction. The internal modelling deficits hypotheses is proposed to explain these impairments in motor coordination. Within this model, sensory and motor predictions regulate motor coordination. Sensorimotor synchronisation tasks can be used to investigate if regulating these predictions, influence motor coordination; for example by asking to align a rhythmic motor task to rhythms in metronomes. To date, no study investigated coordination and sensorimotor synchronisation in children with DCD during simple, and more complex dynamic tasks such as walking and running. Walking and running require rhythmic coordination of the lower legs to effectively constrain the center of mass within their dynamic base of support. Locomotor coordination specify this rhythmic coordination during gait. Therefore, this research investigates locomotor coordination related to synchronisation while walking and running in DCD and typically developing children (TDC). Methods Children with a diagnosis or probably DCD from 8 to 12 years and age-matched TDC participated. Children walked and ran at comfortable tempo for 3 minutes in an oval-path, in 2 conditions (silence, metronomes). Locomotor coordination was expressed by the phase coordination index (PCI), a measure of accuracy and consistency of antiphase stepping. Two synchronisation outcomes were calculated: tempo matching (%cadence/beats per minute) and beat-step synchronisation consistency, which is expressed by the resultant vector length (RVL), ranging from 0 (low consistency) to 1 (high consistency). Mixed model analysis ANOVA (task, group) was performed for data analysis for each outcome per condition (silence, metronomes). The difference in locomotor coordination between silence and metronome conditions was checked using a mixed model ANOVA (group, task, condition). Results Twenty children with DCD and 23 TDC have been included. During the silence condition, children with DCD displayed an atypical locomotor coordination, expressed by a significantly higher PCI ($p=.003$) than TDC while walking (DCD PCI: 8.15%;TDC PCI 6.82%) and running (DCD PCI: 8.90%;TDC PCI 5.92%). Children with DCD matched their cadence with the metronome beats as TDC ($p=.22$) while walking (mean tempo match DCD 100.79%;TDC 100.20%) and running (mean tempo match DCD 99.76%;TDC 99.54%). However, children with DCD synchronized less consistently while walking and running than their peers (DCD RVL: 0.47;TDC RVL walking: 0.75; (running: DCD RVL: 0.37;TDC RVL running: 0.73, ($p<.0001$). Overall, locomotor coordination (PCI) changed positively when running to metronomes ($p=.0031$). Conclusion Results show that children with DCD have an atypical interlimb coordination and a lower synchronisation consistency while walking and running to metronomes compared to TDC. However, metronomes seams to positively influence locomotor coordination during running. These

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results might be used to develop task-oriented interventions for DCD involving auditory-motor synchronisation. Acknowledgements and funding This research was supported by FWO fundamental research.

O.2.3: Comparing anticipatory postural control between DCD, CP and TD children, is there a continuum?

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BACKGROUND AND AIM: Up to 87% of children with developmental coordination disorder (DCD) have balance control deficits, especially during voluntary movements. To anticipate destabilizing forces caused by such movements, anticipatory postural adjustments (APA) are required, which activates the postural muscles in a feedforward manner. Although the feedforward mechanisms of movement in DCD have been hypothesized to be at the basis of the disorder, it is currently unknown whether children with DCD show deviant or delayed development of APA. Evidence suggests that cerebral palsy (CP) and DCD are on a continuum concerning APA deficits, emphasizing a deviant nature of DCD. However, there are also studies highlighting that DCD children catch up when getting older making them more comparable to typically developing children (TDC). We therefore aim to explore the existence of a continuum of APA during a functional balance control task. METHODS: Children aged 5-10 years with DCD, CP and TD were recruited via schools, referral centers, private practices. All children performed 6 one-leg-stance (OLS) trials alternately on both legs (3 left/3 right). Simultaneously, surface electromyography (sEMG) was recorded bilaterally of the following muscles: Erector Spinae, Gluteus Medius, Rectus Femoris, Biceps Femoris, Tibialis Anterior and the Gastrocnemius (lateral head) and 3D accelerometry was recorded on both feet (TrignoTM system, Delsys Inc.). The onset of OLS was determined by the accelerometry signal of the lifted foot. After filtering EMG signals per trial, onset latencies, time-to-peak (TTP) and co-activation rates were calculated using a custom-made MATLAB codes. Statistical analyses were performed on the median values of three trials per side (preferred/non-preferred). A Kruskal-Wallis test with post-hoc analysis and Bonferroni correction identified differences. Significance was set at .05. RESULTS: In this ongoing study, 9 children with DCD (7.48-10.95 years), 7 with CP (6.42-8.68 years, GMFCSI:3/II:4, bilateral:4/unilateral:3) and 11 with TD (6.01-9.74 years) were analyzed. The Kruskal-Wallis test revealed significant differences among the 3 groups of the non-preferred side in the stance leg: between the median TTPs (ms) of Rectus Femoris (p=.047), Gluteus Medius (p=.027), and Gastrocnemius (p=.035) and co-activation rates (%) between Rectus and Biceps Femoris (p=.009). Post-hoc analyses revealed significant longer co-activation of Rectus and Biceps Femoris between CP and TDC (p=0.03). The remaining parameters revealed no significant differences, but the median onset latency of Biceps Femoris was borderline significantly different between the three groups (p=.085). Individual and group results are illustrated in a figure. CONCLUSION: Our preliminary results seem to support the existence of a continuum of APA, where DCD lies between CP and TDC. However, the DCD group presents with heterogeneous results and overlaps with both groups. Still, some children present with difficulties in APA which suggests that these children present with feedforward mechanism deficits. These deficits in APA are consistent with the internal modelling deficit (IMD) hypothesis of DCD. This IMD hypothesis can be further explored in a larger sample.

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O.2.4: Sensory weighting for postural control in children with strabismus: A preliminary analysis from a longitudinal investigation

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Background and aim: Strabismus (misalignment of eyes) is a relatively common childhood ophthalmic disorder affecting at least 2% to 5% of preschool and school-aged children irrespective of ethnicity and geography. Appropriate visual input is crucial in the early years of life to develop effective postural control, by playing an important role in coordinating the body's three sensory systems - namely visual, vestibular, and somatosensory systems. Previous cross-sectional investigations have suggested that children with strabismus have impaired postural control when compared with their age-matched counterparts. The specific aim of this preliminary analysis was to investigate if the sensory weighting for postural control changes over time in children with and without strabismus. Methods: A sample of 24 children with strabismus (study group) and 22 age-matched control participants (control group) were assessed at baseline and 6 months on the following variables: Sensory Organization Test (SOT), BOT® Balance subscale, and Paediatric Balance Scale (PBS). The SOT of the NeuroCom Smart Equitest® consists of six sensory testing conditions (1 to 6) where the sensory system available for postural control is systematically manipulated. Participants' performance on a 20s trial in each of the six sensory testing conditions was scored as a percentage measure of balance (Equilibrium Score) and a weighted summary score across the six conditions (Composite Score). The BOT (0-32) and PBS (0-56) consist of a series of balance assessment tasks which were scored numerically on the items and reduced to a summary score. Analysis of covariance (ANCOVA) was used to compare the main effects on the following key outcome measures: Composite Score and six Equilibrium Scores of the SOT, the summary scores of BOT® and PBS, with groups as fixed effects, timeline as random effects, and age as a covariate. Results: A significant group effect (between-participants, $p<0.001$; F statistic ranging between 71.83 and 2701.76) was found for PBS and ES of the SOT condition 3 (sway-referenced surround - manipulating visual information) and condition 4 (sway-referenced support - manipulating peripheral somatosensory information) and composite score, when adjusted for age. There was no interaction between the groups and time, while ES of SOT condition 4 and composite score was significant between baseline and follow-up in both groups. Conclusion: The preliminary analysis suggests that the sensory weighting for postural control changes over time in children as they develop, and this reweighting phenomenon is different between children with and without strabismus. Funding: This project is funded by the Health Research Council of New Zealand.

O.2.5: Differences and similarities between muscle synergies underlying reactive, voluntary and motor simulated stepping in healthy young individuals

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BACKGROUND AND AIM. Reactive stepping is a final common saving strategy for preventing a fall after a loss of balance in daily life. Perturbation-based training improves reactive stepping, but requires expensive equipment and supervision. Voluntary step training can be done safely at home, but does not transfer to improvements in reactive stepping, as it involves a

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substantially different type of movement [1]. We were interested whether motor simulation of reactive stepping (i.e., stepping along as accurately as possible with an observed reactive step) may resemble reactive stepping more closely in terms of neuromuscular control. Therefore, we compared the structure and activation coefficients of synergies underlying reactive, voluntary and motor simulated stepping. METHODS. Electromyographic (EMG) signals were recorded from eight right leg and trunk muscles of sixteen healthy young subjects (24±2 y/o; 12 f) during three conditions (reactive, voluntary and motor simulated stepping). Each condition involved twelve steps of comparable step size in each of five directions (for-, side- and backward and diagonally for- and backward) in a random order with the right leg. Reactive steps were evoked by platform translations at 2 m/s². Voluntary steps were performed as fast as possible in response to a visual stimulus shown on a large screen in front. Motor simulated steps were performed by stepping along as accurately as possible with video-recorded reactive steps of a third person shown on the screen. EMG signals were filtered and time normalized from the moment of foot off to foot down. The lowest number of muscle synergies accounting for >= 80% of the variance were extracted using non-negative matrix factorization for each condition and subject. We calculated the mean of similar muscle synergies among subjects (Pearson's correlation coefficient (r) >0.5, if present in ≥50% of the subjects) to form group synergies (W) per condition. The structures and activation profiles of the group synergies were compared between conditions. RESULTS. The mean number of synergies was 3.7±1.0 for reactive stepping, 4.1±0.7 for voluntary stepping and 3.9±0.7 for simulated stepping. Four group synergies (W1-W4) were present in the majority of the subjects (9-15 out of 16) (Fig. 1). These synergies were highly similar in structure between conditions (r=0.85-1.00), but differed mainly in activation magnitude and pattern between the reactive stepping condition and the two other conditions, in particular for steps with a lateral component. CONCLUSIONS. The results show that the structure of synergies was largely similar across conditions, yet the activation coefficients were generally higher during reactive stepping. These differences in activation patterns were most pronounced for steps with a sideward component. Presumably, the higher synergy recruitment is due to reactive stepping being more challenging than volitional stepping from a biomechanically point of view. It involves arresting the movement of center of mass (COM) within the base of support in response to a sudden perturbation, instead of self-initiating the propulsion of the COM. It remains for further study to evaluate the potential benefits of motor simulation on reactive stepping. [1] Okubo, 2021.

O.2.6: Deep learning for age-related gait patterns classification based on raw accelerometer signal from 3 minutes walking

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BACKGROUND AND AIM: Gait pattern classification is important for healthcare, for instance to monitor age and pathology related gait changes and recognize groups. Conventional machine learning (CML) has been widely used in gait classification based on accelerometer. However, CML approaches rely heavily on handcrafted features, e.g. walking speed, step length, etc. The extraction of handcrafted features is laborious, requires expert knowledge, and may lead to suboptimal classification performance. In contrast, end-to-end Deep learning (DL) approaches consider feature extraction as a part of the model and therefore, can get rid of handcrafted features. DL has been preliminarily utilized for gait pattern classification. However, not all state-of-the-art DL approaches have been comprehensively explored. Therefore, this study aimed to: 1) Examine the classification performance of Convolutional DL

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model (Convolutional Neural Network (CNN)) which is good at local spatial-temporal features extraction, Recurrent DL models (Long Short-Term Memory (LSTM), Gated Recurrent Unit (GRU), bidirectional LSTM (biLSTM)) which are famous for learning long-time dependent features, and Hybrid DL model (Convolutional LSTM (ConvLSTM)) which combined the convolutional and recurrent structures; and 2) Compare with 4 CML approaches (Support Vector Machine (SVM), Naive Bayes (NB), K-Nearest Neighborhood (KNN), Random Forest (RF)) which use handcrafted gait features. METHODS: A total of 267 healthy adults were involved in this study and were divided into two sub-groups: the adult group (18-65, n=130) and the older adult group (>65, n=137). Each participant completed a 3 minutes walking task, and one 3D-accelerometer (100 Hz) was attached near the lumbar segment L3. Data were divided by subjects into training (n=186), testing (n=54), and validation (n=27) dataset. For each subject, the walking data were split into 1024-sample segments and 10 of segments were randomly selected. These raw acceleration data segments were fed to DL while 36 gait features extracted from each segment were used as input for CML. Bayesian optimization was used to tune the best hyperparameters for DL and CML based on the validation data. The classification performance comparison between DL and CML was evaluated by commonly used evaluation metrics (e.g. accuracy and the area under the receiver operating characteristic curves (AUC)). RESULTS: All DL achieved similar accurate performance (mean AUC = 0.96; mean accuracy = 0.89). SVM got the highest in CML (AUC = 0.82; accuracy = 0.73). CONCLUSIONS: The results show that DL outperformed CML by a significant margin and can get rid of handcrafted features. The accurate performance of convolutional, recurrent, and hybrid models may indicate that, the local spatial-temporal features and long-time dependent features both contain discriminated information for gait classification. It may be useful to combine the classification results of CNN, GRU, and ConvLSTM when making a diagnosis decision, because these approaches focus on different parts of the data and have their own strengths. This study may indicate that DL approaches with one accelerometer have the potential for accurate abnormal gait pattern classification and gait monitoring.

Oral 3: Falls

O.3.1: Physical activity as a risk or protective factor for falls and fall-related fractures in non-frail and frail older adults: a longitudinal study

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Background and aim: Physical activity may be both a risk and protective factor for falls and fall-related fractures. Despite its positive effects on muscle and bone health, physical activity also increases exposure to situations where falls and fractures occur. This paradox could possibly be explained by frailty status. Therefore, the aim of this study was to investigate the associations between physical activity and both falls and fractures, and to determine whether frailty modifies the association of physical activity with falls, and fractures. Methods: Data of 311 community-dwelling participants aged 75 years or older from the Longitudinal Aging Study Amsterdam, who participated in a three-year longitudinal study with five nine-monthly measurements between 2015/2016 and 2018/2019. Their mean age was 81.1 (SD 4.8) years

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and frailty was present in 30.9% of the participants. Physical activity in minutes per day was objectively assessed with an inertial sensor (Actigraph) for seven consecutive days. Falls and fractures were assessed every nine months using self-report during an interview over a follow-up period of three years. Frailty was determined at baseline using the frailty index. Associations were estimated using longitudinal logistic regression analyses based on generalized estimating equations. Results: No association between physical activity and falls was found (OR = 1.00, 95% CI: 0.99-1.00). Fall risk was higher in frail compared to non-frail adults (OR = 2.21, 95% CI: 1.33-3.68), but no effect modification was seen of frailty on the association between physical activity and falls. Also no relation between physical activity and fractures was found (OR = 1.00, 95% CI: 0.99-1.01). Fracture risk was higher in frail compared to non-frail adults (OR = 2.81, 95% CI: 1.02-7.75), but also no effect modification of frailty was present in the association between physical activity and fractures. Conclusions: No association between physical activity with falls or with fractures was found, and frailty appeared not to be an effect modifier. However, frailty was a risk factor for falls and fractures in this population of older adults. Our findings suggest that physical activity can be safely recommended in non-frail and frail populations for general health benefits, without increasing the risk of falls.

O.3.2: StandingTall to prevent falls: replication, learnings from telehealth and a meta-analysis

Kimberley van Schooten[1], Michele Callisaya[2], Mei Ling (Mae) Lim[3], Bridianne O?Dea[4], Thomas Lung[5], Kaarin Anstey[6], Stephen Lord[1], Helen Christensen[4], Alicia Brown[1], Lillian Miles[1], Michelle Ngo[1], Amy Perram[1], Peter Humburg[7], Kim Delbaere[1]

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BACKGROUND AND AIM: Falls are a growing issue among our ageing population. We have previously shown that StandingTall as a digital balance exercise program can reduce falls and fall-related injuries in community-living people aged 70 years and over by about 20%. We sought to replicate this finding in older people with a high risk for falls. We added cognitive-motor exercise and cognitive behavioural therapy for those with slow executive function and low mood, respectively. METHODS: We performed a randomised controlled trial with a one-year follow-up. We recruited 518 community-living people aged 65 years and over who had: 1) a self-reported concern about falling, 2) a history of 1+ falls in the past six months, and/or 3) were aged 80 years or over. Participants were randomly allocated to the health education control group or the intervention group. Participants provided monthly fall diaries (primary outcome: rate of falls over one year) and underwent an extensive assessment of physical activity levels, wellbeing, sensorimotor, cognitive and affective functions at baseline, 6 and 12 months. RESULTS: Statistical analyses are being finalised and we have not unblinded group allocation yet. We find an effect of 0.81 [95% confidence interval 0.61-1.06] on the rate of falls over one year for group B vs A. We find significant differences between group A and B in the amount of hours of standing in everyday life, standing balance, timed up and go, and 5 time sit-to-stand at 6 months, and planned activity, planned exercise, and quality of life at 6 and 12 months. We have yet to complete the analysis of the rate of falls over 6 months, the rate of injurious falls, faller status and our wellbeing, cognitive and affective outcomes. CONCLUSIONS: In addition to our unblinded trial results, I will discuss what we have learned about conducting a completely remote trial using technology in older people to reduce COVID19 infection risk and increase our reach. I will further combine the results of the current

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and previous studies to come to a more precise effect estimate. ACKNOWLEDGEMENTS AND FUNDING: This study was funded by Australian National Health and Medical Research Council grant APP1139673. KSvS was supported by a Human Frontier Science Program Fellowship (LT001080/2017). TL was supported by a NHMRC Early Career Fellowship (APP1141392) and National Heart Foundation Postdoctoral Fellowship (award ID 101956). SRL and KD were supported by Investigator Grants by the Australian National Health and Medical Research Council (APP1117171, APP1105106). The funders did not have a role in study design; in the collection, analysis, and interpretation of data; in the writing of the report; and in the decision to submit the paper for publication.

O.3.3: Predictors of real-world adherence to prescribed home exercise in older patients at risk of falling: a prospective observational study

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Background and aim: Poor exercise adherence negatively affects the efficacy of therapies and is a multifactorial problem. Studies examining predictors of adherence to falls prevention home exercises in older adults are limited and findings have been inconsistent. This study aimed to (1) evaluate real-world adherence to prescribed home exercise designed to reduce fall risk in a multi-ethnic Asian population; (2) explore factors that predict adherence to prescribed home exercise programs; and (3) determine any association between home exercise adherence and physical activity at 6 weeks. Methods: A prospective cohort study was conducted in older adults (n = 68) aged over 64 years from two geriatric outpatient clinics in Singapore, who were receiving tailored home exercise while undergoing six weeks of outpatient physiotherapy for falls prevention. Adherence was measured as the percentage of prescribed sessions completed. Predictor variables collected at baseline included sociodemographic, clinical characteristics, intervention-specific factors, physical, and psychosocial measures. Univariate and multivariate linear regressions were used to develop a model that best predicted adherence to prescribed home exercise. Physical activity levels measured by accelerometry, were compared across adherence levels at six weeks. Results: The mean adherence rate to prescribed home exercise was 65% (SD 34%). In the final multivariate regression model, the number of medications (B=0.36, 95%CI [0.098 to 0.63]), social support for exercising (B=0.08, 95%CI [0.015 to 0.145]), and self-efficacy for exercising (B=-0.034, 95%CI [-0.068, 0.00]) significantly explained 31% (R2 =0.312) of the variance in exercise adherence. Older adults with better adherence took more steps/day at six weeks (B=0.001, 95%CI [0.00, 0.001]). Conclusions: Adherence to prescribed home exercise programs is challenging, and varies, for many older adults in Singapore. Counterintuitively, older adults who take more medications and have greater social support, but also have a lower level of self-efficacy for exercise, adhere to exercise to a greater degree. Clinicians should consider that home exercise may have a greater impact on these individuals. Clinicians should consider how exercise programs are prescribed to increase the likelihood of success, and given individual variation, collaboratively solve barriers to adherence rather than use a one size fits all approach. Keywords: Exercise; Patient compliance; Rehabilitation; Aged; Accidental falls

O.3.4: Does fear of falling affect neural efficiency during walking in older people?

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BACKGROUND AND AIM: Little is known of the neural underpinnings of the attentional load of people with fear of falling during walking. This project aimed to investigate the effect of a fear-inducing walking paradigm on neural efficiency in the prefrontal cortex (PFC) of older people. We hypothesised that compared to older people without FOF, those with FOF would exhibit neural inefficiency in the PFC (i.e. higher brain activation associated with similar or worse dual-task walking performance [1]), after being exposed to a fear-inducing stimulus. This hypothesis was publicly registered on the Open Science Framework prior to data collection (osf.io/gjdw7). METHOD: Healthy older people were categorised as having low (n=15) or high (n=29) FOF (<23 and ≥23 on the Falls Efficacy Scale-International) and fitted with a mobile brain imaging system (functional near-infrared spectroscopy, fNIRS). Participants performed dual-task trials, involving walking and completing a cognitive task, before and after viewing a video of older people encountering unexpected trips on the same walkway (fear-inducing stimulus). The cognitive task required participants to identify the number of times the letter "B" was displayed on a monitor at the end of the walkway. We used mixed-models repeated measures ANOVA to investigate the interaction between groups (low vs. high FoF) and condition (pre vs. post-video trials) on PFC activation, walking speed and step length. We also looked at the change in performance in cognitive task errors from pre to post-video trials between groups, using chi-square tests. RESULTS: Preliminary analysis of the first 44 participants (mean (SD) age: 72.1 (3.9) years) showed no significant group by condition interaction or main effects of group or condition on PFC activation. The change in performance between pre and post-video was similar across groups. However, in both groups, mean step length and gait speed were significantly lower in initial post-video trials relative to pre-video trials. CONCLUSIONS: Our results thus far do not provide evidence of neural inefficiency induced by FoF in older people performing a complex walking task. Final analyses of our complete sample (n=66, based on a-priori sample size calculation) will be presented at the conference. Reference: 1. Holtzer R et al. The effect of fear of falling on prefrontal cortex activation and efficiency during walking in older adults. Geroscience. 2019;41(1):89-100.

O.3.5: Trajectories of mobility outcomes after hip fracture: a time series analysis

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Background and aim: Regaining mobility after a hip fracture is key to recovery. Therefore, it is a major aim of treatment and rehabilitation. Currently, few sensor-based mobility data is available to analyze recovery trajectories after hip fracture surgery. Aim of this study was to pool data from 4 clinical trials to model mobility recovery of different digital mobility outcomes (DMOs) up to 12 months after treatment. Methods: Two cohorts are from Trondheim (Trondheim Hip Fracture Trial, n=357; EvaHip, n=130), Norway and two from Stuttgart (PROFinD 1, n=112; PROFinD 2, n=185), Germany. Inclusion criteria was surgery after femur fracture (age ≥65 years). All cohorts assessed physical activity at three time points during follow-up. Some overlapped between cohorts, some not. Measurement was performed using the activPAL3 accelerometer (PAL Technologies Ltd., Glasgow, Scotland) in all cohorts. The sensor was continuously attached on the thigh for up to 7 days at each time point. The device estimates the durations for walking, standing, and sitting/lying as well as the number of steps

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and sit-to-stand-transfers. Three DMOs were derived to estimate trajectories: walking duration in minutes, maximum number of steps per walking bout, number of sit-to-stand-transfers. Multi-level regression analyses based on fractional polynomials were calculated to estimate the DMO trajectories. In a second step, different trajectories within each DMO were calculated by latent class analysis. The number of classes (2 or 3) was selected based on model fit and clinical considerations. Probabilities for class membership were quantified by odds ratios. Results: The study population consists of 785 patients (76.4% female), with a mean age of 83.4 (SD=6.1) years. Average gait speed was 0.56 (SD=0.22) m/s. The characteristics are comparable between cohorts. The trajectory for daily walking duration increased until week 28 up to about 50 min. with a small decrease afterwards. About 50% of peak mobility was achieved within the first 4 weeks after surgery. The pattern for maximum number of steps per walking bout was similar, but the maximum was achieved first at day 40 (about 200 continuous steps). For number of sit-to-stand-transfers a steep increase was observed within the first weeks after surgery. After week 16, the number of transfers remained stable at about 40. Further separation of trajectories revealed different classes with considerably different outcomes. For example, for daily walking duration three classes achieved values at month 6 of about 25 min. (proportion=75.4%, mean age=84.1 years), 80 min. (19.8%, 81.5 years), and 130 min. (4.9%, 79.3 years), respectively. Conclusions: The results provide a deeper insight in patterns and achievements during mobility recovery from hip fracture surgery. It was possible to identify classes of recovery trajectories within each DMO and describe their characteristics. The results reflect potentials of rehabilitation but also remaining gaps.

O.3.6: Effects of motor inhibitory control during voluntary gait initiation in young and older adults

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BACKGROUND AND AIM: Age-related changes in inhibitory control (IC) are associated with reduced gait adaptability, balance recovery and an increased fall risk. However, since most studies of IC during motor tasks focus on upper extremity tasks (e.g. Stop signal tasks), it is unclear how IC may directly affect balance performance. A recent scoping review of studies investigating balance performance on tasks requiring IC, demonstrated that the few available studies show a large heterogeneity of task conditions and outcome measures and that not much attention has been given to motor inhibition; i.e. the ability to suppress an incorrect motor action. Therefore, we designed a novel gait initiation task which requires a person to block gait initiation in response to a stop signal. Our study aims to determine how different latencies of the stop signal affect voluntary inhibition of gait initiation and balance in young (YA) and healthy older adults (OA). METHODS: Participants (23 YA and 45 OA) were instructed to initiate gait promptly when presented with a "Go" signal (a green light). In some of the gait trials, a "Go" signal was followed by a "Stop" signal (red light) which required the person to immediately block gait initiation and remain standing. The gait initiation task comprised 3 blocks, each consisting of 9 Go and 3 Stop trials. Randomized stop signals were presented with three different delays, and after data-acquisition, the exact timing of a stop signal was determined in relation to onset of gait initiation (i.e. onset of a posterior shift in CoP). Data analyses focused on Stop trials and comprised changes in Centre of Pressure (CoP) position (as measured by a Bertec force plate (1000 Hz)), as well as changes in foot position, success of blocking gait initiation, and the Margin of Stability (MoS) (as measured by a Qualisys motion capture system (100 Hz)). RESULTS: The state of gait initiation at a stop signal depended on the latency of the

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stop signal after onset of gait initiation. Thus, different delays of stop signals presented a person with different degrees of difficulty of blocking gait initiation. In YA as well as in OA, success of blocking gait initiation depended on latency and magnitude of the posterior CoP shift. Results show that CoP variables as well as success rate were significantly affected by age. CONCLUSIONS: This novel method to study motor inhibition during voluntary gait initiation demonstrates that task difficulty, and hence success rate, depend on the timing of Stop signals after onset of gait initiation and that success rate is lower in OA compared to YA. The method addresses an important aspect of mobility in daily life and provides a base for further studies of age-related changes in IC and balance.

Oral 4: Parkinson's

O.4.1: Feasibility and usability of a digital health technology system to monitor medication adherence and mobility in Parkinson's disease

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BACKGROUND AND AIM: Parkinson's disease (PD) is characterised by cardinal motor symptoms and a progressive loss of voluntary motor control. Complex and regularly adjusted medication regimens are necessary to alleviate worsening and fluctuating symptoms in PD. The COVID-19 pandemic, short and sparse assessments with clinicians, and recall and performance biases make functional evaluation of people with PD (PwP) and clinical management, including medication adjustments, challenging. Wearable technology allows for remote monitoring of PwP, providing objective information on patients' daily motor function, and could be used to optimise medication regimes to individual's needs. This study investigates the feasibility and usability of a new digital health technology system (DHTS) for remote monitoring of medication adherence and mobility in PwP. METHODS: Demographic and clinical characteristics of PwP were evaluated during a testing session in which participants were equipped with a DHTS to wear and use remotely for 7 consecutive days. The DHTS was composed of an inertial measurement unit (Axivity AX6) fixed to the lower-back to provide mobility data, a smartphone (Samsung Galaxy) to contextualise mobility data, and a smartwatch (Ticwatch Pro, Mobvoi) featuring a custom-made application extension (Aeqora) to record medication intakes. Medication intake reminders were sent to the smartwatch at pre-programmed times by the Aeqora app, the watch vibrated to alert PwP of medication intake times, and they could acknowledge intakes by interacting with the watch's screen. At the end of the monitoring period, participants completed a usability questionnaire [1]. Feasibility of the DHTS was evaluated as the percentage of complete datasets received, with 68% used as threshold to consider it feasible [2]. Usability of the DHTS was assessed through analysis of responses to the questionnaire (Figure 1). RESULTS: Thirty PwP [22 males, 63±9 years, Hoehn & Yahr stages I (n=1) to II (n=29)] were recruited. Complete mobility, contextual and medication data was collected for 93%, 97% and 73% of participants, respectively. The median usability score of the DHTS was 80% and ranged from 10 to 100%, (0=not usable). This score was

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affected by technical issues with the smartwatch (notifications not received or perceived). Additionally, participants experiencing tremor reported difficulties interacting with the smartwatch. CONCLUSIONS: This study included a small sample of participants but provides encouraging results: sufficient datasets were collected to consider the DHTS feasible for remote monitoring of PwP. Results of the questionnaire highlighted that the design of the DHTS, especially the smartwatch, needs to be refined to improve its usability. Feasibility and usability findings will be used to inform further developments of the DHTS for optimising medication regimes and clinical management of PwP. 1. Rabinovich, R.A., et al., ERJ, 2013. 42(5) 2. Bendig J et al., J Clin Med, 2022. 11(4)

O.4.2: Changes in real-world walking speed over 4.5 years in people with Parkinson's and older adults

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Background and aim: The impact of motor severity upon real-world mobility in Parkinson's (PD) is currently evaluated indirectly through formal assessments of capacity or by asking about perceived changes (1).This may not provide full insight into how motor symptoms and fluctuations impact mobility in the day to day lives of people with PD. Real-world walking speed (RWS) measured using wearable devices is a tool that could directly measure real-world mobility, remotely. RWS can be repeatedly assessed over multiple time points, where changes in RWS could capture novel and meaningful insights related to the progression of mobility loss that complements existing clinical assessment. As such, the aim of this study was to see if RWS using wearable technology changed over time and if the change was different between PD and older adults (OAs) over time. Methods: 88 People with PD and 111 OAs were recruited from the Incidence of Cognitive Impairment with Longitudinal Evaluation - GAIT (ICICLE-GAIT) study. Participants underwent assessment of MDS-UPDRS III and RWS using a triaxial accelerometer (Axivity AX3) on the lower back every 18 months, for 4.5 years. The weekly RWS was estimated in accordance with previously validated algorithms (2) and aggregated at the following walking bout (WB) thresholds; all WBs, 10-30 seconds, 30-60 seconds and > 60 seconds. We employed mixed effects models to investigate whether RWS changed over time in PD and OAs, before modelling interactions of group and assessment time point. The models were adjusted for age and sex and the participant modelled as a random effect. Results: At the first assessment, PD participants had a mean RWS of 1.03 m/s, age of 69 years and PD duration of 7.90 years. Mean RWS of OAs was 1.10 m/s and age of 70 years. Significant annual reductions in RWS were observed for both cohorts, across each WB duration, excluding > 60 seconds for people with PD (Table 1). The rate of decline in RWS was greater in PD compared to OA at each WB duration threshold except for WBs > 60 seconds (Table 1). Conclusions: RWS declined over 4.5 years in both PD and OAs, however the rate of decline was greater in PD in all WB except for durations longer than 60s. This adds interesting new insights into the potential of RWS to monitor changes in mobility in contrast to previous findings in the same cohort where there was no group difference in the rate of decline in walking speed assessed in a laboratory setting (3). RWS may provide a more sensitive means to detect PD-specific deterioration in mobility and add novel complementary information to existing indirect methods of mobility assessment. References 1. Warmerdam E, et al. The Lancet Neurology. 2020; 2. Del Din S, et al. IEEE Journal of Biomedical and Health Informatics. 2016; 3. Wilson J, et al. Frontiers in ageing neuroscience. 2020. The authors would like to thank all the participants and

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assessors of the ICICLE and ICICLE-GAIT study, Dr Rachael Lawson, and Dr Rosie Morris for their support.

O.4.3: Exploring the impact of levodopa on real world digital mobility outcomes in people with Parkinson's disease

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Background and aim: In people with Parkinson's disease (PwP), impaired mobility is associated with increased falls risk[1]; therefore, improving mobility is of primary importance. Dopaminergic medication, such as levodopa, is typically used to improve motor symptoms, including mobility[2]. Identifying the impact of levodopa on mobility is important for both clinicians and PwP. However, this is typically assessed during limited time periods and in controlled environments. Digital health technology (DHT) presents a means to overcome this by continuously monitoring medication adherence and its effect on digital mobility outcomes (DMOs) in the real world, allowing for objective exploration of how levodopa influences mobility. This study aims to understand the impact of levodopa on real world DMOs in PwP using DHT. Methods: Thirty PwP interacted with a novel DHT system (Axivity AX6, smartphone and smartwatch) over seven consecutive days. During this period, participants wore an Axivity AX6 sensor on the lower back to quantify DMOs and a smartwatch (Ticwatch Pro, Mobvoi) to notify them of medication dose/time and acknowledge medication intake times. Validated algorithms quantified DMOs of interest (step velocity, time, and length and their asymmetry and variability)[3]. Means of DMOs were calculated for each time window (30 min before medication intake and within 30, 60, 90, and 120 min after intake)[4]. Wilcoxon signed rank tests compared means of DMOs before and after intake within each window (before vs within 30 min of intake, before vs within 60 min of intake, etc). Results: Twenty-two participants were included in analysis [16 males, 60±9 years, Hoehn & Yahr stage I (n=1) and II (n=21), mean Levodopa equivalent daily dose 627 mg/day], with eight participants excluded due to missing data. During the 90 minutes after levodopa intake, mean step velocity and mean step length significantly increased compared to before intake and remained significantly increased, after 120 minutes (Table 1). Step time variability significantly decreased within 60 minutes of levodopa intake (Table 1). However, within 120 minutes of intake there was no significant effect of levodopa on mean step time; variability of step length or velocity; or asymmetry of step length, time or velocity ($p>0.05$). Conclusions: Results from this exploratory study showed that in PwP the effects of levodopa on selective DMOs may not be observed in the first 60 minutes following intake, but between 60-90 minutes after intake. Although preliminary, these insights enhance our understanding of the effect of levodopa on mobility in the real world and will contribute to personalised clinical management of PwP. References 1. Paker N et al. Journal of physical therapy science, 2015. 27(12), 3675-3679. 2. Smulders K et al. Parkinsonism & Related Disorders, 2016. 31, 3-13. 3. Del Din S et al. IEEE J Biomed Health Inform, 2016. 20(3), 838-847. 4. Araújo-Silva et al. Brain Research, 2021. 1775,147727.

O.4.4: Effects of age on the neuromuscular control of gait

Tjeerd Boonstra[1], Luisa Roeder[2], Michael Breakspear[3], Graham Kerr[2]

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BACKGROUND AND AIM: Changes in human gait resulting from ageing and neurodegenerative diseases are multifactorial. Although the neuromuscular control of gait is thought to be affected by age, it is difficult to assess during overground walking. Here we assess dynamic corticomuscular connectivity to investigate inter-individual differences in the neural control of gait. METHODS: Mobile EEG and EMG was recorded from 24 healthy young adults, 24 healthy older adults, and 21 individuals with Parkinson's Disease (PD) during overground walking. Intermuscular and corticomuscular coherence was estimated in a time-resolved manner between two cortical locations and 8 lower leg muscles to map changes in corticomuscular connectivity within the gait cycle. We use multivariate statistics to extract patterns of corticomuscular connectivity and investigate the inter-subject variability in corticomuscular connectivity during gait. Patterns of corticomuscular connectivity were correlated with participant characteristics (age, sex, weight) and clinical scores (touch sensitivity, UPDRS, Hoehn&Yahr), using the Benjamini-Hochberg procedure to control the false discovery rate. RESULTS: Intermuscular and corticomuscular coherence were observed at multiple frequency bands. Non-negative matrix factorization revealed three brain-muscle networks within a gait cycle: 1) a network of bilateral leg muscles that was active during the double support phase, 2) a left-lateralized network that was active when active from left toe-off until left heel strike, and 3) a right-lateralized network that was active during the right swing phase. Assessing the inter-subject variability, we found a general reduction in neuromuscular connectivity at older age and a selective increase in activation of the bilateral network in participants with impaired tactile sensitivity of the foot. No significant associations were found between neuromuscular connectivity and clinical PD measures. CONCLUSIONS: The three brain-muscle networks provide a parsimonious description of neuromuscular connectivity during gait, which show a modular organization of common spinal input to different lower leg muscles. There is general reduction in common spinal input to leg muscles with older age and the selective increase of the bilateral network may reflect a compensation strategy to maintain mediolateral gait stability in response to impaired sensory processing at the feet. The study demonstrates the use of multivariate statistics to assess inter-individual differences in the neural control of gait during overground walking. ACKNOWLEDGEMENTS AND FUNDING Tjeerd Boonstra was supported by the European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie grant agreement No 895914.

O.4.5: Evaluating the use of a memorised weight-shift intervention for gait initiation in people with Parkinson's and freezing of gait

Yuri Russo[1], Zijing Wang[1], Jiaxi Ye[1], Phaedra Leveridge[1], Mark Wilson[1], Alice Nieuwboer[2], Sarah Lamb[1], Elmar Kal[3], Meriel Norris[3], David Harris[1], James Bassitt[1], William Young[1]

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BACKGROUND AND AIM: Freezing of gait (FoG) in people with Parkinson's (pwPD) often increases the risk of falling and reduces quality of life. When preparing to initiate walking people will typically shift their weight to their non-stepping limb to unload and allow the leading limb to move forward. However, this unconscious mechanism is often impaired in pwPD and FoG. In previous studies, we used a step-in-place paradigm to induce FoG and showed that a weight-shift (WS) intervention could improve step success when initiating forward and turning steps from a freeze. However, due to the nature of this reductionist paradigm, results cannot be generalised. Therefore, we aimed to assess the efficacy and the safety of this WS intervention

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in a more complex, challenging and ecologically valid context. METHODS: 21 pwPD and FoG completed the following tasks ON medication. Participants were fitted with a VR headset showing a complex domestic scene (cluttered corridors; see Fig.1a). The dimensions of the virtual environment matched the size of an instrumented floor made of an array of force plates (3.6m*3.6m). People were instructed to walk in the VR and to stop and turn on a designated spot in the centre of each corridor (Fig. 1b). The study had 3 conditions: Baseline, intervention A (WS training) and intervention B - placebo (Attention management). The order of the two interventions was randomized. Before each intervention, participants were asked to watch training videos. Participants then completed the walking task and were instructed that, when attempting to initiate walking, they should try to use the learned strategies. FoG events and successful/unsuccessful attempts to step from a freeze were identified through the evaluation of video recordings. The following parameters were calculated for each condition: ratio between successful/unsuccessful steps following FoG, amplitude of the WS prior to each attempted step and mean scores for reported safety/efficacy of the intervention. RESULTS: Compared to Baseline, we observed an overall reduction in the number of FOG events following the intervention (~32%). The ratio of successful/unsuccessful steps substantially increased from Baseline to the WS training. These changes were also broadly maintained when intervention B was presented in the final condition. However, intervention B did not result in improved step success when delivered prior to WS training. Self-reported outcomes showed that participants perceived the intervention as safe (8.9/11) and effective (7.4/11). CONCLUSION: The WS training had a clear effect in supporting step initiation from a freeze, even during a complex walking task. Increased step success did not appear to compromise balance safety. Compared to previous data, the current results indicate that the increased task complexity may slightly reduce the effective execution of memorised WS strategies. Nevertheless, we argue that the current results are very promising, as participants were generally able to adapt the strategies to their required action (forward vs turning steps). ACKNOWLEDGEMENTS AND FUNDING: The project was supported by Parkinson's UK (G-2007)

O.4.6: The relationship between express visuomotor responses and postural control in patients with Parkinson's disease

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BACKGROUND AND AIM: The neural mechanisms causing impairments in rapid step adjustments in Parkinson's Disease are unknown. Recently, we studied the initiation of rapid visually-guided steps in healthy young subjects by measuring express visuomotor responses (EVRs), which are target-directed bursts of muscle activity that occur ≈100ms after visual stimulus appearance. We found that EVR expression in the lower limbs was suppressed in posturally unstable situations. These findings implicate a postural control system that can contextually suppress EVRs in the lower limbs. Here, we investigated whether deficits in rapid stepping in PD may be mediated by this postural control system. To do this, we investigated the interaction between express visuomotor responses (EVRs) and postural control in the form of anticipatory postural adjustments (APAs) in PD patients and age-matched control subjects. METHODS: We used an emerging target paradigm, requiring healthy subjects (HC; N = 9, M_age = 64.1) and PD patients (N = 13, M_age = 64.8, UPDRS = 42.4 (range: 19-79)) to rapidly step towards visual targets presented randomly to the left or right. We recorded surface EMG of gluteus medius (GM), a muscle that is involved in both APAs and stepping, and bilateral

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ground reaction forces. We manipulated postural demands as follows. First, in a lateral stepping condition with low postural demands, targets were presented in front of and lateral to the stepping leg. Second, in a medial stepping condition with high postural demands, targets were presented in front of and medial to the stepping leg. Outcome measures were EVR presence, magnitude and latency, APA presence and magnitude, and stepping reaction times. RESULTS: In the lateral condition, EVRs were robustly present in GM contralateral to the target in both the HC group (7/9 subjects, Mag = 0.08, Lat= 118ms) and in the PD group (12/14 subjects, Mag = 0.09, Lat = 122ms). EVR magnitude and latency did not differ between the two groups. In contrast, no subjects exhibited EVRs in medial stepping. Ground reaction forces revealed that APAs were present in both lateral stepping (M_HC= .55; M_PD= .57) and, to a much stronger extent, in medial stepping (M_HC = .67; M_PD = .67). These differences in APA magnitudes between lateral and medial stepping coincided with significantly faster stepping RTs in the lateral (RT_HC = 407ms; RT_PD = 417ms) compared to the medial condition (RT_HC = 534ms; RT_PD = 544ms). Both APA magnitude and stepping RTs did not differ significantly between the two groups. CONCLUSIONS: Despite the known postural control deficits in PD, both PD patients and healthy controls exhibited EVRs and small APAs in the low postural demand condition of this rapid stepping task. These results are in line with previous studies showing that fast visuomotor processes in the upper limbs are largely intact in PD. However, compared to younger subjects, both groups reacted slower, showed weaker EVRs and exhibited stronger APAs. Our findings show that the subcortical EVR system mediating rapid visually-guided stepping is largely intact in PD. However, with increased age, postural demands were potentially perceived as higher compared to younger subjects, leading to a general dampening of the EVR response in HC and PD.

Oral 5: FOG & Awards

O.5.1: Automated freezing of gait assessment in Parkinson's disease using inertial measurement units and deep learning

Po-Kai Yang[1], Benjamin Filtjens[1], Pieter Ginis[1], Maaike Goris[1], Moran Gilat[1], Alice Nieuwboer[1], Peter Slaets[1], Bart Vanrumste[1]

[1]KU Leuven

BACKGROUND AND AIM: Freezing of gait (FOG) is one of the most disabling symptoms in Parkinson's disease. To measure FOG severity, standardized FOG-provoking protocols, including the timed-up-and-go (TUG) and 360-degree turning-in-place (360Turn) with and without a dual-task, are performed. FOG episodes are then annotated post hoc by experts, a notoriously difficult and time-consuming task, often resulting in high inter-rater and inter-trial variability. For these reasons, deep learning (DL) methods have been developed to label FOG accurately and objectively using 3D motion capture (MoCap) systems [Filtjens et al. 2022]. While DL showed the ability to generalize over datasets and patients, 3D MoCap is an expensive approach restricted to lab environments. To work towards free-living FOG assessment, it is imperative to train DL models on data collected with inertial measurement units (IMU), which are cheaper and can be worn outside the lab environment. Moreover, as previous DL models were solely trained on IMU data from standardized gait tasks, its ability to distinguish FOG from voluntary stopping remains to be determined, which is critical for free-

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living assessment. This study provides the first step towards this goal by testing the clinical validity of automatic FOG assessment during standardized TUG and 360Turn with DL based on IMU data. Next, the model's validity for detecting FOG compared to voluntary stopping was assessed. METHODS: This study generalized the Multi-Stage Temporal Convolutional Neural Network to data collected from five IMUs at 64Hz attached to the pelvis and both sides of the tibia and talus [Farha et al. 2019]. Twelve freezers carried out several iterations of the TUG and 360Turn tasks, with and without a dual task and with and without self-initiated or instructed stops, during both ON and OFF anti-Parkinson medication. Based on visual inspection of video data, two experts annotated and verified FOG events of all tasks, which served as ground truth for validating the DL model. The clinical validity of the proposed approach was assessed by the intraclass correlation coefficient (ICC(2,1)) between the model and the expert annotations with a 95% confidence interval (CI) based on two clinically relevant freezing metrics, namely the percentage of time-frozen (%TF) and the number of FOG events (#FOG). RESULTS: For FOG trials without stops, our model trained over both tasks without voluntary stops detected FOG with a strong agreement for both %TF (ICC=0.92, [0.68,0.99]) and #FOG (ICC=0.95, [0.72,0.99]). When evaluating trials with stops, our model trained with stops still detected FOG with a strong agreement for %TF (ICC=0.95, [0.73,0.99]) and moderate agreement for #FOG (ICC=0.79, [0.46,0.94]), with 25% fewer stops being detected as FOG compared to the model trained without stops, showing its improved ability to distinguish voluntary stops from actual FOG. CONCLUSIONS: The proposed DL approach based on IMU data enabled valid FOG assessment that generalized across different gait tasks and could differentiate FOG from voluntary stops. This study, therefore, provides the first step toward reliable real-life FOG detection applications. ACKNOWLEDGEMENTS AND FUNDING: This study is funded by the KU Leuven Industrial Research Fund.

O.5.2: Can electrophysiological analysis of subthalamic nucleus oscillations uncover new biomarkers for freezing of gait in Parkinson's disease patients?

Mathieu Yeche[1], Katia Lehongre[1], Saoussen Cherif[1], Claire Olivier[1], Dorian Bannier[2], Edward Soundaravelou[1], Deborah Ziri[1], Brian Lau[1], Carine Karachi[1], Marie-Laure Welter[1]

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BACKGROUND: In Parkinson's disease (PD), the nigrostriatal dopaminergic pathway's degeneration leads to significant changes in the basal ganglia neuronal activities. In the subthalamic nucleus (STN), increased oscillatory activities in the β frequency band (12-35 Hz) was reported correlated with the severity of the akinesia and its improvement with levodopa treatment or deep brain stimulation (DBS). Recently, alternating increases and decreases in β band activity was also found to be correlated with gait cycle events, with an exaggerated low-β activity during episodes of freezing of gait (FOG) in PD patients. Here, we aim to further explore the role of STN in gait initiation process, and the link between neuronal activities changes and gait and balance disorders of PD patients and try to identify a biomarker of FOG. METHODS: We recorded STN neuronal activity during gait in 18 PD patients (13M/5F, age=57 ± 9 yrs, disease duration= 11 ± 4 yrs, UPDRS III score OFF= 38 ± 15 and ON= 7 ± 5). A force plate and a motion capture system allowed us to measure spatiotemporal parameters of gait initiation, straightforward gait events, turn and FOG episodes, concomitantly with muscles activity using surface EMG. The STN neuronal activity was recorded using externalized cables and an embedded EEG amplifier. The gait task was done with and without cognitive loading in a modified GO/NO GO paradigm. Patients were assessed OFF- and ON-DOPA. RESULTS: At gait initiation OFF-DOPA, we observed a complex modulation of the STN neuronal activity with

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an increase in low (θ-α: 4-12 Hz) and high (γ > 35 Hz) frequency oscillatory activities power at the onset of postural adjustments, with, conversely, a decrease in the β frequency band power. ON-DOPA, we observed an increase in the γ hypersynchronization and a reduction in the β desynchronization. We recorded few episodes of FOG while walking and preliminary analysis suggests a decreased low frequencies power and an increase in the high β power (around 25 Hz), with a loss of the low-β desynchronization. Cognitive loading induced a lower β desynchronization during gait initiation, combined to a higher power in θ-α bands. Regarding the localization of neuronal modulation within the STN, β desynchronization was found more pronounced within the sensorimotor sub-territory, whereas the γ band hypersynchronization was preferentially located more anteriorly at the center of the STN. CONCLUSION: These preliminary results emphasize the possible pathological nature of certain modulations in the β band in relation to gait disorders. This is one step towards the identification of a biomarker for a directional and adaptive DBS effective on gait disorders and FOG. These data also provide new insights into the functioning of the STN in humans, and more specifically its role in the adaptation of locomotor behavior. ACKNOWLEDGEMENTS: We thank the patients for their participation. Study supported by Boston Scientific, Agence Nationale de la Recherche.

O.5.3: Exploring the levodopa-paradox surrounding freezing of gait disease in levodopa-naïve Parkinson populations

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BACKGROUND AND AIM: Freezing of gait (FOG) is a mysterious and very disabling symptom in Parkinson's disease (PD). FOG is a brief, episodic absence or marked reduction of forward progression of the feet despite the intention to walk., and is associated with disease duration, severity, and cognitive impairments. Currently, levodopa treatment is the 'gold standard' and the first step in managing FOG. Paradoxically, however, long-term levodopa treatment has also been linked to an increase in the occurrence of FOG. This levodopa-paradox surrounding FOG is, however, under debate. Dopaminergic treatment is not accessible worldwide, providing an opportunity to study the levodopa paradox. To this aim, we compared the occurrence of FOG in a Brazilian levodopa-naïve PD cohort to Brazilian and Dutch levodopa-positive cohorts. METHODS: Forty-nine Brazilian levodopa-naïve patients, 75 Dutch levodopa-positive patients and 75 Brazilian levodopa-positive patients were included. All participants had a time since the first motor symptom of at least five years. Disease severity was assessed using the MDS-UPDRS part III. The occurrence of FOG was assessed both subjectively, using the new freezing-of-gait-questionnaire, and objectively, using a rapid turning test and the Timed Up-and-Go test, and compared using a non-parametric independent samples Kruskal-Wallis test. In the presence of a significant difference in the occurrence of FOG between the three groups, a binomial logistic regression was performed to explore whether differences in the occurrence of FOG remained when age, disease severity (MDS-UPDRS part III score), time since onset of motor symptoms and cognitive impairments (FAB scores) were included as co-variate. RESULTS: Subjective FOG was more common in the Dutch (mean time since first motor symptoms = 7.5 years, mean MDS-UPDRS part III score = 38, subjective FOG = 25%) and Brazilian (mean time since first motor symptoms = 7.8 years, mean MDS-UPDRS part III score = 36, subjective FOG = 29%) levodopa-positive cohorts compared to the levodopa-naïve cohort (mean time since first motor symptoms = 6.5 years, mean MDS-UPDRS part III score = 30, subjective FOG = 4%; p=0.002). A similar trend was seen when looking at objective FOG


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where in the levodopa-positive groups (Dutch-cohort 15%, Brazilian-cohort 13%) compared to the levodopa-naïve cohort (2%; p=0.066). When taking disease severity and symptom duration into account subjective FOG remained significantly lower and less likely in the levodopa-naïve cohort compared to the levodopa-positive cohorts. CONCLUSIONS: An association was found between long-term pulsatile levodopa treatment and the occurrence of FOG. These findings are in line with the levodopa paradox and suggest a role of long-term nonphysiological stimulation of dopaminergic receptors in generating FOG. This can be an incentive for future studies, with the ultimate aim to develop refined treatment strategies that carry a lower risk of causing FOG.

O.5.4: Exploring the relationship between anxiety-related cognitive processes and freezing of gait in people with Parkinson's

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Background and aim Anxiety can impact the frequency and severity of Freezing of Gait (FOG) in People with Parkinson's. Previous research has documented a relationship between heightened physiological arousal (measured using Galvanic Skin Response (GSR)) and both FOG onset and duration. However, it is unclear the extent to which this association is driven, or at least reinforced, by cognitive processes relating to the appraisal of environmental threats and/or consequences of freezing/falling. More specifically, the experience of fear and/or worrisome thoughts may be responsible for driving increased sympathetic activity measured by GSR, which may in turn exacerbate FOG symptoms. We conducted an exploratory study to identify whether self-reported experiences of fear and worries were associated with differences in GSR profiles prior to, during, and after the freezes. Method Eighteen people with Parkinson's and freezing pathology (PFOG) were recruited to the study. Participants were asked to walk on a pre-determined square path around the internal perimeter of a 3.6m x 3.6m platform. Participants then were required to perform ~7 x 90° and ~14 x 360° turns in both clockwise and anticlockwise directions all within a continuous, cyclical task. Each walking task took between 5-12 minutes to complete (excluding rest periods that were taken at participants' discretion). We recorded GSR throughout each task. Directly after the walking task, we asked participants to give verbal descriptions of any thoughts they recalled having, both in general and specifically around any FOG events that may have occurred. These descriptions were categorised according to whether they represented fear, worrisome thoughts, conscious movement processes, irrelevant distractions, or self-regulatory strategies. Participants also completed self-reports (11-item scales) for each of the above categories of the cognitive process. Results Ten participants exhibited 228 FOG episodes during the walking task. Consistently with previous work, we observed increased GSR prior to FOG onset. However, we also observed marked differences in the rate of change in FOG-related GSR peaks. Verbal descriptions of recalled thought processes offer initial evidence that sustained post-FOG arousal is associated with engagement in worrisome thoughts, primarily relating to the anticipation of future FOG events and their potential consequences (e.g., falls, embarrassment etc.). Conclusion Worrisome thoughts may be associated with sustained physiological arousal around FOG events. We will discuss the theoretical implications arising from these initial observations and suggest that these worry-related changes are likely to be primarily maladaptive and serve to exacerbate FOG. We advise that the current results should be interpreted with caution, primarily because GSR profiles around FOG events will primarily be


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a consequence of the magnitude of the initial response occurring around the time of FOG onset.

Oral 6: Neuro diseases

O.6.1: What patient and intervention characteristics are related to long-term improvement in physical activity after stroke?

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BACKGROUND AND AIM: Physical activity is low after stroke. High intensity treadmill training and self-management strategies have positive effects on physical activity outcomes, but it is unclear how these interventions can be matched to individuals after stroke. To understand this relationship, this study aimed to identify what participant and intervention characteristics predict physical activity six months after an 8-weektreadmill training and self-management intervention for people after stroke. METHODS: This study was a secondary analysis of data from a randomized controlled trial that recruited participants within two months of stroke who were able to walk 10m with or without an aid. Participants randomized to the experimental group received a self-management program embedded in high-intensity treadmill gait training (3 sessions per week, 8 weeks). The self-management program included education, action planning and coping planning, self-monitoring, goal setting and goal review and was guided by the Health Action Process Approach. Outcomes were measured at baseline (Week 0) and six months (Week 26) and included participant characteristics (e.g. age, time since stroke), impairment measures (e.g. fatigue via the fatigue severity scale, anxiety), gait capacity (e.g. spatiotemporal gait measures captured with Gaitrite) and daily physical activity (measured as average steps/day over 4 days using activPAL3?). Intervention characteristics included treadmill performance (e.g. speed, distance) and self-management strategies used. Pearson correlation tests and multiple regression models were completed. RESULTS: Fifty-six participants, 80% male, mean age 62 (SD11) years, mean 28 (SD 15) days post-stroke, completed the intervention. At baseline, participants took 4747 (SD 2731) steps per day, with self-selected gait speed of 0.95 (SD 0.29) m/s and walking distance of 340 (SD114) meters. At 6 months, participants took 6627(SD 3530) steps per day, had a self-selected gait speed of 1.16 (SD 0.29) m/s and walking distance of 430 (SD135) meters. On treadmill, participants walked with speed of 1.42 (SD 0.78) m/s and distance of 956 (517) meters. Participant characteristics at baseline, including fatigue (r=-.333, p=0.012), average steps/day (r=.417, p=0.001), self-selected (r=.404, p=<0.002) and fast (r=.445, p=<0.001) walking speed; and distance (r=.487, p=0.000) were correlated with average steps/day at 6-months. Intervention components related to physical activity outcome at 6-month were action planning strategies (r=.307, p=0.022). Multiple regression showed that no individual intervention or participant characteristic predicted improvement in physical activity. CONCLUSIONS: Interventions targeting long-term physical activity after stroke should consider baseline walking capacity, daily physical activity, and fatigue severity. Self-management action planning strategies are related to long-term improvement in physical activity after stroke. No single patient or intervention characteristic predicted improvement in physical activity over others, suggesting

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a tailored approach may be needed to target post-stroke physical activity. ACKNOWLEDGEMENTS AND FUNDING: This research was funded by National Health and Medical Research Council of Australia

O.6.2: Overground slip-perturbation training to and falls in people with chronic stroke: Interaction of motor memory and motor impairment on reactive balance control

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Background: People with chronic stroke (PwCS) can acquire fall-resisting skills through perturbation-based balance training (PBT) by improving reactive balance control. However, most of the studies were in stance and the long-term retention effects of PBT have not been examined. Further, effects of motor impairment on reactive balance control remained underexamined. The aim of this randomized controlled study was to examine long-term retention of gait-slip perturbation training and if degree of motor impairment affected it. Methods: 60 PwCS were randomized to either training group (n=30) or control group (n=30). The training group which received a single session of 24 slips (a block of non-paretic slips followed by a block of paretic slips and then a mixed block of non-paretic and paretic slips mixed with unperturbed walking). The control group received equal trials of unperturbed walking. The post tests occurred after 30 minutes of rest (immediate) and after 6-months (long-term) where each group was exposed to one slip and one trip in random order. Primary outcomes included percentage of laboratory falls and reactive stability. Generalized estimating equations (GEE) was used to test the effect of group (training vs control), time (immediate vs long-term), and slip-side (paretic or non-paretic) on falls and 2×2×2 ANOVA for all other outcomes. For secondary analysis, GEE and 2×2x2 ANOVA was used to test the effect of impairment (High: Chedoke Mcmaster Assessment ≤4; Low: >4), group (training vs control) and time (immediate vs long-term) for only the paretic-side slips. Results: There was a significant main effect of slip-side and a time × group interaction on fall outcome and reactive stability ($p<0.05$). For the immediate and 6-months post-test, the training group demonstrated lower falls and greater reactive stability on both paretic and non-paretic slips compared to the control group ($p<0.01$). For the immediate post-test where was no difference in falls and reactive stability between the high and low motor impairment groups however, the high motor impairment group had significantly higher falls and lower reactive stability on the 6-month post-test than the low group; the training group for both high and low impairment participants had better outcomes than the control group. There was no difference in clinical balance and motor impairment measures from pre to post-test times. Conclusion: The level of motor impairment did not affect acquisition of reactive balance control and fall-resisting skills after a single training session, however, PwCS with high motor impairment showed greater motor decay 6-months after post-training with worse performance than those with low impairment. Thus, the degree of motor impairment should during planning treatment protocols in terms of dosage or intensity (challenge). For example, PwCS with high motor impairment might need higher training dosage or supplemental agents for long-term retention of balance skills.

O.6.3: The effect of a program of moderate-high intensity treadmill training on brain derived neurotrophic factor (BDNF) in subacute stroke

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BACKGROUND AND AIM: Brain-derived neurotrophic factor (BDNF) is a protein that has been shown to facilitate adaptation in the brain via neuronal growth and maintenance. In animal models of stroke, BDNF has been shown to increase following aerobic exercise, and this increase is linked to functional recovery. Only one study has investigated the impact of a program of aerobic exercise in chronic stroke in humans and found an increase in BDNF. However, participant numbers were low and risk of bias high. The current study aimed to determine whether a program of moderate to high intensity treadmill training could increase levels of BDNF in stroke survivors in the subacute phase of recovery. METHODS: A randomised controlled trial with blinded assessment and intention to treat analysis was conducted. Inclusion criteria were a diagnosis of stroke within the past 2 months, and able to walk 10m with or without an aid. Following baseline assessment participants were randomly allocated to usual care (control group) or usual care group plus an 8-week program of treadmill training (3 x 30min sessions per week at 40-60% heart rate reserve) (experimental group). Participants were assessed at baseline (pre), following the intervention at 8 weeks (post), and at a follow up time point at 26 weeks (follow up). Serum blood was collected via venepuncture and BDNF levels determined via an enzyme-linked immunosorbent assay. RESULTS: Sixty-seven participants (n = 67) were recruited with 32 in the experimental group and 35 in the control group. BDNF levels in the experimental group increased from Week 0 to Week 8 by 18% (24.12 ng/ml to 29.44 ng/ml, change of 5.3 ng/ml, p = 0.020). The control group showed no change (27.60 ng/ml to 29.42 ng/ml, change of 1.8 ng/ml, p = 0.37). From week eight to week 26 the BDNF levels in the experimental group decreased by a margin of 17% (29.44 ng/ml to 24.17 ng/ml, change -5.27 ng/ml, p = 0.021) with no change in the control group. A higher total treadmill distance completed in training had a significant positive correlation with increases in BDNF levels from pre to post training (p = 0.014). CONCLUSIONS: A program of moderate to high intensity treadmill training appears to enhance BDNF levels in the brain after stroke, which has potential to prime the brain to enhance recovery.

O.6.4: Are measures of gait variability associated with sleepiness and fatigue in immune and neurodegenerative disorders? Insights from the IDEA-FAST feasibility study

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BACKGROUND AND AIM: Sleep disruptions and fatigue are symptoms commonly reported in individuals with neurological and immune disorders. Currently, assessments of sleepiness and fatigue rely on patient reported outcomes (PROs), which are subjective and prone to recall bias. Gait variability of healthy older adults has been shown to be impacted by fatigue [1] and sleepiness [2] in the lab and wearable sensors provide objective and reliable estimates of gait. This study evaluates the real-world associations between several measures of gait variability and fatigue and sleepiness in the IDEA-FAST feasibility study. METHODS: 159 total participants with immune and neurodegenerative disorders (Parkinson's disease (PD=25), Huntington's

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disease (HD=14), rheumatoid arthritis (RA=24), systemic lupus erythematosus (SLE=18), primary Sjogren's syndrome (PSS=18), inflammatory bowel disease (IBD=18)) and healthy controls (HC=42) were collected continuously for 10 days at home. Concurrently, participants completed 3 PROs (physical (PF) and mental fatigue (MF), and Karolinska sleepiness scale (KSS)) up to 4 times a day. To combat short walking bouts (only 11% >30s), bouts from up to 2 hours prior to the PRO were concatenated into a continuous signal. From lower-back accelerometer recordings, the initial contacts were identified to give the step time time-series. In total, 89 gait variability measures were extracted from this time-series, including those derived from: statistics, power spectra, Poincaré analysis, asymmetry, fragmentation, and complexity (a full list can be found at [3]). Associations of these features with the PROs were assessed with repeated measures correlation and significant ones were identified (p-value<0.01). RESULTS: 102 subjects had useable data for analysis. For the overall population, 52 features had statistically significant associations with at least one of the PROs. As seen in Table 1, the KSS returned the highest number of statistically significant features for each cohort, except PD where it was PF, and MF had the fewest in most cases. The SLE and PSS cohorts showed the strongest associations with the PROs, with the highest means and correlations up to 0.43 and -0.30. However, the bout concatenation may have impacted some of these outcomes. CONCLUSIONS: While some features showed statistical significance, especially with the KSS PRO and PSS cohort, the correlations were low and much of the data was insufficient for use. Therefore, this approach is unlikely to be powerful for identifying real-world fatigue and sleepiness. REFERENCES: [1] G. Zhang et al., 'Identifying fatigue indicators using gait variability measures: A longitudinal study on elderly brisk walking', Sensors, 2020. [2] S. Nakakubo et al., 'The Association Between Excessive Daytime Sleepiness and Gait Parameters in Community-Dwelling Older Adults', J Aging Health, 2018. [3] D. Makowski et al., 'NeuroKit2: A Python toolbox for neurophysiological signal processing', Behavior Research Methods 2021. ACKNOWLEDGEMENTS AND FUNDING: Thank you to the Brain and Movement group at Newcastle University. This research was funded by the IDEA-FAST project, which has received funding from the Innovative Medicines Initiative 2 Joint Undertaking under grant agreement No. 853981.

O.6.5: An interactive step training system to reduce falls in people with Multiple Sclerosis: a multi-centre randomised controlled trial

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BACKGROUND AND AIM: 50% of people with MS (PwMS) fall at least once within a 3-month period. Although cognitive-motor step training is safe and feasible to improve stepping, balance and mobility in people with Multiple Sclerosis (MS), its efficacy in preventing falls has not been demonstrated. This multisite randomised -controlled trial aimed to determine the effects of a six-month home-based cognitive-motor step training program versus usual care on falls and associated fall risk factors in people with MS. METHODS: 461 people with MS aged 22-81 years (n=366 women, Expanded Disability Status Scale score 1.5-6.0) were randomly allocated to usual care (control) or a six-month home-based step training games program (120 minutes/ week). The primary outcome was rate of falls over six months. Secondary outcomes included physical, cognitive and psychosocial function at six months and falls over twelve months. The study protocol was prospectively registered (ACTR N12616001053415) and the study protocol and statistical analysis plan were uploaded for public view prior to the data analysis on the Open Science Framework (project k8bpg).


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RESULTS: Mean (SD) exergames play duration was 70(51) min/week over six months. Fall rates did not differ between groups at six months (incidence rate ratio (IRR) 0.96, 95% confidence interval (CI) 0.69 to 1.34, p=0.816) nor twelve months (IRR (95%CI) = 0.98 (0.73 to 1.31), p=0.876). Intervention participants performed faster in tests of choice-stepping reaction time at six months, compared with control participants. There were no significant improvements in any of the other physical, cognitive or psychosocial measures. No serious training related adverse events occurred. CONCLUSION: This home-based interactive cognitive-motor step training program did not reduce falls over six or twelve months among people with MS. However, it significantly improved voluntary stepping in cognitively challenging tests. ACKNOWLEDGEMENTS AND FUNDING: This study was supported by funding from the Australian National Health & Medical Research Council and Multiple Sclerosis Limited. We thank Ms Carly Chaplin, Mr Cameron Hicks, Ms Jessica Turner, Ms Natassia Smith, Ms Anna Butler, Ms Mayna Ratanapongleka, Ms Sophie Robinson and Ms Hanna Hensen for their assistance on the study.

O.6.6: Context-sensitive longitudinal analysis of real-life walking reveals one-year change in degenerative cerebellar disease

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BACKGROUND AND AIM: With disease-modifying drugs on the horizon for degenerative ataxias, ecologically valid motor biomarkers are highly warranted, which detect longitudinal changes in short, trial-like time-frames. In this observational study, we aim to unravel biomarkers of ataxic gait which are sensitive for longitudinal changes in real life by using wearable sensors. We hypothesize that, gait measures captured in patients' real life could be more sensitive to progression in short, trial-like time-frames compared to lab-based gait assessments and clinical rating scales. However, in real life walking, gait measures are substantially influenced by contextual and environmental factors, as it has been shown in healthy subjects as well as for different patient populations. Thus, we introduce a context-sensitive matching procedure of individual walking bouts to reveal disease-related rather than purely context-driven longitudinal changes in variability measures. METHODS: We assessed longitudinal gait changes of 24 subjects with degenerative cerebellar disease (SARA:9.4±4.1) at baseline and 1-year and 2-year follow-up assessment by 3 body-worn inertial sensors in two conditions: (1) laboratory-based walking; (2) real-life walking during everyday living. In the real-life walking condition, a context-sensitive analysis was performed by selecting comparable walking bouts according to macroscopic gait characteristics namely bout length and number of turns within a two-minutes time interval. Movement analysis focussed on measures of spatio-temporal variability, in particular lateral step deviation (LD) and a compound measure of spatial variability (SPcmp). RESULTS: Cross-sectional analyses revealed high correlation to ataxia severity (SARA) and patients subjective balance confidence (ABC Scale) in both conditions ($r > 0.8$). While clinical ataxia score and gait measure in lab-based gait assessments identified changes after two years only (SARA: rprb = 0.71; LD: rprb = 0.67) in real life gait assessment the features of lateral step deviation and a compound measure of spatial step variability identified changes already prb after one year with high effect sizes (LD: rprb = 0.66; SPcmp: rprb = 0.68) and increased effect sizes after two years (LD: rprb = 0.77; SPcmp: rprb = 0.82). CONCLUSIONS: Utilizing a context-sensitive matching procedure, real-life gait measures capture longitudinal change within short trial-like time frames like 1 year with high effect size. In contrast, clinical scores like the SARA as well as lab-based gait measures show longitudinal


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change only after two years. Thus, features of real-life gait constitute promising biomarkers for upcoming therapeutical trials, delivering ecologically validity as well as increased effect sizes in comparison with clinical scores and lab-based gait assessment.

Oral 7: Vision & vestibular

O.7.1: The impact of vestibular function on cognitive-motor interference

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Background and aim. This prospective case-control study assessed persons with bilateral vestibulopathy and their healthy control subjects matched for age, sex, educational level, and hearing status. Bilateral vestibulopathy (BV) is a chronic vestibular syndrome that originates from bilaterally reduced or absent vestibular function. Symptoms typically include, but are not limited to, unsteadiness and movement-induced blurred vision (oscillopsia). Additionally, complaints of cognitive dysfunction have also been reported. On the one hand, this can be attributed to extensive vestibular projections throughout the cerebral cortex and subcortex. On the other hand, increased cognitive-motor interference might occur. Therefore, the 2BALANCE dual-task protocol was performed in persons with BV, to elucidate the impact of vestibular function on cognitive and motor performance and on cognitive-motor interference. Methods and Design. The 2BALANCE protocol consisted of seven different cognitive tasks (Danneels et al. 2020). These tasks were performed separately (in single-task condition), and were also combined with a static motor task on the one hand (balancing on a force platform with foam pad) and a dynamic motor task on the other hand (walking at a self-selected speed on a pressure sensitive walkway). A generalized estimating equations model was used to investigate group differences for all cognitive and motor outcome measures. Results. A total of 22 persons with BV and 22 healthy control subjects were assessed (mean age [SD], BV=53.66 [13.35] and HC=53.21 [13.35], 68% male). The BV group had poorer mental rotation skills and visual and auditory working memory in single-task condition, compared to the control group. The BV group also performed poorer on the mental rotation task and the visual response inhibition task in dual-task condition. Additionally, an interaction effect, indicating increased cognitive-motor interference in the BV group, was observed for mental rotation, response inhibition, and auditory working memory. All static motor outcome parameters indicated more postural sway in the BV group compared to the control group for all test conditions. No group differences were noted for the dynamic motor task. Conclusions. These findings suggest a link between vestibular function and cognitive performance, as well as a greater interference between cognitive and motor performance in BV, compared to healthy controls.

O.7.2: Eye-body connection: Exploring links between postural and oculomotor control with saccades

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BACKGROUND AND AIM: Saccades are an important element of oculomotor control and may supply balance-relevant signals to the central nervous system. Many studies have reported postural changes during continuous eye movement tasks, and early work identified postural responses linked to extraocular muscle stimulation (Roll & Roll, 1987). Further work is needed to understand the relationship between oculomotor and postural control, therefore the current project had two primary aims. First, we investigated changes to postural control outcomes during predictable and unpredictable saccade tasks. Second, we conducted a novel analysis of short-latency postural and muscular responses linked to the onset of saccadic eye movement. METHODS: 22 healthy adults (12F; mean age=24) participated in the experiment. Participants stood facing three LED target stimuli which cued vertical saccades in predictable and unpredictable patterns. Saccades were recorded with electrooculography, postural responses were characterized by center of pressure (CoP) and torso motion, and EMG activity was recorded from soleus, tibialis anterior, and sternocleidomastoid muscles. To characterize changes in postural behaviour during continuous eye movement tasks, outcomes were averaged over two-minute trials of repeated saccades. To investigate postural responses linked to saccade onset, outcomes were time-locked to saccade onset and averaged over all saccades (n=40-60) performed. RESULTS: Significant postural control changes were demonstrated during saccade tasks. Compared to visual fixation, CoP and torso motion amplitude decreased during saccade tasks ($p<0.05$). Additionally, the frequency of CoP motion significantly increased ($p<0.05$). Novel postural and EMG responses were found to be linked to saccade onset. A clear average CoP response was evident following saccade onset; this response was characterized by an early backward shift (500ms post-saccade) followed by a larger forward shift (1600ms post-saccade) of CoP position. CoP responses were directionally consistent across task conditions, however the amplitude of the response differed depending on saccade direction. EMG responses were also present, and preceded saccade onset in sternocleidomastoid (70-115ms pre-saccade) and soleus (20-60ms pre-saccade) muscles. CONCLUSIONS: These findings support the existence of a relationship between oculomotor and postural control systems. Tightened postural control during saccade tasks could be related to attentional splitting and functional integration hypotheses. Additionally, the presence of average CoP and EMG responses linked to saccade onset indicate that neuroanatomical connections between regions of postural and oculomotor control likely also exist and may project to descending motor pathways of the neck and lower limbs. Overall, this work contributes novel information to our understanding of interactions between oculomotor and postural control.

O.7.3: Visual feedback-dependent modulation of arousal, postural control, and muscle stretch reflexes assessed in real and virtual environments

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BACKGROUND AND AIM: Virtual reality (VR) provides a unique, low-cost tool for probing the neural control of balance and its dependence on visual feedback. However, neural adaptations in response to altered visual perception may vary in real and virtual environments. We aimed to investigate visual feedback driven neural modulations in balance control across variable visual conditions with and without VR. METHODS: We had 20 healthy young adults (mean age 23.3 ± 3.2 years; 10 females) experience VR 'low' (ground level) and VR 'high' (14 m) height platforms, and simply close their eyes during real-world quiet standing. Across these

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conditions, we measured arousal via electrodermal activity and a psychosocial questionnaire rating perceived fear and anxiety of falling. We recorded surface electromyography over the right soleus, medial gastrocnemius, and tibialis anterior, and performed posturography via a force plate. As a proxy for modulations in neural control, under each visual condition, we assessed lower limb reflexive muscle responses evoked by noisy tendon vibration and electrical H-reflex stimulation. RESULTS: Physiological and perceptual indicators of fear and anxiety increased in the VR high condition. Background soleus muscle activation was not different across conditions; however, significant increases in muscle activity were observed for medial gastrocnemius and tibialis anterior in VR high relative to no VR with eyes open (baseline). The mean power frequency of postural sway also increased in VR high condition relative to baseline. With a fixed stimulus level, mechanically evoked reflex response amplitude remained constant, whereas H-reflex amplitudes decreased in strength with eyes closed, as well as in VR, with the most pronounced reduction occurring in the virtual height condition. Notably, H-reflexes were lower in the VR low condition compared to standing without VR with the eyes open, suggesting that these seemingly similar visual conditions produce different states of reflexive balance control. CONCLUSIONS: These observations provide novel evidence that VR can readily be used to induce modulations in fear and anxiety, muscle activity, and reflexive neural control mechanisms during static standing balance. However, they also provide caution that measures of neural excitability in VR may not accurately represent similar real-world conditions. Finally, compensation for increased presynaptic inhibition during modulated visual states, observed here via NTV, may infer specific fusimotor adaptation; although, these findings require support of direct measurements from individual muscle spindles under similar visual conditions.

O.7.4: Exploring visual search characteristics in older adults and people with Parkinson's disease during adaptive gait

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BACKGROUND AND AIM: Previous literature shows that older and more anxious walkers will not proactively visually search future areas of their intended walking path to the same extent as young adults. Recent evidence indicates that people with Parkinson's disease (pwPD) will also reduce the extent of their proactive visual search when walking. However, this evidence is largely born from tasks that did not require substantial gait adaptability (e.g., walking in an empty hospital corridor) and, therefore, do not represent daily life tasks. This project aims to evaluate potential differences in visual search between pwPD and healthy age-matched controls (HC) during adaptive gait. METHODS:We compared visual search behaviours between 24 HC and 28 pwPD (10 with freezing of gait (FOG) and 17 without FOG (pwFOG & pwNFOG, respectively)) during a complex gait task. Participants walked around a 3.6mx3.6m square platform, navigating between narrow spaces marked by raised cones, turning 90° at the corners of the platform and then walking to a 'turning target' (TT) placed at the midpoint of each side of the platform to complete 2x360° turns. The navigation of these constraints was repeated in a cyclical manner over 7 trials and repeated in both clockwise and anticlockwise directions. We quantified eye gaze behaviour between the completion of the second 360° turn (prior to initiation of forward gait) and the point where participants passed between the cones. We reported the: i) number of fixations, ii) average fixation duration, and iii) fixation duration as a percentage of time to complete task. These outcomes were reported for the following areas

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of interest: TT (where fixations represent proactive visual search), proximal walkway area, and area outside the intended walking path ('outside area'). All participants were assessed using UPDRS, TMT and Self-reported Anxiety Questionnaires. Twelve more pwFOG will be added to the analysis, to allow the analysis of covariates. RESULTS:Compared to both HC and pwNFOG, pwFOG showed: i) smaller percentage of time spent fixating the TT; ii) a greater number of fixations and longer fixations of the walkway; iii) fewer fixations and a longer average duration of fixation on the outside area. There were no significant differences in proactive visual search to the TT between HC and pwNFOG, although the latter group demonstrated a higher percentage of fixation duration on TT than both HC and pwFOG. CONCLUSIONS:Our findings support previous evidence of PD-related alterations in visual search, particularly relating to FOG. However, the current study progresses our understanding of the global visual search 'strategy' adopted by people with FOG, as one that serves to promote balance stability by minimising visual search.

O.7.5: Collision avoidance behaviours of young adult walkers: influence of a virtual pedestrians age-related appearance and gait profile

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BACKGROUND: When approaching another pedestrian, successful collision avoidances require adapting speed and/or locomotor trajectory based on situational- [1] and personal-characteristics [2]. Regarding the latter, it could be linked to the theory of affordances in a social context [3] where, two individuals interact to achieve a joint action by perceiving the other person's possibilities of action. The age of a pedestrian is a personal-characteristic that can easily be observed (i.e., appearance and gait profile), but whether it affects avoidance behaviours is unknown. The current study used Virtual Reality (VR) to allow for an accurate control of experimental conditions. In this VR environment, we proposed to examine the influence of a virtual pedestrian's (VP) age-related appearance and gait profile on spatiotemporal patterns of avoidance during a circumvention task. We expected that gait characteristics and/or appearance of the VP would influence avoidance behaviours. METHODS: Young adults (YA; n=17, 5 females; 23.6±2.7yrs) were immersed in a virtual street using a VR head mounted display (HTC Vive Pro). Individuals walked 8m towards a goal, while avoiding a VP who would approach and steer towards the participant's left, right, or continue straight, under four conditions related to the VP's age-related appearance and gait profile: 1. YA appearance, YA gait profile; 2. Older Adult (OA) appearance, OA gait profile; 3. OA appearance, YA gait profile; and 4. YA appearance, OA gait profile. The gait profile from one female young adult (24yrs) and one female older adult (65yrs) were integrated into the skeleton of the VPs (Fig.1). We only analysed the straight walking trials. Using the position and velocity of both participant and VP, avoidance behaviours of initial path deviation, rate of deviation, time-to-contact, and clearance distance at the time of crossing were examined. RESULTS: A significant main effect of VP appearance on clearance distance [F(1,16)=6.86, p=.019, f=.570] was observed. Clearance was larger when the VP appeared like an OA (M=.79m±.23), compared to YA (M=.76m±.19). There was also a significant main effect of VP gait profile on clearance distance [F(1,16)=7.71, p=.013, f=.610], such that clearance was larger when the VP walked like an OA (M=.80m±.23), compared to YA (M=.76m±.20). There were no significant effects or interactions for any other avoidance behaviours. CONCLUSIONS: Findings provide support for the theory of affordances in social contexts [3] as individuals' behaviours were influenced by the age-related characteristics of the approaching VP. Larger clearance

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distances observed with OA characteristics may be due to societal norms associated with the principle of parental respect as well as a cautious strategy for any potential instability (wavering) in balance commonly observed in OA. ACKNOWLEDGEMENTS: Thank you to Dr. Suzanne Martin (Victoria University, Australia) for providing the kinematic data to create the VP gait profiles. REFERENCES: 1. Cinelli, Patla. Gait Posture 2008; 28 (4):596. 2. Bourgaize, et al. J Mot Behav 2020; 53 (2):166. 3. Fajen, et al. Int J Sport Psychol 2008; 40:79.

O.7.6: Coordination of the body and leg for precise foot placement during a step

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BACKGROUND AND AIM: Bipedal locomotion across irregular terrain requires precise foot placement at safe locations. The position of the foot, and thereby its placement accuracy, depends on the movement of the body plus the stepping leg with respect to the body during the step. The body and leg movements are coordinated in that each differs on average when stepping to targets at different locations. Here we are concerned with finer grain coordination between the two when stepping to the same target repeatedly. If the body movement contained an error the foot would miss the target unless the stepping leg movement was adjusted. Such mid-step adjustments do indeed occur when visual information is available. For repeated steps to the same target from the same initial stationary position, such adjustments would manifest as a covariation between the body and leg. For example, movements that took the body too far to the right would be associated with leg movements that were more biased to the left. The question is whether the foot placement variability is simply the sum of the body and leg variabilities as one would expect if each of the variabilities were just the result of motor output noise. Conversely, if foot placement variability is less than this value it would suggest the variabilities covary to some extent and this would point either to error-based reach adjustments or to a coordinated structure. METHODS: Eighteen healthy young participants stepped repeatedly from the same initial stationary position onto a visually-presented target placed ahead of the foot in various directions. Subjects were instructed to land the foot as accurately as possible. Vision was denied from the instant the stepping foot lifted in 50% of randomly selected trials. Foot, leg (foot w.r.t pelvis) and body (pelvis, CoM) trajectories were measured using motion capture. Observed foot placement variability was compared to that predicted if variations of the pelvis and leg trajectories were independent (computed by a bootstrapping procedure). The spatial relationship between variations of the pelvis and leg at the end of the step was also examined. RESULTS: Observed foot placement variability was significantly less than that predicted assuming independent body and leg movement variances ($p<0.001$). This was found both when visually-based corrections of the step were possible and when they were denied ($p<0.001$) but was greatest when vision was available during the step ($p=0.010$). The leg systematically deviated in the opposite direction to the pelvis both in steps with and without vision. The same relationship was found when using the whole-body CoM as with the pelvis arguing against a simple mechanical coupling effect between the leg and pelvis. CONCLUSIONS: We show for the first time that a fine-grain coordination between the body and leg is present, not only when visual feedback is available as expected, but also when visually-based corrections of the leg movement are not possible.

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Oral 8: Sensory processing

O.8.1: Comparison of dual task gait pattern in Fibromyalgia syndrome before and after repetitive Transcranial Magnetic Stimulation

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BACKGROUND AND AIM: Fibromyalgia is a chronic disease characterized by multi-focal, widespread pain and several other symptoms - fatigue, musculoskeletal stiffness, cognitive dysfunction, mood disorders, balance disturbances, muscle weakness and functional impairments and disability. Treatment of fibromyalgia is still challenging due to complex pathophysiological mechanisms, and additional, different treatment approaches are needed. Treatment with repetitive Transcranial Magnetic Stimulation (rTMS), a non-invasive therapy utilizing a magnetic field to stimulate different brain structures, is not clearly elaborated. The effects of rTMS on fibromyalgia symptoms have to be further examined and elucidated. The aim of the study was to measure and compare gait pattern characteristics of patients diagnosed with fibromyalgia while performing demanding motor and/or cognitive dual tasks while walking before and after repetitive Transcranial Magnetic Stimulation treatment. Aim was also to explore possible correlations of dual task gait pattern alterations to patients' functional status and possible improvement of clinical symptoms associated with FM after repetitive Transcranial Magnetic Stimulation treatment. METHODS: Twenty female fibromyalgia patients performed a basic walking task, a dual motor, a dual mental (cognitive) and a combined, dual motor and cognitive task simultaneously. Their gait was measured before and after sessions of repetitive Transcranial Magnetic Stimulation. Spatial (stride length) and temporal (cycle time, swing time and double support time) gait parameters were measured using GAITRite walkway system and their variability was assessed. Also, patients underwent clinical examination including assessment of functional status, pain and fatigue level, psychiatric and cognitive manifestations before and after repetitive Transcranial Magnetic Stimulation - rTMS frequency of 10 Hz, 130% of motor threshold over left dorsolateral prefrontal cortex, 2000 stimuli per 10 daily sessions (50 stimuli in 40 repeated sessions). RESULTS: The motor, cognitive and combined dual tasks gait performance in FM patients compared before and after rTMS treatment showed no significant difference. Comparison of symptoms of the disease - level of depression, functional status and sleep disturbances showed some slight improvement after rTMS. CONCLUSIONS: Preliminary results of this study showing potential in development of treatment with repetitive Transcranial Magnetic Stimulation. Gait already affected in fibromyalgia patients showing no significant improvement after stimulation. However, results of the study might point the particular patients with depression and cognitive status and their gait characteristics, where repetitive Transcranial Magnetic Stimulation could be effective in symptoms alleviation. That suggests importance of further examination of stimulation effects on certain clinical symptoms of FM, developing potential individualized treatment approach.

O.8.2: Can insole vibration speed up adaptation of balance and locomotor control to simulated gravitational transitions?

Heather McGregor[1], Kristina Hall[1], Daniel Ferris[1], Rachael Seidler[1]

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BACKGROUND AND AIM: When astronauts re-encounter gravity following spaceflight, they exhibit declines in postural and locomotor control. Adaptation following gravitational transitions requires days to weeks. Behavioral evidence shows that astronauts increase their reliance on somatosensory inputs from their feet and ankles to maintain upright stance post-flight. Subthreshold stimulation to the foot sole has been shown to improve postural stability while standing on Earth. Here we test the hypothesis that augmenting foot somatosensory inputs using subthreshold insole vibration will accelerate adaptation of balance and locomotor control after gravitational transitions. METHODS: We used a body weight support (BWS) system to simulate body loading changes that occur with gravitational transitions. Subjects first performed repeated balance and walking tasks in a baseline Earth gravity condition (1 g, 0% BWS) with no insole vibration applied. Next, subjects performed those same tasks in simulated Martian gravity (3/8 g, 62.5% BWS), allowing us to assess their time course of adaptation. Finally, subjects repeated the tasks in Earth gravity (1 g, 0% BWS) to assess deadaptation. Subjects in our experimental group received insole vibration as they adapted to Mars gravity and while deadapting in final Earth gravity condition. Subjects in our control group received no insole vibration. Subjects were instrumented with IMUs on their lumbar region and feet. Each gravity condition consisted of an identical series of repeated tests. Subjects performed 6 blocks of bipedal standing balance tests (3 20-s trials with the eyes open) and 1-min bouts of treadmill walking. Interleaved with behavioral tasks, we assessed subjects' sensitivity to lower limb afferent inputs by electrically stimulating sensory nerves at the ankles. This allowed us to assess whether movement and/or sensitivity change during adaptation. We assessed stability during standing balance and walking as the mean sway area per trial as measured by the IMU over the lumbar region; this is the area of an ellipse covering 95% of the acceleration of sway angles in the coronal and sagittal planes. We compared behavioral adaptation curves, perceptual changes, and sensory reweighting between the experimental and control groups to assess the efficacy of subthreshold plantar somatosensory noise in aiding adaptation of balance and locomotion during gravitational transitions. RESULTS: Preliminary data analyses suggest that insole vibration improved adaptation of locomotor control in simulated Martian gravity, with the experimental group showing a flatter adaptation curve compared to the control group upon transition to simulated Martian gravity. In contrast, across gravity conditions, the experimental and control groups exhibited similar adaptation curves of sway during standing and sensitivity changes. CONCLUSIONS: Insole vibration may improve adaptation to reduced lower body loading when walking.

O.8.3: Effect of sport compression garments on biomechanical determinants of lower limb injuries in cutting maneuvers

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Background and aim. Cutting in competitive sports is associated with multiplanar loading on lower limb joints, which potentially increases the risk of injury. While different protective gears were shown effective in reducing joint loading, recent garment manufacturers attempted to mimic such effects by incorporating stiffness components around joints in compression garments (CGs). Existing evidence remained equivocal as to whether CGs may reduce injury risk through altering lower limb kinematics and kinetics during cutting. Therefore, the aims of the present study were (1) to evaluate the effects of CGs on lower-limb biomechanical injury risk factors; and (2) to examine the posture-related mechanisms. Methods. 62 healthy participants (21.9±2.2 years old; 31 males and 31 females) were recruited to perform pre-

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planned 90˚ cutting as quickly as possible under four garment wearing conditions: control (CON), knee sleeves (KS), placebo leggings (PB), and compression leggings with stiffness components (CG). A motion capture system with force plates was used to evaluate lower-limb biomechanical parameters under the Plug-in Gait lower body model. Model outputs were further processed with customized MATLAB scripts. A mixed two-way 2 (sex) x 4 (condition) ANOVA was performed to compare the differences between conditions and their possible interactions with sex. Results. No significant difference was observed for kinetic variables (e.g., knee abduction moment, non-sagittal knee moment, and anterior tibial shear) that are considered to associate with higher anterior cruciate ligament (ACL) strain. Compared to CON condition, CG significantly reduced the knee valgus alignment at initial contact [mean difference = 2.358˚, $F(3, 150) = 3.069$, $p = 0.030$], and both hip flexion-extension [mean difference = 4.455˚, $F(3, 150) = 7.590$, $p < 0.001$] and internal-external rotation [mean difference = 5.688˚, $F(3, 150) = 23.868$, $p < 0.001$] range of motion (ROM) during stance. Male participants demonstrated significantly greater knee [mean difference = 4.334˚, $F(1, 50) = 4.403$, $p = 0.041$] and hip [mean difference = 11.319˚, $F(1, 50) = 12.523$, $p = 0.001$] internal rotations at initial contact. Conclusions. CGs incorporating stiffness components around lower-limb joints may aid postural alignments for less injurious cutting movements according to a recent technical framework (Donelon et al., 2020). However, the improvement in postural alignment failed to translate to actual reduction in multiplanar knee joint loads and might be confounded by sex differences in cutting postures. Our results suggested that CGs in our study were yet to be as effective as true protective gears. Future CG designs may consider sex-specific factors and focus on reducing joint loadings with minimal compensated ROM. Reference. Donelon et al. Sports Medicine - Open (2020) 6:53.

O.8.4: A Model Predictive Control (MPC) framework for human balance control strategies on a moving platform

Naser Taleshi[1], Amid Kheirandish, James Brownjohn[1], Sarah Lamb[1], Genevieve Williams[1]

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INTRODUCTION Many researchers explore the human balance control system by analysing recovery from external disturbances. For instance, scaling platform frequency is commonly used to identify transitions between adaptive balance strategies. Model predictive control (MPC) is an advanced method to model, understand and predict such postural responses due to its ability to represent fundamental features of the human motor system. Building on earlier MPC models [2] that simulated postural response to sudden and short floor motions, we propose and test an MPC-based model for human balance control, specifically tailored to tackle continuous and more demanding translational perturbations, as illustrated in (Figure 1g). METHODS Using data from our previous study [1], which examined balance strategies in response to small amplitude underfloor movement with a frequency range of 0.4-6 Hz in the AP direction, we tested our four-segment biomechanical model. To maintain an upright standing position, the model uses sensory feedback and an MPC-based neural controller that generates corrective torques through an optimization process while adhering to biomechanical constraints and optimization criteria. Postural strategies are identified by the phase relationship between joint torques, which we described in our previous work [1]. RESULTS The simulation result, as shown in (Figure 1c-d, f), aligns well with our experimental results [1]. Knee-ankle torque and COP-COM relative motion showed a transition from in-phase to anti-phase (blue to red bars) at a frequency of 3.5 Hz, while hip-knee torque remained in-phase at all frequencies. The MPC controller effectively regulated adaptive postural responses and transitioned

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between them, as well as adjusting coordination between COP-COM motion to counteract destabilization induced by scaling platform frequency. Figure 1: (a) Model schematic, (b) balance strategy as defined by (c) hip-knee and (d) knee-ankle torque phase relation, and (e, f) COM-COP phase relation during changes in platform frequency (g). CONCLUSIONS The predictive capabilities of MPC, combined with its ability to adhere to biomechanical constraints, make it a suitable tool for managing complex and unpredictable dynamics, including postural strategy transitions due to scaling platform frequency. Future research will focus on applying this model to investigate the variety of postural strategies that emerge across a wide range of platform amplitudes and frequencies. Additionally, the model can be refined to predict or simulate the behaviour of specific populations, such as the elderly or those with Parkinson's disease, by accounting for their particular constraints and limitations. ACKNOWLEDGEMENTS This work was supported by EPSRC DTP and the College of Life and Environmental Sciences at the University of Exeter. REFERENCES [1] Taleshi N et al. J Nature Scientific Reports 12(1): 21030, 2022. [2] Shen K et al. J IEEE Access 8: 92050-92060, 2021.

O.8.5: Towards bio-inspired active assistance of standing up and sitting down to improve movement independence in older persons

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BACKGROUND AND AIM: Difficulty with standing up and sitting down from a chair affects almost 66% of older persons in long-term care [1]. Active rollator assistance, by leaning on the moving handles with extended, vertical arms, should be a low-effort approach to help people lift out of and into a chair. However, it is unknown what effective support trajectories look like [2], particularly as the biomechanics of these movements are not well described [3]. This study investigates the kinematics of shoulder trajectories for older persons with a wide range of frailty levels and young persons and comparing stand-up with sit-down motions to support the design of bio-inspired robotic rollator assistance. METHODS: Ten younger adults (28±5 yrs) and seven older adults (78±9 yrs; Clinical Frailty Scale: 1-5 [4]) stood up and sat down five times while their full-body motion was tracked and segmented based on a clustering algorithm [5]. An ANOVA with age and movement factors was used to compare peak velocity and movement duration. RESULTS: We found that while seemingly mirrored motions (Fig 1A), people are more cautious sitting down compared with standing up, with 35% longer duration ($p < 0.001$), 19% lower vertical peak velocities ($p < 0.001$), and less smooth trajectories (Fig. 1C,E). The difference in duration was even more pronounced for older persons (+66% stand-up, and +132% sit-down, $p < 0.001$). Regardless of the motion, older persons move more cautiously compared to young, with 36% lower vertical peak velocity ($p=0.006$; Fig. 1C), 100% longer duration ($p=0.001$), and adopting CoM trajectories closer to their ankle horizontal position (Fig. 1F). The overall inverted C-shape shoulder trajectories are remarkably independent of motion direction or age (Fig. 1F). The differences arise mainly with regard to the velocity profiles along the trajectory (Fig.1B,C,D). The parameterization of these displacement and velocity profiles according to age and motion direction can be exploited in the design of appropriate, generally applicable robotic assistance. CONCLUSIONS: While the results indicate standing up and sitting down require different support strategies, we will use the collected data of additional 32 older persons to show if older persons prefer support based on the average older or younger unassisted trajectories and if the found variation in their trajectory smoothness can serve as a predictor for sit-to-stand assistance needs. This study shows how biomechanical evaluation of different movements can inspire the design of robotic assistance and thus contribute to the

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quality of life of older persons. ACKNOWLEDGEMENTS AND FUNDING: This study is part of the project HeiAge, funded by the CarlZeiss-Foundation (Germany). REFERENCES: [1] Jeyasurya+ (2013). J Rehabil Res Dev, 50:835-44. [2] Mourey+ (1998), Age Ageing, 27:137-46.[3] Mombaur+ (2017), J Biomech, 58:131-38. [4] Rockwood+ (2005), Can Med Assoc J, 173:489-495. [5] Sloot+ (2020), Front Sports Act Living, 2:548174.

O.8.6: Longitudinal changes in physical activity and knee osteoarthritis progression: data from the osteoarthritis initiative

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[1]Stanford University

BACKGROUND AND AIM: Knee osteoarthritis (KOA) is one of the leading causes of disability worldwide. Despite the benefits of physical activity for KOA management, there is no systematic investigation of the dose-response relationship between physical activity and KOA progression. This study aims to systematically quantify the effect of physical activity on the longitudinal change in clinical, functional, and structural measures in patients with KOA. METHODS: Longitudinal data from the Osteoarthritis Initiative (OAI) accelerometer (7-day hip-worn Actigraph) sub-study were extracted from 782 participants assessed two years apart. In accordance with a previous study, a worsening group (W group, 14 % of participants) and a stable group (S group, 86% of participants) were defined based on longitudinal changes in self-reported health status from the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC). In addition to WOMAC scores, extracted data included demographic and anthropometric characteristics, functional capacity (gait speed, five times sit-to-stand), radiographic measures (minimum medial joint space width), and accelerometry-based physical activity measures (activity count). Physical activity was further categorized by intensity (Sedentary [SED], light PA [LPA], moderate-to-vigorous PA [MVPA]) using established accelerometry intervals. Average activity accumulation for each 3-hour interval during waking hours was also computed. Paired-wise comparisons between the stable and worsening groups were performed. RESULTS: The worsening group showed greater interval reduction in total daily activity counts compared to the stable group (W group -17.8%, S group -10.4%, p <.05). The differences in reduced activity count accumulation between groups were primarily featured during the 3-9 PM period (W group -20.5%, S group -6.6%, p <.05). Both groups showed a similar interval trend in increasing SED time (min/day, W group 11.9±68.3, S group 13.7±73.5, p =.80) and reduction in LPA (min/day, W group -29.3±57.2, S group -22.7±62.5, p =.27) and MVPA (min/day, W group -5.0±15.4, S group -2.6±14.3, p =.13). The worsening group also showed a greater decline in functional capacity (reduction in gait speed [m/sec, W group -0.1±0.1, S group -0.0±0.1, p <.05] increase in Sit-to-Stand time [sec, W group 0.5±1.9, S group -0.0±2.0, p <.05]) and greater joint space narrowing compared with the stable group (mm, W group -0.3±0.6, S group -0.1±0.5, p <.05). CONCLUSIONS: Compared to those reporting stable health status, the self-reported worsening KOA group had greater deterioration in physical activity, physical capacity, and joint space. The reduction of physical activity accumulation in the worsening group revealed a time-based pattern focused on the late afternoon and early evening. These findings highlight a unique physical activity accumulation pattern that may be helpful for optimizing the management of KOA.

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Poster Abstracts

Poster Session 1

Ageing

P1-B-1: The worse your hearing loss, the worse your balance in older age - results of a systematic review and meta-analysis

Jacinta Foster[1], Sandy Brauer[1], Barbra Timmer[1], Katrina Williams[1]

[1]University of Queensland

BACKGROUND AND AIM There is growing evidence linking hearing impairment to higher falls risk through alterations in postural stability, but studies show mixed results. This systematic review and meta-analysis quantifies the association between hearing impairment and postural instability in older adults, including differences based on severity of hearing impairment METHODS This review was pre-registered in PROSPERO and performed in accordance with PRISMA guidelines across six databases. Primary research on adults aged 60 years and older with hearing loss and an objective measure of postural stability or gait were eligible for inclusion. Methodological quality was assessed using the modified Newcastle-Ottawa Scale (NOS). Inclusion in the meta-analyses required clearly defined audiometrically-assessed hearing impairment, and two subgroups of participants: mild (25-40dB HL) and moderate-to-severe (>40dB HL) hearing impairment. RESULTS Twenty-five eligible studies (n=27,847) were included in the qualitative synthesis, with an average quality rating of good on the modified NOS. Eight studies were included in the meta-analysis which showed individuals with moderate-to-severe hearing impairment were significantly slower on the 5x sit-to-stand test (mean difference= 0.50s, p=0.03), had a slower gait speed (mean difference= -0.11s, p<0.001) and had lower total Short Physical Performance Battery scores (mean difference= -0.79, p<0.001) than those with normal hearing. The impact of age-related physiological processes that impact hearing and postural stability were considered with 20 of the 25 studies (and all studies in meta-analysis) controlling for confounders of age, sex and cardiovascular health. CONCLUSION This review provides evidence there is an inverse association between increasing hearing impairment and poorer postural stability in older adults. This association is statistically significant for those with moderate-to-severe hearing impairment, however less so for mild hearing impairment. As confounders of age and sex were controlled, this suggests there is more to this association than simply the effects of aging processes on both postural and auditory systems.

P1-B-2: Trajectories of accelerometer-measured physical activity and mortality in older adults of the ActiFE-Ulm study

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[1]Ulm University, [2]Bethesda Geriatric Clinic

Background and aim: Physical activity is an essential component of health. Objective measurement of physical activity trajectories spanning several years is sparse in older adults.

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We aimed to analyze the association of objectively measured trajectories of physical activity in older age on mortality in community-dwelling older adults. Methods: Walking duration as a measure for physical activity was recorded from 1,406 participants (≥65 years, 56.2% men) of the ActiFE-Ulm study in 2009/10 and up to 2 times during followed-up (2012/13 and 2017/18), with each measurement period over one week (16,761 total measurement days) using a thigh-worn uniaxial accelerometer (activPAL; PAL Technologies, Glasgow, Scotland). Ten-year mortality was assessed in February 2019. A latent class joint survival model was used to identify trajectory classes over age and estimate its association with 10- year all-cause mortality. The longitudinal sub-model included attained age as fixed, random and mixture effects. Weekday and daily maximum temperature were included as additional fixed effects (as weather conditions and Sundays have previously been found to affect activity levels). The survival sub-model was adjusted for sex. Both sub-models were joined by attained age as the shared component. Results: The analysis identified three walking duration trajectory classes over age. A slowly declining class one (n=1,224, 87.1%), a moderately declining class two (n=158, 11.2%), and a rapidly declining class three (n=24, 1.7%). There were 390 deaths during follow-up. Median life expectancy for individuals following trajectory class one was estimated as 92.4 years. Individuals following trajectory class two showed a hazard ratio (HR) of 4.96 (95%-confidence interval (CI): 3.37; 7.32), and those following class three a HR of 68.7 (95%-CI: 29.0; 162.6) compared to class one; equivalent to 7.2 and 18.6 years shorter remaining median life expectancy. Conclusions: In summary, trajectories of walking duration were clearly associated with overall mortality in community-dwelling older adults. A rapidly declining walking duration trajectory was associated with the highest risk of subsequent mortality.

P1-B-3: Storage of an obstacle representation in visuospatial working memory in young and older people

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BACKGROUND AND AIM: Obstacle crossing requires visuospatial working memory to guide trailing leg trajectory when vision in unavailable. Visuospatial working memory, as assessed with neuropsychological tests, declines with age, however this remains to be investigated functionally in obstacle crossing. There is also evidence that visuospatial encoding during a secondary task interferes with balance control during stepping and walking in older people. Here, we studied the interaction effects of age by delay (study 1) and age by secondary visuospatial task (study 2) conditions on obstacle clearance in a visuospatial working memory -guided obstacle crossing task. We registered our hypotheses prior to data analyses on the Open Science Framework (osf.io/f65b4 and osf.io/t3c8e). METHODS: Healthy young adults aged 19 to 36 years (n=20 in study 1 and n=17 in study 2) and healthy older adults aged 66 to 83 years (n=29 in study 1 and n=21 in study 2) were instructed to step over an obstacle with their leading leg and straddle it for a delay period before completing the crossing with their trailing leg. In study 1, two obstacle height conditions (12cm, 18cm) and two delay durations (20s, 60s) were presented in random order. In study 2, participants were required to attend to either no secondary task (control), a visuospatial secondary (star movement) task, or a nonspatial secondary (arithmetic) task while straddling the obstacle for a delay duration of 20s, at obstacle heights of 12cm and 18cm, randomly presented. Trailing leg kinematics (mean and variability of maximum toe clearance over the obstacle) were determined via motion capture. RESULTS: There were no statistically significant age by delay or age by secondary task


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interactions. In study 1, toe clearance variability was significantly greater in young adults and increased with increasing delay duration in both groups. In study 2, compared with the control condition, toe clearance variability was significantly greater in the non-spatial secondary task condition but not in the visuospatial condition. CONCLUSIONS: Contrary to our hypotheses, these findings suggest that young and older adults alike can store an obstacle representation via visuospatial working memory for durations of at least 60s and use this information to safely scale their trailing leg over an obstacle. However, the increase in trailing leg toe clearance variability with delay duration suggests that obstacle representation starts to deteriorate even within the first 20s regardless of age. The finding that undertaking a concurrent arithmetic task impaired visuospatial working memory -guided obstacle clearance suggests a potential increased risk of tripping during obstacle crossing while dual-tasking in both young and older people. ACKNOWLEDGEMENTS AND FUNDING: This study was supported by a UNSW Goldstar Award grant 2016. We thank Dr Tatsuya Hirase, Ms Bethany Halmy, Ms Carly Chaplin, Mr Cameron Hicks, Ms Jessica Turner and Ms Natassia Smith for their help with data collection and processing as well as Mr Hilary Carter for making the obstacle device.

P1-B-4: Analysis of dynamic postural control related to COP-COM coordination on gait initiation

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[Introduction] Gait initiation (GI), executed from static stability in a stationary standing position to a dynamic state through voluntary postural adjustment and transitioning to a periodic gait pattern, involves more complex control than steady-state gait (SSG). This process requires a higher degree of control and complexity than SSG, and thus has potential fall risks associated with postural control in GI. The purpose of this study was to investigate an involvement of COP-COM coordination on GI of community-dwelling elderly people with different balance abilities. [Methods] Twenty three community-dwelling elderly people (71.9±4.3 years) and eleven young people (22.2±1.4 years) walked 5 times a 12m gait as a comfortable speed. Each gait velocity from the 1st to 3rd step and COM were detected from 15 markers on the subject's body by using a motion capture system. COP was traced by a 2.4m foot pressure distribution sensor. "COP-COM separation" was calculated as root mean square of a period from starting motion to 3rd step in the anteroposterior (AP) and mediolateral (ML) direction. To compare sensitive differences in balance ability, we divided elderly people into two groups; elder(H) and elder(L), based on Timed Up and Go Test (TUG) time. We compared each outcome by applying one-way ANOVA and Bonferroni method as a post-hoc test. Linear regression analysis was executed for each group as explanatory variables were "COP-COM separation" and a response variable was gait velocity. The Significant level was set as $p=0.05$. [Results] COP-COM separation in the AP direction of elder (L) group was significantly lower than the others ($p<0.001$). Gait velocity on the 2nd and 3rd step resulted in significant differences respectively ($p<0.001$). COP-COM separation affected walking speed on GI except for elder (L) group ($p<0.05$). [Discussion] Low performance of COP-COM coordination was found to limit COM transfer on GI. This phenomenon has some reasons in the background. One factor is likely to decrease functional base of support (BOS) due to an age-related decline in postural control. Another factor is due to a decline in control within the "feasible stability region," which is consisted of not only BOS but also COM velocity. In terms of no correlation between COP-COM coordination and gait speed in elder(L) group, it may suppose that an interaction between COP and COM on GI could not be successfully activated to the forward shift of COM and was

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not linked to effective kinematic control during walking. In summary, COP-COM coordination of healthy older adults on GI is likely to be sensitive in the AP direction, suggesting that it contributes to acceleration control leading up to SSG. This fact provides a valid quantification of dynamic postural control ability on GI. [Acknowledgements] First author would like to thank the "Nagoya University Interdisciplinary Frontier Fellowship" supported by Nagoya University and JST, Grant Number JPMJFS2120.

P1-B-5: Phybrata sensor assessment of age-related balance impairments, sensory reweighting, and intrinsic fall risk

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BACKGROUND AND AIM: It is estimated that 35% of U.S. adults over the age of 40 live with age-related balance impairments that limit physical activity, increase the risk of fall-related injuries, and make it increasingly difficult to continue living actively and independently. A primary cause of balance decline is age-related changes in the vestibular balance system. Normal aging also slows the process of sensory reweighting by which the central nervous system (CNS) continuously assesses the reliability and updates the relative weights assigned to visual, vestibular, and proprioceptive information to maintain postural stability. Current diagnostic solutions capable of quantifying these sensory and CNS impairments and resulting balance disruptions, as well as monitoring patient response to treatments and therapy, require specialized lab equipment that many patients do not have access to. The aim of this study is to assess the utility of an easy-to-use head-mounted wearable inertial motion unit (IMU)-based physiological vibration acceleration (phybrata) sensor to quantify age-related balance impairments, sensory reweighting, and related intrinsic fall risks. METHODS: Data were collected and analyzed from 385 participants aged 76.2 ± 7.5 yrs (min 51 yrs, max 98 yrs, 136 males, 249 females) in 3 residential senior living centers. Participants first completed a questionnaire that included their fall history in the past 6 months and a list of risk factors that may contribute to balance impairment and fall risks. 146 participants reported falling one or more times in the previous 6 months. Standing balance tests were then carried out for all participants with the phybrata sensor mounted on the right mastoid. Phybrata time series data and spatial scatter plots, eyes open (Eo) and eyes closed (Ec) phybrata powers, receiver operating characteristic (ROC) curves, and sensory reweighting profiles derived from time-resolved phybrata spectral density distributions were compared for participants with no reported fall history and those reporting one or more falls in the past 6 months. RESULTS: Phybrata data demonstrate progressive degradation of postural stability with age and increasing number of risk factors. Phybrata spectral analyses further demonstrate utility for quantifying the sensory reweighting and impairments across multiple physiological systems that accompany age-related balance degradation and increasing fall risks. Ec phybrata power was found to have strong statistical correlation ($p<0.001$) with both (i) different balance impairment thresholds for female vs. male participants, and (ii) retrospective incidence of falls within the previous six months. ROC curves indicate that Ec may be utilized as a phybrata-based biomarker to support clinical diagnosis of intrinsic fall risk (AUC =0.92, sensitivity = 0.82, specificity =0.92). CONCLUSION: Phybrata testing enables objective assessment of balance impairments, underlying physiological contributions, and related intrinsic fall risks in older populations. The wearable form factor and rapid test protocol enable frequent preventive screening and clinical assessments, providing an important adjunct to standard balance and gait testing to support targeted treatment and rehabilitation strategies.

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P1-B-6: Effect of age on distal leg muscle coactivation during treadmill walking and comparison with MRI metrics

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BACKGROUD Age-related changes in muscle structure including loss and atrophy of muscle fibres are frequently observed in older adults (OA) [1, 2]. These changes are associated with decreased force generation [3]. This may result in impaired gait and increased falls risk [4]. Electromyography (EMG) provides information about changes in muscle activity patterns during the gait cycle and coactivity between muscles [3] which helps in understanding movement efficiency [5]. Structural information including muscle volume which is related to muscle force can be obtained from magnetic resonance imaging (MRI). Currently the link between muscle structural change and performance during walking with age is not clear. Clinically, understanding mechanisms underlying impaired gait in older adults will assist with developing interventions to improve walking and reduce falls. OBJECTIVE To determine effect of ageing on coactivity of distal leg muscles during walking and its association with muscle volume with hypotheses: a) Agonist- antagonist pairs have greater coactivity in OA; b) OA have less muscle volume than younger adults (YA); c) The coactivity index (CI) for muscle pairs is significantly related to their muscle volume ratio. METHODS Data were collected from 6 healthy YA (21-30 years, median 23) and 6 healthy OA (60 -75 years; median 66). Muscle activity while treadmill walking was recorded from 3 leg muscles (tibialis anterior (TA), medial gastrocnemius (MG)), soleus (SO)) using a wireless EMG system (PLUX S.A., Portugal, 1000Hz). Gait events, determined from force resistors on the foot plantar surface, segmented EMG into gait cycles. MRI data included 3-point Dixon for segmentation of muscle volumes obtained by manual segmentation in ITK-SNAP. The CI for 3 muscle pairs (TA-MG, TA-SO, MG-SO) was calculated [5]. Muscle volume ratios were determined for each muscle by dividing individual muscle volumes by the sum of all muscle volumes in order to normalise these values. Linear mixed models were applied with participant group and muscle pairs as main factors, treadmill speed as a co-variate and significance set at $p<0.05$. Correlation was applied for muscle volume ratios and coactivation. RESULTS The CI was greater for YA for agonist-antagonist pairs TA-MG ($p<0.001$) and TA-SO ($p=0.012$) compared to OA. Irrespective of age, TA-SO CI was greater than TA-MG ($p<0.001$). The overall normalised muscle volumes were greater in OA for all muscles with higher variability in TA-SO coactivation. Irrespective of age, there was no significant correlation between muscle pairs and muscle volume ratio ($p>.05$). CONCLUSION Contrary to the hypotheses, co-activity of leg muscles during treadmill walking was higher in YA. The older cohort were more active than YA (OA self-reported a mean of 16.3 hours physical activity/week vs. YA who reported a mean of 7.4 hours physical activity/week) which may be a reason for these results. The difference in coactivation of TA-MG and TA-SO indicates the different function SO has to MG, being a single-joint muscle with a larger volume and greater proportion of slow muscle fibres. ACKNOWLEDGEMENTS AND FUNDING We acknowledge funding from European Commission Marie-Sklodowska-Curie Innovative Training Networks 860173, Royal College of Radiology

P1-B-7: Title: Links between prefrontal cortical thickness, cognitive function and turning performance in older adults

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BACKGROUND: The neurodegenerative effects of aging are known to affect cortical structure, cognitive function, and mobility. A robust body of literature indicates that walking is a complex motor task requiring supraspinal input for safe, effective, and independent walking. Prior studies of cortical structure, cognition and/or walking in older adults have generally not accounted for all three outcomes, and typically assess straight ahead walking performance. As such, it remains unclear whether non-linear walking, such as turning, demonstrates similar associations with cortical structure and cognitive function to those observed in simple, forward walking. Also unclear is whether cognitive function mediates the relationship between cortical structure and turning performance. Therefore, the purpose of this study was to identify associations between prefrontal cortical (PFC) thickness, cognitive function, and turning performance in older adults. METHODS: Twenty-seven older adults (77 ± 7.7 years) completed a series of 180° and 360° turns at their self-selected normal and fastest safe pace while wearing wireless inertial sensors. Turning performance measures included turn duration (seconds), turn angle (degrees), and peak turn velocity (degrees/second). Gray matter thickness of the PFC was quantified using structural MRI analysis (Freesurfer 7.1). For the cognitive assessment participants completed the computer-based Cambridge Brain Sciences battery, which included assessment of executive function (i.e., response inhibition, attention, visuospatial working memory, and visuospatial processing). RESULTS: We observed significant associations between PFC thickness and 180° and 360° turn measures along with significant associations between executive function and 180° and 360° turn measures. The PFC results indicated that less medial orbitofrontal cortical thickness and middle frontal gyri thickness were significantly associated with longer 180˚ turn duration ($R2 \geq .39$, $p \leq .002$) and slower 360° peak turn velocity ($R2 \geq .43$, $p \leq .001$). For executive function, worse performance on response inhibition and attention tasks were significantly associated with slower 360° peak turn velocity ($R2 = .41$, $p = .002$; $R2 = .48$, $p = .001$, respectively). Furthermore, the direct effect of PFC thickness on fast 360˚ peak turn velocity was fully mediated by response inhibition ($c´ = 207.4$, $p = .016$). CONCLUSION: Older adults with less PFC thickness and worse executive function exhibit poorer turning performance, which parallels associations between PFC thickness, executive function, and straight-ahead walking. Moreover, the full mediation of response inhibition indicates that better turning performance requires greater executive function. Based on these preliminary results, future studies should investigate whether improving executive function can also enhance turning performance and potentially reduce fall risk.

Clinical trial

P1-D-8: Longitudinal and continuous gait analysis to monitor fracture healing of the lower leg

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BACKGROUND AND AIM: Non-union of the tibia and fibula occurs in up to 14% of the patients with tibial fractures (Zura et al., 2016). Radiographs reflect fracture healing in intervals of several weeks and with a time lag due to delayed fracture mineralisation following increases in stiffness. It would be desirable to be able to monitor fracture healing in a timelier manner to

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intervene earlier in case of delayed or non-union. For this purpose, the aim of this study was to assess the potential of longitudinal gait analyses to detect fracture healing problems in patients after tibial and ankle fractures in the lab, as well as continuously during their daily life. METHODS: In this ongoing study, 28 patients with lower leg fractures have been included to date. The data of 15 patients were analysed, where data from more than one measurement in the lab were available. These included 7 tibial fracture (46 ± 19 years) and 8 ankle fracture patients (58 ± 11 years). All patients had received surgical treatment. The longitudinal measurements in the lab were conducted a few days after the surgery and during outpatient visits. The majority of the patients received partial weight bearing instructions for the first six weeks. Pressure under the feet was recorded during straight walking with pressure sensing insoles (Moticon OpenGo, Munich, Germany) containing 16 plantar pressure sensors and an inertial measurement unit. In addition, continuous measurements were performed using the same insoles on the tibial fracture patients only throughout the first three months after injury. Several gait parameters were calculated, such as the maximal force per stance phase, the distribution of the pressure on different parts of the insoles, the length of the centre of pressure path, temporal gait parameters and the asymmetry of these parameters. RESULTS: The results of an interim analysis of this ongoing study are shown in figure 1. Large differences between patients are visible, especially during the first six weeks. These differences are probably due to the differences in adhering to the partial weight bearing instructions or absence of partial weight bearing instructions. All average and asymmetry parameters, except the average stance time, show clear improvements from week six on in patients with normal healing. So far, one patient had healing problems that were associated with secondary flap necrosis after reconstruction of an open fracture. These healing problems are clearly visible as a decrease in performance in both the longitudinal and the continuous data (figure 1). CONCLUSIONS: The pressure-related gait parameters improved throughout the healing process. In one patient, after initial improvements, healing problems were reflected in a worsening of the analysed gait parameters, except several temporal parameters. The gait parameters that showed a clear decline from six weeks on with healing problems might be suitable to monitor the healing process. ACKNOWLEDGEMENTS AND FUNDING: This work was supported by the Werner Siemens Foundation (Smart Implants 2.0).

P1-D-9: Gait training for incomplete spinal cord injury: which one is better?

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BACKGROUND AND AIM: Balance and walking capacity are often impaired in people with motor-incomplete spinal cord injury (iSCI), frequently resulting in reduced functional ambulation and participation. In recent years, walking adaptability (WA) training has shown to have potential added value to conventional locomotor (CL) training because it focuses on gait adaptations to environmental demands. However, it is unknown if this intervention is superior to CL training. The objective of this study was to evaluate the effectiveness of WA training compared to a similar-dosed CL training in a randomized controlled trial (RCT) on walking capacity, functional ambulation, balance confidence, and participation in ambulatory people with iSCI. METHODS: In this two-center, parallel-group, randomized trial, 41 people with iSCI were included, of which 21 were allocated to WA training and 20 to CL training. WA training consisted of precision stepping, obstacle avoidance, and/or reacting to perturbations on the

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Gait Real-time Analysis Interactive Lab (GRAIL). CL training consisted of treadmill walking and lower-body strength exercises. In both interventions, participants received 11 training sessions of 60 minutes over a period of 6 weeks. The primary outcome was walking speed, measured with an overground two-minute walk test. Secondary outcome measures included the Spinal Cord Injury-Functional Ambulation Profile (SCI-FAP), the Activities-specific Balance Confidence (ABC) scale, and the Utrecht Scale for Evaluation of Rehabilitation-Participation (USER-P). Analyzes of covariance, controlling for baseline, were used to indicate differences between WA and CL training. Improvements over time, independent of intervention, were tested with dependent t-tests. RESULTS: Analysis of covariance showed no significant difference in walking speed at six weeks follow-up between WA and CL training ($F(1,32) = 1.48$, $p = 0.23$, mean difference (WA-CL) = -0.05 m/s, 95% confidence interval = -0.12 to 0.03). In addition, no significant differences in the secondary outcome measures at follow-up between the interventions were found. Independent of intervention, walking speed, the SCI-FAP score, ABC score, and USER-P restrictions score increased over time. CONCLUSIONS: Our RCT showed no benefit of WA training over CL training in improving walking capacity, functional ambulation, balance confidence, and participation in ambulatory people with iSCI.

Cognition (e.g. dual tasking)

P1-E-10: Exploring the influence of posture on attention

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BACKGROUND and AIM: Recently, Smith et al. (2019) found an influence of posture (sit vs stand) on several cognitive components including sustained attention, task-switching and visual search. Presented here are high-powered multi-institutional pre-registered replications of Smith et al.'s three experiments. The replications explored the influence of posture on sustained attention in the Stroop task; switch costs in a task-switching paradigm; and search rates in a visual search task. REPLICATION 1 METHODS: In the first replication, participants completed the Stroop task in both the sitting and standing conditions. The Stroop task involves naming the color of congruent ('RED' printed in red) and incongruent ('RED' printed in blue) stimuli. Original findings reported by Smith et al. indicated that when participants stood, as opposed to sat, during the task, the Stroop effect (i.e., performance discrepancy between congruent and incongruent trials) was eliminated. RESULTS: Findings from Replication 1 suggest no statistical difference in performance across postural conditions. REPLICATION 2 METHODS: In the second replication of Smith et al., participants completed a task-switching paradigm while sitting and standing. From trial to trial, participants were required to occasionally switch from identifying the color of a stimulus to identifying its word, depending on the cue presented before each trial. Typically, results from a task-switching paradigm show that participants are slower at identifying a stimulus dimension [shape/color] that mismatches than one that matches a preceding stimulus. Smith et al. reported this switch cost to be significantly reduced when participants completed the task standing compared to sitting. RESULTS: We were unsuccessful at obtaining this effect in our second replication.

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REPLICATION 3 METHODS: In our final replication of Smith et al., we had participants complete a visual search paradigm while sitting and standing. This task required participants to search through displays with set sizes of either four or eight letters to find the target letter (H or S) amongst the distractor ones (E or U). Smith et al. reported that participants showed slower search rates when they completed the task while standing, relative to sitting. RESULTS: This pattern was not found in our third replication. CONCLUSION: Overall, close replications of Smith et al.'s three studies revealed no statistical influence of posture on performance in our samples of undergraduate students. The replication effect sizes were an average of 3.28% of the postural effect sizes originally reported. Our findings suggest that when one stands to complete these tasks, one can maintain the same level of cognitive performance typically observed when sitting. ACKNOWLEDGEMENTS AND FUNDING: The U.S. Army Combat Capabilities Development Command, and the Natural Sciences and Engineering Research Council of Canada funded our work.

P1-E-11: Validating the use of the novel attentional distraction-emotional distress paradigm to aid with clinical diagnosis of functional gait disorders

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BACKGROUND AND AIM: Functional movement disorders (FMD) are conditions of abnormal motor control in the absence of clear structural neuropathology. Functional gait disorders (FGD) are a common FMD phenotype that present with atypical gait patterns and seemingly voluntary movements which are difficult to disentangle from other movement disorders, creating challenges for accurate diagnosis. What is unique to FGD is the increased influence from emotional brain networks compared to motor networks during movement, which has been suggested to contribute to a decreased sense of agency over movement. Given that clinical anecdotes suggest FGD symptoms can normalize when distracted but worsen when distressed, the current study aims to validate the use of the novel attentional distraction-emotional distress paradigm in healthy young adults to understand whether: (1) the use of a threat of shock paradigm during gait can effectively elicit anxiety and (2) characterize changes in gait in due to this paradigm to understand healthy behavior for comparison in future use in FMD. METHODS: 12 neurologically healthy young adults (9 female; mean: 22.6 ± 1.7 years) were recruited and completed 15 trials of self-paced walking across a 6 m pressure sensor gait carpet. Trials were pseudorandomized across 4 conditions split by dual-task (+DT/-DT; auditory Stroop task) and shock (+S/-S; delivered in half of +S trials via a wrist-worn device): (1) Baseline (-DT, -S; first and last 3 trials), (2) Dual-task (+DT, -S), (3) Shock (-DT, +S), and (4) Dual-task + Shock (+S, +DT). After each trial, participants reported their anxiety using a Self-Assessment Manikin (SAM). Spatiotemporal variables of gait were assessed. Two-by-two repeated measures ANOVAs were used to evaluate the effect of shock and dual-task on SAM ratings and spatiotemporal measures of gait. RESULTS: A main effect of shock condition ($p < 0.001$) for SAM ratings showed that participants reported higher level of anxiety on trials with a threat of shock compared safe trials (no threat of shock). A main effect of dual-task ($p < 0.001$) for SAM ratings was also found, which showed that subjects also reported higher anxiety during dual- compared to single-task conditions. Finally, a main effect of dual-task was found for velocity ($p < 0.001$), step length ($p < 0.001$), and step time ($p < 0.005$), such that subjects walked slower and took shorter steps when performing the dual-task compared to single-task. CONCLUSIONS: Therefore, the threat of shock paradigm successfully elicited anxiety but did not impact gait in healthy young adults, whereas dual tasking altered both

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anxiety levels and gait. It is expected that this paradigm would reveal opposite effects in patients with FGD from healthy adults, providing clinical evidence for FGD diagnosis. ACKNOWLEDGEMENTS AND FUNDING: Natural Sciences and Engineering Research Council of Canada (NSERC)

P1-E-12: The influence of dual-tasking on posture, gait, and functional mobility among people living with all-cause dementia in residential care facilities

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BACKGROUND AND AIM: People living with dementia have poorer mobility and cognition relative to those without dementia, which increases their risk for falls. Dual-tasking may be used for fall-risk screening, but more evidence is needed. The aim of this study was to compare the effects of single- and dual-task posture, gait, and functional mobility among people living with all-cause dementia in residential care facilities. METHODS: This study is part of a larger ongoing 6-month randomized controlled trial among people living with a diagnosis of all-cause dementia in residential care facilities [NCT05488951]. For this secondary analysis of baseline data, 26 people living with dementia (Age: 81.8±7.3 years; 35% Female; Montreal Cognitive Assessment: 10.5±6.1 points) completed two trials of dual-task posture, gait, and functional mobility tests using APDM inertial sensors. Dual-task posture involved standing with feet apart while completing no cognitive task, as well as while counting backwards aloud by 1's for 30 s. Dual-task gait involved walking 4 m with no cognitive task as well as while naming words starting with the letter F, A, or S. Dual-task functional mobility was measured with the timed-up-and-go (TUG), which involved getting up from a chair, walking 3 m, turning around, walking back, and sitting down. Participants completed the TUG with no cognitive task, as well as while completing a category task (i.e., naming fruits or animals). We conducted separate repeated measures analyses of variance on single- and dual-task posture, gait, and functional mobility. RESULTS: All participants stood independently during the postural task. One participant could not walk without an assistive device and did not complete the gait or TUG tests. Twelve participants used a walker, 2 used a cane, and 11 walked independently during the gait and TUG tests. Dual-task posture resulted in greater frequency (1.04 vs 0.94Hz) and jerk (9.99 vs 6.26m²/s5) relative to single-tasking ($p<0.05$), with no differences in sway area (10.64 vs 5.73°²). Slower gait speed (0.26 vs 0.38m/s), reduced elevation at mid-swing (0.87 vs 1.24cm), greater double limb support (38.66 vs 32.38%), and shorter stride length (0.53 vs 0.68m) were observed during dual-task gait compared to single-task gait ($p<0.05$), with no differences in lateral step variability (1.80 vs 2.11cm) or medial-lateral trunk sway (4.04 vs 3.88°). The dual-task TUG resulted in longer time to completion (37.38 vs 24.26s), reduced turn angle (113.33 vs 138.61°), and slower turn velocity (76.76 vs 90.04°/s) relative to the single-task TUG ($p<0.05$), with no differences in lean angle (35.85 vs 35.02°). CONCLUSIONS: Dual-tasking resulted in poorer postural control, cautious gait, and reduced functional mobility relative to single-tasking among people living with dementia. These findings may suggest that dual-tasking could be included in fall-risk screening procedures among people living with dementia. ACKNOWLEDGEMENTS AND FUNDING: This study was funded by the Intramural Grants Program at Augusta University.

P1-E-13: Effect of gait slip perturbations under single and dual task conditions in older adults with mild cognitive impairment

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Purpose: Older adults with mild cognitive impairment (OAwMCI) experience subtle balance control and gait deficits which are associated with increased fall risk compared to cognitively intact older adults (CIOA). Specifically, on exposure to unexpected fall-inducing events, i.e., external perturbations, compared to CIOA, OAwMCI exhibited a significantly deteriorated ability to initiate compensatory stepping response. However, these results were observed during stance perturbations and a majority of real-life falls occur during walking and/or while performing a secondary cognitive task. It remains unclear whether cognitive status affects the ability to recover balance control when exposed to unpredicted, gait slip external perturbations. Therefore, our study examined the effect of gait slip perturbations under single and dual-task conditions in OAwMCI compared to CIOA. Subjects: OAwMCI (N=15, 18-24/30 on MoCA) and CIOA (N=15, > 25/30 on MoCA) with age > 55 years and the ability to walk 10 meters independently were included. Methods: Subjects were exposed to large magnitude gait slip perturbations alone (single task-ST) and while performing cognitive tasks (DT), i.e., targeting visuospatial and working memory via auditory clock test (ACT); executive function via letter-number sequence (LNS), visuomotor ability via tracking (TrK) and target (TGM) game. Cognitive performance was measured in standing for ST. The margin of stability (MOS), i.e., extrapolated center of mass from the rear edge of the base of support, for reactive balance control; the number of correct responses for LNS; accuracy for the ACT; the sum of errors for TrK; performance error for TGM were computed. Better performance is reflected via high values in MOS, ACT, and LNS; lower values in TrK and TGM. Results: For motor performance, OAwMCI exhibited significantly deteriorated MOS compared to CIOA during ST ($p=0.007$), DT-ACT ($p=0.03$), DT-LNS ($p=0.002$), and DT-TGM ($p=0.001$), but not DT-TrK ($p=0.05$). For cognitive performance, the paired t-test for accuracy in the ACT ($p=0.008$), the number of correct responses in LNS ($p=0.007$), and the sum of errors in TrK ($p=0.04$) showed significantly deteriorated performance among OAwMCI compared to CIOA. Conclusion: Reactive response against gait slip perturbations significantly deteriorated among OAwMCI compared to CIOA during ST and DT conditions. The results provide preliminary evidence that, unlike CIOA, the ability to allocate online attentional resources to process and integrate the perceived balance threat (perturbation-specific information) and prioritize reactive responses is delayed among OAwMCI regardless of the type of task being performed (ST or DT). The deteriorations in both motor and cognitive responses under DT conditions indicate the overlap between domains regulating reactive balance control and cognitive tasks, i.e., executive function, used in this study.

P1-E-14: Response time and accuracy improve from seated to treadmill walking during a visual attention dual-task in athletes

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BACKGROUND AND AIM: In a seated position, athletes perform superior to the general population on a dynamic visual acuity (DVA) task.1 However, it is unknown if this difference in DVA performance is further enhanced during progressive changes in balance control. Therefore, the purpose of this study was to investigate performance on a DVA task during quiet standing and walking in young adult athletes compared to the general population. METHODS: Varsity team athletes (n=16; age= 20.7, SD= 1.4) were compared to young adults from a general student population (n=16; age= 21.3, SD= 1.4). The DVA assessment was conducted

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using the moV& V&MP software program (University of Waterloo, Ontario) viewed at 4m on a 55" monitor. A Tumbling 'E' target was displayed oriented either up/down/left/right in continuous, random walk (RW) motion at a speed of 2.31m/s (30°/s). Participants were asked to quickly and accurately identify the orientation of the Tumbling 'E' using a handheld keypad. The DVA task was completed in four postural conditions: seated; standing; and treadmill walking at low (85-100 bpm heart rate) and moderate (115-130bpm) intensities. When participants responded correctly, the task continued with the target changing orientation and subsequently reducing in size. DVA performance was scored as the log of the minimum angle of resolution (logMAR) of the smallest size threshold correctly identified. DVA performance (i.e., change in logMAR) during each posture was normalized to each participant's seated DVA score. Response time (RT) was the amount of time required for participants to respond using the keypad in milliseconds. RESULTS: Findings revealed no interaction or main effects of posture on DVA performance ($p = 0.278$). There was a significant main effect of group ($F = 7.86$, $p < .05$; $f = 0.25$), where athletes' DVA performance improved in all postures, performing the best during moderate intensity treadmill walking. Whereas the general population group performed poorly across all postures. For RT, a main effect of posture ($F=11.23$, $p < .001$, $f = 0.25$) indicated that both groups responded faster in treadmill walking conditions compared to standing. However, there were no differences between groups observed for RT ($p = 0.384$). Therefore, the general population group demonstrated a speed-accuracy trade-off characterized by an increased response time with decreased DVA performance whereas athletes maintained both speed and accuracy of responses across all postural conditions. CONCLUSION: The findings of the current study suggest that athletes may have superior efficiency in allocating visual attention during dual-task conditions that may be attributed to experience in dynamic, high-intensity sport contexts. 1. Yee A, Thompson B, Irving E, Dalton K. Athletes Demonstrate Superior Dynamic Visual Acuity. Optom Vis Sci. 2021;98(7):777-782.

P1-E-15: Attention mediates relationships between trait anxiety on gait during postural threat

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BACKGROUND: Individuals with high levels of trait anxiety (TA), a stable aspect of one's personality, exhibit diminished prefrontal control of attention, making it challenging to focus on multiple tasks at once. Prior work in clinical populations highlight that trait anxious individuals tend to walk with higher variability and slower speeds when walking while also performing a cognitive task. Additionally, highly trait anxious individuals prioritize attention towards threat in threatening scenarios which reduces the efficiency of other tasks, resulting in slower gait patterns. While TA has been noted to impact dual task walking in clinical populations, there remains a gap in understanding this relationship during conditions of postural threat and in healthy young adults. AIMS: This study investigated how trait anxiety levels can predict gait behavior while dual tasking in i) a virtual reality (VR) environment in the absence of threat; and ii) a VR environment under conditions of postural threat. METHODS: Using a repeated measures design, thirty neurotypical adults aged 19-28 completed five walking trials across a 6m ZENO pressure sensor carpet under four different VR-stimulated conditions: (i) low threat, single task- walking across a virtual plank on flat ground, (ii) low threat, dual task - walking across the plank on flat ground while also counting the frequency of numbers heard on an audio track, (iii) high threat, single task - walking across a virtual plank elevated above a deep pit, (iv) high threat, dual task - walking across the elevated plank while also completing the

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number counting task as before. Primary outcome measures were double limb support %, step length variability (%CV), and velocity (cm/s) based on prior work. Prior to commencing walking trials, participants completed the State Trait Anxiety Inventory to determine trait (personality-based) levels of anxiety, as well as obtain seated, baseline attentional task performance. RESULTS: One-way within subjects repeated measures ANOVA revealed no significant differences between baseline, low, and high threat errors made on the attentional task ($p=0.828$). Linear regressions revealed that higher levels of TA significantly predicted a decrease in velocity and double support time when comparing dual task to single task conditions during the high threat ($p=0.028$, $p=0.027$, respectively). However, this was not significant during the low threat conditions. Finally, higher levels of TA predicted a significant decrease in velocity ($p<0.001$), and an increase in step length variability ($p=0.028$) and double support time ($p=0.001$) when comparing the elevated dual task to the ground dual task highlighting the effect of the threat on dual task. CONCLUSIONS: The dual task was effective at dividing attention, since gait speed was reduced, double support time was increased, and steps became more variable, despite cognitive errors remaining unchanged from baseline. Trait anxiety predicted a more cautious gait behavior only when dual tasking at elevation. In trait anxious individuals, their anxiety may be interfering with gait control as their attention is directed towards the threat, increasing the cognitive load required to dual task effectively which reduced overall movement efficiency.

P1-E-16: Limited adaptive postural capability in Parkinson's disease

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Background and aim: Patients with Parkinson's Disease (PD patients) exhibit impairments in posture, vision and attention, among other aspects. In the present study, we tested if PD patients were still able to exhibit postural adaptation. The literature shows that PD patients are able to modify their postural control depending on the available sensory input. For example, they are able to use visual information to improve their postural adaptation. Moreover, PD patients are capable of better postural control when they focus on the external task vs. on their own postural control. In our study, we tested whether PD patients are able to reduce their center of pressure (COP) and/or body sway as much than age-matched controls when performing a visual task requiring attentional focus (location of targets task) vs. a free-viewing task (free focus). As PD patients usually exhibit greater postural sway than age-matched controls, we assumed that PD patients would i) reduce their COP and/or postural sway more than age-matched controls (greater relative reduction) but ii) would still sway more than age-matched controls in any visual task (lower absolute postural stability). Methods: Thirty-nine PD patients (58 years ±2; 78 kg ± 4; 1.76 m ± 0.02; Hoehn and Yahr: 2.2±0.4; MDS-UPDRS: 23±3; MOCA: 28 ± 1; no dyskinesia; on-drug) and forty age-matched adults (62±2 years; 8 kg ± 3; 1,72 m ± 0.02) participated in the study. All participants had good or corrected to normal visual acuity. They all performed two visual tasks in looking at large images of rooms in house (visual angle: 100°): i) a location of targets task (focus on the task) and ii) a free-viewing task (free focus). Displacements of the COP and of the body (head, upper-back, lower-back) were measured and analyzed. Results: The amplitude of COP and/or body sway was significantly lower in the location of targets task than in the free-viewing task in all participants ($p<0.001$). The reduction in COP and/or body sway (between the two tasks) was stronger in PD patients than in age-matched controls ($p<0.05$). However, the PD patients exhibited greater COP and/or body sway than their age-matched controls in all tasks ($p<0.05$). Conclusions: Our results show

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that PD patients were capable of functional postural adaptation to perform the visual task (to focus on the task). PD patients even showed a greater relative postural adaptation than their age-matched controls. However, PD patients could not exhibit an absolute postural adaptation as great as their age-matched controls as they swayed more than their age-matched controls in both tasks. At the practical level, these findings emphasize benefits of performing rehabilitation in engaging PD patients to perform precise visual task requiring attentional focus such as performing wii games or more generally walking on footprints on the ground.

Exercise and physical activity interventions

P1-G-17: Balance impairment inhibits the degree of comprehensive motor functions recovery by a physical rehabilitation program: a longitudinal observational study in daycare centers for older adults

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BACKGROUND AND AIM: In the aging process, the decline of comprehensive motor functions accelerates, especially in older individuals with disabilities. Thus, it is clinically and economically important to improve comprehensive motor functions in older adults with disabilities effectively. This study aimed to identify the motor factors, which inhibit the comprehensive motor functions recovery in older adults with disabilities in daycare centers, conducting a longitudinal observational study. METHODS: In Japan, we recruited 349 older adults with disabilities from the daycare center who received regular physical rehabilitation regularly from April 2018 to March 2019. At baseline, demographic characteristics of participants were collected using a self-administered questionnaire, and motor function tests; 6-minute walking test (6MWT), timed up and go (TUG) test, knee extension muscle strength test, and berg balance scale, were conducted. The change of scores of six-minute walking and timed up and go tests (Δ6MWT and ΔTUG) in three and six months from baseline, which were used as comprehensive motor functions improvement, were computed. Linear regression models were constructed to investigate the associations between Δ6MWT and ΔTUG and other motor functions at baseline. In all models, coefficient (95% confidence interval) of variables were estimated. RESULTS: A total of 194 participants met the criteria. The 6MWT score increased from 251.7 at baseline to 271.1 and 279.5 m in three and six months, respectively. The TUG test score improved from 14.4 to 14.0 and 12.9 s, similarly. In the f linear regression models results at three month, age, balance impairments based on berg balance scale, and 6MWT score at baseline were significantly associated with Δ6MWT (age; -1.32 [-2.55, -0.09], balance impairments; -15.46 [-28.07, -2.84], 6MWT score at baseline; -0.12 [-0.22, -0.02]). Conversely, the ΔTUG was not associated with all variables. In the linear regression models results at six month, balance impairments and 6MWT score at baseline were significantly associated with Δ6MWT (balance impairments; -19.90 [-37.71, -2.08], 6MWT score at baseline; -0.19 [-0.32, -0.05]), and neurological disorders, balance impairments, and TUG test score at baseline were significantly associated with ΔTUG (neurological disorder; -0.86 [-1.71, -0.01], balance impairments; 1.05[0.11, 1.99], TUG score at baseline; -0.16 [-0.22, -0.09]). CONCLUSION: Balance impairment is an inhibitor for comprehensive motor functions

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recovery in older adults with disabilities. In clinical settings for older adults with disabilities, the assessment of balance impairment may be the first choice. If necessary, appropriate balance exercise should be provided based on their assessment.

P1-G-18: A pilot study evaluating the effect of a low-intensity hip flexor training program on minimum toe clearance variability

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BACKGROUND AND AIM: Trip-related falls in older adults (≥65 years) may be associated with greater minimum toe clearance (MTC) variability.[1] Swing hip flexion variability explained 30% of MTC variability in older adults.[2] This kinematic variability in older adults is attributed to motor output variability--reduced ability to control the force and timing of muscle contractions.[3] Motor output variability may be mitigated by low-intensity resistive training.[3] Therefore, this study evaluated the effect of a low-intensity hip flexor training program on MTC variability in older adults. METHODS: A pretest post-test design was used with 6 (3 male, 3 female) independently ambulating community-dwelling older adults (mean ± SD: age = 72.3 ± 2.2 years; height = 1.73 ±0.09 m; weight = 74.73 ±17.15 kg) without pathologies affecting their walking. Twenty-five gait trails were performed over a 15-meter course during pre- and post-intervention periods with 8 cameras (Vicon, 100 Hz) recording the central 7 meters. To use the same point on the shoe tip at pre- and post-assessment periods to define MTC, the shoe tip was marked at baseline, and this point digitized both times. Motion capture data was analyzed using Visual 3D (C-Motion). The intervention was performed twice weekly for 6 weeks. It consisted of a warm-up and cool-down session (dynamic stretches to bilateral hip flexors and a relaxation technique) and hip-flexor training. Hip flexor training was performed only on the dominant limb (the leg used to kick a ball) in standing. Ten to 15 repetitions of hip flexion focusing on concentric and eccentric phases were performed with 3lb-TheraBand resistance at the ankle. Three sessions were supervised, and the remainder were monitored weekly by phone. Analysis was based on a paired t-test model. RESULTS: Minimum Toe Clearance distributions differed significantly from normality (Shapiro-Wilk). Therefore, the median was used to define central tendency and the interquartile range (IQR) variability. Five participants reported being right limb dominant and 1 left limb. The average difference between baseline and post-training MTC variability on the trained limb was 0.031 (95% CI: (-0.094) to 0.16) cm, 0.262 (Cohen's d), and 5 out of 6 participants demonstrated a reduction in MTC variability. The result for the untrained limb was -0.013 (95% CI: (-0.123) to 0.097) cm, 0.122 (Cohen's d). CONCLUSIONS: On the hip flexor-trained limb, MTC variability was reduced, while variability increased on the untrained limb. However, the effect size was small, and the average amount MTC variability was reduced was 3 times less than the difference between young and older adults.[1] Future studies should investigate whether increasing the number of training days or including other joints may improve outcomes. REFERENCES: [1] Al Bochi et al., 2021. Int J Environ Res Public Health, 18(19):10289 [2] Carter et al., 2019. Gait & posture, 75:14-21 [3] Christou, 2011. ESSR, 39(2): 77-84

P1-G-19: Acute effects of treadmill training on brain derived neurotrophic factor (BDNF) and cognition in stroke

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BACKGROUND AND AIM: Functional deficits are common post stroke and determining effective methods to increase brain plasticity post stroke are needed to optimise recovery of function (including cognitive function), particularly in the chronic phase of recovery. One study has shown that a program of aerobic exercise has been shown to increase brain derived neurotrophic factor (BDNF) levels in people with stroke and this increase was correlated with cognitive performance. The immediate effect of aerobic exercise is yet to be quantified however. The current study therefore aimed to determine the acute effect of moderate- to high-intensity treadmill training on BDNF levels and cognition in chronic stroke survivors. METHODS: This study was a within-subjects, randomised, two-condition cross-over trial with assessor blinding. To be included, participants had to be diagnosed with a stroke at least 3 months prior and be able to walk with or without an aid for 10m. All participants completed 30 minutes of moderate-to-high-intensity treadmill training (experimental condition), and a resting (control) condition on two separate days, with a one-week washout period in between. The order of conditions was randomised. Venous blood was collected immediately before and after each condition. An enzyme linked immunosorbent assay was used to quantify BDNF concentrations. To evaluate cognition, the Cambridge Neuropsychological Test Automated Battery (CANTAB) was administered using a digital tablet and included four tests that covered the domains of psychomotor speed (reaction time), executive function (spatial working memory), memory (paired associates learning). RESULTS: A total of 18 stroke survivors participated (aged 60±14 years, average time post stroke of 3.9±2.4 years). There was a significant effect of time on BDNF concentration for the experimental condition (30 mins treadmill) (increase of 2.99 ng/ml [0.39, 5.59], p= 0.02), but not for the control condition (1.60 ng/ml [0.99, 4.20], p= 0.21). There was no effect of time on the cognitive measures of reaction time, paired associates learning, or spatial working memory. CONCLUSIONS: Treadmill training of a moderate-to-high intensity increases BDNF levels after stroke but the dose required for a clinically meaningful difference, particularly in relation to cognition, needs to be ascertained.

P1-G-20: The effects by difference in difficulties of cognitive loads in dual-task training on performance of stepping task with cognitive loads

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BACKGROUND AND AIM: Previous studies reported that daily activities were influenced by cognitive loads, and the ability to perform motor and cognitive tasks simultaneously, defined as the ability to perform dual-task, is crucial to prevent falls. Several reports revealed that the intervention combined a motor task with cognitive loads was effective to improve dual-task performance. However, the relationship between improvements in dual-task performance and the difficulties of cognitive loads used in dual-task training is unclear. Therefore, this study aimed to investigate the effects by difference in difficulties of cognitive loads in dual-task training on performance of stepping task with cognitive loads. METHODS: We conducted a randomized, single-blind, cross-over design in 15 healthy young adults. This study was composed of training sessions (2 consecutive days), test sessions before and after training sessions (Pre and Post), and a 6-week washout period. Participants were asked to execute

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choice step reaction test (CSRT), which required a forward stepping as quickly and accurately as possible on the foot indicated by a visual stimulus required the choice of right or left side, in test sessions and training sessions. In test sessions, participants underwent CSRT which was used visual stimulus made of number. In training sessions, participants underwent one of three CSRTs, which differ in the difficulty level of visual stimulus: no visual stimulus (Control), visual stimulus made of calculation (Easy), and visual stimulus made of calculation and colors (Hard). The accuracy of task was defined by the error rate of anticipatory postural adjustments (APA error), which was measured from the initial weight transfer of center of pressure using a force plate. We used two-way repeated-measures ANOVA with the factors: condition (Control, Easy, and Hard) and test sessions. Bonferroni pairwise comparison was performed when appropriate. RESULTS: There was a significant interaction between factors ($p = 0.045$). APA error decreased significantly after both Easy and Hard training, but not the Control training, compared to before the CSRT training ($p < 0.01$ and $p < 0.01$, respectively). On the other hand, no significant difference was observed in APA error between Easy and Hard training groups at Post. CONCLUTION: Our findings suggest that dual-task training, but not single-task training, improves the motor performance with cognitive loads regardless of the difficulties of cognitive task used in the training. It may be explained that dual-task training activates executive function; therefore, the ability to perform motor and cognitive tasks simultaneously. ACKNOWLEDGEMENTS AND FUNDING: This study was supported by Grant-in-Aid for Early-Career Scientists (No. 20K19371, NH) and for Scientific Research (No. 18K10702, TA) from the Japan Society for the Promotion of Science (JSPS).

P1-G-21: Gait measurement for different emotions intervened by auditory stimuli using smart shoes

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BACKGROUND AND AIM: Previous studies reported the association of emotional state with gait features. The gait features may provide clues to emotion recognition and diagnosis of neurological diseases. While most previous studies have measured gait in laboratory settings, our goal is to estimate emotion by measuring daily gait, even with information obtained outside the laboratory. Therefore, the present study aimed to investigate how emotional states induced by auditory stimuli affect gait features using smart shoes. METHODS: Forty participants (twelve females, age: 15-75 yr) received an emotional intervention in which they walked in smart shoes and listened to sound through headphones. First, they focused on the sound for 10 seconds and then made two round trips along a 7-meter path. Three emotional conditions were performed using the following auditory stimuli: (1) country music (the happy condition); (2) the sound of a woman wailing (the sad condition); (3) the sound of running water (the neutral condition). The order of the conditions was randomized, and each soundtrack was looped continuously during the walking trial. After each trial, participants were asked to indicate happiness and sadness on a scale of 1 (no feeling) to 9 (highest feeling). Inertial sensors attached to the smart shoes collected the acceleration and angular velocity data. From these data, each step was detected, and then speed, stride length, and cadence for each condition were calculated. In the subsequent analysis, we used the data from when the participants were walking straight. Gait features (i.e., speed, stride length, and cadence) in the happy and sad conditions were normalized by those in the neutral condition and compared between the two conditions. RESULTS: Repeated measures one-way analysis of variance and post-hoc paired t-test showed that the happy condition induced more happiness significantly than the other

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conditions (happy: 5.9±2.3, sad: 1.5±1.0, neutral: 1.7±1.0, mean±SD, $p<0.05$). Also, the sad condition induced more sadness significantly than the other conditions (happy: 1.2±0.4, sad: 3.1±2.1, neutral: 2.2±1.8, $p<0.05$). These results demonstrated that happy and sad conditions induced the targeted emotional state. For the mean values for speed normalized by those in the neutral condition, paired t-test revealed that the speed was significantly faster in the happy condition than that in the sad condition (happy: 1.03±0.10, sad: 1.00±0.10, $p<0.05$). Furthermore, the normalized mean values of stride lengths in the happy condition were significantly greater than in the sad condition (happy: 1.03±0.10, sad: 1.01±0.10, $p<0.05$). There was no difference in the cadence values (happy: 1.01±0.06, sad: 1.00±0.07, $p>0.05$). CONCLUSION: Our results show the differences in gait features between different emotional states. Our findings may lead to the estimation of daily mental states and the detection of mental disorders based on gait features.

Experimental

P1-H-22: Determining the contributions of specific descending neural pathways to the preparation and anticipatory postural adjustment periods in humans

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BACKGROUND: Anticipatory postural adjustments (APAs) are a crucial form of feedforward control used in the preparation for voluntary movement (Belen'kii et al. 1967; Cordo & Nashner 1982; Massion 1992). Although APAs are generally understood to be of cortical origin (Gahéry & Massion 1981), it has been shown that movement plans are also represented in subcortical structures prior to movement (Valls-Solé et al. 1999). Transcranial magnetic stimulation (TMS) has been shown to activate reticular formation cells in monkeys (Fisher et al., 2012) and we have recently shown that early and late motor evoked potential (MEP) responses to TMS are independently modulated by postural tasks (Russell et al., 2022), suggesting that cortical TMS may provide a simultaneous probe of cortical and subcortical motor pathways. Here, we used TMS to assess the contributions of corticospinal and cortico-brainstem pathways to the preparation and APA activity prior to the onset of a reach movement. We exploited the capacity for height anxiety to facilitate the relative contribution of subcortical pathways to postural control (Zaback et al., 2022) by applying TMS prior to reaching tasks carried out at floor level and at a height in a virtual reality environment. We hypothesised that early portions of the TMS response in lower limb muscles would be modulated at both heights, but late portions modulated only when experiencing height anxiety. METHODS: We recorded EMG from the right tibialis anterior (TA) and soleus muscles. Participants were placed into a virtual lab scene, and completed a series of target-directed reaches at floor level and 7 m above floor level. TMS was applied at four timepoints during movement preparation and APA periods. The amplitude of TMS induced MEPs was measured within 4 ms bins from MEP onset in each condition. RESULTS: A significant difference was observed between the amplitudes of early (0-8 ms) and late (8-20 ms) MEPs in both the LOW ($p=0.003$) and HIGH ($p=0.01$) condition in the soleus. There were no significant differences in the TA, which is known to receive preferential input from the corticospinal tract. Late MEPs in the soleus were largest during movement preparation during reaching in the HIGH condition, increasing by almost 100% in some

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participants relative to the same point prior to reaches in the LOW condition. CONCLUSION: Early and late portions of the TMS-induced MEP were modulated differently in the soleus during movement preparation and pre-reach APAs. Late MEPs were largest during movement preparation at a height, suggesting an upregulation of cortico-brainstem motor pathways prior to the APA. Early and late MEPs in the TA were altered together over the same pre-movement period, indicative of the corticospinal control of this muscle (Skarabot et al. 2019). Our results suggest that non-corticospinal pathways are upregulated prior to the APA, but that the APA itself is primarily transmitted along the corticospinal pathways.

P1-H-23: Firing characteristics of motor units of the tibialis anterior during walking in humans as non-invasively revealed by HDsEMG decomposition

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BACKGROUND AND AIM: The firing information of motor units (MUs) is essential for understanding the neuromuscular system in walking. However, the firing behavior of the MUs during walking is still largely unknown because it has been almost impossible to investigate MU firings at a single MU level by non-invasive methods. To overcome the limitation, we utilized a recently developed wireless high-density electromyography (HDsEMG) system and electromyogram (EMG) decomposition techniques and investigated MU firing behavior at a single MU level during walking. METHODS: Thirteen healthy males participated and walked on a treadmill for 9 minutes. They also performed an isometric dorsiflexion task. HDsEMG signals were recorded from the right TA by a wireless HDsEMG system. Then, we obtained spike trains of MUs by the EMG decomposition based on the fast independent component method. After the decomposition quality checking, we investigated the following parameters of MU firings: 1) firing rate, 2) recruitment patterns, 3) synchronization of firings and 4) doublets (two consecutive discharges with interspike intervals < 15 ms). MU synchronization was evaluated by cross-correlation and coherence. We compared the MN activity among the following three conditions: 1) the early swing and 2) initial stance phases corresponding to two peak timings of TA activity during walking, and 3) isometric contraction. RESULTS: Ten to 20 MUs were identified in most participants. Mean MU firing rates were 14.1, 13.0, and 15.9 spikes/s during the isometric contraction, swing, and stance phases, respectively. Some MUs exhibited doublets during walking. The doublets frequently occurred during peak timings of TA activity: pre-swing, mid-swing, and loading response phases. We found differences in the MU recruitment threshold between isometric contraction and walking. This indicated that the recruitment order of MUs during walking did not follow the size principle. We also found activation phase-specific MU recruitment during walking. Some participants exhibited swing phase-specific MUs. We found highly synchronized firings during walking. Cross-correlation analysis showed a clear peak at almost time lag 0 in all conditions. The correlation was high in the order of initial stance, early swing, and isometric contraction. Significant coherence was observed in broader frequencies, especially the delta (below 5 Hz) and beta bands (15−40 Hz) during walking. The coherence values were generally higher during walking than during isometric contraction. CONCLUSIONS: This is the first study exploring MU firing behavior during dynamic human locomotion by non-invasive methods. The novel findings revealed here will expand our understanding of the neural control of walking and will be fundamental for future studies on individuals with gait disorders.


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P1-I-24: Body movement strategies following postural perturbation from different directions with and without sensory impairment

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BACKGROUND AND AIM: Dense crowds are challenging environments in which individuals may experience external perturbations from multiple direction. In such situations, contacts may lead to a loss of stability involving body rotations, sway and step triggering. Since the risk of falling in dense crowd is a key element in crowd studies, understanding the motion induced by contact and pushes in such situation is crucial. In this study, we aim at investigating the body movements linked to non-critical (no step) balance recovery following an external perturbation from different directions and for different sensory impairment conditions. We then propose a model to characterize steps following critical unstable situations, considering perturbation directions. METHODS: 21 young adults (10F, 27.2 ± 4.2yo) underwent 2 blocks of 30 perturbations from 5 different directions (60 trials/participant). Each block corresponds to a sensory condition: Not Impaired and Sensory Impaired. For the latter, participants wore a noise-canceling headset with mounted opaque plastic sheets to limit their peripheral vision and ability to hear their surroundings (i.e. being closer to what one may experience in dense crowds). Participants were asked to stand still and look straight ahead, with feet hip-width apart. They then received an external perturbation from the experimenter using a force sensor mounted pole. Trials ended when participants could maintain a stable final position. Participant motions were recorded using a full body motion capture system. RESULTS: For non-critical balance recovery situations, preliminary results show a correlation between the impulse (N.s) of the perturbation and the angular momentum, with an effect of the perturbation direction on the longitudinal axis. However, consistent behaviors are observed regardless of perturbation direction when looking at the projection of the angular momentum on the axis orthogonal to the perturbation. Further investigations are being carried to investigate the effect of sensory impairment. For critical balance recovery situations, we found that step length and duration could be accurately characterized using a model based on the velocity of participants' center of mass. CONCLUSIONS: While perturbations from different directions affect balance recovery strategies, our results highlight consistent behaviors for several well selected projections of the angular momentum and step characteristics. This opens new modelling perspectives to represent motion at the individual level following perturbation from different directions in dense crowds. Future work will focus on real dense crowds context, to monitor the effect on balance recovery of the surrounding individuals.

P1-I-25: Gait variability as a clinical marker for unsteadiness in individuals with lower limb amputations

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BACKGROUND AND AIM: Falls are a barrier to participation in community-dwelling individuals with lower limb amputation (LLA). Falls occur in 50% of the population, with 49% experiencing fear of falling and 40% sustaining injuries [1]. Limited studies, utilizing a single accelerometer or a pressure-sensitive walkway, found that gait variability contributes to falls within this population [2,3]. The APDM Mobility Lab is a wearable sensor system that is reliable and sensitive for clinical populations (APDM, Inc., Portland, OR, USA) [4]. This study evaluates the efficacy of gait parameters and variability on identifying risk for imbalance among control and individuals with unilateral LLA using the APDM system. We hypothesize gait variability among individuals with LLA will be greater than control, and those experiencing unsteadiness will have a greater gait variability when compared to those without. METHODS: Thirteen adults without LLA and 12 adults with LLA consented to participate in a physical screen and the two-minute walk test (2MWT). The APDM was used to measure variability in gait parameters such as speed, cadence, trunk range of motion, and phase percentages during the 2MWT. The 2MWT is a valid and reliable measure that correlates with functional performance for individuals with LLA [5,6]. The LLA group was divided into two groups: seven with imbalance and six without. The criteria for determining imbalance was defined as the use of an assistive device with ambulation. A one-way ANOVA was used to assess differences among three groups, while a two-way mixed effect ANOVA was used to assess differences between those with and without imbalance. RESULTS: As noted in Table 1, we found that individuals with LLA experiencing unsteadiness have a slower gait speed, increased double support time, and increased frontal plane trunk sway when compared to control. Additionally, they have a shorter swing phase and a longer stance phase of the sound limb when compared to those without using an assistive device. Among those with LLA, decreased gait speed and cadence were found within individuals with unsteadiness. Variability of the double support phase is greater among individuals with LLA experiencing unsteadiness when compared to control. The swing and stance phase variability of the affected limb is higher among those with unsteadiness when compared to those without. No significant group differences were found for sagittal plane trunk sway or among gait variability for cadence and both planes of trunk sway. CONCLUSION: Quantifying gait parameters and variability using wearable sensors can be an efficient and clinically meaningful measure in identifying unsteadiness among individuals with LLA. In clinical settings, utilizing wearable sensors may improve fall risk screening leading to early intervention and fall prevention within this population. 1.Miller WC et al. Arch Phys Med Rehabil 2001;82: 1031-7. 2.Hordacre BG et al. Phys Med Rehabil. 2015;96:1162-1165. 3.Parker K et al. Gait Posture. 2013;37:269-273. 4.Mancini M et al. J Bioeng Biomed Sci. 2011;Suppl 1:007. 5.Daines KJF et al. PLoS ONE. 2021; 16(4): 1-15. 6.Balbi LL et al. Fisioter Pesqui. 2021; 28 (4) 393-399.

P1-I-26: Exploring the effects of wearing a face mask on stair descent behaviour

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BACKGROUND AND AIM: During the COVID-19 pandemic, public health experts recommended wearing a facemask (FM) to help limit the spread of infection [1]. Many individuals, particularly those at an increased risk for falls (e.g. older adults), continue to regularly wear a FM. Wearing a FM can occlude areas of your lower visual field (LVF), compromising the acquisition of visual information necessary to guide safe movement [2]. This

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is particularly important when descending stairs, where an inability to see where we are going will directly increase fall-risk but may also disrupt (visual) control of gait through anxiety-related increases in conscious movement processing (CMP) [3]. Intermittently looking down by tilting the head forwards may help acquire environmental information from the occluded LVF but could negatively affect safe stair behaviour. This study aimed to determine (i) the effects of wearing a FM on LVF occlusion and stair behaviour whilst descending stairs, and (ii) whether adjusting the fit of the FM mitigates potential negative outcomes. METHODS: Eight young adults (2 females, 25±4 yrs) descended a 7-step staircase under three conditions at self-selected speed; 1) no FM, 2) FM worn without any adjustments, 3) FM worn with adjustments made by the participant to optimise the fit (e.g. pinch the nose piece, adjust ear loops). All participants wore a Type IIR certified surgical FM. Three blocks of five trials (randomised order for each participant) were captured for each condition. Immediately prior to each block, participants completed a test of available LVF occlusion. After each block, they completed a 4-item questionnaire that assessed anxiety-related CMP [4]. Measures of stair behaviour, captured at 120Hz using a 26-camera Vicon system, included stair duration, foot clearance and placement, and peak head flexion. A Paired-Samples t-test or Wilcoxon Signed-Rank Test determined differences in each outcome measure between conditions (alpha=0.025). RESULTS: When wearing an unadjusted FM, LVF occlusion (median=42.5°, p=0.012), CMP (16±5, p=0.013), stair duration (3.9±0.6s, p=0.018) and peak head flexion (18±13°, p=0.022) were significantly increased compared to no FM (LVF=12°, CMP=11±4, stair duration=3.6±0.5s, peak head flexion=8±13°). There were no significant changes to foot clearance or placement. Compared to the unadjusted FM condition, adjusting the FM led to significant reductions in LVF occlusion (median=25°, p=0.011) and peak head flexion (11±12°, p=0.017) but no changes to CMP (16±6, p=0.45), stair duration (3.7±0.5s, p=0.027), foot clearance or placement. CONCLUSIONS: Participants increased their head flexion and took longer to descend with an unadjusted FM, possibly to counter the reduction in their available LVF. This compensatory strategy likely allowed them to use their vision to plan ahead for safe foot clearance and placement on subsequent steps. Descending stairs with increased head flexion could destabilise the sensory system [5] and affect safe stair behaviour, especially in older adults, but more evidence is required to support this. Adjusting the FM meant that participants regained a large proportion of their available LVF and reduced head flexion, which is likely a safer stair descent approach.

P1-I-27: Frictional requirements of roof-to-ladder transitions: influence of body positioning

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BACKGROUND AND AIM: Falls from ladders are a burden on the working population and general public. Transitions, such as stepping from a roof to a ladder, cause 14% of ladder fatality incidents [1]. Roof-to-ladder transitions typically require stepping around the top of the ladder to a rung. Ladder attachment accessories allow the user to step through the top of the ladder, although their efficacy has yet to be demonstrated. The required coefficient of friction (RCOF) quantifies the amount of friction needed to complete a task and is relevant to slipping risk on a ladder. Body positioning has been associated with RCOF in gait, particularly when decomposed into anatomically meaningful directions [2] but has yet to be investigated in a roof-to-ladder task. The aim of this study is to determine the association between body positioning and RCOF for roof-to-ladder transitions. METHODS: Seventeen healthy

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participants who regularly climb ladders completed roof-to ladder transitions. Four conditions were completed including two ladder types: traditional and walk-through, and two roof types: flat and pitched. The transition rung was rigidly attached to a force plate. Forces were transformed to the coordinate system defined by the contact plane of the shoe. The resultant RCOF and its ML and AP components were calculated. Body orientation was also calculated at the time of the RCOF using a vector from the toe center to the trunk center of mass. This vector was decomposed into its sagittal and frontal plane components. Spearman's rho tests determined the association between body angle metrics and corresponding RCOF values (α=0.05). RESULTS: A significant, positive correlation was found between the frontal plane body angle (larger indicates more deviation from neutral) and the ML RCOF component (ρ=0.782, $p<0.001$, Figure 1). The walkthrough ladder was associated with a lower ML RCOF and body angle compared to the traditional. An insignificant yet positive relationship was found between the overall body angle and RCOF (ρ =0.224, p=0.080), and the sagittal body angle and AP RCOF (ρ =0.169, p=0.190). CONCLUSIONS: ML friction during transition is dominated by frontal plane body positioning. For tasks which require high frontal plane angles, such as a roof transition with a traditional ladder, design changes that increase the available friction on the rung in the ML direction could reduce chance of a lateral slip. In cases where friction cannot be increased, accessories that limit motion in the frontal plane could decrease the risk of ML slips. In the sagittal plane, body angle may not be as strongly related to the RCOF as would be expected; other factors may be more important for AP slips (like foot angle) [3]. ACKNOWLEDGEMENTS AND FUNDING: This research was funded by NIOSH R01OH011799 and NSF GRFP 2139321. REFERENCES: [1] Shepherd et al., Ergo., 2006. 49(3): 221-234. [2] Yamaguchi et al., J of Biomech., 2018. 74: 163-170. [3] Martin et al., J of Biomech., 2020. 99: 109507.

P1-I-28: Impacts of a loss of binocular or motion parallax on static postural stability

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BACKGROUND AND AIM: Vision plays an essential role in postural stability. Since the eyes are horizontally separated, the different images on each retina to view an object with depth are provided (binocular parallax). Similarly, the change of observation point generated by head movements provides depth information (motion parallax). Previous studies reported that both motion parallax and binocular parallax contribute to postural stability. However, it is unknown the different impact of both motion and binocular parallax on postural stability. Therefore, this study aimed to investigate the impact of a loss of binocular or motion parallax on static postural stability. METHODS: Twenty-four healthy young adults with normal visual acuity participated in this study. Participants were asked to stand quietly on a foam pad to enhance the power of postural perturbation fixed on a force plate. They wore a head-mounted display and faced visual background in the virtual reality under four visual conditions: normal vision (Control), without motion parallax (Non-MP) or binocular parallax (Non-BP), and without both depth information (Non-P). The same image was projected to the left and right eyes under the condition without motion parallax. On the other hand, the visual background and the participant's head movement were linked under the condition without binocular parallax. The 95% confidence ellipse area and mean velocity in anteroposterior (AP) and mediolateral direction (ML) of the center of pressure (COP) sway were calculated. Before the statistical analysis, all measures were transformed into their natural logarithms. We used a one-way

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repeated-measures ANOVA to compare the COP parameters among the visual conditions. RESULTS: The COP sway area and mean velocity in each direction were higher in the Non-MP and Non-P conditions compared to those in the Control condition (area: $p = 0.001$ and $p = 0.003$; velocity AP: $p = 0.015$ and $p = 0.004$; velocity ML: $p = 0.001$ and $p = 0.001$, respectively) and to those in the Non-BP condition (area: $p < 0.001$ and $p < 0.003$; velocity AP: $p = 0.003$ and $p = 0.014$; velocity ML: $p < 0.001$ and $p < 0.001$, respectively). On the other hand, there were no significant differences in COP parameters between Control and Non-BP condition. CONCLUSIONS: Our findings reveal that the loss of motion parallax impairs postural stability while standing on an unstable surface regardless of the presence of binocular parallax. On the other hand, the presence of motion parallax compensates for the postural instability caused by the loss of binocular parallax. In other words, motion parallax would play a more prominent impact on static postural stability than binocular parallax. ACKNOWLEDGEMENTS AND FUNDING: This study was supported by Grant-in-Aid for Early-Career Scientists (No. 20K19371, NH) and for Scientific Research (No. 18K10702, TA) from the Japan Society for the Promotion of Science (JSPS).

P1-I-29: Synergy for center of mass trajectory in the medial-lateral direction of patients with hip osteoarthritis

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Background and aim: Medial-lateral (ML) balance is controlled by whole-body movements and is an important predictor of falls. Many studies have investigated the balance of patients with hip osteoarthritis (OA), and most have reported an increased fall rate. However, some studies observed no differences in ML balance between patients with and without hip OA. Thus, there is no consensus regarding the impairment of ML balance and risk of falling. One possibility is that, although there may be impaired ML balance in patients with hip OA, patients may use compensatory strategies to adjust ML balance and reduce the risk of falls. The aim of this study was to investigate whether there is whole-body synergy that stabilize the center of mass (COM) in patients with hip OA. Methods: We used a public dataset of 106 patients with unilateral hip OA (hip OA group) and 80 who were asymptomatic (control group). The participants walked on a level surface and were recorded using motion analysis instruments. The data from the stance phase were analyzed with uncontrolled manifold analysis, which detected whether the variance of the elemental variable affected the variance of the performance variable. The performance variable was set as the COM trajectory in the mediolateral (ML) direction, and the elemental variables were set as each body segment angle. The synergy index (ΔV) and the variances which did and did not affect the performance variable (VORT and VUCM, respectively) were calculated. In addition, COM displacements were examined. In the statistical analysis, whether ΔV was larger than zero was determined in both groups with a one-sample t-test of statistical parametric mapping (SPM), which determined whether there was some mechanism in elemental variables stabilizing the performance variable. The ΔV, VORT, and VUCM were compared between the two groups using a two-sample t-test of SPM. The COM displacement was compared with a two-sample t-test if the data followed a normal distribution, and with the Shapiro-Wilk or Mann-Whitney U test if not. Results: The ΔV was higher than zero in both groups ($p < 0.001$). The ΔV was higher in the hip OA group than in the control group ($p < 0.001$, Figure 1). The VUCM was larger in the hip OA group ($p < 0.001$ Figure 1), whereas

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the VORT was not different between the two groups (Figure 1). The COM displacement was larger in the hip OA group than that in the control group ($p < 0.001$, effect size = 0.38). Conclusion: In both groups, the COM trajectory in the ML direction stabilized during gait. The hip OA group tried to stabilize their COM more than the control group. The larger VUCM and COM displacement suggested that patients with OA had coordinated their bodies to control their COMs in the ML direction; however, they had a decreased ML balance (the function did not seem to decline, but the margin of COM displacement decreased), which increased the possibility of falling.

P1-I-30: Gaze behaviour and gait stability during adaptive locomotion in older adults at risk of falling

Toby C.T. Mak[1], Thomson W.L. Wong[1], Candy W.Y. Chan[1], Polly P.Y. Chan[1], Carman K.M. Leung[1], Celia S.N. Ng[1], Shamay S.M. Ng[1]

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BACKGROUND AND AIM: Paying more attention to the environment is important for safe navigation and negotiating obstacles during walking in real-life situations to avoid falls. Allocating an inward attention at the expense of sampling visual information on the environment could turn out to be hazardous and increase the risk for falls through the adoption of suboptimal gaze behaviour. The aim was to investigate the association between gaze behaviour and gait stability during an obstacle circumvention task in older adults at risk of falling. METHODS: Twenty-one older adults (mean age: 72.8±5.2) who were recruited from the local elderly community centres were involved in this preliminary analysis. They were instructed to circumvent an obstacle while walking along a pathway at a self-selected pace for five trials. The outcomes for gait stability included body sway and the variabilities of spatial and temporal gait parameters. The outcomes for gaze behaviour included the location of fixations (i.e., obstacle, ground, and destination), number of fixations, and fixation duration. Correlation analyses between the outcomes for gait stability and gaze behaviour were performed by Pearson's product-moment correlation coefficient. RESULTS: The number and duration of fixation on the ground were found to be negatively correlated with gait velocity and positively correlated with medial-lateral body sway of the sternum, shoulder, and pelvis regions (all $p < 0.05$). Furthermore, the variabilities of stride time, swing time, and stance time were increasing with the increase in duration of fixation on the ground (all $p < 0.05$). The increase in duration of fixation on the obstacle were found to be positively associated with stride time, double-support time, and stance time and negatively associated with gait speed, stride length and step length (all $p < 0.05$). CONCLUSIONS: Our preliminary analysis suggested that gaze behaviour was significantly associated with gait stability during an obstacle circumvention task in older adults at risk of falling. Older adults appear to walk with compromised gait stability when they allocated more attention (or spent more time gazing) towards the ground. Further research is needed to support a causal relationship between gaze behaviour and gait stability during adaptive locomotion in the older population. ACKNOWLEDGEMENTS AND FUNDING: This work was supported by the Postdoctoral Fellowship Scheme from the Research Grants Council of the Hong Kong Special Administrative Region, China (reference number: PDFS2122-5H02).

P1-I-31: Intramusclar and intermuscular coherence while stepping over an obstacle during treadmill gait

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Background and Aim Falls are one of the serious problems for the elderly, caused by tripping obstacles. Compared to automatic movements, complex movements were proposed to require greater involvement of the primary motor cortex (M1). Coherence analysis has been used to elucidate involvement of M1 and movements, especially β-band (15-35Hz) coherence can show the relationship between M1 and the corticospinal tract. The involvement of M1 during stepping over an obstacle have been demonstrated in cats, but not yet in humans. Furthermore, the previous study confirmed that lower limb joint angles and muscle activations increased with increasing obstacle height, so changing obstacle height may lead to become more complex physical coordination. For this reason, changing obstacle height might increase β-band coherence during stepping over an obstacle. Therefore, the purpose of this study was to examine the change in β-band coherence during stepping over an obstacle of different heights using intramusclar [the proximal and distal ends of tibialis anterior (TAp and TAd)] and intermuscular [biceps femoris (BF) and semitendinosus (ST)] coherence analysis. Method Sixteen healthy volunteers (8 males and 8 females, age 21.9 ± 0.8 years) participated in this study. Three gait conditions were conducted at the same predetermined speed: 1) nomal gai for 5 minutes (NOMAL), 2) stepping over low obstacles (LOW: 2cm) and 3) high obstacles (HIGH: 13.5cm) on a treadmill. Subjects stepped over a total of 100 obstacles that would appear randomly and unpredictably with the right leg during gait. β-band coherence was calculated by surface electromyography (EMG) from TAp, TAd, BF and ST in the right leg. Joint angle was calculated the maximal ankle dorsiflexion and knee flexion in swing phase using an optical motion capture system with 10 cameras. In the statistical analysis, after application of the Shapiro-Wilk test, Tukey test or Steel-Dwass test was performed as post-hoc analysis. The significance level was set at 0.05. Result The results demonstrate 1) β-band coherence in HIGH was higher than in NOMAL for TAp-TAd and BF-ST, 2) in LOW was higher than in NOMAL for BF-ST and 3) between HIGH and LOW was not significance difference for TAp-TAd and BF-ST($p<0.05$). Conclusions β-band coherence in HIGH was higher than NOMAL for TAp-TAd and BF-ST, suggesting that M1 via the corticospinal tract contributes visually guided gait modifications for stepping over an obstacle. Regarding LOW for BF-ST, previous study showed young people significantly moved of knee joint rather than hip and ankle joint during stepping over obstacle, so our subjects might significantly move the BF and ST as knee flexor muscle. No significance difference between HIGH and LOW might be related not clearly differences in obstacle height to detect the differences in cortical involvement.

P1-I-32: Muscle synergies for the transition from double to single -leg stance under the opened/closed eyes conditions in young adults

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Background and aim The single-leg stance (SLS) is used to assess the ability of postural control. Recently, muscle coordination patterns of SLS were revealed by using muscle synergies analysis. However, it reflects only static-state postural control. It is not known how posture is controlled during the transition from double to single -leg stance (DLS to SLS) which is as important as SLS. Muscle synergies analysis in postural control also assesses the effect of visual information. We aimed to assess the muscle coordination patterns of DLS to SLS and the effect of visual information on them in this study. Method Twenty young healthy subjects

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participated in this study. Subjects were asked to pass from DLS to SLS in open eyes (OE) and closed eyes (CE) conditions on the dominant leg, maintain the SLS position 10s and return to DLS on the force plates. Muscle activations were recorded from 12 muscles from the supporting leg. Muscle synergies (time-independent weight vectors and time-dependent activation coefficients) and variance account for (VAF) were extracted from 12 muscles data using non-negative matrix factorization and clustered via the k-means method. The center of pressure trajectory and velocity were used to define the DLS-SLS transition. VAF, time-independent weight vectors and time-dependent activation coefficients were compared between OE and CE conditions. Result It was revealed that no statistically significant difference in the VAF between the two conditions. Four muscle synergies were needed to accurately model the motor control strategies during both two conditions. In both conditions, two ankle/hip dominant synergies, one knee dominant synergy, and one ankle dominant synergy were found. No differences between the two conditions were found for the time-dependent activation coefficients in four synergies. By focusing on the time-independent weight vectors, we found that rectus femoris, vastus lateralis, and biceps femoris showed a higher active ratio in CE condition compared with OE. Conclusion Ankle/hip dominant synergies are specific to DLS to SLS, because only single joint dominant synergies are used in SLS. Muscles controlling knee movement showed higher active ratio under CE condition.

P1-I-33: Characteristics of fatiguing activities and their effect on fall-related gait parameters in community-dwelling older adults: A systematic review using artificial intelligence

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BACKGROUND AND AIM: As a result of being active, muscle fatigue is a common phenomenon. This activity or exercise-induced fatigue leads to changes in gait parameters and thereby to higher fall-risk in the community-dwelling older population. However, due to the variety in fatiguing activities and protocols used in experimental settings it is not yet clear if there are specific characteristics of these activities and protocols (i.e., intensity, duration) that lead to fall-related changes in spatiotemporal-, gait stability or gait variability parameters. This is important since it will show what type of fatiguing (daily) activities lead to higher fall-risk. METHODS: We conducted a systematic review according to PRISMA guidelines and used Open Science Software were possible. From September'22 until January'23 we searched multiple databases (PubMed, Web of Science, Cochrane, Cinahl and Scopus) using synonyms and variations of Older Adults, Exercise-Induced Fatigue and Gait Parameters. Two independent researchers conducted the screening of title and abstract with the Open Science software ASReview. This software uses state-of-the-art active learning techniques, every decision trains the machine learning algorithm so only a percentage of the studies needed to be screened. We decided to stop screening after 100 consecutive irrelevant articles after at least 10% of the total amount being screened. The screening of full text was done by the same reviewers using Rayyan. We extracted data only from studies that reported on fatiguing or prolonged activity in relation to gait parameters in healthy older adults (55+). The ROBINS-I and GRADE criteria were used to rate the quality of the included studies. Our search strategies and additional data are stored on OSF.io. RESULTS: Our search resulted in 41.347 articles. After removal of duplicates, we screened the remaining 25.912 articles using ASReview. With the use of this software, we found 41 relevant articles based on title and abstract. None of

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these studies were retracted and contact with these 41 authors resulted in 1 unpublished study we have included. After screening of full text, we included 28 articles. The mean age of the participants of all studies was 69,2 years and 47,5% of all participants were males. Results on fatiguing activities are to be announced. CONCLUSIONS: Together, our results provide insight into what characteristics of fatiguing activities influence fall-related gait parameters and the magnitude of this influence in community-dwelling older adults. It thereby will also give more insights into how fatigue as a result of daily activities can lead to a higher fall-risk. Finally, these findings help to purposeful experimentally induce fatigue in the older population when studying fatiguing effects on gait parameters.

P1-I-34: Extension ladder missteps: foot placement corrections as an unanticipated outcome measure in a pilot study

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BACKGROUND AND AIM: Ladder falls are the second most common cause of falls [1]. Of these ladder falls, 28% have been attributed to slips/missteps by the climber [2]. A particular challenge in ladder climbing is during the transition across multiple ladder sections in extension ladders. This study characterizes foot placement corrections during these transitions. METHODS: The testing apparatus consisted of two ladder configurations set at 75.5° angles. One configuration was a traditional extension ladder with the fly section being placed on top of the base section, towards the participant (Figure 1A). The other configuration was a reversed extension ladder with the fly section being placed on the underside of the base section, away from the participant (Figure 1B). The transition between the fly and base sections consists of the 3rd and 4th ladder rungs where the ladder changes from the rungs of one to the rungs of the other. Participants were asked to ascend and descend the ladder to the 5th rung at a comfortable but urgent pace for three trials of each configuration. The 3rd rung of each configuration was attached to a force plate and 12 motion tracking cameras (Vicon) collected kinematic data that was time-synced to the kinetic data from the force plate. 18 participants (9 male, 9 female; 33.83 ± 14.69 years) completed the testing protocol. A trial was considered to have a Foot Placement Correction (FPC) if the participant applied force to the transition rung and repositioned their foot, presumably because a foot placement error had occurred. These FPCs were categorized based on a review rater of motion tracking videos. FPCs were not a planned outcome measure and were only analyzed after frequently observing this event during the study. After the testing protocol, participants were asked for their preferred ladder type. RESULTS: There was found to be a total of 13 FPCs at the transition across 6 participants (1-4 FPCs event each). All 13 FPCs occurred in the traditional extension ladder with 6 occurring during ascent and 7 occurring during descent. 89% of the participants preferred the reversed fly condition over the traditional extension ladder configuration with the other 11% having no preference for either. CONCLUSIONS: FPCs were found to occur more frequently in the transition of the traditional fly configuration than the reverse fly configuration. This finding, along with the user preference for the reversed fly, highlights an opportunity for improving extension ladders by reversing the fly configuration. Interestingly, the perturbations observed in this study were naturally occurring and not caused by experimental controls. ACKNOWLEDGEMENTS AND FUNDING: This work was supported by NIOSH R01OH011799. REFERENCES: 1.Webster, Workplace Falls. Compensation and Working Conditions. 2000. 2.Faergemann, et al., J Safety Research, 2001. 32(3): p. 333-343

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P1-I-35: The effect of attention focus walking training on conscious motor processing during gait rehabilitation in older adults: An interim analysis

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Background and aim: Older adults with a history of falling are suggested to have a higher propensity for conscious motor processing (i.e., reinvestment) during walking, compared to those without a history of falling. Conscious motor processing could affect walking automaticity, which could cause older adult falls. However, no rehabilitation intervention has been clinically developed to ameliorate the propensity for conscious motor processing. This study aims to examine the effect of external, internal, and no attention focus walking training during gait rehabilitation in older adults at risk of falling on their real-time conscious motor processing propensity. Methods: Thirty-four older adults (mean age = 78.1±8.1) participated in the study and were reviewed in this interim analysis. They were randomly assigned to participate either in a No Attention Focus Walking Group (NAFWG, n = 10), an External Attention Focus Walking Group (EAFWG, n = 18), or an Internal Attention Focus Walking Group (IAFWG, n = 6). Participants in different groups participated in 12 training sessions (45 minutes each) with expertly-designed exercise training programs and different walking training protocols. Participants in different groups received specific instructions during walking training in their attention focus group. Assessment sessions were completed before training at baseline (T0) and just after the completion of all training sessions (T1). The primary outcome measure of the real-time conscious motor processing propensity during walking (EEG T3-Fz coherence) was evaluated in this interim analysis. A 3 (Group: NAFWG, EAFWG, IAFWG) x 2 (Time: T0, T1) analysis of variance with repeated measures was conducted to explore the between-group differences (Group [NAFWG, EAFWG, & IAFWG]), within-group differences (Time [T0, T1]), and the interaction effects (Group x Time). Results: There is a trend of a Group x Time interaction effect ($F(2, 31) = 3.093$, $p = 0.06$, $\eta p2 = 0.166$). The main effect of Group is not significant ($F(2, 31) = 1.397$, $p = 0.262$, $\eta p2 = 0.083$). The main effect of Time is not significant ($F(1, 31) = .273$, $p = 0.605$, $\eta p2 = 0.009$) as well. Conclusions: Although no statistically significant findings could be revealed in this interim analysis for the primary outcome measure of the real-time conscious motor processing propensity during walking (EEG T3-Fz coherence), participants in the EAFWG demonstrated a decrease in the real-time conscious motor processing propensity during walking (EEG T3-Fz coherence) after the external focus walking training, but the trend was not observed in the NAFWG after the no attention focus training and the IAFWG after the internal focus walking training. Further analysis after the completion of data collection is needed to confirm the potential beneficial effects of the external focus walking training in ameliorating the real-time conscious motor processing propensity during walking in at-risk older adults. Funding Acknowledgement: The work described in this abstract was supported by the General Research Fund from the Research Grants Council of the Hong Kong Special Administrative Region, China [grant number 17600419].

P1-I-36: Effects of a reactive balance training ReacStep on fall risk in older people

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Background: Trips and slips are the leading causes of falls in older people. Systematic review evidence indicates reactive balance training using repeated perturbations can reduce falls but training methods were not easily accessible (McCrum et al., 2022; Okubo et al., 2017). Thus, this study aimed to examine the effects of a novel ReacStep training using simple and low-cost equipment. Methods: We conducted a randomised controlled trial involving 75 older people (65+ years). An intervention group (N=37) received the ReacStep program (Figure 1) including warm-up, tether-release reactive step training and intentional slip training using a plastic sheet (Figure 1) for 45 min/day, 1 day/week for 6 weeks. Both intervention and control (N=38) groups received home-based strength training using bands for 15 min/day, 2 days/week for 8 weeks. Anxiety during each ReacStep session was evaluated using a 10-point visual analogue scale (0 'Not at all to 10 'Extremely anxious'). Blinded staff assessed reactive balance (laboratory-falls induced by a trip and slip), gait speed, maximum step length, leg muscle strength, postural sway and reaction time at baseline (week 1) and post intervention (week 8). Weekly SMS surveys are ongoing to collect falls in daily life for 12 months. Results: Both groups were similar in demographics with a mean age 72 ± 5.6 years old and ~80% reporting at least mild fear of falling. High adherence was noted for ReacStep session attendance (90%) and home exercises (92%). Anxiety during ReacStep sessions was mostly around "Just a little" and improved over time (session 1: 3.7 ± 2.6, session 6: 3.1 ± 2.2, $P<0.05$). Compared to controls, the intervention group had higher exercise enjoyment ($P<0.05$), slightly lower rates of falls following trip (odds ratio [OR]: 0.82, 95% confidence interval [CI] 0.31-2.18) and slip (OR: 0.68, 95% CI: 0.25-1.85) exposure, but this difference was not significant. The intervention group also showed significantly greater usual gait speed, maximum step length and choice stepping reaction time ($P<0.05$) compared to controls at post test. Conclusion: The ReacStep program showed excellent adherence, mild anxiety and high enjoyment in older people but may not be sufficient to address unexpected trips and slips. ReacStep improved gait speed, maximum step length and step reaction time which are known fall risk factors in older people. Falls in real life are being monitored.

Neurological trauma (e.g. Stroke, TBI, concussion)

P1-J-37: Changes in behavioral complexity and walking velocity while passing a narrow aperture for individuals with stroke

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Background and Aim To avoid collisions with obstacles during walking, it is necessary to have the ability to accurately perceive the spatial relationship between the body and obstacles and to adaptively adjust walking. Individuals with stroke have a higher collision rate with obstacles because of unilateral physical and/or higher brain dysfunction (Said et al. 1999). Muroi et al. (2022) showed that individuals with stroke have improved collision avoidance behavior when passing through an aperture while entering from the paretic side of their body. However, the

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underlying mechanism remains unknown. We aimed to investigate the process by which individuals with stroke walk through the aperture from the paretic and non-paretic sides by comparing two successive processes (i.e., steady walking period and before-passing period). Based on previous studies, we hypothesized that 1) walking velocity and behavioral complexity (i.e., sample entropy: SEn) decrease for narrow aperture widths and 2) the direction of penetration has no significant differences depending on walking velocity, although penetration from the paretic side may reduce SEn. Methods We analyzed the three-dimensional motion analysis data from 20 individuals with stroke (mean age 66.2 years, standard deviation [SD] = 5.9) to reveal how individuals with stroke walk through an aperture. We examined changes in walking velocity and behavioral complexity (i.e., SEn) by focusing on the approaching process. In this study, individuals with stroke were asked to approach and walk through a door-like aperture positioned 4 m ahead of the start line, without colliding with it. Each participant performed the obstacle-avoidance task under two conditions: (1) penetration from the paretic side and (2) penetration from the non-paretic side. The participants performed 12 trials (four different widths [0.9, 1.0, 1.1, and 1.2 times the width of participants' shoulders] three times each) per side. Results The results showed that individuals with stroke had reduced velocity and SEn before passing through the narrow aperture when approaching from the paretic side. Conclusions We investigated whether meaningful behavioral properties lead to safe obstacle avoidance in individuals with stroke from the time they initiated walking to approaching the opening. Our findings suggest that these individuals adjusted their walking velocity before passing through the aperture. The mean velocity got significantly slower as the door width decreased in most pairs of four aperture widths in the before-passing period. In particular, in the penetration from the paretic side, the velocity reduced before passing through narrow apertures. We also found a decrease in lateral sway complexity in difficult task conditions just before passing the aperture. In our previous studies, we interpreted safe obstacle avoidance due to penetration from the paretic side in terms of motor and cognitive aspects.

P1-J-38: Increased head rotation in individuals with moderate paralysis due to stroke while passing a narrow aperture

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Background and Aim: Safely walking through a narrow aperture requires fine-tuning and adjusting posture to avoid collisions with the aperture. Individuals with stroke mainly collided with the upper extremity on the paretic side when walking through the aperture from the non-paretic side (Muroi et al. 2017, 2022). The severity of the paretic side may be a factor in increasing the collision rate, but its effect on walking through the aperture behavior is unknown. We aimed to investigate the postural coordinates of the whole body by dividing stroke participants into two groups according to the degree of upper extremity paralysis. Methods: We analyzed the three-dimensional motion analysis data from 25 individuals with stroke (mean age 66.2 years, standard deviation [SD] = 5.9) and 19 healthy older adults (mean age 67.1 years, SD = 4.6) to reveal how individuals with stroke coordinate their body parts when walking through an aperture by examining rotation angles of the head, shoulder, and pelvis. Stroke participants were graded according to the Brunnstrom recovery stage (BRS) upper extremity classification. We classified BRS 3 and 4 into the moderate paralysis group (n=8, MDR), and BRS 5 into the mild paralysis group (n=17, MLD). In this study, participants were asked to

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approach and walk through a door-like aperture positioned 4 m ahead of the start line without colliding with it. Each participant performed the obstacle-avoidance task under the following two conditions: (1) penetration from the paretic side and (2) penetration from the non-paretic side. The participants performed 12 trials (four different widths [0.9, 1.0, 1.1, and 1.2 times the width of participants' shoulders] three times each) per side. Results: We found significant main effects of the head and pelvis angles when passing through the aperture. The head angle was significantly larger in the MDR group than other two groups. The pelvis angle became significantly larger as the door width narrowed for all groups. Conclusions: We investigated how individuals with stroke with different levels of upper-extremity motor paralysis coordinate their body parts when walking through an aperture. Our findings suggest that participants adjusted their body rotation in the pelvis according to environmental properties, regardless of the level of paralysis. However, the MRD group rotated their head more significantly than the other two groups. We interpret this result in terms of motor difficulty and visual attention. Because the MDR group had a higher muscle tone than the MLD group, they tended to fix their movements around the neck and shoulder girdle. They then rotated their heads at higher angles depending on body rotation. We also speculated that an increased head rotation might reflect increased visual attention to the body and environment as individuals with stroke tend to collide with doors on their upper limbs. Thus, the participants of this study might have rotated their heads at higher angles because of difficulty in movement adjustment and careful visual attention.

P1-J-39: Task-sensitive postural control patterns as a target for stroke rehabilitation

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BACKGROUND AND AIM: People with stroke (PwS) commonly demonstrate increased center of pressure (COP) variability (i.e., COP SD) in both the anterior-posterior (AP) and medial-lateral (ML) directions compared to age-matched controls. Thus, stroke rehabilitation has commonly focused on mitigating overall COP variability. This approach is somewhat at odds with basic motor control research which suggests that low postural variability might not facilitate the achievement of all goals. Rather, posture must be sensitive to supra-postural task demands, and for some tasks, this sensitivity may be reflected by an increase or a directional bias in COP variability (e.g., higher AP, lower ML). The aim of this study was to evaluate the postural control patterns of PwS during the performance of two supra-postural tasks and determine how the amount and structure of these patterns relate to task success. METHODS: Twenty-three PwS (age: 53.7±7.3) with unilateral upper extremity (UE) impairments participated. Participants stood on a force platform (AMTI AccuSway) recording COP for Tasks 1 and 2. In Task 1, participants aimed to produce 0.5-1N of light force with the hand on a force transducer (2, 30 sec trials/UE). In Task 2, participants were immersed in a virtual environment and aimed to maintain the position of a virtual laser pointer (via handheld controller) in an anteriorly positioned target (2, 30 sec trials/UE). Mixed effects models and correlations were used to detect differences in COP patterns between UEs (paretic, nonparetic) and directions (AP, ML) and evaluate associations between task performance and COP patterns. RESULTS: PwS demonstrated lower COP SD using the nonparetic UE compared to the paretic UE in Task 1, $F(1,152)=7.25$, $p<.01$, and there was no difference between the AP and ML directions (AP:ML ratio = 1). Task performance was moderately and negatively associated with COP SD using the paretic UE, $r=-0.45$, $p<.001$. In Task 2, PwS showed lower COP SD using the nonparetic compared to the paretic UE, $F(1,152)=36.80$, $p<.001$. COP SD was also greater in

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the AP compared to the ML direction (AP:ML ratio >1) in both UEs, F(1,151)=31.31, p<.001. Task performance was moderately and positively associated with the AP:ML ratio when using the paretic UE, r=0.40, p=.01. CONCLUSIONS: Task 1 performance benefitted from an overall reduction in COP variability. However, Task 2 was predicated on attaining a relative pattern of COP variability between the AP and ML directions and not a simple gross reduction in variability. The findings of this study might inform the selection of clinical goals for stroke rehabilitation. Postural control should be considered in relation to task demands, and motor patterns (e.g., increased postural variability) post-stroke may reflect the demands of a task goal and not a fixed feature of pathology. These appear to be particularly relevant considerations when PwS use the paretic UE. FUNDING: This project was funded in part by a Foundation for Physical Therapy Research Promotion of Doctoral Studies (PODS) Level II Scholarship.

P1-J-40: Effects of high visual dependence on balance control and gait strategy among patients with chronic stroke

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BACKGROUND AND AIM: Visual dependence is characterized by an excessive reliance on vision. Most studies have investigated the effects of visual dependence on balance, but the effects on gait have rarely been reported. We investigated the effects of high visual dependence on balance control and gait strategies among patients with chronic stroke. METHODS: This study originally recruited 97 patients with chronic stroke. Their level of visual dependence, balance performance, and gait pattern were evaluated. Visual dependence was measured through the rod and disc test, and the participants were categorized into two groups accordingly: high visual dependence (HVD; 33 participants) and low visual dependence (LVD; 32 participants). Balance assessment was performed using the double-leg balance test under different visual conditions, Berg Balance Scale (BBS), and timed up and go (TUG) test. Gait pattern was analyzed under normal and disturbed visual conditions. RESULTS: The participants in the HVD group exhibited significantly larger postural sway in the double-leg balance test under disturbed visual conditions than those in the LVD group. No differences were observed between the groups in the remaining balance assessments. The participants in the HVD group exhibited significantly smaller foot strike angle, shorter stride length, and larger toe-out angle compared with those in the LVD group under normal visual conditions. Furthermore, the HVD participants additionality exhibited shorter swing phase, longer double support phase, and smaller toe off angle under disturbed visual conditions. CONCLUSIONS: High visual dependence affects balance only under disturbed visual conditions but affects gait pattern under both normal and disturbed visual conditions. Such changes in balance performance and gait strategy may increase the risk of falls among patients with chronic stroke and high level of visual dependence.

Other clinical pathologies (e.g. musculoskeletal disorders)

P1-K-41: What effect does reduced knee flexion movement during gait have on patients with knee osteoarthritis?

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Background and Aim A reduced knee flexion angle during loading response is identified as progressive for knee osteoarthritis (OA) and is reported to be a good indicator of the pathological knee joint condition. In addition, increased co-contraction of knee joint muscles during gait enhances knee joint stability. However, when normal knee joint movement is inhibited, mechanical stress on the knee joint increases, which may lead to joint degeneration and destruction, increased pain, and impaired physical function. Therefore, the purpose of this study was to clarify the relationship between knee flexion excursion (KFE) during stance phase of gait and mechanical stress on the knee joint, muscle strength, pain, and physical function in patients with knee OA. Methods Participants were 20 women diagnosed with knee OA (age: 72.1±4.6 years old, body height: 1.54±0.08 m, and body mass: 56.6±6.7 kg). They performed 10 gait trials on a level ground at a comfortable speed. Kinematic and kinetic data were obtained using a three-dimensional motion analysis system with 6 infrared cameras (VICON, UK) and eight force plates (Tec Gihan, Japan). From the obtained data, we calculated the gait speed, KFE from initial contact to maximum knee flexion angle, external knee adduction moment (KAM) impulse, and external knee flexion moment (KFM) impulse during stance phase. The Knee injury and Osteoarthritis Outcome Score (KOOS) was used to evaluate pain, symptoms, activities of daily living, sports and recreation function, and knee-related quality of life subscales. Knee joint extensor muscle strength was also calculated using a hand-held dynamometer (Anima, Japan). Statistical analysis was performed using the statistical software SPSS (IBM Japan, Japan). Partial correlation coefficients were calculated controlling for age and gait speed to examine the relationship of each dependent variable with KFE, the independent variable. The significance level was set at $p<0.05$. Results We found significant positive correlations of KFE with KFM impulse ($r=0.60$, $p<0.05$), KOOS (pain: $r=0.52$, symptoms: $r=0.74$, ADL: $r=0.52$, sports and recreation function: $r= 0.51$, $p<0.05$), and knee extension muscle strength ($r=0.58$, $p<0.05$). Additionally, we found significant negative correlations between KAM impulse (r-0.52, $p<0.05$) and KFE. Conclusions Patients with knee OA reportedly have an altered gait pattern to increase knee joint stability by co-contraction. This study revealed that gait with reduced KFE is a pattern that responds to muscle weakness, pain, symptoms, and physical function but may result in increased mechanical stress on the knee joint in the coronal plane. The findings suggest that physical therapy for knee OA should consider pain, symptoms, and physical function when reacquiring knee joint flexion movement in the affected lower limb during stance phase of gait.

P1-K-42: Socket suspended prosthesis use negatively affects extended physiological proprioception

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BACKGROUND AND AIM: Individuals with transhumeral (TH) limb loss have the highest rate of prosthesis abandonment, up to 60%, often citing an inability to control the device as the cause [1-4]. This control is termed extended physiological proprioception (EPP), a learned skill that allows the extension of proprioception beyond the body to control a simple tool [6]. As individuals with TH amputations transition to percutaneous osseointegrated (OI) endoprostheses, it is critical to understand if they also experience improved EPP. This study aimed to quantify differences in EPP between the intact limb and prosthetic limb in individuals

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using socket-suspended TH prostheses, with the intent of using these results in future studies comparing socket-suspended systems to percutaneous OI endoprosthetic systems for functional changes. METHODS: Eight male subjects with TH limb loss and socket-suspended prostheses participated in the study (median age: 58 years [range 29-77)]). Four of the subjects used a body-powered hook, one a myoelectric hook, and three a myoelectric hand. The subjects reported using their current device for a median of 5 years (range 2-12). Subjects completed an EPP targeting task protocol while simultaneously being recorded using motion capture. A custom MATLAB script calculated precision (consistency in targeting), accuracy (distance between the intended target and subject result), and average location relative to the intended target for the task. Elbow, shoulder, and trunk angles during the task were calculated from the motion capture data using Visual3d. RESULTS: Results from the EPP task demonstrated subjects were more precise when targeting with the intact limb compared to the prosthetic limb, $p<.008$. There was no significant difference in accuracy between the intact limb and the prosthetic limb. When targeting with the intact limb, all eight subjects undershot the target and seven biased ipsilateral to the target. With the prosthetic limb, four subjects undershot the target with ipsilateral bias, two undershot the target with contralateral bias, and two overshot the target with contralateral bias. The motion capture results demonstrated trunk flexion, lateral flexion, and rotation were significantly greater when subjects targeted with their prosthesis compared to their intact limb, $p<.02$. Shoulder flexion was significantly less when subjects targeted with their prosthesis compared to their intact limb, $p<.008$. CONCLUSIONS: The differences in precision and location relative to the target support a lack of control over the prosthesis and indicate disruption to proprioceptive planning. The compensatory motion in the trunk supports the need for strength and range of motion training during rehabilitation. These results will be used in future comparative studies as individuals transition from socket-suspension to a TH percutaneous OI endoprosthetic system to quantify changes to functional prosthesis use related to the suspension system. ACKNOWLEDGEMENTS AND FUNDING: Funded by VA RRD 1 I01 RX002513-01A2 and National Science Foundation Graduate Research Fellowship under Grant No. 1747505.

P1-K-43: The effect of mechanical stress during descending stairs on the behavior of medial meniscus extrusion

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Background and aim Patients with knee osteoarthritis often experiences the difficulty of descending stairs due to occurring pain with greater mechanical stress. Medial meniscus extrusion (MME) expands with greater mechanical stress. Especially, the increase in MME is an indicator to be associated with knee pain whereas it is still unknown the dynamics of MME during descending stairs. Since the mechanical stress is known to be higher in descending stairs than that in gait, the increase in MME might expand according to the greater mechanical stress. Then the aim of this study is to investigate the effect of mechanical stress during descending stairs on increase in MME. Methods Twenty healthy participants (females: 10, age: 22.3 ± 0.9 years) were recruited in this study. They were asked to perform in two tasks both of gait and descending stairs. The kinematic and kinetic data were evaluated by three-dimensional motion analysis system and obtained vertical grand reaction force as the representative mechanical stress during stance phase. MME was evaluated by ultrasonography. A prototype transducer with a flat-shaped linear-array was placed

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longitudinally on the medial joint space and record the dynamics of meniscus during task on video mode. The evaluation of meniscus was performed in two locations as the middle and posterior segments to obtain the detail information of meniscal movement according to the different knee angle. Then, the tasks in each segment were set by four conditions (gait in middle and posterior segments: m-gait, p-gait, and descending stairs in middle and posterior segments: m-descending, p-descending). The MME was shown as the distance from the medial tibial plateau cortex to the outermost edge of the medial meniscus. Moreover, the increase in MME was identified as the difference in MME from the initial contact to the maximum during task. Results In the p-descending condition, the increase in MME was significantly higher than those in conditions ($p < 0.05$, m-gait: 0.48 ± 0.20 mm, p-gait: 0.65 ± 0.23 mm, m-descending: 0.03 ± 0.03 mm, p-descending: 0.84 ± 0.33 mm). In the ground reaction force, the descending conditions were higher than those in gait conditions ($p < 0.05$, m-gait: 519.26 ± 174.55 N, p-gait: 549.45 ± 172.26 N, m-descending: 756.12 ± 174.55 N, p-descending: 741.15 ± 258.07 N). Conclusions The increase in MME during descending stairs expanded according to greater mechanical stress, in especially the posterior segment of meniscus. These results could contribute to understand the dynamics of meniscus under mechanical stress.

P1-K-44: Association of the degree of varus thrust during gait assessed by an inertial measurement unit with pain, symptoms, and disability in patients with knee osteoarthritis

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Background and aim: Varus thrust during gait is a clinically crucial gait characteristic in patients with medial knee osteoarthritis. The presence of varus thrust has been associated with symptoms, functional ability, and disease progression. However, whether the more severe the varus thrust give, the stronger impact on clinical outcomes remains unclear. Therefore, this study aimed to assess the association between the degree of varus thrust assessed by an inertial measurement unit and pain, symptoms, and disability. Methods: A total of 70 patients with knee osteoarthritis (mean age: 59.8 ± 8.6 years; women: n = 40) were recruited in this cross-sectional study. Patients were instructed to walk on a treadmill with an inertial measurement unit attached to the tibial tuberosity. As an index of varus thrust, the root means square of acceleration in the mediolateral direction adjusted by the swing speed (adjusted root means square) was calculated. The index reliability and validity were confirmed in our previous study. The Knee Injury and Osteoarthritis Outcome Score was a questionnaire used to assess pain, symptoms, and disability. Data on age, sex, and body mass index were collected as potential confounders. Additionally, disease severity, synovitis, and central sensitization were assessed by x-ray imaging; Kellgren and Lawrence classification, magnetic resonance images, and a questionnaire; and central sensitization inventory, respectively. Multiple linear regression analyses were performed to evaluate the relationship between varus thrust and Knee Injury and Osteoarthritis Outcome Score subscore after adjusting the confounders. Results: The number of patients per Kellgren and Lawrence classification was 19 (27.1%), 45 (64.3%), and 6 (8.6%) for classes II, III, and IV, respectively. The regression analysis results revealed that the adjusted root means square in the mediolateral direction were significantly associated with pain (standardized $\beta = -0.290$, $p = 0.016$), symptom (standardized $\beta = -0.266$, $p = 0.030$), and disability (standardized $\beta = -0.289$, $p = 0.009$) subscores independent of potential

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confounders. Conclusions: Our results indicate that more severe varus thrust during gait is associated with more severe pain, symptoms, and disability independent of disease severity, synovitis, central sensitization, and other potential confounders. Although the causality is not confirmed as the cause of a limited study design, targeted interventions that mitigate varus thrust may improve patient-reported outcomes.

P1-K-45: Effect of asymmetry of cumulative knee adductor load on medial meniscus extrusion in healthy volunteers

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BACKGROUND AND AIM: Increase in medial meniscus extrusion (MME) under loading stress is associated with the development of early stage of medial knee osteoarthritis (OA). Especially, the increase in MME reflects the disfunction of load-distribute function and is associated with knee adduction moment (KAM) which is known as an indicator of medial tibiofemoral load. High KAM has been revealed on the affected side in patients with unilateral knee OA, which indicating that the asymmetry of KAM is important to prevent the pathomechanical development of knee OA. Moreover, previous study reported that repetitive loads of mountain marathon aggravated MME even in healthy individuals. Then, it might be expected to reveal the aggravated MME by cumulative KAM which is reflected in repetitive loads. Therefore, this study aimed to clarify the effect of laterality with cumulative knee adductor load on the increase in MME and provide insight into whether the loading stress asymmetry of loading stress can be a factor in the development of early knee OA. METHODS: Ten healthy participants (age, 22.4 ± 0.4 years; female, 6) were enrolled and imposed on walking effort including up-downhill 5km road. The participants wore a wearable device to record their steps. At pre-effort, KAM impulse was measured by motion analysis system (VICON MX) and force plates (AMTI Inc.). Then, the higher side and lower side were defined as "greater side" and "lesser side", respectively. The cumulative load of KAM during effort was calculated as the product of steps per unilateral leg and KAM impulse. At pre- and post-effort, the MME was measured by ultrasonography (SNiBLE, Konica Minolta) and obtained two positions both of supine and standing. MME was defined as distance between the cortex of the medial tibial plateau and outermost edge of the medial meniscus, and ΔMME was calculated as the difference in MME between supine and standing. Laterality of KAM parameters and ΔMME were compared using paired T-Test, and the level of significance was set at 0.05. RESULTS: The steps per unilateral leg during gait task was 4075 ± 453 steps. KAM impulse and cumulative load were significantly higher in greater side than those in lesser side, and large laterality was observed in cumulative load ($p < 0.001$; laterality: impulse 0.17 ± 0.06 Nm*s/kg, cumulative load 711.8 ± 241.3 Nm*s*steps/kg). At pre-effort, there were no significant asymmetry in ΔMME (greater, 0.23 ± 0.14 mm; lesser, 0.34 ± 0.22 mm; $p = 0.16$). ΔMME had no significant difference between pre- and post-effort, and no significant laterality was observed at post-effort (greater, 0.31 ± 0.20 mm; lesser, 0.24 ± 0.12 mm; $p = 0.37$). CONCLUSIONS: Aggravation of MME wasn't induced by the asymmetry of cumulative KAM. Then, asymmetry of KAM could not be directly caused to the development of early stage of knee OA, because of remaining the meniscal function of load-distribution.

P1-K-46: Can dynamic ultrasound capture the morphological change of infrapatellar fat pad during walking?

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Background and aim Knee pain during walking with knee osteoarthritis (OA) is associated with occurring of the mechanical stress. Knee flexion moment (KFM) is a representative mechanical stress and reflect to high pressure in patellofemoral joint. However, the reaction of KFM is vary in individual knee OA patients based on complex pathology, in which the association with knee pain is still remain controversial. The infrapatellar fat pad (IFP) has a role of buffer capacity in the patellofemoral joint due to flexibly morphological change. However, the flexibility of IFP gradually lost with knee OA pathology such as scarring and adhesion and it leads to functional disability. Therefore, it is important to include the information of IFP during walking for elucidation of the mechanism of knee pain. Ultrasonograpy can evaluate the flexibility of IFP by its morphological change. Especially, the dynamic ultrasound is available tool to sensitively capture the morphological change during walking whereas the validity for IFP is still unknown. The purpose of this study is to provide the validity of IFP morphology in healthy participants during walking based on relationship with KFM. Methods Thirteen healthy participants (5 males, 8 females; age: 22.1 ± 1.1 years) were involved in this study. Three-dimensional motion analysis system was evaluated KFM and knee flexion angle with single gait cycles. The IFP longitudinally evaluated using an ultrasonography with prototype transductor, and was recorded during walking on video mode. The IFP value was identified as the thickness between the patellar tendon and tibia which is 10 mm proximal of the tendon insertion. To detect the dynamic of IFP during walking, the waveform constructed by sequence of IFP thickness. These data were calculated with maximum and minimum values. Especially, the morphological change of IFP (ΔIFP) was shown as the difference in IFP between maximum and minimum. On statistical analysis, the correlation between IFP and KFM, IFP and knee flexion angle were evaluated using Pearson?s correlation coefficient. The significance level was set at 0.05. Results In a single gait cycle, the thickness of IFP was increased in the early stance phase whereas it gradually was decreased in the swing phase. Moreover, the KFMmax was occurred in the early stance phase and was correlated with IFPmax ($r = 0.88$, $p < 0.01$) and ΔIFP ($r = 0.65$, $p = 0.02$). On the other hand, IFPmax and ΔIFP were not correlated with knee flexion angle. Conclusions The thickness of IFP expanded at the early stance phase, and its amount of change was correlated with KFM. Therefore, these results indicate the morphology change of IFP presents according to the mechanical stress of the knee and provide the reference data as the dynamic IFP during walking.

P1-K-47: Effect of dynamic knee valgus on lower limb muscle synergies during single leg squat

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Background and aim Dynamic knee valgus (DKV) during single leg squat (SLS) is used to assess lower limb dynamic alignment. Larger DKV is considered one of the risk factors for lower limb musculoskeletal disorders. The differences in kinematics observed from outside the body may be due to differences in the motor coordination system created inside the body. The motor coordination can be assessed using muscle synergy analysis and has been reported to differ between people with and without musculoskeletal disorders. However, those with

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musculoskeletal disorders have many potential influences on muscle synergies, including pain, structural disorders, and kinematic characteristics. Therefore, it is necessary to clarify whether changes in muscle synergies affect the kinematic characteristics of asymptomatic people. The purpose of this study was to compare muscle synergies during SLS in healthy subjects grouped by the amount of DKV. Methods Twenty-six healthy young adults (13 males, 13 females, age: 21.8 ± 0.7 years) participated in this study. The task was SLS with 60° of knee flexion at a comfortable speed as perceived by the subjects on the dominant leg. DKV was calculated using frontal plane projection angle (FPPA) and subjects were divided into two groups (Large group vs Small group) according to the median of the value. Muscle synergies were extracted from surface electromyography data of 12 dominant lower limb muscles using non-negative matrix factorization. Statistical analysis for the synergy vectors was performed by applying the Shapiro-Wilk test, followed by the t-test or Mann-Whitney U test. For the activation coefficients, statistical parametric mapping was performed. The significance level was set at 0.05. Results The FPPA as a grouping criterion was Large group: 17.7 ± 3.7 ° and Small group: 8.4 ± 2.7 ° ($p < 0.05$). There were no significant differences in the number of muscle synergies between groups, and three muscle synergies were used for intergroup comparisons. These three synergies showed activity in the transition from descending to ascending SLS, ascending SLS, and throughout the SLS, respectively. The Large group showed higher values in vastus lateralis and biceps femoris in synergy vectors during the transition phase. However, no significant differences were found in the other muscles of synergy vectors. Furthermore, the activation coefficients of the two groups did not differ significantly. Conclusions In healthy subjects, muscle synergies were found to differ depending on kinematic characteristics, even for the same task movement. The increased demands on vastus lateralis and biceps femoris of synergy vectors with a crucial role during the transition phase shown by the Large group is involved in the large DKV. Focusing on changes in kinematic characteristics and muscle synergies could be developed for the prevention of musculoskeletal disease.

Other neurological disease (e.g. Multiple sclerosis)

P1-L-48: Daily-living gait and physical activity metrics can identify people with multiple sclerosis who experience physical fatigue and fatigability

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BACKGROUND AND AIM: Physical fatigue (PFe) and fatigability (Pfy) negatively impact the everyday functioning and mobility of people with multiple sclerosis (pwMS). The general state of physical fatigue, as reported by questionnaires, and perceived fatigability, as reported following prolonged, fatigue-inducing effort, and their objective representatives studied in laboratory settings have been previously reported. Recent work in several populations described an association between physical fatigue and activity patterns during the day. However, objective markers of Pfy and Pfy based on daily-living performance have not been well defined in MS. Here we aim to examine daily-living activity patterns and quality of daily-living walking of pwMS with different levels of Pfe and Pfy. METHODS: 45 pwMS (47.9±11.23 yrs old; 69% female; EDSS 2, IQR: 0-5.5) completed the Modified Fatigue Impact Scale (MFIS)

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questionnaire, from which we used the physical component to assess Pfe. The participants then performed a fatigability provoking test (6MWT), and, afterward, reported their perceived fatigability (Pfy) using a visual analog scale 0-10 (VAS), and were asked to wear a 3D accelerometer on their lower back for a week (24/7). Physical activity patterns, top percentile (ranking across all bouts during a day), and bottom percentile of gait spatio-temporal characteristics were extracted from bouts of 30 and 60 sec of the daily living data and averaged across days. Logistic regression models adjusted for age, sex, and EDSS were used to identify pwMS with less or more physical fatigue (<15.9 vs >16 on the MFIS, the PFe model), and less or more fatigability (<4 vs >4.5 on the VAS scale, the Pfy model). RESULTS: The PFe model correctly classified 82% of the subjects as more or less severely physically fatigued, explaining between 48.9% (Cox & Snell R square), and 65.2% (Nagelkerke R square). The Pfy model correctly classified 86% of the subjects who perceived more or less fatigability following the 6MWT, explaining between 43% (Cox & Snell R square), and 57% (Nagelkerke R square). Lower top percentile of step time (of 30-sec bouts), higher asymmetry in the medio-lateral direction of the worst bouts, and higher average duration of active bouts were the main predictors of more severe Pfy. Fewer bouts >1 min, and higher average duration of active bouts were predictors of more severe PFe. CONCLUSIONS: These results suggest that among pwMS, fatigue and fatigability are associated with daily-living walking bout duration, the number of relatively long walking bouts (for Pfe), and with poorer gait quality (for Pfy). The daily-living mobility markers related to PFe and Pfy overlap, to some degree, as expected, although there are some specific differences. More generally, these findings take us a step closer to defining objective markers of physical fatigue and fatiguability based on continuous 24/7 monitoring of gait and activity in pwMS using a wearable sensor. ACKNOWLEDGEMENTS AND FUNDING: The study was supported by Israel Innovation Authority

P1-L-49: The effect of gait stability and arm swing on walking speed during the 6-minute walk test in persons with Multiple Sclerosis

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BACKGROUND AND AIM: Fatigue is a major complaint in patients with multiple sclerosis (pwMS)[1]. Previous research identified walking fatigability in pwMS by assessing the change in distance walked between minute 6 and 1 of the 6-Minute Walk Test (6MWT)[2]. Further, pwMS show lower limb gait deficits[3], resulting in decreased gait stability compared to healthy controls[4]. Additionally, upper limb movements can be altered in pwMS due to direct MS lesions[5], which have an important role during gait[6]. Therefore, the aim was to assess to what extent change in walking speed in pwMS is associated by changes in gait stability and arm swing from minute 6 to 1 of the 6MWT. METHODS: Participants were included if they had: MS, age between 18-65, disease severity score from 1 to 5.5 on Expanded Disability Status Scale, ability to walk without walking aids. Participants were excluded if they had: a relapse 3 months, lower limb fracture 12 months, or lower limb botulinum toxin 6 months prior to the study. Participants performed the 6MWT on the CAREN (Motek), equipped with the Human Body lower limb and trunk model, including extra markers for arm swing (acromion and ulnar styloid). Participants walked as fast as possible using self-paced mode. Two familiarization rounds of 3min, incl. breaks, were provided. Step width and variability of spatiotemporal parameters (i.e. step width, -length & -time) were used to assess gait stability[7]. Arm swing length was calculated as the difference between maximum anterior and posterior hand

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position. Most affected side was taken into account and defined as the side with greatest motor impairment (i.e. spasticity and/or weakness). Difference scores between minute 6 and 1 of the 6MWT were used for analyses. First, 1-tailed Pearson correlations between gait stability measures & arm swing, and walking speed during the 6MWT were tested. Then 1-tailed partial correlations were assessed to determine whether gait stability measures influenced walking speed when taking arm swing into account. Finally, significant factors were used in generalized estimation equations (GEE) to determine the extent of their effect on walking speed and possible interactions. RESULTS: Preliminary results included data of 11 pwMS(Table1/T1). Walking speed was significantly related to step length variability, step time variability and arm swing(T1). Partial correlation of step length variability and step time variability remained significant when controlling for arm swing(T1). GEE determined interaction effects between step length variability, step time variability and arm swing on walking speed(T1). CONCLUSIONS: Results indicate that both gait stability and arm swing are significantly associated to walking speed during 6MWT in pwMS. These outcomes have a separate effect on walking speed as well as an interaction effect. Future studies could investigate whether gait stability and arm swing might be underlying factors driving walking fatigability in pwMS.

P1-L-50: Lyapunov Exponent from novel placement of inertial sensor detects subclinical gait instability in non-disabled people with multiple sclerosis

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Background and Aims: A common clinical measure of gait deterioration in Multiple Sclerosis (MS), the timed 25-ft walk test (T25fwt) is insensitive in the early stages of disease, when optimizing treatment strategy is most critical. One alternative measure, the Lyapunov Exponent (LyE), quantifies gait stability, the ability to cope with step-to-step perturbations and return to the attractor state. LyE reflects higher-level organisation surrounding variability within a time series (e.g. 5-min walk). We recently showed LyE calculated from motion capture data is sensitive to subclinical gait deterioration in people with MS (pwMS) and is closely associated with axonal damage in motor tracts using diffusion MRI. However, studies assessing the validity of LyE in pwMS in clinical settings are lacking. We aimed to examine LyE sensitivity utilizing wearable inertial measurement unit (IMU) sensors during overground walking in a clinical setting by assessing known-groups validation. We also compared output from novel sensor placement at the sternum with traditional placement at the sacrum, and aimed to further develop construct validity by exploring clinical covariates of LyE measures. Method: 56 pwMS (relapsing-remitting, Expanded Disability Status Scale (EDSS) 0-4) and 23 age-matched healthy controls (HC) walked for 5 minutes along a 20m walkway wearing APDM sensors (Oregon, USA) at the Sternum and Sacrum. LyE was calculated from acceleration data for each plane and composite 3D using Rosenstein's method, within the 0-0.5 stride region, in Matlab (Natwick, USA). Statistical Analyses were conducted in SPSS 27 (IBM Inc., Chicago, IL, USA). MANOVA was used to examine group differences. Associations of LyE with clinical Kurtzke Functional System scores were examined (Spearman's coefficient). Results: Sternum3D and Sacrum3D demonstrated between-group differences ($F(3,33)=9.45$, $p<0.001$ and $F(1,74)=4.29$, $p=0.042$, respectively). All sternum-derived LyE measures detected significant differences between disability groups with moderate to large effect sizes ($\eta 2=.170$-297). Effect sizes for sacrum-derived LyE were lower ($\eta 2=.065$-$.135$). Sternum3D best distinguished EDSS0-1 from HC ($\eta 2=.198$), whereas T25fwt was insufficiently sensitive. Sternum3D correlated best with pyramidal score ($rs=.447$, $p=.001$). Sensory score correlated

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with frontal plane LyE [SacrumML(rs=.362, p=.009) SternumML(rs=.293, p=.037)]. Conclusion: Assessment using single-sensor-derived LyE was feasible in a clinical setting and sensitive to gait deterioration pwMS with mild disability. Novel sensor placement at the sternum was even sensitive to sub-clinical gait instability (EDSS 0-1), demonstrating potential capacity as a digital biomarker for deterioration early in MS, when optimal clinical management is most critical to avoid accumulation of disability. Funding: Multiple Sclerosis Research Australia

Paediatric (e.g. Cerebral Palsy)

P1-M-51: Unravelling the relationship between balance control and ankle proprioception in children with CP: a case report

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BACKGROUND AND AIM: Central processing of ankle proprioceptive signals is critical for standing balance control [1]. In children with cerebral palsy (CP), however, proprioceptive deficits are prevalent (44%-72%) [2,3]. As such, these children might be limited in their ability to rely on proprioceptive pathways for balance control, and, therefore, experience balance problems in particular sensory situations [4]. Regardless, to date, there is little to no understanding of ankle proprioception as a possible determinant for (sensory orientation) of balance control in CP. METHODS:Ankle proprioception was assessed in terms of Joint Position Sense (JPS). Each child was asked to re-identify a target position by pressing a button when the ipsilateral ankle was passively moved in the same sagittal range at the same predetermined speed. Testing was repeated three times for both dominant (less affected) and nondominant (most affected) body side. The absolute joint reproduction error (JRE, °) between the target and reproduction joint angle was calculated from 3D kinematics [Vicon, ISB lower limb marker model[5]] and used as a measure of JPS accuracy[6]. Standing balance was assessed by Center of Pressure [CoP]-based postural sway measures. Children performed 40-second quiet standing trials under two sensory conditions: eyes open (EO) and eyes closed (EC) on a firm surface. The Romberg Quotient (RQ), defined as ratio between CoPvelocity (EC) and CoPvelocity (EO), was calculated along anteroposterior (AP) and mediolateral (ML) direction and used as an outcome. RESULTS:Figure 1 shows preliminary data from 14 TD children (8.55±1.06 years; 7 boys/7 girls) and three age-matched children with CP (8.01±1.38 years; 1 boy/2 girls; GMFCS level I-II; spastic diplegia). Overall, in both case-groups, only RQ larger than one were observed. Within CP cases, unlike TD children, from 9 to 6 years old, > 60% increment in JRE values (i.e., poorer ankle JPS) was observed with increasing RQ (i.e. more EC related changes in CoPvelocity), predominantly along AP direction. Regarding limb dominance, a similar trend for a positive linear relationship is observed for both sides. CONCLUSIONS: When the sensory environment changes and dependence on ankle proprioceptive input for spatial orientation increases[1], balance control in CP deteriorated, as shown previously[4], and more so, in relation to potential ankle proprioceptive deficits. To further support this, a larger sample will be tested and a multiple regression analysis will be applied to determine the extent to which ankle proprioception contributes to (sensory orientation of) balance control, considering their chronological age. The latter is important, since the processing and integration of different sensory stimuli for balance control still

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modifies through child development[7]. This ongoing study highlights the importance of also mapping proprioception, alongside motor functions, in the evaluation and treatment of balance disorders in CP. REFERENCES: [1]Goble et al (2011); [2]Goble et al (2009); [3]Jason et al (2011); [4]Pavao et al (2015); [5]Wu et al (2002); [6]Horváth, Á., Ferentzi, E., Schwartz, K., Jacobs, N., Meyns, P., & Köteles, F. (2022); [7]Casselbrant et al (2007)

P1-M-52: Relationships between sedentary behavior and physical activity, secondary impairment of physical function in adults with cerebral palsy: cross-sectional study

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Background and aims: The adult with cerebral palsy (CP) experiences secondary disabilities with aging, primarily a decline in physical function. In addition, it has been shown that adults with CP have increased sedentary time and decreased physical activity. Prolonged sedentary behavior and reduced physical activity in adults with CP may be risk factors for health problems. Therefore, it is an important task to reduce the sedentary time and increase the physical activity in adults with CP. The aim of this study was to clarify the relationship between sedentary behavior and physical activity and secondary impairment in adults with CP. Methods: Twenty-two adults with CP participated in the study (age, 37.4 ± 14.7 years, Gross Motor Function Classification System: GMFCS Level I: 6, II: 12). The ActiGraph triaxial accelerometer (wGT3X-BT) was used to objectively assess sedentary behavior and physical activity. Based on the acceleration rate, the intensity of physical activity was classified into Sedentary Behavior (SB), Light Physical Activity (LPA), and Moderate-Vigorous Physical Activity (MVPA). The percentage of each intensity of physical activity (%SB, %LPA, %MVPA) to the total measured time was calculated, and the average value for the three days was used as the representative value. Secondary impairments were measured with the Fatigue Severity Scale (FSS), knee extension strength, walking ability (comfortable and maximal walking speed), and the Timed Up and Go Test (TUG). Statistical analysis was performed using Pearson's correlation coefficient or Spearman's rank correlation coefficient to examine the association between sedentary behavior and physical activity and secondary disability. Additional analysis was performed by partial correlation analysis with gender and age as adjustment factors. The probability of significance was set at 5%. Results: Significant correlations were found between %SB and age ($r = 0.431$, $p = 0.045$), %MVPA and age ($r = -0.580$, $p = 0.005$), maximum walking speed ($r = 0.440$, $p = 0.046$). and TUG ($r = -0.434$, $p = 0.044$). Furthermore, partial correlation analysis adjusted for gender and age showed no significant correlation between %SB and %LPA and secondary impairments. Significant correlations were found between %MVPA and maximal walking speed ($r = 0.602$, $p = 0.023$) and TUG ($r = -0.600$, $p = 0.023$). Conclusions: The results of this study indicate that age affects sedentary behavior and physical activity in adults with CP, and that aging is a risk factor for increased sedentary time and decreased physical activity. Furthermore, MVPA was associated with maximum walking speed and TUG, suggesting that maintaining and/or increasing walking and balance ability may be effective in prevention of physical activity decline in adults with CP.

Parkinson's disease

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P1-N-53: What is the relationship between volume and intensity of physical activity in people with mild-moderate Parkinsons disease?

Sandra Brauer[1], Sjaan Gomersall[1], Katrina Kemp[1], John O'Sullivan[1], Robyn Lamont[1]

[1]The University of Queensland

Background and aim: Volumetric measures of physical activity such as step count are commonly collected via accelerometry to characterise physical activity in people with Parkinson's disease (PD). However, measures of intensity of activity are needed to understand whether physical activity guidelines are met (e.g. time spent in moderate-vigorous physical activity, MVPA). Some bouts of activity have been suggested to reflect intensity (e.g. high cadence = high intensity activity), but it needs to be determined if these measures are related in people with PD, who can have altered cadence. In addition, not all physical activity is related to walking. The aim of this study was to determine the relationship between volume and intensity measures of physical activity in people with mild-moderate PD. Methods: A total of 69 community-dwelling people diagnosed with mild-moderate PD (mean age 65±9 years, Hoehn and Yahr stage 1-3), with a score of >23/30 on the Montreal Cognitive Assessment Scale (MoCA) were recruited to the study. Physical activity volume was assessed using an activPAL3TM accelerometer over 7 days, including measures of time spent sitting, upright and walking, total number of steps, and time, steps and numbers of bouts of >100 steps/minute. Intensity of physical activity was measured using self-report via the Multimedia Activity Recall for Children and Adults (MARCA), a computerised 24-h time-use tool where participants are asked to recall all activities in 5-minute increments. MARCA phone calls were scheduled during the 7 days participants were wearing the accelerometer. For 2 days of recall, average time spent sedentary (1-1.9METs), light intensity PA (2-2.9 METs), and MVPA (3-99 METs) were reported. Gait capacity was measured using single and dual-task TUG tests. Results: MVPA was weakly associated with mean daily total walking time ($r=0.390$, $p=0.002$), sitting time (-0.347, $p=0.007$), upright time ($r=0.282$, $p=0.031$) and total steps ($p=0.281$, $p=0.031$). There was no association between sedentary or light physical activity and accelerometry data ($p>0.069$). Similarly, there was no association between MVPA, sedentary or light physical activity and activity bouts (time spent in bouts of >100 steps/min: $r=-0.139$, $p>0.294$; number of steps taken in bouts of >100steps/min: $r=-0.223$, $p=0.089$; or number of bouts of >100 steps/min: $r=0.005$, $p=0.970$). There was no relationship between physical activity intensity and gait capacity measures (TUG tests). In contrast, there was a moderate correlation between volume measures - e.g. mean total daily steps and TUG ($r=-0.480$, $p<0.001$), TUGmotor ($r=0.465$, $p<0.001$), and TUGcognitive ($r=-0.447$, $p<0.001$). Conclusions: Volume and intensity of physical activity are weakly related in people with PD. Cadence-defined bouts of volume of physical activity do not reflect activity intensity. Measures of both volume and intensity should be captured to fully describe physical activity in people with PD. Acknowledgements and funding: This research was supported by Wesley Medical Research.

P1-N-54: Self efficacy for exercise is not related to actual physical activity levels in people with mild-moderate Parkinson's disease

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Background and aims: Self-efficacy in the context of exercise behavior is defined as a person's belief in their capability to overcome personal, social, and environmental barriers to exercise.

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Studies have reported that self-efficacy for exercise is more strongly associated with self-reported readiness to exercise than disease severity in ambulatory, community-dwelling people with mild-moderate Parkinson's disease (PD). The aim of this study was to determine if self efficacy for exercise was related to actual physical activity levels, underlying gait capacity or characteristics associated with exercise beliefs in people with mild-moderate PD. Methods: A total of 82 community-dwelling adults diagnosed with mild-moderate PD (mean age 65±8 years, 3.8±3 years since diagnosis, Hoehn and Yahr stage 1-3), with a score of >23/30 on the Montreal Cognitive Assessment Scale (MoCA) attended one test session. All participants completed the self-efficacy for exercise scale, asking how confident they are that they could exercise 3x/week for 20 minutes under challenging conditions (rated 0, not confident to 10, very confident). Physical activity was assessed using an activPAL3TM accelerometer over 7 days, including measures of time spent sitting, upright and walking, total number of steps, and activity bouts. Gait performance was characterised as gait speed during single and dual task TUG tests, and endurance via the 6 minute walk test. The outcome expectations for exercise scale assessed agreement with statements about the positive effects of exercise (rated 1, strongly agree to 5, strongly disagree). Results: Self efficacy for exercise was high in this cohort (mean 7.1±1.9), with 85.4% of participants with a total score of >5/10. Exercise self efficacy was not related to actual physical activity levels as measured with accelerometery (volume or bout measures $p>0.149$) in the whole group or for those who had a low average step count/day of <6500 steps (n=30). Similarly, it was unrelated to gait speed ($p>0.266$) or endurance ($p>0.147$). Self efficacy for exercise was associated with outcome expectations for exercise overall (Total: $r=-0.308$, $p=0.005$), expectations that exercise improves endurance in performing daily tasks ($r=-0.443$, $p<0.001$), and that exercise makes you more alert mentally ($r=-0.247$, $p=0.026$). Conclusions: Belief that one can overcome barriers and exercise was not related to actual exercise behaviours in people with PD who have high self efficacy. When changing behaviour, beliefs are needed first in a motivational phase to drive behaviours, but then a volitional phase is required where self-regulatory skills and strategies such as action planning or coping planning, are required to translate intentions into action, and should be incorporated into interventions to increase physical activity in people with PD. Acknowledgements and funding: This research was supported by Wesley Medical Research.

P1-N-55: Predictors of sustained physical activity during the COVID-19 pandemic in people with Parkinson's disease

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BACKGROUND AND AIM: During the first wave of the Covid-19 pandemic people with Parkinson's disease (PwPD) reported deterioration in health and physical activity. The aim of this study was to describe 1-year changes in physical activity and perceived health in PwPD during the COVID-19 pandemic and to identify predictors of sustained physical activity. METHODS: This study compared perceived health and sensor-derived physical activity (Actigraph GT3x) in PwPD living in Sweden between the first wave (June − July 2020) and third wave (June − July 2021) of the pandemic. Multiple logistic regression analyses were used to predict sustained physical activity across the study period using personal factors, disease severity and functioning as independent variables. RESULTS: 63 PwPD (mean age 71.0 years, 41% females) completed both the baseline and 1-year follow-up (26 lost to follow-up). PwPD showed a decrease in average number of steps per day (Δ415 steps, P=.048), moderate-to-vigorous-physical activity (Δ7 min, P=.007) and increase in sedentary time (Δ36 minutes,

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P<.001) between baseline and the 1-year follow-up. While self-perceived walking impairments and depressive symptoms increased significantly, balance confidence decreased between baseline and the 1-year follow-up, no significant changes occurred for self-rated health, quality of life or anxiety. The multiple logistic regression analyses showed that significant predictors of sustained physical activity level were ≥15 years of education (OR = 7.38, P=.013) and higher perceived walking ability (OR = 0.18, P=.041). CONCLUSION: For future pandemics, development of strategies are warranted for PwPD with a focus on those with low education level and higher walking impairments to counteract reductions in physical activity. ACKNOWLEDGEMENT AND FUNDING: We wish to thank all participants, the uMove Core facility at Karolinska Institutet as well as Petra Koski and Linda Jaktholm for their work with recruitment and data collection.

P1-N-56: Validation of fNIRS measurement of cognitive load during complex walking tasks

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BACKGROUND AND AIM: Safe walking requires both a degree of automaticity as well as executive control processes, especially in more complicated walking situations such as navigating around obstacles or walking with a simultaneous cognitive task. Aging and Parkinson's disease (PD) is thought to shift gait towards attention-demanding voluntary control, relying more on cortical structures than subcortical networks. The prefrontal cortex (PFC) and especially the dorsolateral PFC and cingulate cortex have been found to be involved in executive function. Using functional near-infrared spectroscopy (fNIRS), the activation in these areas during overground walking can be measured but has not been studied heavily during complex walking. To validate that measured fNIRS signal during complex walking reflects PFC activation as a response to executive demand and not extra-cortical sources, movement artifacts, or other confounding sources, we tested several hypotheses regarding convergent, discriminant, and known-group validity. METHODS: This study is preregistered at: https://osf.io/uqy6d/?view_only=fa44dbf4f5a8461499cdb88f6c8484b4 The validation study involved a total of 120 participants from three groups: younger adults (YA) (18-50 years), older adults (OA) (≥ 60 years), with no medical conditions affecting gait or balance, and people with PD (≥ 60 years, clinical diagnosis ≥ 6 months prior to enrolment) with the ability to walk without any mobility device at least 5 minutes continuously. Participants carried out a complex walking protocol containing blocks of straight walking, standing still while performing an auditory Stroop task, and walking while performing an auditory Stroop task. fNIRS measurement was performed with a NIRSport2 (NIRx) with 8 sources and 8 detectors, with short-separation channels. Optodes were arranged over the prefrontal area according to the international 10-20 system (Fig 1). Data analysis was performed in the MATLAB based NIRS Brain AnalyzIR toolbox. First-level analysis to obtain changes in oxygenated hemoglobin (HbO2) in the PFC was performed via general-linear-model (GLM) with autoregressive pre-whitening and second-level group analysis via a linear mixed-effects model. RESULTS: We included 38 YA (18-50 yrs, mean 36.0), 40 OA (60-84 yrs, mean 68.7), and 39 PD (60-91 yrs, mean 69.4) after exclusion of missing data. As hypothesized, group level ROI analysis on HbO2 data indicated a significantly increased activity in OA and PD during straight walking compared to rest but not for YA (YA β=0.23, t(336)=1.06, q=0.37; OA β=0.79, t(336)=4.53, q=2.41e-05; PD β=0.72, t(336)=3.79, q=0.40e-3). When contrasting dual-task walking to single-task walking, there was

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an increase for YA and OA as hypothesized, but against expectations, not for PD (YA β=0.85, t(336)=2.98, q=0.0062; OA β=0.69, t(336)=3.01, q=0.0046; PD β=-0.04, t(336)=-0.17, q=0.8665). CONCLUSIONS: Results indicate that fNIRS is a valid instrument to measure demand-induced PFC activity in complex walking situations but requires additional validation in neurodegenerative populations. ACKNOWLEDGEMENTS AND FUNDING: This study was supported by grants from the Swedish reseach Council. Swedish Parkinson Foundation, the Promobilia Foundation and Karolinska Institutet.

P1-N-57: Segmental coordination in people with Parkinson's and freezing of gait when turning towards their most- and least-affected sides

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BACKGROUND AND AIM: Freezing of gait (FOG) is a common and debilitating symptom of Parkinson's disease (PD) which is commonly triggered by turning. There is evidence that people with PD and FOG (PD+FOG) turn with an 'en-bloc' turning strategy, where the head, torso, and pelvis rotate together in the transverse plane rather than the head leading the torso and pelvis as seen in healthy adults. Evidence of 'en-bloc' turning strategies in previous research has been characterised based on discrete maximum separation angles. In order to capture the time-varying nature of head-shoulder-pelvis coordination throughout the turn, as well as consider the variability in the coordination across multiple turns this work will use Vector Coding techniques to quantify the coupling angle between pairs of segments. PD often displays a unilateral onset, and PD+FOG seem to have greater impairment when turning towards the most affected side which may indicate different rehabilitation targets. This study aimed to quantify head-torso-pelvis coordination comparing 360° turns towards the most- and least-affected side in PD+FOG. METHODS: Twenty-three PD+FOG (tested ON medication) completed an adaptive gait task (including repeated requirements for 360° on-the-spot turns in both directions) within a complex environment designed to broadly simulate those encountered in daily life. Turns were classified according to whether they were in the direction of the most-affected side (MAS) or the least-affected side (LAS). 3D motion capture data were used to calculate head, torso, and pelvis angles from the start to finish of each of the eighteen 360° turns (nine in each direction). Maximum angular difference and vector coding analysis (coupling angle and coordination variability) between head and torso, head and pelvis, and torso and pelvis were calculated, and related to stepping events. Paired t-tests will be used to compare MAS and LAS. The following results represent the analysis from a sub-sample of three participants. Outcomes from the full cohort will be presented in full. RESULTS: Based on values from a sub-set of three PD+FOG participants, maximum angular displacement between upper-body segments was larger when turning toward the LAS, compared to turning towards the MAS. Vector coding reveals the transient emergence of this segmental decoupling in relation to stepping events. There appears to be different strategies emerging at the start of each turn, whereby turns to the LAS appear to represent more 'top-down' head-torso-pelvis coordination. In contrast, turns to the MAS appear to be instigated by torso rotation relative to foot position. CONCLUSIONS: This novel analysis allows more in-depth interpretations of how head-torso-pelvis segments move together and what this represents in terms of the strategies employed to initiate and maintain prolonged turning actions in PD+FOG.

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Perturbation

P1-O-58: Action observation with motor simulation improves reactive stepping responses following strong backward balance perturbations in healthy young individuals

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Background and aim. Adequate reactive stepping is critical for preventing falls following external balance perturbations. Perturbation-based training has a great potential to improve reactive stepping performance in different populations, but it requires expensive equipment and supervision. Voluntary step training (e.g. using the Clock Yourself application) can be done safely at home, however, this type of training does not improve reactive stepping performance. We aimed to investigate whether action observation of reactive steps with either motor imagery (AOMI) or motor simulation (AOMS) is effective to improve reactive stepping responses. Methods. Sixty healthy young subjects (23.7 ± 3.1 y/o; 36 f) were allocated to a control group (CTR), an AOMI group or an AOMS group. They were subjected to a series of 20 strong balance perturbations (i.e., a forward translation of a movable platform at 4.5 m/s²) that elicited backward stepping reactions. The CTR group was tested without any prior observation of a third person reacting to the perturbations. Before being subjected to the perturbations themselves, the AOMI group was instructed to first attentively observe and imagine the third person's movements. The AOMS group was additionally instructed to step along with the third person as accurately as possible. Our primary outcome was the quality of the first trial response, which best represents an unexpected real-life loss-of-balance, quantified as the leg angle at first stepping-leg contact (Fig 1a). We also determined the success rate of recovering balance with a single step as instructed. Additionally, we studied whether gains in reactive step quality over the course of repeated trials differed between groups. Results. The first-trial leg angle was significantly larger in the AOMI ($p=0.012$) and the AOMS group ($p=0.005$) compared to the CTR group, but did not differ between the AOMS and AOMI ($p=0.771$) groups (Fig 1b). Single step success rates were higher in the AOMI and AOMS groups than in the CTR group (Fig 1c), albeit not significantly ($p=0.095$). In all three groups, reactive step quality improved over the course of repeated trials (Fig 1d), but the number of trials needed before reaching plateau performance differed between the groups (Fig 1e). In the AOMS group, the mean leg angle was significantly smaller than the reference leg angle in the first trial only ($p<0.001$). In the AOMI group, this was true for the first two trials ($p<0.001$). In the CTR group, this was the case in the first four trials ($p\leq0.001$), while trials 5 and 6 bordered significance. Conclusions. The present results demonstrate that both AOMI and AOMS improved first and repeated trial reactive stepping performance. Solutions for home-based reactive balance training could therefore exploit the potential of AOMI and AOMS, as real balance perturbations cannot be safely trained at home. The use of AOMS may have benefits over AOMI, since it elicits overt movements (rather than just mental imaginations), which is expected to increase home-user engagement. Whether similar beneficial effects of AOMI and AOMS also apply to the target populations of reactive balance training (e.g., persons with stroke) remains to be investigated.

P1-O-59: Children with developmental coordination disorder are less able to fine-tune muscle activity in anticipation of postural perturbations than typically developing counterparts

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BACKGROUND/AIM: Developmental coordination disorder (DCD) is a movement disorder characterised by reduced motor competence and poor motor coordination, in the absence of other neurological or medical disorders.1 In children with DCD, strategies for regulating muscle activity to maintain balance are less consistent than typically developing (TD) children. These deficits have significant impact on their ability to predict and react to postural disturbances, predisposing them to trips and falls.2 Thus, the aim of this study was to examine the neuromuscular mechanisms that may underpin poor balance control in children with DCD with balance deficits. METHODS: Eighteen children with DCD (9±1yrs; MABC-balance percentile: 3±3) and seven TD children (9±1yrs) aged 7-10yrs completed a postural analysis on an oscillating platform, using a previously established method.3 In brief, the platform progressively translated antero-posteriorly at three frequencies (0.1, 0.25 and 0.5Hz), while postural muscle activity of eight lower-limb muscles (2000Hz), full-body 3D kinematics (200Hz), and centre of pressure (1000Hz) data were recorded. Muscle onset latencies were calculated by manually identifying muscle bursts respective to the relevant platform change of direction (direction specific for anterior/posterior muscle groups; Fig 1). At each frequency, postural data were divided into a transition state (first 3-5 cycles) and steady state (final 8-10 cycles) for subsequent analyses. RESULTS: Preliminary analyses indicate that children with DCD had a greater centre of mass movement variability in the antero-posterior direction at 0.25Hz (4.10 vs. 3.67cm; Effect Size [ES]: 1.25±1.16) and 0.5Hz (4.58 vs. 3.77cm; ES: 2.30±1.16), and medio-lateral direction at 0.1Hz (1.20 vs. 0.67cm; ES: 0.75±0.83) and 0.5Hz (1.84 vs. 0.97cm; ES: 1.26±0.83), and a greater centre of pressure area at 0.5Hz (335 vs. 115cm2; ES: 1.50±1.08) than TD children. At 0.5Hz, children with DCD activated their medial gastrocnemius (MG) muscles earlier (30 vs. 14% of half-cycle time; ES: 1.90±0.81), and their MG (0.30 vs. 0.15s; ES: 1.31±0.94) and bicep femoris (0.44 vs. 0.23s; ES: 1.05±1.04) muscles for longer than TD children. CONCLUSIONS: Children with DCD were more unstable than TD children. At the fastest oscillation frequency, children with DCD adopted a different muscle activation strategy to TD children. Activating the posterior muscles earlier and for longer suggests that children with DCD attempt to predict and react to postural disturbances, however the resulting anticipatory muscle activation patterns are not as finely tuned to the perturbation as those demonstrated by TD children. Future work should examine the impact of balance training interventions on the muscle activation strategies of children with DCD. REFERENCES: [1] Blank et al. (2019). Dev Med Child Neurol, 61(3), 242-285 [2] Zwicker et al. (2012). Eur J Paediatr Neurol, 16(6), 573-581 [3] Mills & Sveistrup (2018). Exp Brain Res, 236(5), 1479-1490 ACKNOWLEDGEMENTS AND FUNDING: This work was funded by the Waterloo Foundation [2268/4188].

P1-O-60: Kinematic synergy of speed reduction during stair descending

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BACKGROUND AND AIM: Descending stairs, frequently performed in daily life, requires control of two tasks: the center of mass (COM) and the swing foot. The trajectories of the COM and the swing foot are controlled by multi-segmental coordination, which can be evaluated using UCM analysis. In addition, descending stairs with decreased speed is performed by the elderly and patients with functional impairment. This decreased speed has been reported to

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affect lower limb kinematics, which is expected to affect the coordination to the tasks. This study aimed to quantify the multi-segmental coordination using UCM analysis to examine the effect of speed reduction on the control of stair descending. METHODS: The participants were 20 healthy people (10 men and 10 women, 21.6 ± 1.1 years old). Infrared-reflecting markers were attached to 60 anatomical landmarks. Kinematic data were collected using a three-dimensional motion analysis system (Vicon) with ten infrared cameras. Kinetic data were collected using eight force plates (ANTI) to measure ground reaction forces. Participants descended one step per foot from the right foot using 4-step stairs. Ten trials were performed in each of two conditions: normal speed at the self-comfortable pace, and slow speed set to a metronome at 60 beats/min. The left foot swing phase was used as the analysis duration and was time normalized to 100%. Synergy index (ΔV) was calculated by UCM analysis with the segment angle as the element variable, the COM and swing foot in the anteroposterior and vertical directions as the task variables, and it was compared between the two conditions. For statistical analysis, statistical software was used to perform a two-sample t-test was used for data with normal distributions, and a Mann-Whitney U test, when no normality was observed. The significance level was $p < 0.05$. RESULTS: The ΔV of the swing foot in the vertical direction was not significantly different between conditions, but that in the anteroposterior direction was significantly higher at slow speed than at normal speed ($p = 0.03$). The ΔV of COM in the anteroposterior direction was not significantly different between conditions, but that in the vertical direction was significantly lower at slow speed than at normal speed ($p = 0.001$). CONCLUSIONS: Descending stairs with decreased speed revealed more coordinated lower limb segments to control the swing foot in the anteroposterior direction, while the segmental variability that destabilizes the vertical COM was increased. In other words, it is possible that during the stair descending, the swing foot concentrated on using the multi-segment synergy to ground to the stair tread, thereby leading to low control of the COM position instead.

P1-O-61: Forward protective stepping during dual-task condition in young and older adults

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Background and aims: Protective stepping in response to the loss of balance is critical for fall prevention. Although divided attention during mobility tasks is important for preventing falls, the impact of dual-task on protective stepping in older adults has not been conclusively determined. The aims of this study were (1) to characterize the effects of a cognitive secondary task on protective stepping to external perturbations in older adults and (2) to investigate the relationships between the change in task performance during a dual-task condition (i.e., dual-task cost) on protective stepping and physical and cognitive performance in older adults. Methods: We recruited 22 healthy young adults (age, 21.6 ± 1.4 years) and 29 older adults (age, 79.5 ± 6.4 years). We assessed the physical and cognitive performance in the older adults using the Montreal Cognitive Assessment (MoCA), the Falls Efficacy Scale-International, and the timed up & go test and measured their hand grip strength. The participants were suspended in a forward-leaning position by a lean control cable with a load of 12% of their body weight and were instructed to regain balance upon release by taking a single step forward. The protective stepping was induced while carrying out two conditions: (1) simple front fixed gaze (single-task condition) and (2) reading color names written in different color (dual-task condition). We measured the vertical ground reaction force to determine the pre-perturbation load on the stepping limb, and the time to foot-off and reach stability were

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measured for both single- and dual-task conditions. We calculated the dual-task costs on protective stepping. Results: Both groups showed a significant delay in the foot-off time during the dual-task condition compared to the single-task condition, but no change occurred in the pre-perturbation load on the stepping limb. In older adults, but not young adults, the time taken to reach stability was significantly extended during the dual-task condition compared to the single-task condition. In addition, a large dual-task cost for the foot-off time in older adults was moderately correlated with lower MoCA scores. Conclusions: Young and older adults have similar effects on initiating stepping upon perturbation in the dual-task condition. However, as opposed to young adults, older adults took a remarkably longer time to reach stability during the dual-task condition compared to the single-task condition. Our results suggest that the impact of a secondary cognitive task on protective stepping may cause a decreased ability to recover balance in older adults. Furthermore, the dual-task cost on the foot-off time is associated with cognitive function in older adults. A longer foot-off time in the dual-task condition due to cognitive disfunction may delay balance recovery in older adults, which might be a contributing factor to fall incidents.

Sensors (e.g. IMUs, activity monitors, machine learning)

P1-P-62: Wearable technology to meet unmet needs and priorities in in-patient rehabilitation: A mixed methods study

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BACKGROUND AND AIMS: Wearable devices such as inertial measurement units are increasingly accepted and available in rehabilitation to detect and measure movement. However, to be clinically useful, the development of current and emerging technologies must meet the needs and priorities of clinicians, consumers and rehabilitation services. The aims of this study were to (1) explore unmet needs and priorities of in-patient rehabilitation in an Australia setting that could be supported by wearable sensor technology from the perspective of clinicians, and (2) understand how current technology might be used or modified to meet identified needs and priorities. METHODS: This study used a mixed methods design including structured workshops, surveys and consensus development. Participants were clinicians working at an Australian rehabilitation service, rehabilitation researchers, biomedical engineers experienced in wearable technologies and consumers. Workshop 1 focused on understanding the rehabilitation context and how mobile sensor technologies might enhance rehabilitation. Qualitative content analysis was applied to workshop 1 findings to identify 20 potential priorities. Workshop 2 used the Nominal Group Technique to collaboratively identify and reach consensus on leading priorities. Workshop 3 used co-design methods to refine concepts associated with leading priorities and rank design features needed in mobile sensor development. RESULTS: A total of 26 participants (clinicians=10 [physicians, physiotherapists, occupational therapists], biomedical engineers=6, researchers=8, consumers=2) were involved across three 2-hour face-to-face workshops. The top three priorities for wearable technology development included: 1) helping patients feel motivated to engage in or initiate rehabilitation activities; 2) available and accessible technology to support rehabilitation (eg:

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affordable, safe, easy to use); 3) capturing quality of movements (eg: type, range, intent of movement). Four design feature domains were compared on two 9-point scales. In scale 1, participants ranked useability and size (65%) as more important in design than precision and comprehensiveness of information (35%). In scale 2 participants ranked battery life and cost (58%) as more important than collecting a diverse range of measurements (42%). CONCLUSIONS: Development of useable and affordable wearable devices are needed to address rehabilitation priorities. Consensus-based design features included: gamification (eg: range of self-selecting, individually motivating activities), self-management (eg: clear incremental feedback on rehabilitation goals), and adaptability (eg: patient can set their own targets). Other considerations included ensuring simplicity of design for patients with language impairments and incorporating a suite of sensors that are scalable from in-patient rehabilitation to supporting engagement and self-management after discharge. Future research should explore broader consumer perspectives. ACKNOWLEDGEMENTS AND FUNDING: None

P1-P-63: Frailty status assessed by quantity and quality of gait in community-dwelling older adults with an increased risk of falls

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Background and aim: Frailty is a consequence of cumulative decline in several physiological systems during life and is associated with the consequence of ageing. Monitoring changes in frailty status of older adults is important to timely intervene when frailty increases. The quantity and quality of gait might be an indication for frailty, which can objectively be assessed by wearable inertial sensors. Quantity of gait, especially the number of steps, is a commonly used quantitative parameter for the objective identification of frailty, but it is less known what the value of other inertial sensor parameters is, such as quality of gait, for the assessment of frailty. Methods: The study sample consists of 256 non-frail and pre-frail community-dwelling adults of 65 years or older with an increased risk of falls. Frailty was assessed using Fried's frailty criteria: unintentional weight loss, weak grip strength, exhaustion, slow gait speed and low physical activity. Quantity, for example number of steps and the duration of being physically active, and quality of gait, such as walking speed and gait symmetry, were determined using wearable sensor technologies. The wearable sensor used in this study is the McRoberts tri-axial inertial sensor. Independent associations between quantity and quality of gait and frailty were determined using logistic regression models. We will correct for covariates such as age and sex, and we will correct for multiple testing. Results: To be announced. Conclusions: This study will provide insight into parameters related to quantitative and qualitative gait based on wearable inertial sensors for the assessment of frailty status. Advantages of the wearable sensors used are the low cost and the possibility of measuring in any place without needing controlled environments.

P1-P-64: Prediction of three-directional ground reaction forces during walking using sole sensor system and machine learning

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BACKGROUND AND AIM: Ground reaction forces during walking are generally measured using a force plate, however, measurement in a wide range of environments, including daily

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life, is difficult due to the limitations of measurement locations. A method for predicting ground reaction force using machine learning from kinematic data obtained from camera images has been proposed. However, this method cannot predict ground reaction forces in places where it is not possible to take pictures with a camera. Recently, a sole sensor system mounted triaxial force sensors on shoe soles have been used to measure ground reaction forces in the triaxial direction. However, the small rate capacity of force sensors or an impact on gait that cannot be ignored limits the efficacy of the sole sensor system to measure the ground reaction forces. In the current study, we developed a sole sensor system equipped with four high-capacity compact three-axis force sensors using a Cr-N thin film. Using the sole sensor system and machine learning, time-series data of the three-directional ground reaction forces during straight and turning gait was predicted. METHODS: A small triaxial force sensor (capacity:±500 N in x and y directions, 1000 N in z direction) was equipped at four locations on the sole of the shoe: heel, fifth metatarsal, first metatarsal, and toe areas. The total weight of the sensor system, including the wiring and the microcomputer, was 375 gf, and no effect on gait was observed. Seven healthy adult subjects walked in a straight line or changed direction with step or spin turn by 20 degrees, and the ground reaction force was measured by the sole sensor system and a force plate. A prediction model of triaxial ground reaction force was created by multiple regression analysis and Gaussian process regression using the measured three-directional force from four sensors in the sole sensor system. The estimation accuracy of the prediction model was evaluated using % root mean square error (%RMSE) and the degree-of-freedom adjusted coefficient of determination (R2). RESULTS: Compared to multiple regression analysis, the accuracy of Gaussian process regression in predicting ground reaction forces was superior in the left-right, anterior-posterior, and vertical directions. Gaussian regression showed %RMSE of 13.3% in the left-right direction, 6.4% in the front-back direction, and 4.8% in the vertical direction, with R2 values of 0.40 in the left-right direction, 0.91 in the anterior-posterior direction, and 0.93 in the vertical direction. CONCLUSIONS: The results indicate that the sole sensor system developed in this study can predict the three-directional ground reaction forces precisely using machine learning. Our findings will provide new insight into the measurement of ground reaction forces without location constraints. ACKNOWLEDGEMENT: This work was partially supported by JSPS KAKENHI Grant Number 20H04558.

P1-P-65: An open source, externally validated algorithm to detect daily-life gait from on inertial sensor data

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Background: Gait captured by inertial sensors has been shown to reflect gait quality and to correlate with the incidence of falls in older adults. Several algorithms exist to extract episodes of gait from daily-life inertial sensor data, but not all of these are open, and most of these have no external validation. Aim: We aimed to develop an open, externally validated algorithm to detect gait episodes from daily life gait data. Methods: We used data from the ADAPT project, which contains a dataset of semi-structured and free-living movements recorded with activity monitors and video cameras (25fps) from 21 elderly subjects. Video labelling of the subjects' movements was performed by five raters using 11 different category labels. Our study only focused on the lumbar sensor data and classified these labels into walking and non-walking. The segmented and down-sampled tri-axial accelerometers and three-axis gyroscope of all participants were used to train a convolutional neural network (CNN) and a long short-term

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memory network (LSTM). In doing so, we will not only train the network on the original dataset, but also on 1000 surrogate datasets, which mimic 1) rotation of the sensor (10 levels) 2) differences in movement execution speed (10 levels) 3) differences in sensor noise level (10 levels). We will validate our trained networks on an external dataset with known walking and standing episode. Results: Initial results (without surrogate data) showed good to excellent recall for both LSTM and CNN networks. We are currently working on including the surrogate analyses, as well as external validation. Conclusions: When our algorithm is done, it should lead to an easy (and valid) pipeline to extract gait episodes from any kind of inertial sensor, which can be implemented in both Matlab and Python. This can then be used in conjunction with our earlier developed gait analysis toolbox (10.5281/zenodo.7362138). We believe that such open methods will help to move the field forward, as they allow for replicability, and make that others can start of where we finished. Acknowledgements and Funding: Many thanks to Norwegian Research Council, who funded the ADAPT project, and many thanks to professor Jorunn L. Helbostad and Dr. Espen Alexander F. Ihlen at the Norwegian University of Science and Technology, who gave us the right to use the dataset. YZ was funded by China Scholarship Council (CSC) (202009110145); MP and SMB were funded by Dutch Organization for Scientific Research (NWO) (no. 91714344, 016.Vidi.178.014).

P1-P-66: Sleep may impact activity levels in people with stroke with greater disability

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Background and Aim: Sleep is vital for health and may be associated with activity levels. Little is known about the association between sleep and activity levels in people with stroke. The aim of this study was to explore the associations between sleep characteristics and activity levels in people with stroke (PwS). Methods: 37 PwS wore an activity monitor (ActivPal) and a sleep monitor (Actigraph) for 7 days at 60 days post stroke. Using Spearmon rho correlation, we explored the associations between mean daily activity variables (steps/day, upright time, total sitting time, time sitting >30 minutes, and time sitting >60 minutes) and mean nightly sleep characteristics (sleep efficiency, total sleep time, wake after sleep onset [waso], and duration of awakenings) of the total sample. We performed the same analysis on participants with greater disability who required assistance with ADLs (modified Rankin Scale > 2). Results: For the full sample there was a significant association between mean duration of nightly awakenings and time sitting >30 minutes (rho=0.37, p=0.026) and time sitting >60 minutes (rho=0.38, p=0.02). For the subset of participants with greater disability (mRS>2) there was a significant association between upright time and total sleep time (rho=0.44. p=0.042), and waso (-0.48, p=0.025). Conclusions: There is a complex relationship between sleep and activity in people with stroke. In our full sample we found that greater duration of nightly awakenings was associated with greater sedentary behaviors during the day. In participants with greater disability, we found that greater time awake during the night was associated with less upright time during the day, and total time asleep during the night was associated with greater standing and walking time during the day. Improving sleep may reduce inactivity and increase activity. Further research is needed to better understand the relationship between sleep and activity.

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P1-Q-67: Self-reported cycling performance and impact on falls in persons with bilateral vestibulopathy

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Background and aim. Bilateral vestibulopathy generally leads to postural imbalance, gait disturbances, and problems with gaze stability. These symptoms can have an impact on many daily life activities. For example, even though 94% of persons with bilateral vestibulopathy suggest an increase of symptoms while cycling, detailed studies about cycling abilities in this population were lacking (Lucieer et al., 2020). The objective of this study was to investigate cycling skills, cycling difficulties, fall concern, and fall history while cycling in this population. Methods and Design. Fifty-one persons with bilateral vestibulopathy and 51 healthy control subjects filled out a questionnaire about cycling abilities. This questionnaire consisted of four parts: (1) general information about audiovestibular function, vision, and physical activity, (2) general cycling abilities, history, and difficulties, (3) fall concern while cycling in various situations, and (4) fall history. Results. Out of the 51 patients, 61% found riding a bicycle difficult, 29% were not able to bicycle anymore, and 10% reported not having any problems riding a bicycle. Their mean cycling time decreased from 3.15 hours weekly before to 1.27 hours weekly after disease onset ($p = 0.002$). This also differed significantly from the mean cycling time of 3.51 hours weekly in control subjects ($p < 0.001$). The main complaints while cycling were: not being able to look behind (88%), having difficulties with visually stabilizing the environment (65%), and not being able to ride in a straight line (61%). The fall concern was significantly higher in the patient group than the control group, with falling while cycling in the dark and at dusk, and while turning their head as their main concerns ($p < 0.001$). Falls were reported in 50% of the participants, while 65% reported near-falls. Only the latter differed significantly from the control group. However, the number of reported falls differed significantly from the control group. Conclusions. This study demonstrates cycling difficulties in persons with bilateral vestibulopathy, related to problems with postural control and gaze stabilization. Knowledge about specific complaints and triggers is important to prevent future falls. A combination of coping strategies and aids, with vestibular rehabilitation focused on gaze stabilization might be considered, as well as avoidance of cycling in specific cases.

P1-Q-68: Sensorimotor gain reweighting of vestibular reflexes in the presence of vestibular-light touch conflict

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BACKGROUND AND AIM: The balance control system is sensitive to vestibular inputs because they provide a potent signal of head and body motion with respect to gravity. Electrical vestibular stimulation (EVS) can be used as a tool to evoke reflexive body sways as a probe of vestibular control of balance. However, EVS decouples vestibular input from real body motion, creating sensory conflict which the central nervous system could resolve by considering vestibular signals as being less reliable. In contrast, light touch decreases sway because it adds

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reliable balance feedback about body movement and its relationship to the external space. Juxtaposing reliable versus unreliable sensory cues can reveal how balance control systems integrate multisensory information to remain upright. Here we hypothesized that light touch (independent of EVS) will decrease CoP RMS, as seen in prior research [1,2,3]. We also hypothesized that coherence and gain between EVS and CoP will decrease with the addition of light touch cues. METHODS: Participants recruited to date (n=3, age:23-30) did 4 trials, 2 with continuous stochastic EVS (0-25 Hz frequency, ± 4 mA, 200s duration) and 2 without. In all trials participants stood as still as possible on force plates from which CoP was calculated while either lightly touching a load cell at hip height (<2N), or not touching. Coherence and gain between the EVS signal and ML CoP were calculated, along with ML CoP RMS. RESULTS: Light touch led to a decrease in RMS with and without EVS (average 18% decrease). Significant coherence between EVS and ML CoP was found between 0.5-17 Hz for both no touch and touch conditions, peaking at R^2 =0.17 at 10.5 Hz for no touch and at R^2 =0.18 at 7.5 Hz for touch. In contrast, gain was significantly lower for the touch condition between 1-11.5 Hz (average 47.6% reduction). Although there were no significant differences in coherence across conditions for the small pilot sample, there were significant and robust reductions in both ML CoP RMS and gain for touch conditions. CONCLUSIONS: Previous studies show ML CoP displacement reduced by 17%-47% with light touch [2,3] and ML vestibulomotor gain during stochastic EVS exposure decreased by 38% during a walking task [4], which is comparable with the reductions in ML CoP and gain found in this study. These data suggest that the balance system does not filter out vestibular inputs but may suppress the magnitude of responses to those inputs when in conflict with other sensory systems. We argue that when integrating multiple sensory inputs for balance, different neural processes may be responsible for 1) constructing a representation of body orientation and posture and 2) scaling the balance response. We are increasing our sample to further test these claims and to uncover the time course of gain modulation in response to sensory conflict. REFERENCES: [1] Jeka et al (1996), Percept Psychophys; [2] Holden et al (1994) J Vest Res; [3] Rabin et al (2006) Exp Brain Res; [4] Hannan et al (2021), Sci Rep. FUNDING: UWaterloo New Faculty Start-up to BCH.

P1-Q-69: The effects of wearing textured versus smooth shoes insoles for 4-weeks in people with diabetic peripheral neuropathy: a randomised controlled trial

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Background and Aim: Peripheral neuropathy is one of the most common complications of type 2 diabetes, which can lead to walking instability, poor balance, and falls. Innovative footwear devices designed to stimulate sensory receptors at the feet, could offer a new route to improve motor impairments in people with diabetic peripheral neuropathy (DPN). Textured insoles comprising raised nodules designed to augment plantar sensory input, have been shown to enhance balance and walking in ageing and neurological disease populations. The aim of this randomised controlled trial was to determine whether short-term wear of textured insoles alters balance, gait, foot sensation, physical activity, or patient-reported outcomes in people with DPN. Methods: 53 ambulant men and women with peripheral neuropathy, secondary to type 2 diabetes, were randomly allocated to wear textured (intervention) or smooth (control) insoles for 4-weeks. At baseline and post-intervention, assessments of standing balance

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(foam/firm surface, eyes open/closed) and level-ground walking were completed whilst barefoot, wearing shoes only, and two different insoles (textured/smooth). The primary outcome was centre of pressure (CoP) total sway velocity. Secondary outcomes included other CoP measures, spatiotemporal gait measures, foot sensation and proprioception, physical activity levels, and patient-reported outcomes (foot health, fear of falling). To identify any differences in outcomes between groups, analysis of covariance was performed adjusting for baseline (alpha level set to 0.05). Results: Wearing textured insoles led to improvements in CoP measures when standing on a foam surface with eyes open, relative to smooth insoles ($P \leq 0.04$). At post-intervention, the textured insole group demonstrated a 5% reduction in total sway velocity, which is indicative of greater upright stability. The intervention group also demonstrated a 4% reduction in CoP anteroposterior sway velocity and 19% reduction in elliptical area, both suggestive of improved balance. Further, the textured insole group showed a 9-point improvement in self-perceived vitality score ($P=0.03$), which coincided with a trend towards more optimal foot health, specifically foot pain ($P=0.07$). No other significant between-group difference was found. Conclusions: For people with DPN, wearing textured insoles may increase the ability to reweight their dependence on sensory information for balance control. Specifically, short-term wear of textured insoles that provide continuous change in plantar stimulation, may train the user to decrease their reliance on proprioception when standing on compliant surfaces. Wearing textured insoles for 4-weeks may also enhance a users' self-perceived vitality, which may result from underlying improvements in foot pain. It is possible that tactile stimulation of the foot, by way of textured insoles, may have the capacity to modulate the perception of foot pain in DPN.

P1-Q-70: How much lower peripheral vision do you need to walk safely on stairs?

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BACKGROUND AND AIMS: Previous studies have shown an important role for the lower peripheral visual field in guiding stair walking by obscuring the lower regions of the lenses of glasses worn by participants and observing the effects on biomechanics. Graci et al (2017) showed increased foot clearance when vision was occluded during stair ascent but only on the first and last steps. Miyasike-da Silva et al (2019) showed that participants pitched their head downwards to compensate for visual field occlusion during both ascent and descent, and walking speed decreased and handrail usage increased. Neither study systematically controlled the amount of vision available to participants (since they could look down) and therefore were unable to accurately assess how much of the lower visual field is essential for effective stair negotiation. Our aim was to study the effects of occluding the lower peripheral visual field, using a method that removed the possibility of confounding compensatory head rotations, on: anxiety, self-confidence and stair walking biomechanics (including measures of dynamic stability), with a view to understanding the extent to which lower peripheral vision is necessary for safe stair negotiation in young healthy adults. METHODS: Twelve healthy young adult participants (age 18-24) were recruited from the host institution's student and staff population. All participants had normal or corrected to normal vision confirmed with the Freiberg visual acuity test. Participants were asked to carry a lightweight object that obscured different amounts of the lower visual field (0, 10, 20, 30 or 40° from vertical) while walking up and down a 7-step staircase. Measures of stair behaviour captured at 120Hz using a 26-camera Vicon system, included gait speed, foot clearance with step riser edge, foot clearance variability, and margin of stability. RMANOVA was used to test for mean differences between

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visual occlusion conditions. Prior to the first ascent and descent in each new occlusion condition, participants responded to questions about their state confidence and anxiety which were adapted from the Sport-Anxiety Scale (Smith et al., 1990). Chi-square analysis was used to test for mean differences between conditions RESULTS: Lower peripheral field occlusion greater than 20° resulted in statistically significant effects ($p<0.05$) on the following walking characteristics: decreased self-reported confidence and increased anxiety, slower gait speed, increased foot clearance with step edge during ascent, increased foot placement variability, increased margin of stability. The effects became increasingly pronounced with greater occlusion angles. CONCLUSIONS: Our results support the importance of the lower peripheral visual field for effective walking on stairs and provide evidence that as little as 20° of visual occlusion is problematic in terms of safety and stability. These findings have important implications for design of face-worn items (e.g. eye glasses, face masks) and the size of containers that can be safely carried on stairs. Graci V et al (2017) Gait & Posture 52:52-56 Miyasike-daSilva V, et al. (2019) Gait and Posture 70:162 - 167 ACKNOWLEDGEMENTS: This study was funded by a project grant award by Dunhill Medical Trust, UK

P1-Q-71: Effects of useful field of view by cognitive loads for postural stability on a stable and unstable surface.

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BACKGROUND AND AIM: Central nervous system integrates sensory information such as visual, somatosensory, and vestibular sensation to maintain equilibrium. Previous studies reported that elderly people greatly depend on visual information for postural stability. In addition, a useful field of view (UFOV) is one of the most important factors which is related to fall history in elderly people. UFOV is defined as a field in which people can instantly storage and process visual information around a gazing point and is influenced by cognitive load or motor behaviors. Our previous study reported that a physically limited peripheral visual field caused postural instability during a static stance. Therefore, the purpose of this study was to investigate the effects of cognitive tasks on the range of UFOV and postural stability while standing on a stable or unstable surface. METHODS: Eighteen healthy young adults participated in this study. Participants were asked to stand quietly on a firm or foam surface with their feet together. They were required to answer the three different levels of a cognitive task; Control, Easy, and Difficult, which was displayed at the center of the screen in front of them. At the same time, they were supposed to push a sensor when they detected a visual stimulus. The visual stimuli were randomly displayed on the horizontal line of the screen at their eye level to measure the range of UFOV. The reaction time to the visual stimulus and the 95% confidence ellipse area and the mean velocity of the center of pressure (COP) sway were measured. We used a one-way repeated-measures ANOVA with the factor Condition (Control, Easy, and Difficult) in each surface for COP measures, and a two-way repeated-measures ANOVA with the factors Condition and Stimulus position (20, 30, 40, 50-degree) in each surface. RESULTS: COP velocity significantly decreased on the firm surface with the Easy condition and the Difficult condition compared to the Control condition ($p=0.043$, $p=0.020$), but it decreased on the foam surface only with the Difficult condition compared to the Control condition ($p=0.024$). On the other hand, the reaction time to a distant point was extended with cognitive loads on the foam surface, but not on the firm surface. CONCLUSION: Current study suggests that the UFOV is reduced while standing on an unstable surface by cognitive loads,


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but the cognitive loads affect the postural stability more on a stable surface rather than on an unstable surface. These findings indicate that healthy young adults could give a priority to postural stability over cognitive tasks during a stance on an unstable surface. ACKNOWLEDGEMENTS AND FUNDING: This study was supported by Grant-Aid for early-Career Scientists (No.20K19371, NH) and for Scientific Research (No. 18K10702, TA) from the Japan Society for the Promotion of Science (JSPS).

P1-Q-72: Electrical vestibular stimulation therapeutics in older adults

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Electrical Vestibular Stimulation Therapeutics in Older Adults Jordan A King, Christopher Banman, Noah Walters, Sadie Clark, John Ralston, Ryan M Peters Faculty of Biomedical Engineering, University of Calgary, Calgary, AB, Canada Background and aim: Anatomical studies indicate that, by age 70, healthy older adults have lost ~40% of their hair cell receptors and afferent nerves. Reduced function of the vestibular system can lead to mobility impairments and falls, especially in older adults. Electrical Vestibular Stimulation (EVS) is a promising therapeutic intervention to slow or reverse this age-related decline, increase ambulatory performance, and reduce fall risk in older adults. We aim to investigate the magnitude and persistence of EVS-induced balance recovery and clarify parameters for optimal dosing. Methods: 50 older adults aged 50-90 (half female), are randomly assigned to stimulation and sham groups. Each participant will first be assessed to determine the minimal stimulus level that evokes EVS-induced postural sway, by delivering EVS stimulation with a range of amplitudes between 0.00625mA - 0.5mA for 3 minutes while standing on a force plate with feet together and eyes closed. The intervention study will then take place over the following 6 weeks, with 3 lab visits per week during which participants will complete balance tests (quiet standing on floor/foam with eyes open/closed) and gait tests (Timed Up-and-Go, 25' walking) before and after exposure to EVS for 20 minutes. A second sham group will receive no EVS for the first 3 weeks and will cross over and receive EVS for the final 3 weeks. Subjects will come back for follow-up balance testing at weeks 9 and 12 in order to assess the persistence of EVS-induced enhancements. All participants completed balance confidence and physical activity questionnaires before and after the 6-week intervention. Results: Data collection is ongoing. With the current dataset, paired one-tailed student T-test show a significant increase in perceived confidence in balance. Additionally, decreased sway measured via head accelerometry was observed following the intervention standing with eyes open and closed on both hard floor and foam surfaces. Force plate posturography before and after the intervention also showed a significant decrease in anterior-posterior centre of pressure amplitude. EVS-induced sway thresholds were lowered in 2 of 5 test subjects. Conclusion: These observations suggest that EVS therapeutic intervention can increase balance confidence and performance. Further data collection is needed to make concrete conclusions over the target 50-90 age range, to inform future research on the underlying neuroplastic mechanisms contributing to peripheral vestibular and CNS performance enhancements, and to determine the magnitude and persistence of EVS-induced therapeutic benefits such as balance enhancement and fall risk reduction in older adults and other individuals with neuromotor impairments.

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P1-Q-73: Effect of visual and foot measurement conditions on balance control variables in healthy adults

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BACKGROUND AND AIM: Evaluating static posture allows us to understand the systems involved in balance control. To this end, the practitioner usually disrupts sensory information at the visual or podal levels. Numerous studies have shown the impact of vision on posture [1], removing visual information which increases static postural oscillations. In addition, the visual target individuals have to focus on during the measurement, can modify their posture [2]. For podal information, a foam can be interposed between the floor and the feet, increasing the difficulty of the task [3]. Our objective is practitioner oriented and aims to understand the effect of the measurement condition on the static balance evaluation. METHOD: 76 healthy subjects (18 to 45 yo) were included after orthoptic tests if their results fell within the norms (convergence, divergence, accommodation) of a visually healthy population. The experimental task was to stand still for 30s on a stabilometry platform. Following a repeated measure design, participants performed this task in a randomized order according to 3 main factors : Visual (eyes closed (EC), without target (NT), round target (Target = TG), round target included in an image (Textured = TX)); Podal (without (Control) or with foam (Depron®, 6mm thick); distance to wall (40 cm or 200 cm) (Fig.). We hypothesize that each experimental condition has an impact on balance control, measured as the best measurement -min value, among the 3 repetitions of the length of center of pressure trajectory (CoPL) and surface area (CoPS). A 3-way repeated measures aligned rank transformed (ART) Anova was performed with Tukey post hoc tests since the distribution was not normal. RESULTS: Results showed a main effect of "distance to wall" on CoPL ($p<0.0001$, $\eta^2p=0.54$) and CoPS ($p<0.0001$, $\eta^2p=0.72$) values with lower values for "40cm" condition. Visual target characteristics also affects CoPL ($p<0.0001$, $\eta^2p=0.11$) and CoPS ($p<0.001$, $\eta^2p=0.08$ for CoPS), where the textured target (TX) differ from the other visual conditions. Results did not show any effect of the foam. CONCLUSIONS: As expected, visual information is important on balance control. However, the type of information given changes the response. Particular attention should be paid to the clinical and scientific evaluation procedures of static posture in order to standardize the measurements. Contrary to our results, past work has observed an impact of foam on visual integration. Further works are needed to better understand those differences (population, foam, distance to the wall). [1]Kapoula Effects of distance and gaze position on postural stability in young and old subjects. Exp Brain Res 2006. [2]Gautier Postural control and perceptive configuration: influence of expertise in gymnastics. Gait Posture 2008. [3]Foisy Plantar Exteroceptive Inefficiency causes an asynergic use of plantar and visual afferents for postural control. Brain Behav 2017

Tools and assessment methods

P1-R-74: Handshake-algorithm: AI-Driven clinical decision support for post-stroke gait rehabilitation

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André Böni[1], Alain Ryser[2], Deepak Ravi[3], Mathilde Legrand[2], Meret Branscheidt[4], Julia Vogt[2], Andreas Luft[5], Chris Easthope[1]

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BACKGROUND AND AIM: Current objectives of neurorehabilitation for gait mainly target functional outcomes, such as gait speed, while placing less emphasis on gait quality metrics (Mohan et al. 2021). One underlying contributor to this is that selecting movement parameters for gait quality treatment is a time-consuming and complex task. Commonly, physicians use visual-based approaches to assess gait quality. Although numerous approaches exist to guide visual estimation of gait quality (Ridao-Fernández et al. 2019), the sensitivity of quality metrics depends on the assessor's experience. An alternative approach is to use quantitative methods that rely on instrumentation, such as 3D motion capture (Mohan et al. 2021). While these advances provide more sensitive and objective metrics, they are complicated to translate into clinical terminology and treatment recommendations (Chau 2001). We propose an AI-based clinical decision support system that merges the strengths of these two systems: highly precise outcomes of 3D motion capture are combined with target parameter recommendations given by clinical experts. We evaluate our automated clinical decision support workflow against purely visually based recommendations or purely heuristic outputs of current analysis systems. METHODS: Existing motion data (kinematics, kinetics, video) collected from clinical routine of 20 stroke patients while walking at their preferred speed are used to identify main movement deficits using two state of the art (SoA) approaches. In addition, we train an AI-based clinical decision support to predict the main movement deficit from motion data. For this, 30 gait-analysis experts are recruited and randomised to analyse either video or enriched video data visually. Enrichment contains an interactive representation of gait analysis metrics in combination with a 3-D model reconstruction and 2-D videos. Enriched-visual expert opinions are then used as ground truth to train the clinical decision support algorithm from motion data. SoA approaches consisted of expert video labelling and heuristic outputs calculated from motion data that exceeds a 2 SD threshold of speed-matched reference data. RESULTS: Data collection is currently ongoing, however, we expect high correlations between ground truth (enriched visual expert opinion) and ML-based impairment detection (Lau et al. 2009; Pradhan et al. 2015). As studies already suggested, we further anticipate good interrater reliability in both expert opinions (Krebs et al. 1985; Ridao-Fernández et al. 2019). CONCLUSIONS: Gait quality is a complex construct to assess (Mohan et al. 2021). Simple methods like visual-based approaches and threshold-based detection do not capture the whole complexity of gait movements. Enriched expert opinions in combination with machine learning approaches carry promise for use in clinical settings to provide decision support for physicians in post-stroke gait-quality rehabilitation. ACKNOWLEDGEMENTS AND FUNDING: Supported by the P&K Puehringer Foundation, the medical research center "The Loop Zurich", and the Vontobel Foundation.

P1-R-75: Synchronisation of multiple unconnected inertial measurement units: Impact and correction of variations of internal clock speeds

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Background & Aims: Subtle differences of inertial measurement unit (IMU) internal clock speeds may impact on the synchronisation between multiple IMUs collected over long periods, precluding multi-segment gait analysis. The aims of this study were to establish the consistency and impact of relative clock speeds on synchronisation between multiple IMUs over 24 h, and examine the effects of adjusting for variations in relative clock speeds. Methods: Tri-axial acceleration and angular velocity were collected using 14 IMUs (AX6, Axivity, 100 Hz) taped in parallel on a rigid board. The rigid board was tilted about the y axis several times over 24 h to create multiple epochs of shared signals between the devices. We chose one of the IMUs to be the 'parent' device. To account for sampling errors, we resampled the data from each device to a shared isochronous timestamp (100 Hz). The delay between the parent and each child device was calculated using normalised cross correlation of angular velocity signals about the y axis for every time the rigid board was tilted during the 24 h period. After correcting for initial delays, we calculated the difference in timing between devices at the final tilting episode to determine the impact of relative clock speeds on synchronisation. The process was completed twice at room temperature and once at low temperature. Next, we resampled the signal from each device, adjusting for relative clock speeds to test if this improved IMU synchronisation within- and between-sessions. Results: After resampling and correcting for initial differences in starting timestamps, the timing of shared signals at 24 h differed between devices by up to 2780 ms (mean: 1125 ms) during session 1 (24.5°C). Almost perfect agreement of relative timing was seen at 24 h between the two room temperature sessions (session2, 25.2°C, mean absolute difference: 9 ms, ICC2,1: 1.0). Agreement was still excellent between session 1 and session 3 (cold session, 5.4°C) but not identical (mean absolute difference: 106 ms, ICC2,1:0.992). Correcting for internal relative clock speeds calculated from session 1 resulted in almost perfect synchronisation (within 1 frame, 10ms) for all other shared signal epochs within the 24 hour testing session, as well as when applied to the session 2 (within 20 ms at 24 h). However, moderate differences still existed between devices (mean absolute difference: 106 ms at 24 h) after applying the relative internal clock speed adjustments session 1 and 3 (cold session). Conclusions: Variation of internal clock speed can lead to substantial desynchronisation between multiple IMUs over long sessions - precluding long-term continuous monitoring of mutli-segment analysis of walking in the field and fre-living contexts. Accurate synchronisation between unconnected IMUs is possible by correcting for sampling errors, and variations in initial timestamps and internal clock speeds. We recommend applying relative clocks speed corrections derived from within the same session, using at least two epochs of a shared signal. Applying relative clock speed corrections from a different walking session is feasible but only when collected at similar and consistent temperatures.

P1-R-76: Neuro-muscular modeling predicts subtle gait changes in early spastic paraplegia

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BACKGROUND AND AIM In Hereditary Spastic Paraplegia (HSP) type 4 (SPG4) a slowly length-dependent axonal degeneration in the cortico-spinal tract leads to continuously increasing hyperreflexia, spasticity, and muscle weakness of the lower extremities. First gait changes in the prodromal phase [1], before the manifestation of spastic gait, occur mainly around the minimal plantarflexion in the swing phase [2]. These subclinical gait changes increase from the prodromal to the early-to-moderate manifest SPG4 stage. In clinical examinations, hyperreflexia, spasticity, and muscle weakness are detectable symptoms in

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SPG4 already in the prodromal phase [1]. It is still unclear how these altered mechanisms contribute to the subclinical gait changes and their progression. We hypothesize that disease-specific dysfunctional neuro-muscular mechanisms, such as hyperreflexia and muscle weakness, explain these severity-related gait changes of prodromal and early-to-moderate manifest SPG4 subjects and investigate their contribution. METHODS A neuromuscular-skeletal model of human walking [3] is used to reproduce subtle gait changes by isolated sensory-motor alterations [4]. To introduce neuro-muscular dysfunction, as in SPG4, we gradually increased sensory-motor reflex sensitivity based on increased muscle spindle velocity feedback and muscle weakness by reducing the maximum isometric force in seven muscles per leg. RESULTS Figure 1 shows the study design and the gradual change of kinematic features modulated by sensory-motor reflex sensitivity. The increased simulated sensory-motor reflex sensitivity predicted gradual muscular and kinematic changes that are comparable to the subtle gait changes found in prodromal and early-to-moderate manifest SPG4 subjects. Minimal plantarflexion was reduced during the swing phase and the knee joint angle increased at the heel strike. Plantarflexor activity was reduced during the late stance and push-off phase, while dorsiflexor activity increased after push-off. During the swing phase, increased plantarflexor activity did lead to higher agonist/antagonist coactivation. Muscle weakness did not lead to characteristic changes. However, muscle weakness in combination with increased sensory-motor reflex sensitivity produced a toe-gait pattern characteristic of the severe phase of SPG4. CONCLUSION The gradual alteration of sensory-motor reflex sensitivity to predict kinematic and muscular changes of prodromal SPG4 subjects, allows us to identify neuro-muscular changes and link them to gait as a directly accessible performance marker. These insights explain the subclinical gait changes before manifestation of spastic gait may help to design future therapeutic interventions in particular in early phases of the disease. 5. References 1. Rattay et al., Brain. 2022; doi:10.1093/brain/awac15. 2. Lassmann et al. Movement Disorders. 2022; doi:10.1002/mds.29199. 3. Geyer H, Herr H. IEEE Transactions on Neural Systems and Rehabilitation Engineering. 2010; 4. De Groote F, Falisse A. Proceedings of the Royal Society B: Biological Sciences. 2021;

P1-R-77: Using lower limb exoskeletons to assess motor performance: a systematic review

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BACKGROUND AND AIM Lower limb exoskeletons are mainly developed for individuals with a decreased level of motor performance to provide support or maintain walking ability. Particularly active exoskeletons use sensors to detect their internal state to control movement trajectories. Due to the proximity and the direct connection of the exoskeleton to the human body, data collected from these sensors can be used to calculate user-related motor performance data such as joints range of motion (RoM) or step length. This information may further be used to provide a real time feedback on current motor performance level, adapt training plans, or evaluate rehabilitation progress. The aims of this review were to provide an overview of research studies on motor performance parameters measured by lower limb exoskeletons, and to analyze how these parameters were measured. METHODS We followed the guidelines outlined in the PRISMA Statement, and conducted a systematic review (PROSPERO registration: CRD42021274215) by searching PubMed, Scopus, and Web of Science databases in July 2021. All steps including title, abstract and full text screening based on predefined inclusion and exclusion criteria, data extraction and quality assessment were

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done independently by two authors. RESULTS Overall, 39 studies were included in this review. 16 studies used lower limb exoskeletons to measure joint angles or RoM, 14 studies measured joint torques or strength, and 10 studies measured gait parameters such as gait phase detection, step length or speed. Furthermore, 9 studies assessed spasticity, and 4 studies assessed proprioception. To this end, both stationary (n=5) and mobile exoskeletons (n=18) were used. Most exoskeletons supported only one joint (hip (n=7) and ankle (n=7); all mobile). 3 stationary exoskeletons only supported knee and hip, and 6 exoskeletons supported the full leg (stationary n=2; mobile n=4). 14 studies examined exoskeleton-based motor performance assessments in terms of validity (n=14) and/ or reliability (n=6). The stationary exoskeleton "Lokomat" was used in nearly one third of all included studies. CONCLUSIONS Our review shows that various motor performance paramters can be measured using built-in sensors of exoskeletons. Compared to manual (e.g., clinical) test procedures, motor performance measurement through a lower limb exoskeleton may be more objective and specific for certain parameters such as proprioception or spasticity. Of note, assessing motor performance using exoskeletons is feasible, but validity and reliability studies are still scarce. More research is thus needed before exoskeletons can be used in clinical or research settings to assess human motor performance. Furthermore, adequate familiarization protocols, specific test control algorithms, and non-disturbing hardware designs, are critical. ACKNOWLEDGEMENTS AND FUNDING This research was conducted as part of the JuBot project which is funded by the Carl-Zeiss-Foundation.

Poster Session 2

Affect (e.g. Fear of falling, depression)

P2-A-1: Does altering egocentric location in a threatening height experience modify arousal: pit versus elevated platform

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Background It is well established that arousal (fear/anxiety) increases with postural threat. Similar virtual heights can be created virtually and it is not known whether the type of virtual height experience influences overall arousal changes. Here we investigate the effects of two different egocentric high height positions with differing motion parameters (egocentric versus allocentric). Methods Fifteen healthy young subjects age 21.5 (5.2) years participated in this experiment across two days. Electrodermal activity (EDA), surface electromyography (EMG), body sway, and subjective ratings were collected while standing subjects were exposed to two different virtual height scenarios: Elevated platform versus Pit. Both scenarios consisted of 60 second trials: 3 at low, 3 at high, and 1 at low. Co-contraction index for tibialis anterior and medial gastrocnemius was calculated from EMG. Tonic and phasic EDA parameters were calculated. Median sway frequency was calculated for low (< 0.5 Hz), mid (0.5-1.8 Hz) and high (1.8-5.0 Hz) ranges. Height and condition main effects and interactions were determined with ANOVAs. Results Subjective ratings of anxiety and fear were significantly greater at virtual heights ($p < 0.001$). Subjective stability was significantly lower at virtual heights ($p < 0.05$). There was no significant interaction between conditions and height. Tonic EDA increased with

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both height exposures ($p < 0.05$), but there was not a height condition interaction. We found no difference for leg co-contraction index. High frequency anterior-posterior sway was less in the Pit condition ($p < 0.05$). Conclusions The majority of physiologic measures and subjective reports confirm that the two high height positions have a similar effect despite different motion profiles leading to the threatening position. Either an Elevator or Pit simulation could effectively generate increased arousal in individuals for research or clinical purposes.

Ageing

P2-B-2: Gait speed associated changes in minimum toe clearance (MTC) in young adults

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BACKGROUND AND AIM: Studying Minimum toe clearance (MTC) may improve our understanding of trip-related falls in older adults (≥65 years).[1] However, if MTC is affected by speed, findings from studies examining age differences in MTC may be confounded by differences in gait speed between age groups. Alcock et al.[2] examined the effect of speed on MTC in older adults and identified a significant association between MTC and gait speed, with MTC increasing between 9.3 -13 mm for every 1 m/s increase in gait speed.[2] Miller et al. also found a significant effect of speed in younger adults, with MTC decreasing 4.3 mm for every 1 m/s increase in gait speed.[3] However, based on Miller et al.'s study, it is unclear how speed affects MTC in young adults since it included middle-aged adults. This is important as the ability to control MTC over different speeds may decline with age. Therefore, this study aims to determine the effect of speed on MTC in a sample of young adults (18≥30 years). METHODS: For this cross-sectional study, 30 participants (20 females, 10 males: mean ±SD: age = 22.2 years±2.55; height = 1.66 m±0.09; weight = 68.9 kg±13.17) were recruited and given a 50 $ gift card. All participants were free of pathologies affecting walking, scored ≥ 3 on the MiniCog, and took < 13 seconds to complete the Timed Up and Go test (TUG). Each participant was fitted with a modified Cleveland Clinic marker set, and a digitized point defined the shoe tip. Twenty-five walking trails were performed at self-selected normal, fast, and slow speeds over a 15-meter level surface. Eight infrared cameras (Vicon, 100 Hz) recorded walking trials in the central 7 meters. Five-minute rest breaks were provided after each speed. Motion capture data was analyzed using Visual 3D (C-Motion). A multilevel model/regression (MLM) was used for data analysis (Stata version 16). RESULTS: A two-level random intercepts model (RI) was the most parsimonious MLM model and improved upon the ordinary least squares model (OLS). The slope coefficient for right MTC was 1.734 (95% CI: 1.297 - 2.172) (p<.001), and left MTC was 1.334 (95% CI: 0.799 - 1.870) (p<.001). CONCLUSIONS: There was a significant association between MTC and speed, with a 1.7 mm increase in right MTC and a 1.3 mm increase in left MTC for every 1 m/s increase in gait speed. This study reported a smaller increase in MTC than the 9.3-13mm noted by Alcock et al. in older adults. This finding may suggest an age-related decline in the ability to control MTC over different speeds. However, further confirmation is needed as an OLS model was used by Alcock et al., and a MLM was used in this study. ACKNOWLEDGEMENTS AND FUNDING: This work was supported by an internal grant from the Milton Lev Memorial Faculty Research Fund.

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REFERENCES: [1] Delfi et al. 2021. Int. J. Environ. Res. Public Health, 18(20): 10848 [2] Alcock et al. 2018. J Biomech, 71: 30-36 [3] Miller et al. 2009. J Biomech, 25(1): 32-42.

P2-B-3: Impact in older adults of reducing anticholinergic and sedative medication burden on physical function measured by wearables in lab and real-life environments: a feasibility study

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Background and aim Medications with anticholinergic and sedative effects have been associated with impaired physical function in standardised tasks such as gait speed and Timed Up and Go. Wearables are increasingly used to capture refined measures of mobility (cadence, gait asymmetry) and activity. We assessed the feasibility of measuring the impact of reducing anticholinergic and sedative medication burden on physical function measured with wearables in lab and real-life environments. Methods Feasibility (n=5), intervention trial of community-dwelling adults, 65 and older, with a Drug Burden Index (DBI) score ≥ 1 and a targeted reduction in DBI score ≥ 0.5. The Short Physical Performance Battery (SPPB) and Mini Balance Evaluation Tests (mBESTest) were assessed using 6 APDM Opal sensors during 3 lab visits at varying DBI scores. Mobility and activity were measured daily for 7 days in real-life environments using 2 Apple Watch Series 6 on the left wrist and right ankle as well as home sensors. Feasibility evaluations included recruitment capacity, duration of the deprescribing process and completion of the lab evaluations. Results Five participants with a mean age of 69.0 ± 6.8, median DBI at recruitment of 1.8 (min 1.3, max 5.4) including 4 patients of female sex were recruited. The lifting of COVID-19 measures enabled the recruitment of 3 patients in 16 days in June 2022 in 1 primary care clinic. Second lab visits were conducted after reductions ≥ 0.25 in DBI score in 4 patients. The deprescribing process is still ongoing in 3 patients ≥ 5 months after their baseline visit. Lab visit time was decreased from 2h30 to 2h by optimising complementary assessments. Promising preliminary lab results on controlled gait assessments included increased cadence (110.2 to 116.4 steps/min), gait speed (1.05 to 1.33 m/s) and stride length (1.15 to 1.37m) between lab visits 1 (T1) and 2 (T2) in a 70 old self-identified male participant. Mobility parameters returned within normative range for that participant whose DBI decreased from 1.40 to 1.16. Outdoor real-life metrics showed increases in average active time (2.2%) and total number of steps performed outside (6.5%) from T1 to T2. The time in outdoors purposeful walking (>120 steps) increased by nearly 6 minutes per day, while cadence remained unchanged (118.3 to 118.0 steps/min). The time spent in outdoors brisk walking increased significantly (4.2 to 14.6 min). Complete results of the 5 patients will be presented. Conclusions The pilot study validated the recruitment goal, indicated the need to plan a deprescribing process of 4 to 6 months and optimized lab visits in preparation for an already funded subsequent trial to be conducted in 182 patients.

P2-B-4: Age-related changes in the performance of balance tasks requiring inhibitory control

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BACKGROUND AND AIM: Age-related changes in executive functions affect behaviour of older persons and contribute to an overall decrease in functioning, which ultimately lead to mobility

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limitations and an increased fall risk. Inhibitory control (IC) is one of the main components of executive functions that enables a person to suppress irrelevant information or incorrect motor actions to successfully achieve goal-directed behaviour. Recent studies in older persons show an association of reduced IC with impaired gait adaptability and an increased risk of falls. However, it is not clear how impaired IC affects tasks which integrate balance and IC. This study aims to determine the impact of IC on performance of tasks which require balance control and compare performance of young (YA) and old (OA) adults. METHODS: Two types of balance tasks, i.e. step- or gait-initiation in response to visual stimuli, were designed to assess performance of YA and OA in conditions which respectively required perceptual or motor inhibition. During tasks requiring perceptual inhibition, subjects (in total n = 66) performed three stepping tasks. Each of these tasks included 20 congruent and 20 incongruent trials. During the task requiring motor inhibition, subjects (in total n = 68) needed to initiate gait (Go) and, if needed, immediately stop gait initiation (Stop). The gait initiation task comprised 3 blocks, each consisting of 9 Go and 3 Stop trials. Data analyses of the tasks comprised changes in centre of pressure (CoP) position and foot movements (as measured by a Bertec force plate (1000 Hz) and a Qualisys motion capture system (100 Hz)). Performance of the tasks were analysed in association with the outcomes of a selection of standardised cognitive and motor tests. RESULTS: Both types of balance tasks show that inhibitory control affected task performance in YA as well as in OA. Results in OA show a task dependent prolonged duration of CoP and step onsets during step initiation tasks that require perceptual inhibitory control, and less success in blocking gait initiation compared to YA. Outstanding analyses will focus on the associations of balance performance with standardised cognitive and motor tests. CONCLUSIONS: This study presents outcomes of two novel tasks that assess performance of balance tasks integrating balance and inhibitory control. Results show that inhibitory control affects the performance of step- and gait-initiation in YA as well as in OA, but has more impact in the OA. Further analyses of our results may help to increase our understanding of the impact of age-related changes in inhibitory control on motor performance and give input into the development and evaluation of new interventions.

P2-B-5: Higher physical activity level is associated with smaller ground reaction forces during gait in middle-aged adults with obesity

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BACKGROUND: Osteoarthritis is a leading cause of disability. Adults with obesity are twice as likely to develop osteoarthritis than normal weight adults. Cartilage changes in adults with obesity indicating pre-symptomatic joint degeneration have been observed decades before older adulthood. Joint loading during walking is implicated in cartilage health and osteoarthritis development. Regular physical activity in healthy young adults is associated with smaller ground reaction forces (GRFs) during walking. AIM: Evaluate the association of physical activity level (PAL) with GRFs during gait in middle-aged adults with obesity (MOB). METHODS: 29 MOB performed overground walking. GRFs were collected with an embedded force platform. GRF variables include: maximum vertical GRF (MvGRF), normalized MvGRF (MvGRFn), vGRF loading rate (LR), total vertical load during stance (TL), and normalized TL (TLn). PAL was quantified with 1 week of Actigraph monitoring. Associations of GRF variables with PAL were calculated with Spearman correlations. Mediation of body fat percentage (BFP) and plantarflexor strength (PF) were explored. RESULTS: MvGRF (ρ=-0.64,p<0.01), TL (ρ=-0.57,p<0.01), and TLn (ρ=0.50,p=0.01) were associated with PAL. BFP and PF mediated the

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relationships between GRF measures and PAL. More active MOB with higher BFP had smaller MvGRF (R2=0.31,p=0.01) and MvGRFn (R2=0.28,p=0.02). Less active MOB with higher BFP had smaller TLn (R2=0.27,p=0.02). More active MOB with weaker PF had smaller MvGRF (R2=0.50,p<0.01) and smaller TL (R2=0.36,p<0.01) but larger TLn (R2=0.22,p=0.04). CONCLUSIONS: Lower overall joint loading is associated with greater PAL in MOB indicating adults MOB can be more active without exposing their bodies to higher loads. Higher BFP and weaker PF, combined with higher PAL, are associated with lower overall joint loading. Future work should explore mechanisms behind these relationships to inform interventions aimed at protecting MOB from joint degeneration. ACKNOWLEDGEMENTS AND FUNDING: Grant TL1TR001858.

P2-B-6: Balance stabilizing benefit of interpersonal light touch: the influence of an individual's anthropometry and person characteristics relative to the partner's

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BACKGROUND AND AIM: Interpersonal light touch (IPLT) interaction improves balance stability across the whole lifespan. It has been shown that the benefit of IPLT is greater in the comparatively more unstable individual. The aim of this study was to investigate to what extent the benefit of IPLT is associated not only to individual characteristics such as baseline sway, age and anthropometry, but also to interindividual differences in these characteristics in a pair. METHODS: We assessed body sway in 82 pairs in the age of 4 to 80 years during single-legged stance trials of 20s under four sensory conditions (with/without vision; with/without IPLT). We extracted the variability of center of pressure velocity (SD dCoP; baseline sway) and the proportional change in SD dCoP (PropChange) due to IPLT for both visual conditions; negative change indicates a greater benefit of IPLT. For statistical analysis 62 pairs (77 children/adolescents (<18y): 40 f, 37 m; 47 adults (≥18y): 19 f, 28 m) were included after removing pairs with extreme values (> 3SD) in dependent and independent variables. Bootstrapped backward multiple linear regression (N=1000, BCa95%, stratified by age group) of the PropChange on individual characteristics (age inverse , height, weight, body mass index (BMI), BMI mean centered squared, SD dCoP) and relative partner characteristics (relative difference in individual characteristics) was computed. RESULTS: The best prediction of the PropChange during no vision, with the lowest number of predictors, was provided by the amount of SD dCoP (β=-.636) and the relative age difference (β=.175) (R2=.441). These findings indicate a greater benefit for individuals with a greater baseline sway and for younger partners in a pair. With vision, PropChange was predicted by age inverse (β=.638), followed by BMI (β=.632), baseline sway (β=-.525), relative age difference (β=.314), relative BMI difference (β=-.312), and BMI squared (β=-.182) (R2=.378). This indicates a greater benefit of IPLT for more matured individuals, and individuals showing greater baseline sway. Moreover, there is a greater sway reduction expected in individuals with a higher BMI when comparing two groups with a high BMI who differ by 1 unit in BMI. Finally, in relation to the partner, the benefit is greater for a partner, who is up to 38 years younger, as well as for a partner with an up to 15 units greater BMI. CONCLUSIONS: Besides individual characteristics also relative differences between interacting partners are associated with the amount of stabilizing benefit of IPLT on body sway. Especially, much younger partners benefited more, independent of the availability of visual feedback. The observation that the availability of vision resulted in a more complex model involving both individual and partner characteristics demonstrates that the amount of multisensory feedback determines the factors of interpersonal dependency during IPLT.

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P2-B-7: Peroneal muscle response to an expected and unexpected fall in young and middle-aged adults before and after neuromuscular training: a cross-sectional study

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Background and Aims Balance and postural control during middle age (MA) may be affected by age-related changes in the nervous system and by a decrease in muscle mass, strength, and flexibility. The aim of this study was to investigate the anticipatory response of the peroneus longus muscle (PL) to landing after an expected fall (jump) and its postural response to an unexpected fall (perturbation) in MA and young adults. A second aim was to investigate the influence of neuromuscular training on PL postural responses in both age groups. Methods Twenty-six healthy MA (55.3±4 years) and 26 healthy young adults (26.3±3.6 years) participated in the study. Assessments were performed before (T0) and after (T1) PL EMG biofeedback (BF) neuromuscular training. To assess PL response to an expected fall, subjects performed a single-leg drop jump, and the PL EMG activity in preparation for landing (PL activity as % of jump time) was calculated. PL time to onset and time to peak were measured to assess PL response to an unexpected fall (perturbation). In this test, subjects stood on a custom-made trap door that produced a sudden 30° ankle inversion. Repeated measures ANOVA was used to analyze the effects of age and EMG-BF training on PL EMG activity in preparation for landing (% of jump time), and MANOVA for repeated measures was applied to assess these effects on unexpected fall performance (PL onset time and time to peak). Results Before training, the MA group showed significantly shorter PL activity in preparation for landing compared to the young adults (25.0% vs. 30.0%, p=0.016), while after training there was no difference between the groups (28.0% vs. 29.0%, p=0.387). There were no differences between groups before and after training in peroneal activity after the unexpected fall. Conclusions The results suggest that automatic anticipatory peroneal postural responses are reduced in MA, whereas reflexive postural responses appear to be intact in this age group. A short PL EMG-BF neuromuscular training may have an immediate positive effect on PL muscle activity at MA. The results may highlight the need to investigate both anticipatory and reflexive muscle responses when studying age-related changes, as well as the need to investigate postural control in middle-aged adults. In addition, our results should encourage the development of specific interventions to ensure better postural control in this group.

P2-B-8: NONAN GaitPrint: A public repository of overground walking data

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BACKGROUND AND AIM: Biometric identification using a range of technologies (e.g., videos, pictures, voice recognition, and fingerprint scanning) is a major area of current research. At the same time, humans possess an impressive ability to identify specific family members when walking without direct line of sight. This implies that individuals exhibit invariant patterns that translate across gait cycles and allow identification. Contemporary biometric research

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attempts to exploit those regularities for the purpose of identification and diagnosis of disease. Hence, the acquisition of full-body kinematic gait data is essential to identify gait patterns over time. The first aim of this study is to accumulate high quality data across a variety of populations to specify identifying characteristics of an individual's gait, much like a fingerprint. The second aim of this dataset is to provide an online repository of freely accessible data that can be used by researchers. Our dataset overcomes the limitations of previous datasets since it (1) incorporates walking in a straight line and a curvilinear trajectory, (2) is within a natural environment, (3) uses portable equipment that is less expensive than optical motion capture systems, (4) emphasizes a large amount of data for a large number of participants, (5) offers a large scope of potential analyses, and (6) allows for test-retest reliability to be determined for time series analyses applied to uninstructed, continuous overground walking. METHODS: Whole body kinematics were collected during self-paced overground walking on a 200-meter indoor track using 16 Noraxon Ultium Motion inertial measurement units recording at 200Hz. 35 healthy young adults (19-35 years old, 16 female) completed a total of 18, 4-minute walking trials spread across two sessions exactly one week apart. We provide a technical validation of traditional spatiotemporal parameters alongside nonlinear analyses such as Relative Phase, the Largest Lyapunov Exponent, and Hurst Exponents. Participants were recruited if they were (1) able to provide informed consent, (2) able to walk independently without an assistive device, (3) did not self-report diagnosis of neurological disease, and (4) did not self-report diagnosis of any lower limb disability, injury, or disease. RESULTS: The spatiotemporal calculations of this dataset are comparable to other online datasets of varying methodology, and our nonlinear analyses also estimated values similar to previous literature. We also provide detailed timesheets of each trial as well as characteristics of each participant including height, weight, and anthropometric measurements. CONCLUSIONS: The strength of this dataset lies within its long time series (~40,000 samples). This is the first step of a larger project to collect overground walking data on middle (36-55 years) to older (56+ years) adults and individuals who have had a stroke, lower limb amputation, or are diagnosed with Peripheral Artery Disease. ACKNOWLEDGEMENTS AND FUNDING: NSF award 212491, NIH awards P20GM109090 and R01NS114282, the University of Nebraska Collaboration Initiative, the Center for Research in Human Movement Variability at the University of Nebraska at Omaha, the NASA EPSCoR mechanism, and the IARPA WatchID award.

Clinical trial

P2-D-9: Three-dimensional rigid-body and articular kinematics of the knee between level and slope walking using 3d fluoroscopy

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Background and Aim Slope walking is an inevitable part of daily living, placing more challenges on the locomotor system than level walking does, which consumes more energy than level walking and requires coping with inertial forces acting upon the body, which may increase the loads on the cartilage [1]. Computerized tomography (CT) based 2D/3D registration

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techniques using bi-plane fluoroscopy is a non-invasive method for accurately measuring in-vivo joint kinematics. Therefore, the purpose of the current study: (1) measure in-vivo three-dimensional kinematics of the knee joint rigid body walking on the slopes ;(2) use the statistical shape model (SSM) of the knee cartilage morphology to calculate the surface kinematics of the knee joint during the stance phase of the gait. METHODS Five normal subjects (age:25.4 ± 1.85 years; BMI: 24.30 ± 1.63 kg/m2) performed level walking and 6 degrees of slope uphill walking under the surveillance of a biplane fluoroscopy system. Each subject received a CT scan (Brilliance iCT 256, Philips) while supine to obtain subject-specific models of the femur and tibia. The 3D fluoroscopy method [2] was used to determine the pose of the knee bone models through the respective X-ray images, which were then used to calculate the rigid-body kinematics of the femur and the tibia, respectively. The surface kinematics were then used in the SSM-based method to reconstruct the personalized cartilage morphology (Figure 1 (a)), which attaches to the bone models. Then use the penetrated region between two cartilages to calculate the contact patterns to quantify the effects on the knee joint during level walking and 6- degree slope uphill walking. Wilcoxon signed-rank test was used to compare level walking and slope walking data with $\alpha=0.05$. RESULTS During 6-degree uphill walking, the flexion angle of the knee joint was found to increase significantly in the early stance phase and the toe-off (Figure 1 (a)). Meanwhile, during the uphill slope walking, the lateral meniscus contact area through the SSM-method simulation showed significantly greater value than level walking in the early stance phase and the toe-off (Figure 1 (b)(c)(d)). CONCLUSIONS Compared to level walking, the knee experienced greater flexion angle in the early stance phase and contact loads in lateral compartments, as indicated by the significantly increased contact areas ($p<0.05$). This study provides the baseline data of the knee joint's rigid body and surface kinematics during up-slope walking. REFERENCES [1] Kimel-Naor S., et al., (2017). J Biomech, 26;60:142-149. [2] Lin, C.-C., et al., (2014). Med Eng Phys, 36(2) 267-3

P2-D-10: Three-dimensional knee kinematics during sit-to-stand in patients with medial knee osteoarthritis following high tibial osteotomy measured using 3D fluoroscopy

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BACKGROUND AND AIM Knee osteoarthritis (OA), a common disease caused by articular cartilage degeneration, causes joint pain and stiffness, affecting the movement of the joint and daily activities, including sit-to-stand. High tibial osteotomy (HTO) surgery, a joint-preserving surgery, has recently been widely used for patients with medial compartment OA [1], aiming to shift the contact load in the medial compartment towards the lateral and increase the medial articular gap. The dynamic inter-articular distance changes are decisive parameters to evaluate the recovery post-surgery. However, owing to technical difficulties, no study reported the effects of HTO surgery on the articular kinematics of the knee during sit-to-stand in terms of the measured inter-articular distances in vivo. The current study aimed to bridge the gap by measuring in vivo the three-dimensional kinematics of the knee during sit-to-stand pre- and post-HTO using biplane fluoroscopy. METHODS Fifteen patients with knee OA performed sit-to-stand before and after the HTO surgery with the 3D motions of bones measured by a biplane fluoroscopy system. Three-dimensional bone models of the femur and tibia were reconstructed from computed tomography images, and the motions of the bones were determined using the 3D fluoroscopy method [2]. The angles of the tibiofemoral joint and the

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inter-articular distances of the medial and lateral compartments of the joint during sit-to-stand were calculated to quantify the efficacy of HTO. A paired-T test was used to compare pre and post-HTO conditions with α=0.05. RESULTS The pre-surgery inter-articular distance in both medial and lateral compartments of the joint was compared with the post-surgery inter-articular distances. The patients who underwent HTO surgery showed significantly greater inter-articular distance in the medial compartment for knee flexion between 35° and 65°, and there was no significant difference in the lateral compartment in all degrees. These results showed that after the HTO surgery, the change of the tibial alignment led to medial condylar lift-off, which increased the distance between the medial compartment articular surfaces, which may help stop the progression of the cartilage degeneration in the medial compartment. The current results suggested that patients with medial compartment knee OA can expect improved clinical outcomes after HTO surgery. CONCLUSIONS The HTO surgery successfully shifted the contact load in the medial compartment to the lateral, as indicated by the statistically increased inter-articular distances in the medial compartment. The current findings may contribute to a better understanding of the underlying mechanism for a current treatment for medial compartment arthritis. ACKNOWLEDGEMENT MOST 107-2221-E-341 -001 -MY3 REFERENCES [1] Robert F. LaPrade., et al. The Journal of Arthroscopic & Related Surgery 28(3): 354-364,2012 [2] Lin, C.-C., et al. Applied Sciences 10(23): 8426, 2020

Cognition (e.g. dual tasking)

P2-E-11: Effects of augmented reality head-mounted display character type and contrast ratio on gait

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BACKGROUND AND AIM:The use of a smart device such as an Augmented Reality Head-Mounted Displays (AR) is being seen more and more in daily lives as their functions and usability have improved and proliferated with the advancements in wearable technology. People might even wear the AR and read over information shown on the display while walking. However, when doing so, there is a possibility that people need to adjust their gait in order for them to accommodate the additional cognitive workload demands from reading and processing the messages. Very few researches that examine if the display interface design of the AR will affect gait when people walk and use the AR simultaneously. In this study, we investigate the effects of message character type shown on the AR interface and the contrast ratio between the character and the display background on gait. METHODS:A total of twenty healthy participants' data is used for analysis in this study. A full factorial design was employed with two main factors: character type (Hei and Ming type) and contrast ratio (4.5:1 and 8:1 contrast ratio of the character and background). For each test condition, participants were instructed to walk straight at their own comfortable speed from a starting point to ending point (about 10 meters) while being asked to read out one of randomly selected articles composed of traditional Chinese characters on the AR from the article database. Each article only appears once in the experiment. The walking speed, stride length, stance phase, and minimum foot clearance of each participant were collected from the motion tracking system. To reduce the influence of individual differences among the participants, the variations in the walking speed,

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stride length, stance phase, and MFC were calculated and used as dependent variables for analysis. RESULTS:The analyses show that the character type had a significant effect on walking speed variation ($p = 0.03$) and stride length variation ($p = 0.02$). When walking and reading the article shown on the AR simultaneously, the Chinese character of Ming type yielded a 12.60% reduction in walking speed variation while Hei type resulted in a 10.85% reduction. And there is a 24.59% reduction of using Ming type in the stride length variation and a 21.42% reduction of using Hei type. There was no significant effect found on the stance phase variation and the minimum foot clearance variation between both character types. Compared to the Ming type, the Hei type had a smaller effect on walking speed variation and stride length variation. It may be due to the Chinese character Hei type having the same horizontal and vertical stroke widths which results in better visual recognition for the participants. The contrast ratio had no significant effect on any of the four dependent variables. CONCLUSIONS:The overall findings indicated that it is important to take the display interface design of AR into consideration as it could affect the user's gait performance.

P2-E-12: Effect of executive function training on cognitive-motor dual-tasking in middle aged and older adults: Insights from functional near infrared spectroscopy

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Background: Poor cognitive-motor dual-tasking increases the risk of falls and cognitive decline in older adults. Compensatory scaffolding theories suggest that older adults compensate for declining brain structure by up-regulating brain activity in the prefrontal cortex (PFC). Yet, there are inconsistent findings when examining differences in brain activity during dual-tasking in younger versus older adults. Additionally, while current evidence suggests that executive function training may improve dual-task performance, there is less knowledge about how brain activity changes following the intervention. Therefore, the aim of this study was to elucidate changes in brain activity during dual-tasking following executive function training in middle-aged and older adults. Methods: Participants consisted of healthy middle-aged (n = 19; Mage = 54.0 ± 3.58) and older adults (n = 23, Mage = 71.0 ± 3.34) randomized to either 12 weeks of at-home executive function training (n = 22; 30 min., 3x/week) or a wait-list control group (n = 10). Single- and dual-task performance (treadmill walking with an auditory 2-back task) was assessed before and after 12 weeks. Accuracy (% correct) and reaction time (sec.) on the 2-back task was evaluated using handheld response buttons, gait characteristics (i.e., stride time (sec.) and variability (SD)) were assessed via electronic pressure sensors, and oxygenated hemoglobin (HbO; μmol.L-1) in the PFC was measured using functional near infrared spectroscopy. Cognitive functioning was assessed with several other neuropsychological tests (e.g., Coding, Stroop, Digit Span, Trail Making Test). Results: At baseline, there was a significant age effect, wherein middle-aged adults had higher HbO levels and were more accurate on the 2-back dual-task compared to older adults. HbO levels were also highest during dual-tasking, followed by single-task walking, and then single-task 2-back. Following training, 2-back accuracy and reaction times significantly improved, particularly for the middle-aged adults. Additionally, HbO levels during single-task walking significantly increased following training. Finally, in correlating HbO levels with cognitive performance, we found negative correlations in middle-aged adults, wherein lower HbO levels were associated with better performance on

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tasks of processing speed and task-switching. In contrast, we found positive correlations in older adults, wherein higher HbO levels were associated with better performance on tasks of global cognition, processing speed, short-term memory, and task-switching. Conclusions: This study highlights the benefit of an at-home executive function training program in improving dual-task performance in middle-aged and older adults, while elucidating previous inconsistent findings regarding neural activity during dual-tasking across the adult lifespan.

P2-E-13: Influence of postural control difficulty on changes in visuospatial attention after leftward prism adaptation

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BACKGROUND AND AIM: Leftward prism adaptation (PA) induces not only after-effects on sensorimotor adaptation but also cognitive expansion in healthy adults. However, after-effects of leftward PA on visuospatial attention remain unclear. Visuospatial attention can be affected by non-spatial attentional aspects, such as increasing cognitive load with a concurrent task. Postural control difficulty delays the reaction time (RT) to external stimulation, as similar to increasing cognitive load during dual tasks. Therefore, the aim of the present study was to investigate the influence of postural control difficulty on changes in visuospatial attention after leftward PA in healthy adults to clarify the features of visuospatial cognitive after-effects of leftward PA. METHODS: Fifteen healthy young adults underwent 15- and 5-min PA procedures, in which they randomly pointed to one of three visual targets, instructed every 5 s, while wearing the prism lenses shifting the perceptive visual field displacement at 30 diopters to the lateral left. We split two phases of PA procedures and post-evaluation measurements for avoiding de-adaptation effects due to the long test-time required for the visuospatial attention test. The participants underwent the Posner cueing tests immediately before the 15-min PA procedure (pre-evaluation), and between the 15- and 5-min PA procedures and after the 5-min PA procedure (post-evaluations). The Posner cueing tests were randomly performed under two standing conditions in the pre- and post-evaluations: barefoot on the floor (normal standing condition) or balance-disc (balance standing condition). We calculated the average RTs for each condition at each evaluation time point by removing the RTs < 200 ms or > 3 standard deviations for the participants' mean RT for each trial. RESULTS: For valid and invalid targets in the right hemifield, the repeated measures two-way analysis of variance (ANOVA) revealed that RT in the pre-evaluation was significantly prolonged in the balance standing condition compared to the normal standing condition. However, RT in the post-evaluations was not significantly different in the balance standing condition compared to the normal standing condition because leftward PA improved RT in the balance standing condition for targets in the right hemifield. The repeated measures two-way ANOVA revealed that RTs in the balance standing condition were significantly prolonged compared to the normal standing condition regardless of the pre- and post-evaluations, for valid and invalid targets in the left hemifield, on which leftward PA exerted no after-effects. CONCLUSIONS: Leftward PA modulated visuospatial attention and improved RT for targets in the right hemifield with postural control difficulty, but not in the left hemifield. Postural control difficulty may enhance sensitivity to features of visuospatial cognitive after-effects of leftward PA.

P2-E-14: Aging and cognitive-motor interference during reactive stepping responses to stance and gait perturbations

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BACKGROUND AND AIM: Dual tasking (DT) studies have examined cognitive-motor interference (CMI) during volitional balance and gait, although it has rarely been examined how different cognitive task domains affect reactive responses to unpredicted balance threats. Further, it is unknown how age-related cognitive and sensorimotor decline affect CMI during reactive balance. This study compared CMI between young and older adults during large magnitude perturbations to understand how DT in daily living could affect fall risk in aging populations. METHODS: 15 young (24.1±5.0 y) and 15 older adults (68.3±5.6 y) were exposed to unexpected, forward support surface perturbations that elicited stepping while standing and walking on a treadmill. 4 cognitive tasks were completed during perturbations: Target: Turn the head to control a computer mouse and catch a virtual ball; Track: Turn the head to track a computer-controlled target; Auditory Clock Test (ACT): Hear a time and identify if the clock hands are on the same or opposite side; Letter Number Sequencing (LNS): Continue a sequence of letter and number pairs (e.g., A1, B2). Tasks were also performed during unperturbed sitting and gait. We examined the effects of task (No task, Target, Track, ACT, LNS) and age group (young, old) on post-perturbation margin of stability (MOS) using ANOVA. We also examined the effects of DT (sitting vs. perturbed stance, gait vs. perturbed gait) and group on cognitive performance. RESULTS: Older adults had lower MOS than young adults during stance and gait ($p<0.01$). Both groups had lower stance MOS in Track vs. LNS ($p=0.01$), although task did not affect gait MOS. Overall, older adults had lower LNS, Target, and Track performance than young adults ($p<0.05$). Compared to unperturbed conditions, both ages had lower LNS and Target performance for perturbations ($p<0.05$). There was a significant group*DT interaction for Track performance; only older adults had lower performance during stance perturbations vs. unperturbed performance ($p=0.03$). CONCLUSIONS: Older adults had more CMI than young adults during reactive balance. Older adults showed mutual interference (reduced motor and cognitive performance) for the visuomotor Track task, whereas young adults showed cognitive-related motor interference (reduced motor performance only). For Target and LNS, both groups demonstrated motor-related cognitive interference (reduced cognitive performance). Higher interference in older adults could increase fall risk during daily balance threats, especially given their reduced stability. Further, both ages had higher CMI for stance vs. gait perturbations, possibly due to increased reliance on cognitive resources when initiating a step from a static position, rather than modifying a motor program that has already been implemented during gait. Lastly, the highest CMI was observed for tasks involving visuomotor processing, which could share the most overlapping resources with reactive stepping.

P2-E-15: Does sport-specific training influence how humans avoid collisions with a virtual player approaching on a 45-degree angle under dual-task conditions?

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BACKGROUND: Sports provide varying scenarios where athletes must interact with and avoid opposing players in dynamic environments. As such, sport-specific training can improve one's ability to integrate visual information which may result in improved collision avoidance behaviours. For instance, trained rugby players both consistently, and accurately avoided an approaching person later compared to their untrained counterparts (Pfaff & Cinelli, 2018). The

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effects of sport-specific training on collision avoidance are controversial, and improved visuomotor capabilities are highly task-dependent (i.e., athletes should be tested in sport-specific environments). AIM: The current study aimed to examine whether sport-specific training influenced individuals' collision avoidance behaviours during a sport-specific task in virtual reality. We expected that athletes would consistently avoid collisions later than their untrained counterparts while making fewer errors on the secondary task. METHODS: Untrained young adults (UYA; N=21, 22.9±1.9 yrs, 11 males) and specifically trained athletes (ATH; N=18, 20±1.5 yrs, 7 males) were immersed in a virtual environment using the HTC VIVE Pro2 headset and were instructed to walk along a 7.5m path towards a goal located along the midline. Two virtual players (VP) positioned 2.83m to the left and right of the midline (Fig.1) approached participants on a 45º angle at one of three speeds, 0.8x, 1.0x, and 1.2x each participants' average walking speed. Participants were instructed to walk to the goal without colliding with the approaching VP. Participants performed a secondary task, where they reported whether a shape changed above the VPs' heads. The shape changed 2s after the participant began walking and would remain changed for 0.5s (on ½ of trials). Using the position of the VP and the participant, avoidance behaviours of minimum clearance and time to first avoidance behaviour were examined. Further, the percentage of correct responses on the secondary task were recorded. RESULTS: There was a significant difference in the percentage of correct responses on the secondary task between groups (p=.001) as ATH (95.1±3.1%) had a higher percentage of correct responses compared to UYA (88.9±7.9%). There was no difference in the average minimum clearance maintained by ATH (.99±.2m) and UYA (.93±.2m), but ATH were more variable in their avoidance behaviours (p=.03, η2 =.12). Further, both groups deviated at the same time regardless of the VP's approach speed, as demonstrated by the consistent time to first avoidance behaviour between ATH (1.7±.3s) and UYA (1.7±.3s). CONCLUSIONS: Findings from this study demonstrate that athletes may be more effective at allocating their attentional resources to complete multiple tasks simultaneously. Similarities in the avoidance behaviours between the two groups may be a result of the task lacking sport-specificity (i.e., athletes were not running) or due to the predictability of the VP's path.

Exercise and physical activity interventions

P2-G-16: Posture (standing vs. sitting) and consequences on task performance, work productivity and health

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1) Background and aim: The question could be asked in which body position do individuals perform ongoing tasks most efficiently? It may seem obvious that individuals should perform tasks more efficiently when sitting than when standing. Indeed, when individuals are standing, they sway at all time and need to control their equilibrium. When standing and performing challenging dual-tasks, it is assumed that individuals divide their attention. To answer the initial question, I considered both task performance (in short tasks: < 1 hour) and work productivity (in longer tasks: > days). 2) Methods: In this presentation, I review and synthetize the literature to discuss various related findings. First, task performance and work productivity when

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standing vs. when sitting are discussed. Second, health problems related to prolonged sitting are illustrated because they can impact work productivity. Third, what is meant by "prolonged sitting" is defined in terms of time duration. Fourth, the prevalence of sitting since 1950 until nowadays is illustrated. Fifth, a review synthetizing positive vs. detrimental effects of swaying vs. only standing is discussed. Overall, experimental evidences in various fields of research (Human Factors Ergonomics, Postural control, Epidemiology, Human History) are used to discuss how to optimize task performance, work productivity and health status in relation to posture (body positions). 3) Results: First, the literature shows that task performance is approximately equal when sitting and when standing. However, work productivity is clearly lower when individuals spend too much time in the seated position as they get both light and heavy health issues. Second, I synthetize the large number of health problems caused by prolonged sedentariness as problematic as premature mortality, cancer, diabetes, cardio-vascular disorders and cognitive issues. Third, the threshold of 8h/d spent in the seated position is discussed as a high threshold not to cross by any individuals to avoid these issues. Fourth, I highlight that the prevalence of the time spent seated today is higher than 8 h/d in almost all high-income and emerging countries. Fifth, the literature unilaterally shows that swaying, but not standing as such, is beneficial (and surely not detrimental) for task performance. 4) Conclusions: Modern societies are going in the wrong direction for health concerns, work productivity and task performance in constraining individuals to sit to work (for desk-based jobs). In terms of recommendations, being more active (e.g. standing) and controlling equilibrium (when swaying) during the day are key solutions to lower health problems, to recover work productivity and potentially to favor task performance. In our rapidly evolving society, relations between posture (standing vs. sitting, swaying vs. not swaying), performance and health should be discussed in a conference such as ISPGR.

P2-G-17: Physical activity is low prior to and during an acute general medicine hospital admission

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BACKGROUND AND AIM: Little is known about physical activity before hospital admission and the potential impact this has on mobility and physical activity whilst in hospital. The aim of this study was to quantify physical activity in patients prior to and during an acute general medical hospital admission and explore relationships with mobility and physical activity. METHODS: This was a prospective, single-site secondary observational study conducted on the general medical wards at a tertiary hospital. Pre-hospital physical activity, measured via the Physical Activity Scale for the Elderly (PASE; scored 0 - 400). In-hospital physical activity, measured via accelerometry (Sensewear Armband, time spent being physically active at METs >1.5). Mobility, measured via the de Morton Mobility Index (DEMMI). Associations were determined via Spearman's correlations. RESULTS: Forty-six participants were included: median age 81 [76-85] years, 59% female, DEMMI on admission 39 [30-49]. Pre-hospital physical activity was low (PASE median 27.1 [1.6 - 61.9]). In-hospital physical activity was also low (0.5 [0.2-1.5] hours per day being physically active and 54 [16 - 194] steps per day taken). No statistically significant relationships existed between pre- and in-hospital physical activity (Spearman's rho 0.24 (95% CI -0.08-0.53, p=0.07). However, physical activity levels, in the pre- and in-hospital settings, were positively associated with patients' mobility in-hospital (Spearman's rho 0.44;95% CI 0.15-0.67, p=0.002; Spearman's rho 0.40;95% CI 0.08-0.645, p=0.011 respectively). CONCLUSIONS: Physical activity is low both before and during a general

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medical admission. Assessment of usual physical activity patterns should be part of the clinical assessment of patients in general medicine, however the low activity levels observed indicates a need for valid and reliable tools suitable for an older, frail cohort. Findings will inform development of physical activity guidelines during hospitalisation. ACKNOWLEDGEMENTS AND FUNDING: This study was funded by the Royal Melbourne Hospital Mary Elizabeth Watson Early Career Fellowship in Allied Health

P2-G-18: A pilot study on the effects of home-based power training on neuromuscular performance, functional mobility and fall risk in healthy older adults

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BACKGROUND AND AIM: The age-related declines in maximal strength and especially, in rate of force development (RFD) and muscle power, play a significant role in the functional mobility deficits and increased fall risk observed in older adults. Home-based resistance training can mitigate these age-related declines. While these improvements are less robust than those in interventions with greater supervision, the home-based approach has a very strong community outreach. Power training (PT) may be a better alternative to traditional resistance training, as it generates greater improvements in neuromuscular performance and function. However, the understanding on the effects of PT on functional mobility and fall risk, especially with a home-based approach, is very limited. Hence, the objective of this pilot study was to investigate the effects of 10 weeks of home-based PT on neuromuscular performance, functional mobility and fall risk in older individuals. METHODS: 21 healthy older adults (72.67±7.01 years) were randomly assigned to a control (CON, n=9) or experimental (EXP, n=12) group. Both were part of an ongoing community exercise program consisting of different activities. In addition, the EXP group participated in a PT program carried out twice a week for 10 weeks. In the PT program participants performed (bilaterally) 3 sets of 10 repetitions, of knee and hip extension and hip abduction exercises, at maximal execution speed. Elastic bands were used to provide and adjust the resistance to moderate intensity, based on a Borg scale. Testing sessions before and after (Pre and Post) the 10 weeks of the intervention consisted of knee and hip extension and hip abduction maximal isometric voluntary contraction tests, the Mini-BESTest and the Four Step Square Test (FSST). Main effects for group (CON vs EXP) and time (Pre vs Post), and group*time interactions were performed by a linear mixed effects model, for a significance level of $p<0.05$. RESULTS: This study observed significant main effects of group for normalized maximal strength of the knee extensors (0.40±0.02 EXP vs 0.26±0.03 CON) and hip extensors (0.27±0.02 EXP vs 0.21±0.02 CON). Main effects of time ($p<0.05$) were also identified for normalized maximal strength of the knee extensors (0.29±0.03 Pre vs 0.37±0.03 Post) and hip extensors (0.21±0.03 Pre vs 0.27±0.03 Post), normalized hip extensors RFD (0.08±0.01 Pre vs 0.11±0.01 Post), mini-BESTest score (24.3±0.37 Pre vs 25.7±0.37 Post) and FSST (7.78±0.20s Pre vs 6.24±0.20s Post). CONCLUSIONS: While no significant interactions were identified, the observed better performance of the EXP group and the pre-to-post improvements seemed to be generally driven by the home-based PT intervention. These results may suggest that home-based PT has the potential to improve neuromuscular performance, functional mobility and reduced fall risk in older individuals, with an easy-to-conduct community-wide outreach. ACKNOWLEDGEMENTS: We thank the municipality of Maia and specifically, the 'Clube Maia Sénior' for their invaluable help in the recruitment of participants and data collection of the project.

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P2-G-19: Feasibility, acceptability, and preliminary efficacy of a multi-modal intervention combining non-invasive brain stimulation and behavior counseling to improve physical activity in older adults

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Background: While engagement in physical activity improves health, only 10-15% of older adults meet the recommended guidelines. This stems from interrelated factors including lack of motivation, depressed mood, pain, and executive impairments. Each of these factors is associated with the functionality of brain networks that include the left dorsolateral prefrontal cortex (dlPFC). Transcranial direct current stimulation (tDCS) targeting left dlPFC may safely improve motivation, depression, pain, and executive functions. Separately, behavioral interventions using 'implementation intentions' show promise to increase physical activity. We designed and conducted a pilot study to examine the feasibility, acceptability, and effects of combining tDCS targeting left dlPFC and behavior counseling to improve physical activity in older adults. Methods: Inactive older adults living within subsidized housing and without overt illness or disease were recruited into this randomized controlled trial. Participants wore a Fitbit throughout the study. Baseline physical activity was measured as daily steps for two weeks. After baseline, participants received eight weeks of intervention. During the first two weeks, participants received their first behavior session and then ten once-daily sessions of tDCS or sham stimulation. Participants then received three additional bi-weekly behavior sessions. Physical, cognitive, and patient-reported outcomes were assessed at baseline, after the ten brain stimulation sessions, and after the entire eight-week intervention. After the final assessment, participants were encouraged to complete a three-month, step-count-tracking-only retention period. Results: 28 participants completed the study (tDCS: N=15, 78±8y/o, 14F; sham: N=13, 83±6y/o, 11F). Compliance was high: 99%, 98% and 98% of the brain stimulation, behavior, and assessment sessions were completed, respectively. All participants agreed to complete the retention phase. Fitbit adherence rate was 96% and 71% during intervention and retention period. The tDCS arm, compared to sham, exhibited a greater increase from baseline in average daily steps during the first week of intervention (p=0.016, adjusted for age and study site, Fig.). This group effect, however, was not observed at any other study week, or when step counts were averaged over the entire intervention period. For those participants who wore the Fitbit for more than 50% of days during the retention phase, average daily steps remained greater than baseline (tDCS: N=11, +1406±2001 steps, sham: N=11, +710±670 steps). At the end of the study, 86% (tDCS) and 73% (sham) of participants reported that they became more active via study participation. Study satisfaction was 9±1 (tDCS) and 10±0 (sham) a 10-point scale. Conclusions: The combination of non-invasive brain stimulation and individualized behavior interventions to improve physical activity was feasible and acceptable in a cohort of inactive older adults living within subsidized housing. While both study arms improved physical activity compared to baseline, tDCS appeared to accelerate this change at the beginning of the intervention. Larger more definitive studies are warranted to examine the optimal tDCS dose and duration of this combination of interventions.

P2-G-20: Design, development, and evaluation of an individualized exergame-based motor-cognitive training concept for older adults with mild neurocognitive disorder

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BACKGROUND AND AIM: Simultaneous motor-cognitive training is considered promising to prevent the decline in cognitive functioning in older adults with mild neurocognitive disorder (mNCD) [1 - 3]. In 'Brain-IT' we aim to design and develop a novel exergame-based training concept with the aim to halt or reduce cognitive decline and improve quality of life of older adults with mNCD. METHODS: We introduce our structured, iterative, and evidence-based design and development process that resulted in the 'Brain-IT' training concept. The process was guided by a theoretical framework (the MIDE-Framework [4]). This involved the target group, therapists, and experts from different fields to ensure that the training meets requirements and needs of older adults with mNCD. This is expected to foster usability and acceptance of the approach in 'real life'. Our methodological approach was published previously [5] and included (1) a thorough literature review, (2) a qualitative study including focus groups with 10 experts and health care professionals and 8 individual semistructured in-depth patient interviews, (3) a pilot feasibility RCT. RESULTS: Our interactive and participatory design and development process allowed identification of key requirements for the exergame design as well as the training characteristics. The 'Brain-IT' training concept [5] was already shown to be feasible, usable, and highly accepted in our pilot feasibility RCT including 18 older adults with mNCD (mean age = 77.6 years, 44 % females). Mean adherence and compliance rates were 85.0 % and 84.1 %. Mean system usability score was 71.7. High levels of exergame enjoyment, an increase in exergame enjoyment and an internalization of training motivation with large effect sizes ($p = 0.034$, $r = 0.750$ and $p = 0.035$, $r = 0.744$, respectively), and an acceptable perceived usefulness were observed. Preliminary data on effects of the intervention seem promising. Minor modifications were incorporated to further optimize the 'Brain-IT' training concept. Evaluations on the effectiveness of the 'Brain-IT' training concept are ongoing. CONCLUSION: The development of novel exergame-based training concepts is greatly facilitated when it is based on a theoretical framework (e.g., the MIDE-framework). Applying this framework resulted in a structured, iterative, and evidence-based approach that led to the identification of multiple key requirements for the exergame design as well as the training components that otherwise may have been overlooked or neglected. This is reflected by our results showing that the resulting intervention is feasible, usable, and highly accepted in "real life" settings. Therefore, it is strongly recommended to implement a theoretical framework for future research projects when serious games for motor-cognitive rehabilitation purposes are to be developed. References: [1] Gavelin et al. 2021; Ageing Res Rev.; doi: 10.1016/j.arr.2020.101232 [2] Meng Q et al. 2022; Aging Clin Exp Res.; doi: 10.1007/s40520-021-01877-0 [3] Dove and Astell 2017; JMIR.; doi: 10.2196/jmir.6518 [4] Li Y et al. 2020; SpringerLink; doi: 10.1007/978-3-030-50164-8_9 [5] Manser and de Bruin 2021; Front Aging Neurosci.; doi: 10.3389/fnagi.2021.734012

P2-G-21: Partial bilateral blood flow restriction of the legs whilst walking challenges mediolateral balance: Implications and opportunities for community implementation

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Background & Aims: Blood flow restriction (BFR) gait training involves partially restricting blood flow to the legs whilst walking. This type of training can improve lower limb strength and hypertrophy over multiple training sessions1, making it an attractive alternative for those older adults who may otherwise be unable to participate in high impact exercises such as running or high load resistance training. However, it is plausible that BFR may induce acute balance

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impairment whilst walking, increasing falls risk during BFR training sessions. The aim of this study was to test whether walking with bilateral BFR to the legs worsens mediolateral balance, and so help inform safe implementation and prescription of BFR gait training in older adults. Methods: This study forms part of a larger experiment attempting to identify optimal walking speeds and blood flow restriction to guide evidence-based prescription of BFR gait training in community dwelling older adults. Participants walked for 10 minutes on a treadmill at 50%, 60% and 70% of their sustained (10 min) fast walking speed, and with 10cm-wide cuffs (Hokanson rapid cuff inflator, Bellevue) on the upper thigh of both legs set to 0% (no BFR), 40% or 60% of complete blood flow occlusion. Each combination of walking speed and BFR were tested in separate sessions. Mediolateral balance was measured as the magnitude (root mean square, RMS), consistency (autocorrelation) and symmetry (harmonic ratio) of mediolateral accelerations using an inertial measurement unit (Axivity, AX6, 100 Hz, ±16g, ±2000°.s-1) taped to the participant's lower back.2 These measures were calculated for 30 s epochs every 2 minutes of each walking trial. Linear mixed effects models were used to test the association of fixed effects (BFR, walking speed and time) on mediolateral accelerations, with participant modelled as a random effect. Results: Ten community dwelling older adults volunteered for this sub-study (mean age: 73 ± 3 y; missing data for 4/90 sessions). Participants experienced larger ($p < .001$) and less consistent ($p < .05$) mediolateral accelerations when walking with BFR compared to no BFR, independent of walking speed and with larger differences observed with 60% compared to 40% BFR. Blood flow restriction did not influence harmonic ratios, nor were there any consistent effects of time on mediolateral accelerations. Conclusions: BFR gait training induces larger and less consistent mediolateral accelerations whilst walking, indicating acute challenges to mediolateral balance consistent with an increased falls risk. We recommend supervised BFR gait training trials to assess the safety of BFR gait training in the community prior to wider implementation. Speculatively, the acute effects of BFR on balance whilst walking may also stimulate chronic balance adaptations, warranting future investigation of BFR training to reduce falls risk in older adults. References: 1. Ozaki et al. J Gerontol A, 66A:3 (2011) 2. Buckley et al. Gait Pos, 71 (2019)

Falls and fall risk

P2-I-22: Objective measure of balance and fall risk in people with Parkinson's disease: impact of freezing of gait

Carla Batista[1], Jacqueline Ellison[2], Graham Harker[1], Patricia Carlson-Kuhta[1], Marian Dale[1], Giorgia Marchesi[3], Alice De Luca[3], Fay Horak[1], Valentina Squeri[3], Martina Mancini[1]

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Background and Aims: Falls in people with Parkinson's disease (PD) are complex and involve a composite interplay of multiple factors linked to postural control such as static and dynamic balance, sensory integration, reactive balance, sit-to-stand ability, limits of stability, gait speed, as well history of previous falls. Objective measures of fall risk in PD involving all these factors are lacking. A novel posturography system called Hunova is able to integrate all these factors into a composite score, validated for fall risk in older adults (Silver Index). In PD, freezing of gait (FOG), cognitive dysfunction, and falls are closely intertwined. Here, we explore balance factors potentially connected to falls in people with PD with and without FOG (PD+FOG and

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PD-FOG, respectively). Methods: Nineteen PD+FOG (age= 69.7 years, MDS-UPDRS-III= 38.7 score) and 29 PD-FOG (age= 67.6 years, MDS-UPDRS-III= 31.9 score) were assessed (On medication) in the novel posturography system called hunova (Movendo Technology, Genoa, Italy) to measure their Silver Index (0-25%= low fall risk, 26-50%= medium-low fall risk, 51-75%= medium-high fall risk, and 75-100% = high fall risk) and the subscores (static and dynamic balance, sensory integration, reactive balance, sit-to-stand, limits of stability, and gait speed). History of previous falls and age are already integrated in the Silver Index. Overall cognitive function was assessed by the Montreal Cognitive Assessment (MoCA). Results: All participants with PD were able to complete the balance assessment on the hunova. PD+FOG showed a worse Silver Index (mean= 56.4%), lower MoCA (mean= 25.7 score), and higher disease duration (mean= 13.6 years) compared to PD-FOG, who showed a medium-low Silver Index (mean= 34.5%), higher MoCA scores (mean= 27.2 score) and lower disease duration (mean= 5.9 years) ($p<0.05$). Out of the 7 factors composing the Silver Index, only the sensory integration subscore (i.e., the center of pressure path length on static base with eyes closed) was worse in PD+FOG (mean= -1.7 z-score) than PD-FOG (mean= -0.1 z-score) ($p<0.018$). A correlational analysis showed that a higher Silver Index was associated with worse cognitive function (higher MoCA scores) only for PD+FOG ($r= -0.73$, $p=0.003$). Disease severity did not correlate with the Silver Index in any PD group. Conclusions: People with PD and FOG have a medium-high Silver Index related to cognitive impairment. These results indicate the feasibility of using hunova, a novel posturography system, to potentially quantify the risk of falls in individuals with PD. However, future studies need to validate the Silver Index for prospective falls in PD. ACKNOWLEDGEMENTS AND FUNDING: Thanks for the participants and the NIH for the R01 Turning grant.

P2-I-23: Exploring the role of health inequalities on home falls and near-falls in older people

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BACKGROUND AND AIM: Older people living in areas of high deprivation experience a higher number of hospital admissions due to falls, compared with areas of low deprivation [1]. The reason for this difference is likely multifactorial, with recent world fall guidelines recommending assessing environmental fall hazards alongside the behaviour of the individual when investigating home falls [2]. Environmental fall hazards in deprived areas could include things such as poor lighting or unsafe stairs. Living in deprived areas is also linked with chronic diseases (e.g. diabetes, cardiovascular diseases) which worsen with physical inactivity, resulting in reduced function and increased fall risk. Older people living in deprived areas might also be more concerned about falling due to unaddressed home fall hazards and restrict their daily activities due to the fear of additional falls. To investigate this further, we surveyed older people and explored the number of falls and near-falls in the home environment in relation to levels of deprivation, concern about falling and environmental fall hazards. METHOD: An England-wide online survey was conducted with older people (≥60 yrs) between March and July 2021. The survey captured fall and near-fall history in the home environment during the previous 2-year period. Additional outcome measures included indices of multiple deprivation (IMD) based on postcode, the 7-item Falls Efficacy Scale International (FES-I), and

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environmental fall hazards influencing the fall. Outcome measures were reported for all fallers, near-fallers, and non-fallers in IMD quintiles one (Q1, high deprivation) and five (Q5, low deprivation). RESULTS: 190 older people completed the survey, with 11% (N=21) living in areas of high (Q1) and 31% (N=59) living in areas of low (Q5) deprivation. Of those living in Q1, 48% (N=10) experienced a home fall, 19% (N=4) experienced a near-fall, and 33% (N=7) were non-fallers. Of those living in Q5, 36% (N=21) experienced a fall, 30% (N=18) experienced a near-fall, and 34% (N=20) were non-fallers. FES-I scores were similar for fallers, near-fallers, and non-fallers in Q1 and Q5, with the median score ranging between 7 and 11. The largest proportion of falls (Q1=40%, Q5=52%) and near-falls (Q1=50%, Q5=44%) occurred when negotiating steps/stairs and this was comparable across both groups. CONCLUSIONS: A similar proportion of older people living in areas of high and low deprivation experienced a fall or near-fall, with most falls/near-falls occurring on steps/stairs. Concern about falling did not highlight any differences between groups. Despite similarities across all outcome measures, survey responses from people living in areas of high deprivation were low, which might be the consequence of digital exclusion. Recent UK figures highlight that 79% of all digital exclusion is among those aged ≥65 yrs [3]. Tackling the digital divide by improving older people's digital health literacy and embedding digital health hubs in primary care services might enable a better understanding of the fall-incidence and fall-cause in areas of high deprivation, so that appropriate home-based interventions can be developed. REFERENCES: [1] https://doi.org/c5xbd4 [2] https://doi.org/gq2xqc [3] shorturl.at/cerZ0

P2-I-24: In adults with diabetes, gait variability is related to mid-thigh circumference

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[1]Instituto Mexicano Del Seguro Social

Aim: To assess the influence of the circumference of the thigh and calf on the spatiotemporal characteristics of the gait of adults with type 2 diabetes, while walking outdoors/shod and indoors/in-socks, taking into account their body mass index (BMI), quadriceps isometric strength, arterial stiffness (ankle/brachial index), and mood (General Health Questionnaire of 12 items). Methods: 48 adults (58.1±10.6 years old; 34 women/14 men) participated in the study; with no history of orthopedic/rheumatology/otology/neurology disease or traumatic injuries. Preliminary assessments included ophthalmology, vestibular, and physiatry evaluations. Acceleration of each foot was recorded by 3D sensors while walking either at self-selected speed or maximum speed, in two settings: outdoors/shod and indoors/in-socks. Dimensionless scaling methods were used to process the data, according to leg length. Results: Multivariate analysis of variance showed that mid-thigh circumference, BMI, arterial stiffness and mood were related to gait velocity and cadence; while mid-thigh circumference, BMI and mood were related to gait velocity variability. This relationships were stronger while walking outdoors (Multiple R2= 0.33 to 0.49, $p<0.0001$) than indoors (Multiple R2= 0.20 to 0.28, $p<0.05$). The ankle/brachial index was particularly related to gait velocity while walking at maximum speed, either outdoors/shod or indoors/in-socks. Moderate linear correlations were observed between mid-thigh circumference and velocity, velocity variability, and cadence (Pearson's $r=0.33$ to 0.53, $p<0.05$). Stride length and velocity variability were always smaller while walking indoors/ in-socks than outdoors/shod, either at self-selected speed or at maximum speed. Calf circumference showed no significant relationships with the study variables. Conclusions: In adults with diabetes, mid-thigh circumference, BMI, peripheral

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arterial stiffness and mood may contribute to gait variability. Patients may display cautious walk while indoors in socks; to walk shod instead of in-socks could be recommended.

P2-I-25: Can we predict falls over 18 months in individuals aged 60-70 yrs with no history of falls? Insights from the CLSA dataset

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[1]McMaster University

Background and aim: Falls are the leading cause of injury-related hospitalization and death in older adults. Therefore, detecting fall-prone individuals as early as possible is critical for preventing these incidents in later life. Previous studies showed that commonly used mobility tests such as Timed Up and Go (TUG), Single Leg Stance (SLS), and chair-rise do not have sufficient discriminability to identify fallers in a sample of Canadian older adults [1]. This can be due to inability of these tests in capturing the impacts of various risk factors that can lead to falling. A multi-domain fall risk assessment approach evaluates different aspects of an individual's intrinsic capacity, functional ability and environmental interactions, which could result in more promising predictive ability. The objective of the present study was to develop a multi-domain machine learning model to predict prospective falls occurring in ~18 months in Canadian adults aged 60-70 yrs with no history of falls at baseline. Methods: The Canadian Longitudinal Study on Aging Research (CLSA) [2] is a population-based prospective cohort study of >50,000 community-dwelling adults aged 45-85 yrs at the time of the recruitment. From the participants aged 60-70yrs at the time of recruitment, the baseline data of 552 prospective fallers (reported ≥1 fall at ~18 months) and 552 prospective non-fallers (53% females) were selected for analysis. The selected participants reported no falls in the past 12 months at baseline. Of 4012 available measures, 680 multi-domain measures including biomarkers (e.g.,cholesterol, ferritin), mobility tests (e.g., TUG, SLS), cognitive tests (e.g., Rey Auditory Verbal Learning Test), behavioral measures (e.g., alcohol use), and Dexa scan measures were considered for developing random forest models. Results: Using a feature selection algorithm, 220 most relevant measures were automatically selected. The subsequent random forest model resulted in the area under the receiver operating curve of ~0.71. Conclusions: Our findings indicate that a multi-domain machine learning model has acceptable performance in predicting falls over 18 months in individuals aged 60-70yrs with no history of falls. Future works will investigate the development of multi-domain deep learning models to highlight the key factors leading to falls at the individual level to address more precise fall prevention strategies. Acknowledgements and Funding: This work received ethical approval from the Hamilton Integrated Research Ethics Board (project number 15103-C). M. N. received MIRA Postdoctoral Fellowship in Aging Research. [1] Beauchamp et al. "Mobility screening for fall prediction in the Canadian Longitudinal Study on Aging (CLSA): implications for fall prevention in the decade of healthy ageing." Age and ageing 51.5 (2022): afac095. [2] Raina et al. "The Canadian longitudinal study on aging (CLSA)." Canadian Journal on Aging/La Revue canadienne du vieillissement 28.3 (2009): 221-229.

P2-I-26: Linking brain dynamics to balance training improvements

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BACKGROUND AND AIM: Falls among older adults is a global concern. Nearly one-third of older adults fall each year with 20-30% of these falls resulting in mild to serious injury[1]. To

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reduce falls among older adults, multiple balance training paradigms have been employed[2,3]. Yet, there is a lack of knowledge on the underlying computational processes that contribute to balance training improvements. With recent advancements in electroencephalogram[4], we can record human brain dynamics during mobile tasks like balance training. The goal of this study is to quantify the computational processes associated with balance training. This will link the human brain dynamics that facilitate balance improvement. METHODS: 12 and 8 healthy participants have completed balance training with (intervention) and without (control) intermittent sensory perturbations, respectively. Balance training entails 30 minutes of walking on a 1-inch-tall beam connected to a treadmill moving at 0.6 m/s. Participants perform a 6-minute beam walking test before training and after training. The objective of the test and training periods was to avoid stepping off the beam. The beam width is tailored to each participant's baseline beam walking ability. All participants are equipped with a 128-channel cap and electrodes to record electrocortical activity, goggles that can temporarily occlude vision, and a safety harness connected to a fall arrest system. Two speakers were set up on each side of the participant. Participants in the intervention group received visual occlusions via goggles or auditory tones at 1000 Hz via speakers between 500 and 1500 ms every 8-10 s during the training period. Participants in the control group did not receive any sensory perturbation during the training periods. Balance performance was assessed as the duration of time participant stepped off the balance beam compared to their total walking time. Balance performance was assessed during the test periods. This abstract shares preliminary results, characterizing balance performance between control and intervention groups. RESULTS: Participants in the intervention and control group spent a comparable amount of time off the beam before balance training, 28.8% (18.4%) and 29.9% (14.2%), respectively. Participants in the intervention groups spent less time off the beam (u:15.8%,std:11.8%) than the control group (u:27.4%,std:24.4%) after balance training. This led to greater improvements in the intervention group than control group, as denoted by a larger difference in balance performance between test periods (Fig1). CONCLUSIONS: Preliminary results suggest balance training with intermittent sensory perturbations to result in greater balance improvement than balance training without intermittent sensory perturbations. While not assessed at this time, we expect to find the timing of sensory perturbation onset to be linked to phase resting of oscillatory brain activity. If these brain dynamics are found, this would support cross-modal synchronization[5] as an underlying mechanism leading to greater balance improvements in the intervention than control group. ACKNOWLEDGEMENTS AND FUNDING: NIH-NIA [1]WHO.(2007)[2]Okubo et al.(2019)[3]Symeonidou&Ferris.(2022)[4]Nordin et al.(2019)[5]Brauer et al.(2020)

P2-I-27: Association between fall risk parameters independent of sensor placement and prospective falls

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BACKGROUND AND AIM: Nowadays, researchers are seeking to complement fall risk assessments by adding real-life gait measures, usually collected by a single dedicated inertial measurement unit (IMU). However, data processing is limited to a fixed and specific sensor placement (lower back, torso, or feet), decreasing users' compliance. Making this data processing independent of sensor placement would allow using non-dedicated sensors (e.g.

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smartwatches or smartphones) enabling large-scale monitoring. As a first step, we recently showed that fall risk parameters based on discrete step time series could be calculated independently of sensor placement in the presence of a robust step detection algorithm. Nevertheless, the association of these parameters with prospective falls is not evident. Therefore, the aim of this study is to assess the association of fall risk parameters, calculated independently of sensor placement, with prospective falls. METHODS: 301 community-living older adults wore an IMU on their lower back for 1-week. 40% of older adults had prospective falls over a 12-month follow-up period. Steps and walking bouts were detected using a previously developed ubiquitous step detection method. Then, fall risk measures were derived for walking bout segments greater than 200 steps (i.e. minimum requirement for calculation of some measures). They included the total number of steps, cadence, coefficient of variance of stride time, fractal exponent on step time, and sample entropy on stride and step time. A negative binomial regression model was built and evaluated by calculating the Area Under the Curve (AUC). RESULTS: All model coefficients were significant. The fall rate increased with a lower gait complexity described by sample entropy and sample entropy, higher gait variability described by coefficient of variance of stride time, higher gait quantity described by number of steps, and higher gait intensity described by cadence. Most of these trends were previously reported in other studies. The AUC was 0.69 using only these real-life gait measures. It is comparable to the performances of most recent models relying on fixed sensor placement. Based on these studies, one may expect to reach an AUC of around 0,8 by adding additional basic clinical data. Yet, a drawback lies in the exclusion of 6% of the population for not having walking bouts of more than 200 steps. CONCLUSIONS: This study shows that prospective fall prediction from real-life gait data can be achieved using ubiquitous data processing (agnostic and independent against sensor placement) with a performance similar to the current approaches relying on the assumption of fixed sensor placement. This can open doors toward ubiquitous fall risk monitoring using non-dedicated inertial sensors. Future studies should still confirm these results using data collected with non-dedicated sensors.

P2-I-28: Dynamic stability metrics exhibit different periods of familiarization to treadmill walking

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Background: The dynamical nature of gait increases fall risk as the Center of Mass is volitionally moving in relation to the base of support. Treadmill-based protocols are commonly used to assess dynamic stability, as they allow for longer uninterrupted steady-state gait. However, treadmill walking differs from overground walking as individuals require a familiarization period to adjust to the sensorimotor input from treadmill belts before reaching a steady-state gait. While the length of the familiarization period was examined for kinematic metrics, it remains uninvestigated for dynamic stability metrics. As each dynamic stability quantifies a distinct aspect of neuromuscular control, altered sensorimotor input from the treadmill would require adequate familiarization to avoid confounding the analyses and interpretation for fall risk. Objective: To determine when dynamic stability metrics (spatiotemporal variability, short-term Lyapunov exponent, Harmonic ratios (HR), and mediolateral Margin of Stability) reach a steady-state during treadmill familiarization. Methods: Twenty healthy young adults (18-30yrs) walked for 10 min on a Treo Fitness 30750 treadmill. Belt speed was set at 1.2m/s and trajectory data were collected with a 12-camera Vicon Motion Capture System (Nexus 1.7.1, Oxford UK) at 100Hz. The first and last 30 sec of the trial were cropped to avoid belt start-up and stopping

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effects. A total of 420 steps were analyzed and split into 3 consecutive bins of 140 consecutive steps each (bin1 = 1-140, bin 2 = 140-280, bin 3 = 280-420). A one way repeated-measures ANOVA was used to examine differences between bins. Results: The anteroposterior HR increased from bin 1 to 2 ($F(2,19) = 4.89$, $p = 0.013$), step width variability ($F(2,19)= 5.51$, $p = 0.008$) decreased from bin 1 to 2 but increased from bin 2 to 3, step length ($F(2,19)=12.02$, $p = 0.001$) and step time variability ($F(2,19) = 12.29$, $p < 0.001$) decreased between bin 1 and bins 2 and 3. A significant effect for average step width and length occurred but post-hocs were non-significant. Conclusions: Treadmill walking differs from overground walking due to differences in sensorimotor input. Thus, individuals require an initial familiarization period to reach a steady-state. Step time and length variability decreased within the first 280 steps with no further changes in subsequent steps. Similarly, the anteroposterior HR increased from bin 1 to 2 indicating that the acceleration signal of the Center of Mass was more periodic and completed its cycle within each stride before beginning the next cycle in the following stride. In contrast, step width variability decreased from bin 1 to 2 but increased from bin 2 to 3 potentially indicating difficulty familiarizing to the treadmill width. Funding: Gesellschaft für Forschungsförderung NÖ (SP19-004), Natural Sciences and Engineering Research Council of Canada (NSERC) Discovery grant RGPIN-2016-04928.

P2-I-29: Using motor analogies to promote safe landing following a fall

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BACKGROUND AND AIM: Approximately one third of older people aged 65 years and above fall unexpectedly each year. Besides the significant costs associated with medical care, falls have negative consequences for the physical, psychological, and social well-being of the fallers. The majority of research until now has focused on fall prevention with little to no interest to establishing strategies to improve how people land when they fall. In two experiments we investigated whether motor analogies (i.e., rules-of-thumb that convey the complex rule structure of the to-be-learned movement using a familiar concept) can be used to help people land more safely (i.e., with reduced impact force and lower fracture risk ratio) when falling. METHODS: In experiment 1, ninety young adults self-initiated backward, forward, and sideways falls onto a padded surface. Participants in the analogy group were instructed to 'land like a snowflake: soft, silent, slow' and participants in the control group were instructed to 'fall on the ground'. In experiment 2, thirty young adults fell backward, forward, and sideways onto a padded surface following a 'nudge' that was applied to their shoulder unexpectedly. Participants in the analogy group were instructed to 'land like a feather' and the participants in the control group were instructed to 'land safely'. For both experiments, acceleration data (g) were extracted from inertial measurement unit sensors attached to different body segments. Additionally, for experiment 2, fracture risk ratios (i.e., the ratio of force at impact divided by the load necessary to cause a fracture) were calculated based on the data from wrist sensors. RESULTS: Collectively, the results show that the participants in the analogy group displayed significantly lower maximum acceleration at ground contact than participants in the control group when self-initiating falls (experiment 1) and when being 'nudged' unexpectedly (experiment 2). Furthermore, the results from experiment 2 show that the participants in the analogy group displayed significantly lower fracture risk ratios at the wrist (11-17% reduction) than the participants in the control group. CONCLUSIONS: The findings of the two experiments show that motor analogies can positively affect biomechanical variables associated with landing on a ground. Furthermore, the results of experiment 2 show that motor

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analogy instructions may reduce the likelihood of upper extremity injuries. Collectively, the results suggest that motor analogies may be viable tools to help people land more safely when falling, reducing the risk of severe injury. Future research targeting older people is needed to assess the feasibility of using motor analogies in different age groups.

P2-I-30: How to identify fallers and non-fallers in hereditary spastic paraplegia - An exploratory prospective cohort study

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Background and objectives: Balance and gait impairments are common in people with hereditary spastic paraplegia (HSP) and often result in falls and fall-related injuries. Variables that can distinguish between individuals at risk of falling and those who are not are essential for daily clinical decision making, but are still relatively unexplored in HSP. Here, we evaluated the potential of different constructs of stability (i.e., subjective balance confidence, objective balance and gait capacity, and biomechanical gait stability parameters) to differentiate between (1) healthy controls and people with HSP, and (2) fallers and non-fallers among people with HSP. Methods: We recruited 33 people with HSP (age: 48.7±11 years; spastic paraplegia rating scale (SPRS): 10.1±3.9) and 15 healthy controls (age: 49.0 ±11 years) for this laboratory-based exploratory cohort study. We assessed balance confidence with the 6-item Activities-Specific Balance Confidence scale (ABC-6), balance capacity with the Mini Balance Evaluation Systems Test (MiniBEST) and gait capacity via the Ten-meter Walk Test (10mWT). Biomechanical gait stability parameters consisted of spatio-temporal gait variability, mediolateral margin of stability (MoS), and local divergence exponents (LDEs) of trunk and pelvis in three directions, derived from 3-minute treadmill walking at both comfortable and fixed gait speed. Participants with HSP prospectively logged their falls during a 15-week period and were categorized as 'faller' (individuals that logged one or more falls) or as 'non-faller'. Differences between (1) HSP and controls and (2) fallers and non-fallers were assessed with independent samples t-tests or Mann-Whitney U tests when appropriate. The ability of variables to discriminate fallers from non-fallers was evaluated through calculating the area under the curve (AUC) of the receiver operating characteristic curve. Results: People with HSP had significantly lower scores compared to healthy controls on ABC-6 (56 vs. 92 points, $p<0.001$), MiniBEST (19 vs. 27 points, $p<0.001$) and 10mWT (1.3 vs. 1.6 ms-1, $p<0.001$). At self-selected gait speed, people with HSP walked slower and showed reduced gait stability, expressed by increased spatio-temporal gait variability and increased LDEs of the trunk and pelvis. Reduced gait stability in HSP compared to controls was also seen at the fixed gait speed. In total, 44% of the people with HSP were categorized as a faller, and ABC-6 (44 vs. 78 points; AUC 0.837) was best able to differentiate fallers from non-fallers, followed by MiniBEST (18 vs. 21 points; AUC 0.750) and MoS (38 vs. 51mm; AUC 0.746). Discussion: Our findings provide preliminary evidence that both subjective and objective gait and balance variables are able to distinguish people with HSP from healthy controls, but that subjective balance confidence is superior to more objective and instrumented balance measures to identify fallers from non-fallers among people with HSP.

P2-I-31: Fall risk prediction based on gait pattern in healthy older adults: A machine learning approach

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Background: Trip and slip perturbation, responsible for 60% of accidental falls, was proposed to be the leading cause of falls in older adults. Perturbation-based reactive balance training is an emerging method for reducing fall risk from such environmental perturbations. However, given that the causative factors and strategies for recovering from these opposing perturbations are different, treatment strategies should be task-specific compared to generic. Accurate assessment of one's fall-risk type would be a prerequisite to developing such fall-type-specific interventions. We aimed to develop slip- and trip-specific fall prediction models from one's regular/unperturbed walking pattern using machine learning approaches and laboratory-induced fall outcomes. Method: 298 older adults (≥60 years) who experienced a novel obstacle-induced trip perturbation and a slider-induced slip perturbation were included in this study. Their trip outcomes were classified into three classes: no-falls (n=192), falls with lowering strategy (L-fall, n=84), and falls with elevating strategy (E-fall, n=22), and their slip outcomes were classified into two classes: no-falls (n=131) and falls (n=167). 40 gait characteristics, which could potentially affect perturbation outcomes, were calculated in the regular walking trial, such as gait speed, joint angles, step length, and gait duration. To eliminate all the redundant and highly correlated features, the top 50% of features were selected to train the model using a Relief-based feature selection algorithm. Next, the automated machine learning method (Fitcauto) was used to select the machine learning algorithm with the best performance from eight popular algorithms, and then the optimal algorithm (ensemble classification for trips, and support vector for slips) was re-trained using Bayesian optimization with different numbers of features (1-20). A 10 times 5-fold stratified method was used to embrace randomness in machine learning. Results: For the trip-related fall risk prediction model, the trained models with different feature numbers showed an overall accuracy between 67%-89%. In general, the prediction accuracy increased along with the number of features. Among all the models, the one with 17 features showed the best prediction accuracy (88.9%), Specifically, 99% of the no-falls and 83% of the L-falls could be predicted, while only 18% of E-falls were accurately predicted. The model with 11 features could be considered an optimal model, which has fewer features but comparable accuracy (86%). With a single feature as the predictor, the prediction accuracy for trip falls was very low (<19% for both). For the slip-related fall risk prediction model, the trained model with 20 features could only predict the slip outcomes with an overall accuracy of 73%, and its accuracy reduced below 70% when the number of features was less than 18. Conclusion: This study revealed that gait characteristics in regular walking could accurately predict trip-related fallers with lowering strategy and hence training certain gait characteristics could reduce such falls. Regarding to slip-related falls, only 73% of falls were related to gait characteristics, the inclusion of kinetic factors might further improve the prediction accuracy.

P2-I-32: The effects of attentional focus instructions on real-time conscious movement processing and gait stability during walking on a compliant surface by older adults at risk of falling: A preliminary analysis

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Background and aim: Conscious movement processing (i.e., reinvestment) through an internal focus has been suggested to compromise movements by interfering with automatic movement

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control. Previous literature has observed the potential effect of an external focus on reducing real-time conscious movement processing in older adults during adaptive locomotion. This study aims to investigate the effects of attentional focus instructions on real-time conscious movement processing and gait stability in older adults at risk of falling during walking on a compliant surface. Methods: Ten older adults (mean age: 70.3±3.8) were involved in this preliminary analysis. Each participant performed nine walking trials on a compliant surface along a 7.4m straight walkway at a self-selected pace, with three repetitions of three different attentional focus conditions (external focus, internal focus, and control) in a randomized order. Electroencephalography (EEG) T3-Fz coherence was used to indicate real-time conscious movement processing. Body sway and the variabilities of spatial and temporal gait parameters were used to indicate gait stability. The outcome measures of gait parameters and real-time conscious motor processing (EEG T3-Fz coherence) were evaluated in this interim analysis. A series of 2 (Group: High reinvestor, Low reinvestor) x 3 (Condition: External focus, Internal focus, Control) analysis of variance with repeated measures were conducted. Results: We discovered the significant main effects of attentional focus condition for body sway, stride time, stance time, and swing time (body sway at shoulder region: $F [1.274, 11.469] = 5.836$, $p = 0.03$; stride time: $F [2, 18] = 5.130$, $p = 0.02$; stance time: $F [2, 18] = 3.967$, $p = 0.04$; swing time: $F [2, 18] = 4.167$, $p = 0.03$). Post hoc comparisons revealed significantly reduced body sway under the external focus condition relative to the internal focus condition ($p < 0.05$). Moreover, significantly shorter stride time, stance time, and swing time were observed under the external focus condition relative to the internal focus or control condition ($p < 0.05$). No significant difference in EEG T3-Fz coherence was observed among the three conditions ($F [2, 18] = 2.166$, $p = 0.14$). Conclusion: Our preliminary analysis discovered an altered gait pattern, including reduced body sway (indicative of enhanced stability) and reduced stride time, when older adults were given an external focus instruction relative to an internal focus or no instructions when walking on a compliant surface. No statistically significant difference in real-time conscious movement processing was yet detected. Further analysis with a larger sample size will be conducted after the completion of data collection for a more solid conclusion. Funding Acknowledgement: The work described in this abstract was supported by the General Research Fund from the Research Grants Council of the Hong Kong Special Administrative Region, China [grant number 15601021].

P2-I-33: Environmental risk factors for home stair falls among older adults: perceptions vs actuality

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BACKGROUND AND AIM: In the United Kingdom (UK), falls on domestic staircases cause up to 575 deaths and 350,000 injuries each year (Roys et al., 2013). Falls can have profound, long-lasting effects on the quality of life for the faller and can often be preventable. Moreover, poor housing conditions, such as steep and/or narrow stairs, and poor lighting are a considerable hazard for stair falls (Centre for Ageing Better, 2021). With the ageing population increasing, understanding housing conditions and stair falls is crucial to improve the quality of life for older adults. The aim of this study was to establish older adults' perceptions about the safety standards of their staircases to identify whether these perceptions reflect existing staircase features/designs that may modify the stair fall risk. METHOD: Previously we conducted an

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online survey with 164 UK residents aged ≥ 50 years between June and October 2021, to understand the extent to which COVID-19 lockdowns increased home stair falls. Twenty-two survey respondents (10 fallers, 12 non-fallers) also agreed to a subsequent home stair assessment, which captured the physical dimensions (i.e. pitch, rise and goings) and visual appearance (i.e. handrail design, and type of flooring) of their home staircase, and asked participants to describe their staircase dimensions (i.e. steepness, narrowness, wear and tear) and if they perceived their stairs safe to negotiate. RESULTS: During the home stair assessment, only 20% of stair fallers stated they struggle to fit most of their foot on their steps, and 30% said their stairs were steep but 100% of the stair fallers perceived their stairs to be safe to negotiate. However, stair dimensions measurements revealed that 45% of staircases did not meet UK government guidelines, with 50% of them belonging to stair fallers. Eighty percent of stair fallers had turning stairs with quarter landings (90°/180° turn to a second flight) compared to 58% of non-fallers, 40% of stair fallers had patterned carpet compared to 25% of non-fallers, and 30% of stair fallers had items left on steps in comparison to 8% of non-fallers. Moreover, there was a difference in the use of handrails while descending stairs, with 45% of stair fallers using handrails compared to 55% of non-fallers. CONCLUSION: Despite all of the participants perceiving their stairs as safe, a considerable proportion of them had stairs that did not meet the government guidelines. The stair measurements did not differentiate between participants who experienced a home stair fall and those who did not, as both groups equally failed to meet the government guidelines for safe stairs. This suggests that behaviour, such as leaving items on the stairs or not using handrails, may be influential in home stair safety, signifying the need for targeted interventions to improve behaviour and promote safer stair use.

Neurological trauma (e.g. Stroke, TBI, concussion)

P2-J-34: The effects of previous concussion on postural reactions to short and long duration visual perturbations

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BACKGROUND AND AIM: Approximately 15-20% of people who experience concussion will develop chronic symptoms characterized by persistent dysfunction in the visual and vestibular systems. Post-concussion it is often reported that moving through cluttered visual environments (e.g., a grocery store aisle) can be subjectively disruptive, causing disorientation and dizziness; however, objective behavioural measures of visual-vestibular-somatosensory integration under such circumstances have not yet been well-characterized. Therefore, the objective of this study was to assess the extent to which the velocity of a translational optic flow stimulus (visual perturbation) affects static postural control during a realistic simulation of a familiar task. METHODS: Thirty adults aged 20-54 years participated; 14 had no history of diagnosed concussion or brain injury, and 16 had previously experienced a concussion. Participants were asked to stand comfortably while a virtual environment was projected onto a curved screen around them (240° horizontal by 105° vertical field-of-view). To mimic real-world conditions, the virtual reality environment was a simulated grocery store, and the optic

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flow stimulus mimicked translating in a forward direction down an aisle. Optic flow was presented over 1 second bursts (short) or 30 second trials (long; maintaining a longer constant peak velocity). Each trial represented a different optic flow velocity ranging from 0.06 - 4.0 m/s max velocity (order randomized). For short trials, 15 trials per stimulus velocity were presented (15 visual acceleration/deceleration profiles along one grocery aisle). For long trials, one continuous 30 second trial was presented. Centre of pressure (COP) was analyzed in terms of peak displacement, path length, and mean position. RESULTS: All results reported are in the anteroposterior direction. During short perturbation trials, participants typically responded with an early (within 1.5 seconds) positive peak displacement, and a later negative peak in the opposite direction. There was a main effect of group on peak amplitude for COP, where participants with a concussion had larger COP displacements than the control group. During long perturbation trials, responses were more variable. However, there was a main effect of group and stimulus velocity on COP path length during continuous perturbations, where participants with a concussion had larger COP path lengths than controls, and COP path length increased as stimulus velocity increased. CONCLUSIONS: Individuals with concussion have a stronger postural reaction to short and long duration linear visual perturbations. In addition, as linear velocity increased, COP displacements increased for long duration perturbations. These findings can provide parameter guidance for similar studies representing an innovative means to sensitively detect impairment after concussion. ACKNOWLEDGEMENTS AND FUNDING: Funded by VISTA, NSERC, CFI.

P2-J-35: Statistically significant improvement in walking capacity and performance may not be clinically important during the subacute stage of recovery after stroke

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Background and Aim: Improvement in walking ability is often a primary goal and focus of rehabilitation for people with stroke (PwS). Research studies commonly report statistically significant differences between groups in gait speed (GS), capacity, and steps/day (S/D) measured with an activity monitor, performance. However, clinically important changes are not often reported. The aim of this study was to compare statistical changes and clinically important changes in GS and S/D in PwS during the subacute stage of recovery. Methods: GS and S/D were measured in 31 PwS at 60- and 90-days after stroke. PwS were categorized as home (<0.49 m/s, <2,000 S/D)), limited community (0.49-0.92 m/s, 2,500-4,999 S/D) or community (>0.92 m/s, >4,999 S/D) ambulators. No specific intervention was provided, PwS received physical therapy based on the individualized plan developed by their rehabilitation team. A paired t-test was used to determine if changes in GS and S/D were statistically significant between 60- and 90-days post stroke. McNemar-Bowker test was used to determine if the proportion of PwS in the functional walking categories changed between 60- and 90-days post stroke. Results: The paired t-test determined that PwS demonstrated statistically significant improvement in GS (mean change of 0.12 m/s [0.17]), p<0.001, and S/D (mean change of 576.7 [1,375]), p=0.026 between 60- and 90-days post stroke. The McNemar-Bowker test determined that there was not a statistically significant difference in proportion of PwS who were in the functional walking categories between 60- and 90-days post stroke for both GS (p=0.17) and S/D (p=0.26) Conclusions: In our sample, PwS demonstrated statistically significant improvements in GS and S/D. However, based on the McNemar-Bowker's test, this

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did not translate to functional improvements in walking. Only 5 PwS improved on the GS functional walking categories and 3 on the S/D functional walking categories. Researchers should perform analyses that examine clinically important improvements as well as statistically significant changes when determining the effects of rehabilitation interventions aimed at improving walking ability.

P2-J-36: What interventions lead to long-term improvement in physical activity after stroke? A systematic review

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BACKGROUND AND AIMS: Adults with stroke remain inactive. Increasing daily volume (daily step count) and intensity (time spent in moderate-vigorous physical activity, MVPA) of physical activity can improve secondary prevention and recovery post-stroke. However, it is unclear how best to design interventions to target these outcomes. We aimed to determine what clinical interventions (therapeutic or behaviour change) were effective at increasing and maintaining volume and intensity of physical activity after stroke. METHODS: A systematic review with meta-analysis of randomised controlled trials targeting accelerometer-derived measures of physical activity in adults with stroke was conducted. Two reviewers independently examined the studies for eligibility, assessed risk of bias and extracted relevant data. Measures of volume of physical activity included daily step count and intensity of physical activity included time in MVPA (all collected via accelerometers). Effect size was calculated as mean difference (MD) or standardised mean differences (SMD). PROSPERO ID: CRD42017065613. RESULTS: Twenty-four eligible studies (1720 adults with stroke) were identified. The quality of the trials was high (PEDro score 6.5/10). Therapeutic interventions (n = 16 studies) typically targeted balance, gait and fitness via treadmill training, gait re-training and circuit class therapy in adults with stroke who were limited in their walking (weighted mean baseline gait speed = 0.51m/s, range = 0.32m/s - 0.95m/s). Behaviour change interventions (n = 8 studies) targeted physical activity behaviours, and used a diverse combination of strategies such as feedback, goal setting, barrier identification, self-monitoring and action planning in adults with stroke who were mostly independent community ambulators (weighted mean baseline gait speed = 0.89m/s, range = 0.52 to 1.5m/s). Therapeutic interventions alone increased daily step count (MD:405, 95%CI:239 to 571 steps) with improvements maintained at 3-month follow up (MD:553, 95%CI:322 to 784 steps). Behaviour change interventions also increased step counts (MD:1771, 95%CI: 1004 to 2537 steps) and time in MVPA (SMD:0.64, 95%CI:0.24 to 1.04) immediately post-intervention. There were insufficient trials exploring the effect of therapeutic interventions on MVPA, and the long-term effect of behaviour change interventions. CONCLUSIONS: Both therapeutic interventions (targeting balance, gait and fitness) and behaviour change interventions are effective at increasing volume and intensity of physical activity after stroke. Behaviour change interventions incorporating immediate feedback, goal-setting, regular therapist support, practice of the target behaviour and action planning may have larger effects on daily activity levels for community ambulators. Long-term effects of interventions, clinical significance of effect sizes and active ingredients of interventions need further investigation. ACKNOWLEDGEMENTS AND FUNDING: Nil.

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P2-K-37: Coordination of hip and spine in individuals with acute low back pain during unstable sitting

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BACKGROUND AND AIM: Postural control differs between individuals with and without low back pain (LBP), in sub-acute and chronic stages. Whether hip/spine coordination differs in acute LBP (ALBP) is unclear. This study aimed to investigate hip/spine coordination between individuals with and without ALBP when balancing on an unstable seat and to determine whether there are different coordination strategies to maintain balance. METHODS: 130 individuals with ALBP (<2 weeks) and 72 pain-free controls maintained balance while sitting on a seat fixed to a hemisphere (Figure 1). Seat, hip and spine (lower lumbar, lumbar, upper lumbar, thoracic) angular motion and force plate data were recorded. Frequency domain measures of hip/spine kinematics (amplitude spectrum, phase angle, coherence) and overall balance performance (center of pressure [CoP], upper thorax motion) were calculated. Hierarchical clustering based on coherence data of all participants was performed. RESULTS: Seat and thoracic movements (amplitude spectrum) were higher and coherence between all hip/lumbar measures and the seat was lower in ALBP than controls in the sagittal plane. RMS displacement of CoP was higher in ALBP than controls in both planes. Cluster analysis revealed some unique coordination strategies to maintain balance in each plane. Some strategies indicated that some individuals of both groups preferred to more entrain coordination of certain segments to counteract seat movements whereas some in other less coherently strategies were less able to move hip/spine segments in a coordinative manner, reflecting different solutions to control the hip/spine during unstable sitting. CONCLUSIONS: ALBP strategy generally appears to be less ideal as it was associated with poor hip/lumbar coordination in conjunction with lesser quality of overall balance performance.

P2-K-38: The effect of skilled motor training on corticomotor control of back muscles in different presentations of low back pain

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Background: Transcranial magnetic stimulation (TMS) has revealed differences in the motor cortex (M1) between people with and without low back pain (LBP). There is potential to reverse these changes using motor skill training. Although earlier studies found no effect of back muscle training on TMS measures in healthy individuals, it remains unclear whether changes can be induced in people with LBP or whether this differs between LBP presentations. Aims: (1) To compare TMS measures of M1 and performance of a motor task between individuals with LBP of predominant nociceptive or nociplastic presentation; (2) to compare these measures pre- and post-training; and (3) to explore correlations between TMS measures, motor performance, and clinical features. Method: Eighteen participants with LBP (9 nociceptive, 9 nociplastic) trained a lumbopelvic motor learning task for three 5-minute blocks. Single- and paired-pulse TMS measures were undertaken pre- and post-training. Data were compared with 16 pain-free individuals from a prior study. Results: TMS measures did not differ

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between groups at baseline. The nociplastic group undershot the target in the motor task. Despite improved motor performance for all groups, only MEP amplitudes increased across the recruitment curve and only for the pain-free and nociplastic groups. Baseline or change in TMS measures did not correlate with motor performance or clinical features. Conclusion: Some elements of motor task performance and changes in corticomotor excitability differed between LBP groups. Absence of changes in intra-cortical TMS measures suggests regions other than M1 are likely to be involved in skill learning of back muscles.

P2-K-39: Postural sway during static standing balance tasks in adults with moderate-severe hallux valgus compared to controls

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BACKGROUND AND AIM: Hallux valgus (HV) is a common foot deformity linked with postural instability and increased falls risk in older adults. The mechanisms underlying postural instability in adults with HV are unclear, and previous studies have reported conflicting findings. The primary aim of this study was to investigate differences in postural sway between adults with moderate-severe HV compared to matched controls. The secondary aim was to explore correlations between postural sway during single limb stance and foot characteristics such as intrinsic foot muscle morphology, toe flexor strength, arch height and foot pain. METHODS: Thirty adults with moderate-severe HV (7 men, 23 women; mean age 53.7±19.3 years; BMI 26.3±4.4 kg/cm²) and 20 matched controls (5 men, 15 women; mean age 50.0±20.1 years; BMI 28.5±4.0 kg/cm²) were recruited. Participants performed two static standing balance tasks of increasing difficulty: bipedal stance (120 seconds) and single limb stance (3 x 30-sec trials). During these tasks, excursion of centre of pressure (CoP) was recorded using an AccuswayPLUS balance platform, and five CoP variables were calculated for analysis: mediolateral sway, anteroposterior sway, path length, velocity, and 95% ellipse. Selected foot characteristics were measured, including foot pain, foot posture (Foot Posture Index (FPI)), hallux flexion strength, and intrinsic foot muscle morphology (measured using ultrasound). Repeated measures analysis of covariance was used to analyse between-group interaction effects (adjusting for age), and Pearson's correlations were used to explore the secondary aim. Significance level was set at $p<0.05$. RESULTS: In relation to the primary study aim, results showed that HV and control groups did not differ in terms of CoP outcomes during bipedal or single limb standing balance tasks ($p>0.05$). Regarding the secondary aim, no significant correlations were found between foot characteristics and CoP excursion during single limb stance ($p>0.05$). In terms of sample characteristics that may help interpret these findings, few participants reported foot pain >30mm on a 100mm visual analogue scale (HV n=4; control n=1), and hallux flexion strength did not significantly differ between groups (mean difference (95% confidence interval)=-5.4 N (-15.3 to 4.5 N), $p=0.28$). The HV group had a more pronated foot posture compared to controls (median FPI: HV=7 (range 1 to 11); control=2 (range -3 to 8), $p<0.01$) and larger cross-sectional area of the abductor hallucis muscle (MD (95% CI)=0.36cm² (0.06 to 0.66cm²), $p=0.02$). CONCLUSIONS: The findings of this study indicate that asymptomatic adults with moderate-severe HV who maintain toe flexion strength, demonstrate postural control equivalent to age-matched controls in static standing balance tasks. Future research directed at understanding postural instability in HV could focus on symptomatic populations and more dynamic postural tasks. ACKNOWLEDGEMENTS AND FUNDING: This work was supported by grants from the Menzies Foundation (Allied Health

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P2-K-40: Changes in ground reaction force in the mediolateral directions do not affect the external hip adduction moment

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Background and Aim External hip adduction moment (HAM) has been focused on as a surrogate measure of hip mechanical loading in the frontal plane. Wider step-width gait is known as a gait modification that reduces HAM, but the center of mass moves more medially and laterally with the widening of the step width. As a result, the ground reaction forces in the mediolateral directions increase, which may affect the HAM, but this has not yet been clarified. In this study, we investigated the effect of wider step-width gait on the ground reaction force in the mediolateral directions, and its effect on the HAM. Method Twenty-six healthy young adults participated in the study. The task was a level walk with normal and doubled step-width. Kinematic and kinetic data during walking were acquired by a three-dimensional motion analysis system, and joint angles, ground reaction forces, and joint moments were calculated. The stance phase was determined from the ground reaction force values and two peaks in the HAM were identified (1stHAM, 2ndHAM, respectively). The ground reaction force in mediolateral components at the same timing as the identified HAM peak values were extracted (1stGRFx, 2ndGRFx, respectively). Each variable, including the step-width (SW), was compared between the normal and doubled step-width conditions, and then a correlation analysis was performed on the rate of change in each variable. The statistical significance level was set at 5%. Results In the double step-width condition, 1stHAM and 2ndHAM were significantly lower and 1stGRFx, 2ndGRFx, and SW were significantly higher than in the normal step-width condition. Correlation analysis showed significant positive correlations between the rates of change for 1stHAM and 2ndHAM, 1stGRFx and 2ndGRFx, and 1stGRFx and SW, but not for other combinations. Conclusion Ground reaction forces in the mediolateral directions varied with step-width, but were not directly associated with the HAM, which was affected by the step-width. In addition, the mediolateral components of the ground reaction force in the early phase of stance were related to step-width, but this relationship was not observed in the late phase of stance. Further investigation is needed to determine the effect of the mediolateral components of the ground reaction force, which varies with the center of mass movement, on the mechanical loading of the hip joint.

P2-K-41: Effect of postural alignment on rearfoot and medial longitudinal arch kinematics during gait

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Background and Aim: Abnormal rearfoot eversion/inversion during gait affects medial longitudinal arch (MLA) dynamics, causing ankle and foot disease. Thus, identifying the factors responsible for abnormal rearfoot motion is important. Postural alignment changes affect lower limb motion during gait; however, their role in rearfoot and MLA kinematics are unknown. Therefore, we aimed to clarify the effects of postural alignment changes on rearfoot and MLA kinematics during gait. Methods: Eleven healthy men participated in this study (age, 20.5 ± 1.5

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years; height, 172.8 ± 4.1 cm; weight, 61.6 ± 5.1 kg). Participants performed gait trials using three different postural alignments, normal posture (NP) and two controlled postures, defined as follows: - 1) Sway back posture (SBP, defined as the pelvis tilted posteriorly and shifted forward with the trunk inclined posteriorly). 2) Anterior tilt posture (ATP, defined as the pelvis and trunk tilted anteriorly). Data were collected using a motion analysis system (Motion Analysis Corporation, 100 Hz) and force plates (AMTI, 1,000 Hz). A Helen Hayes marker set and Istituti Ortopedici Rizzoli foot model were used to collect the kinematic data. In each trial, the participants were instructed to walk at a pace of 1.0 m/s ± 5%. The average values of the ankle joint angle in the sagittal plane and the rearfoot angle in the frontal plane were analyzed at each stance phase. Further, the stance phase was divided into the loading response (0-16% stance phase), mid-stance (17-48% stance phase), terminal stance (49-81% stance phase), and pre-swing (82-100% stance phase). Peak MLA was also analyzed with the MLA angle calculated from the coordinate positions of reflective markers placed on the first metatarsal head, navicular tuberosity, and medial calcaneus. Repeated-measures analysis of variance tests were performed for statistical analysis, and post-hoc tests were performed using Bonferroni correction. The alpha level was set to 0.05, and the mean value of the three trials in the right lower extremity was used for the analysis. Results: Besides the pre-swing phase, ankle dorsiflexion and rearfoot eversion angle increased significantly more in the SBP than in other postures. In the ATP, the ankle dorsiflexion angle was significantly increased more than in NP during mid-stance, with no significant difference in rearfoot angle. Peak MLA angle did not change significantly, regardless of postural alignment. Conclusions: SBP increases rearfoot eversion during gait and also has the largest ankle dorsiflexion angle. Ankle dorsiflexion at weight-bearing conditions is accompanied by subtalar joint eversion. This finding suggests that the ankle dorsiflexion angle increases due to postural change, and the rearfoot responds with an increased eversion movement. The SBP altered rearfoot motion but not MLA kinematics. Future studies are needed to clarify changes in rearfoot motion due to postural alignment differences and their effects on MLA motion.

P2-K-42: Effects of spinal manipulation and mobilization techniques on trunk compliance in chronic low back pain: a secondary analysis of the relief study

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Background and Aim: The efficacy of spinal manipulation therapies (SMTs) in chronic pain are contentious as their mechanism of action are unclear. Considering associations of pain with increased spinal stiffness (or decreased compliance), and biomechanical changes to spinal tissues through SMTs, this secondary analysis explored the effect of SMTs on global trunk compliance, through the Trunk Compliance Index (TCI). We have shown that TCI was less (i.e., greater trunk stiffness) in this cohort with chronic low back pain (LBP) compared to matched healthy controls. Methods: A subset of chronic LBP individuals (n=58/162) from an investigator-blinded, placebo-controlled randomized trial comparing cold-laser sham placebo, to spinal manipulation, or mobilization (6 treatments over 3-weeks) received directional trunk-based perturbations across antero-posterior, medio-lateral, and rotational axes. Eligibility conforming to standard definitions of chronic LBP, and including specific pain (>2/10, numeric pain rating scale), disability (>4/24, Roland Morris Disability Questionnaire) and clinical characteristics associated with positive outcomes to SMT were used. TCI was calculated from perturbation force and trunk kinematics at; baseline (T1), after first treatment (T2), following all treatments (T3), and 4 weeks post-treatment (T4). Separate linear mixed effects models for each direction

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(n=6) of the TCI were calculated. Each model included sex, as well as, baseline pain and disability measures as covariates. Within-subject dependence and clustering due to replicated measurements were also accounted for via a first-order autoregressive correlation structure and a subject-by-session random effect, respectively Results: For each direction, there was no significant interaction between treatment groups across any of the recorded time points (flexion: F(6,147.7)=0.4; p=0.895; extension: F(6,156.3)=0.4, p=0.860; right lateral flexion: F(6,153,1)=0.5, p=0.779; left lateral flexion: F(6,149.5)=0.7, p=0.640; anti-clockwise rotation: F(6,190.9)=0.9, p=0.510; clockwise rotation: F(6,216.6)=0.6, p=0.737). Conclusion: Findings echo reported clinical outcomes, which found no effect of SMTs on pain and disability. However, increasing values of TCI over time (i.e., greater compliance/reduced stiffness) lend support from a global trunk perspective to previous evidence showing reductions in stiffness (at local spinal levels) following SMTs. Considering the ability for the TCI to distinguish between those with and without chronic LBP, and for the differential effects of SMT on responders and non-responders, further work should consider biopsychosocial factors that may predict greater responsiveness and better elucidate mechanisms underlying SMT.ACKNOWLEDGEMENTS AND FUNDING JST received funding from the NIH. BCC received funding from the NIH, Osteopathic Heritage Foundations, and American Osteopathic Association. This study was supported by the National Center for Complementary & Integrative Health under the NIH grant R01AT006978 awarded to Drs Thomas and Clark

P2-K-43: Stanmore Tumour OutcoMes Project: Measuring survivorship and rehabilitation outcomes after treatments for musculoskeletal tumours - A presentation of preliminary findings

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Background and Aim: People undergoing surgeries to manage musculoskeletal tumours (including sarcomas) experience significant physical limitations. Stanmore Tumour OutcoMes Project (STOMP) aims to develop a platform for comprehensive description of functional and quality of life (QoL) outcomes for this clinical group. Methods: This is a cross-sectional pilot and feasibility study (Ethical approval reference number: 21/WA/0027; IRAS ID: 291087) using a bio-psycho-social approach; the International Classification of Function, Disability and Health (ICF) model to capture functional limitations after musculoskeletal tumour surgery. The ICF uses a combination of subjective and objective functional assessments including patient reported outcome measures (PROMs), qualitative interviews and movement analysis approaches e.g., gait analysis using Gait Real Time Analysis System (GRAIL) and activity monitoring using ActivPAL (PAL Technologies Ltd, Glasgow, United Kingdom). Data were analysed using SPSS or thematic analysis. Results: 46 post-operative patients (14 females and 32 males) of mean age 50.7±16.8 years who underwent surgery in the hip/pelvis (n=16), diaphyseal femur (n=2), knee (n=27) or multi-location (n=1) for a lower limb musculoskeletal tumour were enrolled. 39 underwent limb salvage surgery while 7 amputations. Early analysis revealed, mean scores of Toronto Extremity Limb Salvage Score (TESS) [67.9±19.0], Quality of Life for Cancer Survivors (QoL-CS) [5.4±1.6], EuroQol questionnaire (EQ-5D) [67.5±18.5] and Modified Re-integration to Normal Living (mRNL) [71.6 ± 23.4] suggested poorer functional outcomes compared to reference values. Interviews (n=20) highlighted lacking psychological support and the need for better information about what to expect after surgery. Gait analysis of 10 hemipelvectomy patients showed impaired gait and posterior and medial dynamic balance compared to controls ($p<0.05$*). Community accelerometery (n=15) over seven days,

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showed patients with lower limb musculoskeletal tumours present with lower physical activity levels and higher sedentary activity compared to reference values, e.g., total steps/day were 5103±3604, stepping time 68.3 ± 36.8 minutes, standing time 176.1±64.9 minutes, energy expelled 32.5± 1.5 metabolic equivalents (METs) and significant time during the day was spent in sitting [582.6± 123.5 minutes]. This highlights sedentary activity in patients (Fig.1). Conclusions: This biopsychosocial ICF approach captures wide-ranging, holistic, personalised and relevant functional and QoL limitations, not routinely captured in clinics. Main issues identified were physical disabilities, balance and gait impairments, activity restrictions, reduced QoL and impacted return to normal living. This warrants the development of evidence-based rehabilitation guidelines and targeted delivery of physiotherapy care. Ongoing recruitment will allow inter-cohort comparisons and inform best practice care.

Other neurological disease (e.g. Multiple sclerosis)

P2-L-44: A pilot study of developing a novel frequency response analysis of postural sway behaviours to assess spinocerebellar degeneration (SCD)

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BACKGROUND AND AIM Frequency response analysis is one of the methods to evaluate the characteristics of postural sway behaviours. Several approaches such as Fast Fourier Transform and Maximum Entropy Methods (MEM) have been used in power spectral analysis. However, these methods are not always enough to show the characteristics clearly, especially for clinical usage. With the aim of visualising the features of frequency response clearly and easily for clinical evaluation, we have developed a new method of frequency response analysis for postural sway. In this pilot study, we have applied the new analysis approach to a patient with spinocerebellar degeneration (SCD) to investigate whether the new method is useful to explain the postural sway behaviour of SCD. METHODS We evaluated postural sway data retrospectively in 194 healthy adults (male: 95, female: 99, age: 51.0±22.9 years, age range: 15-89 years). Centre of pressure (COP) of upright stance was measured with Gravicorder GP-5000 (ANIMA Corp.) in the condition with eyes-open and hard surface for 60 seconds at 20Hz sampling frequency. We performed frequency response analysis with MEM for the COP in the healthy population to establish the baseline of healthy group. The frequency response of COP in the patient with SCD was then compared with the baseline. The difference between the baseline and the data of the SCD patient was divided by the standard deviation (SD) of baseline data. Subsequently, the calculated data were filtered with a moving average. In addition, the filtered power spectra were divided into bins with each width of 0.5Hz. RESULTS While the different frequency response was observed in medio-lateral sway between a healthy adult and the patient with SCD in the analysis with logarithmic scale (Figs. 1 and 2), specific frequency showing the difference cannot be identified precisely. Nonetheless, our novel analysis revealed that the postural sway of healthy participant was in the range of baseline data of the healthy group: [(mean - 0.86xSD) ~ (mean + 1.2xSD)], whereas the patient with SCD showed the clear peaks outside the baseline area at 2-3 Hz (the light green area on Figs. 3 and 4). Moreover, we also observed the distinct peaks at 2.5 and 3Hz in the SCD patient as visualised in Figs. 5 and 6 with 0.5Hz frequency bins. CONCLUSIONS The proposed analysis method showed that the

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frequency response of postural sway could be visualised more clearly at specific frequencies in the patient with SCD compared with the healthy population. The new analysis approach of using the baseline mean and variability of postural sway in healthy adults could be useful to understand the different postural sway behaviours of various movement disorders. The results of this research warrant further research by comparing the two groups with an increasing sample size and by applying the same approach to data measured in those with different movement disorders to investigate the practicality of proposed analysis.

P2-L-45: Pre-frontal cortex activity during gait in pre-manifest and early spinocerebellar ataxia

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Background and Aims: Spinocerebellar ataxia (SCA) causes characteristic impairments of gait and balance that greatly disrupt quality of life. It has been hypothesized that compensation for impaired cerebellar control of gait and balance in individuals with early SCA may occur via increased prefrontal cortex (PFC) control. Wireless, functional near-infrared spectroscopy (fNIRS) provides direct, physiological measures of PFC activity while performing actual movements. However, only a few studies have examined PFC activity in individuals with early SCA while walking and none in those with pre-manifest SCA. Here, we investigated whether PFC activity is increased during walking in subjects with pre-manifest and early spinocerebellar ataxia (SCA) compared to healthy controls. Methods: Sixteen participants with genetically-determined SCA (age: 55, SD:12) and 15 age-matched healthy controls (age: 55.6, SD:13) participated in the study. The Scale for the Rating and Assessment of Ataxia (SARA) was administered by a movement disorders specialist before the gait assessment. An 8-channel, mobile, fNIRS, with two reference channels, was used to record changes in oxygenated hemoglobin (HbO2) and deoxygenated hemoglobin within the PFC. Participants walked for 2-minutes at a comfortable pace back and forth over a 10-meter distance, with a 180-degree turn at each end while wearing wireless, inertial sensors to derive gait and turning characteristics. Results: Of the 16 individuals with SCA, 9 were classified as pre-manifest (SARA<3) and 7 as early SCA (SARA<10). PFC activity (HbO2) while walking was larger than controls of similar age in individuals with early SCA. Specifically, pilot findings showed that increased PFC activity was also present even in the individuals with pre-manifest SCA (Fig.1). In addition, when grouping the subjects with pre-manifest and early SCA, we observed a significant correlation between higher PFC activity while walking and greater gait impairments, such as increased double-support time ($r=0.54$, $p=0.03$) and increased toe-off angle ($r=-0.56$, $p=0.03$). Conclusions: Our pilot data suggest that PFC activity is increased in pre-manifest SCA, even when clinical scores are minimal (in the normal range). Increased PFC activity is consistent with requirement for less automatic, cortical control of gait to compensate for impaired automatic, cerebellar control. In fact, the correlations between PFC and gait metrics support this hypothesis. Although studies in larger populations and test-retest reliability are needed to confirm these promising pilot findings, fNIRS during functional activities could be employed to select SCA subjects to enroll and/or as an outcome measure in clinical trials for early treatments of these gait disorders.

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P2-M-46: characteristics of muscle activation and inhibition based on surface electromyography in a newly postural control model for cerebral palsy

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Background and aim: To observe the changes of electrophysiological indexes of healthy subjects under a newly designed biomechanical postural control model for cerebral palsy. Methods: This is a cross-sectional observational study carried out in a motor control laboratory. The A step of Gusu Constraint Standing Training (GCST-A2), a newly designed biomechanical model was applied on fifteen healthy adult individuals. Electrophysiological indexes of root mean square (RMS) and median frequency (MF) of eight muscles of lower limbs on both sides. Results: Over 40% muscles had significant changes of the RMS ($P<0.05$), the activation ratio was highest when the α angle was 25°. Compared with the static standing position when the α angle was 0°, the RMS of the bilateral VM, VL and the TA increased, while those of the right GM and the SL decreased significantly ($P<0.05$) , and the MF of the bilateral VM and SL, the left VL, and the right GM decreased significantly ($P<0.05$) under the other two conditions. under the other two conditions. There were no significant differences of the RMS and the MF between the two conditions ($P>0.05$). Conclusions: The GCST-A2 model, as a biomechanical feedback system, could induce a consistent and methodic pattern of neuromuscular control by in-outside force coupling system. The force on trunk from back and upward can activate anterior muscles of the whole lower limbs, and can reciprocally inhibit posterior muscles of the calf. The co-contraction pattern involving the active and antagonist muscles of patients with CP is reversible to some degree, and may be orientated reorganized by the GCST.

P2-M-47: Multi-joint lower limb proprioception in children with cerebral palsy: a comparative case study

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BACKGROUND AND AIM:In 44% to 72% of children with cerebral palsy (CP), motor deficits are accompanied by proprioceptive impairments [1-3]. Up to now, however, studies focused primarily on single-joint upper limb proprioception, leaving lower limb proprioception, for multiple joints, much less understood in this child population. Therefore, this study aims to provide new information on proprioception of the ankle, knee and hip joints in children with CP compared to age-matched typically developing (TD) children aged 5 to 12 years old. METHODS: Lower limb proprioception was assessed in terms of Joint Position Sense (JPS) of the hip, knee and ankle joints. Each child was asked to re-identify a target position by pressing a button when the ipsilateral limb was passively moved in the same sagittal range at the same predetermined speed. Testing was repeated three times for both dominant (less affected) and nondominant (most affected) body side. The absolute joint reproduction error (JRE, °) between the target and reproduction joint angle was calculated from 3D kinematics [Vicon, ISB lower limb marker mode[4]] and used as a measure of JPS accuracy[5] for dominant (JREd) and nondominant side (JREnd). RESULTS: Figure 1 shows preliminary JRE data from fifteen TD children (8.55±1.06 years; 8boys/7girls) and three CP children (8.01±1.38 years; 1boy/2girls;

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GMFCS level I-II; spastic diplegia), categorized by age. In TD children, JRE linearly declines with increasing age for all joints. In CP, poorer ankle JPS scores were observed (JREd=4.9°-12.1°; JREnd=5.6-13.9°) with 25-60% increment in JRE compared to age- and gender-matched TD children (JREd=2.6°-7.8°; JREnd=2.4°-10.6°). However, hip JPS appears to be similar or even slightly better (JREd= 4.9°[CP6y] - 6.4°[TDC6y]; 2.3°[CP9y] - 2.8°[TDC9y]) than expected for their age, whereas mixed results are observed for knee JPS depending on limb dominance. CONCLUSIONS: In TD, JPS of the ankle, knee and hip becomes more refined with increasing age, similar to upper limb JPS maturation [6,7]. CP children with spastic diplegia show a similar trend for an age-dependent refinement of JPS, however, with a potential (bilateral) JPS deficit of the distal joints. This likely reflects a true proprioceptive deficit as inter-group differences in JRE are larger than random errors in ankle JRE (SEM=1-1°-1.3°) and knee JRE (SEM=1.5-1.8°) defined within TD children. Following this, previous evaluations based on bilateral limb position matching [2] or single-joint assessments [1-3] might be incomplete. Ongoing research will further explore this hypothesis in a larger sample, mapping lower limb proprioception deficits in children with CP. REFERENCES: [1] Cooper, J., et al (1995); [2] Goble, et al. (2009); [3] Jason R. W., et al. (2011); [4] Wu, G., et al. (2002); [5] Horváth, Á., Ferentzi, E., Schwartz, K., Jacobs, N., Meyns, P., & Köteles, F. (2022); [6] Goble, D. J., et al. (2005); [7] Holst-wolf, et al. (2016)

Parkinson's disease

P2-N-48: Fall circumstances in the home environment in people with Parkinson's disease: An exploration of walking aid users

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BACKGROUND & AIM: In the recent falls guidelines, multidomain interventions are recommended for people with Parkinson's disease (PD) targeting the individual and their environment[1]. Walking aids provide an additional point of contact with the floor improving local stability, increasing perceived confidence and reducing mechanical effort associated with walking[2]. Walking aids are prescribed as an intervention for improving locomotor safety, however walking aid use is associated with recurrent falls in PD[3]. This study aimed to understand pre-fall activity and environmental fall risk factors in people with PD who have fallen and differences associated with walking aid use. METHODS: An online survey was developed to evaluate falls in adults ≥60 years. Out of a total of 358 respondents, 117 respondents were diagnosed with PD. The survey was available online March-July 2021 and covered a range of questions including; basic descriptors, 2-year fall history and contextual information about falls. 48 PD (41%) used a walking aid and of those 43 (90%) had fallen. 69 PD (59%) did not use a walking aid and of those 36 (52%) had fallen. Descriptives concerning perceived health, pre-fall activity, and environmental risk factors are reported for fallers who did (n=43, PDfaller+AID) and did not (n=36, PDfaller-AID) use a walking aid. RESULTS: The groups were similar in age (PDfaller+AID 72.4±5.0y, PDfaller-AID 70.4±4.4y) and sex (PDfaller+AID 49% female, PDfaller-AID 58% female). Fear of falling (Short FES-I) was higher in PDfaller+AID (18.4±5.0) compared to PDfaller-AID (14.3±4.0). 77% of PDfaller+AID were not using their walking aid at the time of the fall. Findings related to perceived health, home modifications, housing type, pre-fall activity

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and environmental risk factors are presented in Fig.1. For PDfaller+AID, the top three pre-fall activities were: turning (72%); walking (63%); and moving too quickly (51%). For PDfaller-AID, the top three pre-fall activities were: turning (67%); moving too quickly (42%); and bending down (31%). For both groups, the top three environmental risk factors were: objects on the floor (PDfaller+AID 30%, PDfaller-AID 33%); slope/uneven surface (PDfaller+AID 16%, PDfaller-AID 12%); and steps/stairs (PDfaller+AID 15%, PDfaller-AID 13%). The top reason for falling over objects on the floor in both groups was misjudging the position of the object in the environment. CONCLUSION: Holistic approaches simultaneously targeting functional capacity and home modifications are required. Pre-fall activity and environmental risk factors were similar in PD fallers regardless of walking aid use, which may be a consequence of the majority of PDfaller+AID not using their walking aid when they fell. Barriers to using walking aids in the home should be explored. Interventions that enhance the visual appearance of obstacles have been shown to elicit gait adaptations earlier in a lab setting[4] and may be beneficial in the home environment. ACKNOWLEDGEMENTS AND FUNDING: The authors would like to thank Parkinson's UK for their support promoting the survey. [1] Montero-Odasso et al 2022 Age & Ageing [2] Cetin et al 2010 Annals of Phys & Rehab Med [3] Canning et al 2014 Neurodegen Disease Management [4] Alcock et al 2020 Neurosci

P2-N-49: Home-based augmented-reality gait-and-balance training for people with Parkinson's disease: a clinical feasibility study

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BACKGROUND AND AIMS: Clinical physiotherapy guidelines for Parkinson's disease (PD) stress that, alongside pharmacological treatment, exercise should be given a central role to disease management to improve gait and balance [1,2,3]. Adhering to regular exercise remains a challenge in PD [4]. Exergaming has the potential to increase adherence to training through play and personalised programs, both in clinic and at home [5]. Cue X is an augmented-reality (AR) home-based gamified gait-and-balance exercise program developed in collaboration with Strolll Limited (www.strolll.co), specifically designed for people with PD as an extension of in-clinic physiotherapy. The primary objective of this (single-arm) clinical feasibility study in people with PD is to evaluate the feasibility and potential efficacy of Cue X. METHODS: 30 individuals with PD (Hoehn & Yahr stage 2-4) with self-reported gait and/or balance difficulties will participate in this study. The study comprises three visits to the gait laboratory, a home visit and a 6-week AR training program consisting of five gait-and-balance exercises (Figure 1). The first laboratory visit is planned 6 weeks prior to the start of the training (waitlist control), the second at the start of the training intervention, followed by a home visit to prepare the participant for training, and the third after 6 weeks of Cue X exercise training. At each laboratory visit, gait and balance will be assessed using standard clinical gait-and-balance measures and targeted walking-related fall-risk assessment based on outcome measures of walking adaptability as determined by the Interactive Walkway (IWW) [6]. A movement expert will set and adjust the games difficulty levels on a weekly basis, based on objective and subjective data from the AR headset and participant, respectively. Cue X is prescribed for minimally 5 days a week for 30 minutes per day. RESULTS: The main study parameters to evaluate the clinical feasibility of Cue X are usability, safety, adherence, and patient-reported experience and outcome measures. The main study parameters to evaluate the potential effect of Cue X are standard clinical gait-and-balance tests and laboratory based IWW gait-and-balance tests. Inclusion has started in December 2022 and preliminary results will be available

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before the ISPGR 2023 conference. CONCLUSIONS: This clinical feasibility trial is the first remotely supervised, home-based AR gait-and-balance intervention for people with PD. The results in terms of clinical feasibility (i.e. usability, safety, adherence) and potential efficacy (gait and balance outcomes) form the basis for future randomized controlled studies on the effectiveness of home-based AR gait-and-balance interventions for people with PD. REFERENCES: [1] Keus SHJ, et al. 2014; European Physiotherapy Guideline for Parkinson's disease. KNGF/ParkinsonNet, the Netherlands [2] Osborne JA, et al. Phys. ther. 2022; 102(4) [3] Parkinson's disease in adults: diagnosis and management. London: National Institute for Health and Care Excellence (NICE); July 2017. [4] Schootemeijer S, et al. J Parkinsons Dis. 2020;10(4):1293-1299. [5] Gallou-Guyot M, et al. Disabil Rehabil. 2022;in press [6] Geerse DJ, et al. Gait Posture. 2019;70:203-210.

P2-N-50: Effects of dance on regular gait and dual-task gait in Parkinson's disease

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Background and aim Gait impairments are well-evidenced in people with Parkinson's disease (PD). Parkinson's gait is characterised by reduced gait speed, stride length, and swing times, and increased stride-to-stride variability. Walking becomes especially attention demanding when performing a secondary task, resulting in a poor gait. While dance based interventions could improve gait, further studies are needed to determine if the benefits generalise to different terrains and when dual tasking. The aim was to assess the effects of a dance intervention, based on the Dance for PD® (DfPD®) program, on gait under different dual-tasks (verbal fluency, serial subtraction) and surfaces (even, uneven), and to determine if a larger scale follow-up RCT is warranted. Methods A dance group (DG; n = 17; age = 65.8 ± 11.7 years) and a control group (CG: n = 16; age = 67.0 ± 7.7 years) comprised of non-cognitively impaired (Addenbrooke's score: DG = 93.2 ± 3.6, CG = 92.6 ± 4.3) independently locomoting people with PD (Hoehn & Yahr I-III). The DG undertook a one-hour DfPD® based class, twice weekly for 12 weeks. The CG had medication and exercises as usual. The spatiotemporal variables of gait were assessed at baseline and post-intervention while walking on two surfaces (even, uneven) under three conditions: regular walking; dual-task: verbal-fluency (DTVERB), serial-subtraction (DTSUBT). The data were analysed by means of a linear mixed model. Results At baseline, there was no significant group difference for any spatiotemporal gait variable. The DG improved significantly compared to the CG with and without a dual task when walking on even surface. During regular walking, DG improved in gait velocity (p=0.017), cadence (p=0.039), step length (p=0.040) and stride length (p=0.041). During DTVERB significant improvements were noted in gait velocity (p=0.035), cadence (p=0.034) and step length (p=0.039). The DG also exhibited significant improvement compared to the CG during DTSUBT in the measures of gait velocity (p=0.012), cadence (p=0.021), step length (p=0.018) and stride length (p=0.151). On the uneven surface, improvements were noted when walking while performing serial-subtractions only. During regular walking, improvements were noted for the CG but not for the DG. CG has spent less time in double support following the intervention than DG. While DTVERB condition had no significant group differences for any gait parameter (p's >0.05), in the DTSUBT condition, the DG improved significantly compared to the controls on gait velocity (p=0.048), cadence (p=0.026), and step length (p=0.051). Conclusions DfPD®-based classes produced clinically significant improvement on

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spatiotemporal gait parameters under dual-task conditions and on uneven surfaces. This could arise from improved movement confidence and coordination; emotional expression; cognitive skills (e.g., planning, multitasking), and; utilisation of external movement cues. A large-scale RCT of this program is warranted. Acknowledgement and funding We are thankful to the participants with PD, the caregivers, volunteers and DfPD®-trained instructors from Queensland Ballet. This research was supported by Queensland University of Technology, Australia and University Grants Commission, Sri Lanka.

P2-N-51: Association between daily-life gait quality characteristics and clinical rating scales in Parkinson's disease

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BACKGROUND AND AIM: Gait impairments are a prominent feature of Parkinson's disease (PD). They are commonly present early in the disease course and are a major cause of disability in advanced disease. Dopaminergic replacement therapy may improve some aspects of gait impairment, but eventually patients develop daily fluctuations in their response to dopaminergic treatment. Additionally, as the disease progresses other aspects of impaired gait are unresponsive to dopaminergic treatment. In the management of PD, assessment of gait is therefore of great importance, but daily variability of patient's symptom severity may jeopardize the validity of a single clinical assessment. Ambulatory activity monitoring (AAM) using inertial measurement units (IMUs) may complement clinical evaluation by providing objective measurements of motor symptoms over longer time intervals in a cost-efficient way. The main objective of this study is to explore the extent to which AAM gait quality characteristics are associated to PD symptoms using commonly applied rating scales of PD. METHODS: Gait characteristics were determined using an IMU (Axivity AX6, Newcastle) worn on the lower back. Patients were instructed to wear the IMU 24 hours a day during a period of 1 week. From the raw accelerometery data obtained with the IMUs, episodes of locomotion were identified and gait characteristics were determined. Associations between all combinations of gait characteristics and PD rating scales were tested with correlation analyses while controlling for multiple comparisons. RESULTS: Data collection is still in progress. During the congress we will present the preliminary results of our analyses. The data of approximately 200 PD patients with a disease duration of less than 10 years will be analysed. CONCLUSIONS: Our results will provide an overview of the various associations between daily-life gait quality characteristics and clinical rating scales used in the assessment of PD. These results may support the prospect of performing frequent, objective and unsupervised assessments to aid in the clinical evaluation of PD patients.

P2-N-52: Can activity monitors be used to accurately detect time in bed in people with Parkinson's disease?

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BACKGROUND AND AIM: To meet the recognized definitions of sedentary behavior, waking hours need to be identified and separated from sleep in passively collected activity monitoring data. Automated algorithms for identifying start and end of time in bed have shown promise

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for healthy adults. This study aimed to compare existing and customized automated algorithms and self-report with manual data inspection in a population of people with known movement and sleep difficulties (Parkinson's disease). METHODS: Thirty people with mild to moderate Parkinson's disease wore the activPALTM for seven days. Participants also completed a daily wear diary to record any time they napped or removed the device. The Multimedia Activity Recall Questionnaire for Children and Adults (MARCA), a 24-hour self-report use of time recall tool, was also completed. Time to bed (TTB) and time out of bed (TOOB) were determined using six methods: self-report determined from the MARCA, visual inspection of activity data, automated PAL CREATM analysis, and three customized algorithms. The algorithms used varied duration of sit/lie time (4/5 hours) and thresholds for breaks in sit/lie time (6/15 minutes) and step count (20/50steps) to estimate TTB and TOOB. Manual inspection of the data was considered the gold standard as it included visual inspection of the device-measured data and knowledge of self-reported activity and time in bed. Accuracy was determined by calculating absolute mean difference (MD) between visual inspection and each of the other methods, and proportion of estimations accurate to within 30 minutes. RESULTS: Thirty people (age of 63.4 years, SD 8.4) with idiopathic Parkinson's disease (disease duration 4.1 years, SD 3.2 years) participated. Visual inspection returned TTB and TOOB times that most closely match self-report with a MD of 27.7 minutes (SD 34.3 minutes) and 34.1 minutes (SD 44.6 minutes), respectively. MD for TTB ranged from 31.6 to 50.7 minutes (SD 116.2- 130.2 minutes), with the PAL CREA calculation on average closest to the visual inspection. MD's for TOOB were larger, ranging from 37.2 to 45.0 minutes (SD 76.1- 80.8 minutes) with a customized algorithm using 5 hours of sit/lie time with breaks less than 15 minutes and with less than 50 steps performing best. TTB was accurately calculated (to within 30mins) in 82% of cases, and TOOB in 75% of cases. CONCLUSIONS: Automated methods of calculating TTB and TOOB are convenient and may offer better accuracy than relying on self-report alone. However, rules applied to estimate TTB, are likely to differ from those that accurately estimate TOOB. No one algorithm proved highly accurate in all cases, so for populations with disrupted sleep or movement patterns self-report should still be collected to provide context and improve accuracy.

Perturbation

P2-O-53: Is the coherence between distinct sub-populations of motoneurons comprising the triceps surae different during voluntary leaning?

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BACKGROUND & AIM: In previous studies, we observed that when leaning in multiple directions, participants recruited distinct sub-populations of motor units (MUs) within the triceps surae muscles: common units that were active in more than one leaning direction and unique units that were active in only one leaning direction. Further, the MU sub-populations had different firing behaviours according to the leaning direction. The purpose of the study was to determine an underlying mechanism contributing to the observed differential recruitment and firing behaviours. METHODS: Thirty-one participants (14 young adults: 7 females, 7 males, mean ± SD: age 27 ± 2.5 years; 17 older adults: 8 males and 9 females, age

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74.8 ± 5.3 years) stood on a force platform and maintained their center of pressure leaning in 5 directions with 0 degrees (º) laterally right, and the next 4 directions every 30° counterclockwise. High-density surface electromyography recordings from medial gastrocnemius (MG) and soleus (SOL) were decomposed into single MU action potentials. A MU tracking analysis identified groups of MUs as being common or unique across the leaning directions. A coherence analysis, known as the proportion of common input (PCI), was used to assess the neural connectivity of MUs from distinct motoneuron pools (the unique and common units) within the same muscle. A linear mixed effect model determined the effect of the MU subgroup (among common units, among unique units, and all motor units), muscle, leaning direction, and age on the PCI values. RESULTS: There was a main effect of MU subgroup on the PCI values ($F = 25.92$, $p < 0.0001$), with PCI being higher in the common compared to the unique units (Mean Difference ± Confidence Interval = 0.08 ± 0.01, $p < 0.001$). However, there were no statistical differences between the individual MU subgroup analysis and all of the MUs ($p > 0.05$). The PCI was higher for the MG compared to the SOL for both MU subgroup analyses (main effect of muscle: $F = 231.44$, $p < 0.0001$; MD = 0.127 ± 0.008). There was a significant directional effect on PCI ($F = 11.12$, $p < 0.0001$) for both MU subgroups and muscles, with the lowest PCI during the 90deg (MD = 0.08 ± 0.012) leaning direction. Finally, the older adults had higher coherence for both MU subgroups (main effect of age: $F = 4.56$, $p = 0.04$; MD = 0.07 ± 0.02). CONCLUSIONS: The findings suggest that there are separate neural signals sent to distinct subgroups of motor neurons within the same muscle during voluntary leaning. The PCI values of the common units were higher compared to the unique units across all leaning directions. However, the PCI between the MU subgroups was not statistically different from the PCI for all of the MUs combined. This may demonstrate that there is overlap of neural inputs that are shared with each MU subgroup. Further, the higher PCI values in older adults compared to young adults may demonstrate a decreased ability to flexibly control the MU subgroups.

P2-O-54: Treadmill belt accelerations do not replicate kinematic responses to trips on a walkway in older people

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BACKGROUND AND AIM: Treadmill belt perturbations have high clinical feasibility for use in perturbation-based training in older people. However, the kinematic validity of treadmill belt perturbations has not been examined in comparison to overground trips. This study examined the kinematic validity of treadmill belt accelerations as a surrogate method for overground walkway trips during gait in older people. METHODS: Thirty-eight community-dwelling healthy older people were exposed to two unilateral belt accelerations (8 m/s²) whilst walking on a split-belt treadmill (M-Gait, Motekforce Link) and two trips induced by a 14 cm trip-board whilst walking on a 10 m walkway with condition presentation randomised. Anteroposterior (AP) margin of stability (MoS), extrapolated centre of mass (xCoM), maximum AP velocity of the centre of mass (CoM), number of falls into the harness, step length, maximum toe clearance, and sagittal plane angles of the trunk, hip, and knee were quantified for one step prior, and five recovery steps following the treadmill and walkway perturbations. Kinematic measures of recovery from treadmill perturbations were compared to elevating and lowering recovery strategies elicited by obstacle-induced trips on the walkway. RESULTS: The rate of falls following treadmill and walkway perturbations were 0% and 13.1%, respectively. Figure 1

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displays the time normalised trunk angles during the previous and recovery steps on the treadmill and in walkway elevating and lowering strategies. The change in trunk flexion angles following perturbation onset on the treadmill were significantly smaller than following walkway trips during either strategies. The maximum CoM AP velocity was lesser for all steps on the treadmill compared to both walkway strategies ($P < 0.05$). MoS was similar across conditions during the first recovery step ($P > 0.05$) but less negative during subsequent recovery steps following treadmill belt accelerations compared to walkway trips regardless of recovery strategy ($P < 0.01$). Excluding the first recovery step in the lowering strategy, xCoM was less anterior, and recovery step lengths, toe clearance, maximum trunk, hip, and knee angles were smaller during recovery on the treadmill compared to on the walkway ($P < 0.05$). CONCLUSIONS: Destabilisation as measured by MoS, quickly dissipated following only one recovery step for treadmill belt accelerations but continued for multiple (4+) recovery steps following walkway trips. Less anterior xCoM and lesser maximum CoM AP velocity, trunk displacement, step lengths, toe clearance, and no falls on the treadmill indicate treadmill belt accelerations do not accurately simulate the biomechanical challenge of obstacle-induced trips in older people. Due to the lack of physical obstruction of the swing foot, less hip and knee flexion were required in this population of older people during recovery from treadmill belt accelerations.

P2-O-55: Determining perception thresholds of young adults to small continuous moving platform perturbations

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[1]University of Toronto

Background and aim: Using 'sub-threshold' perturbations that are not perceived by participants may be beneficial in studies that aim to determine the effect of unperceived small external errors on motor learning. The purpose of this study is to identify continuous moving platform perturbation magnitudes that are large enough to cause balance errors, but small enough that they are not consciously perceived by participants. Method: This study used psychophysics methods to determine the perception threshold of healthy young adults for small balance perturbations. Participants (age=20-35 years) completed one data collection session using a multiple staircase paradigm. Participants stood on a stabilometer mounted on a moving platform. During each 10-second trial, participants were instructed to try to keep the stabilometer horizontal while they experienced small balance perturbations from the moving platform. Root mean square of perturbation displacement, velocity and acceleration ranged between <0.01 and 2.75 cm, <0.01 and 7.23 cm/s, and <0.01 and 21.33 cm/s2, respectively. After each trial, participants were asked whether they perceived the platform movement. Perturbation magnitudes were scaled up in the next trial if participants could not perceive them, and scaled down if participants could. There were four perturbation waveforms; two waveforms followed a descending staircase whereas two followed an ascending staircase. Each staircase protocol ended when there were four reversals, and the perturbation perception threshold was defined as the average of the last two reversals. Following detection of the threshold, participants performed eight 40-second trials on the stabilometer, two trials in each condition: without perturbation, perturbation at the perception threshold, perturbation 10% below the perception threshold, and perturbation 10% above the perception threshold. Balance performance was defined as time-in-balance (the proportion of the trial time when the deviation angle was ±2.5° from horizontal) and root mean square deviation of the stabilometer from horizontal. Results: Preliminary results from 5 participants show that perception

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thresholds vary between individuals (with displacements RMS ranging from 0.45 to 1.27 cm). In addition, balance performance was degraded when participants experienced sub-threshold perturbations compared to when there was no perturbation (time-in-balance (Mean=0.15,Std=0.06) versus (Mean=0.19, Std=0.07); angular RMS (Mean=9.49, Std=1.99) versus (Mean=8.17, Std=2.10)). Conclusion: This study presents an approach for quantitatively measuring perception thresholds of young adults to small continuous moving platform perturbations. The final subthreshold for the magnitude of the perturbation waveforms will be used in a subsequent study. The present findings suggest that the perception threshold varies for different individuals.

P2-O-56: The effects of perturbation-based balance training on reactive stepping quality in people with chronic stroke

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BACKGROUND AND AIM: In people with chronic stroke falls are often due to a reduced ability to recover from postural perturbations, with reactive stepping responses being more impaired than feet-in-place responses. There is emerging evidence that training involving repeated exposure to balance perturbations (perturbation-based balance training; PBT) can improve reactive balance capacity in people with stroke-related deficits. However, there is still limited evidence on the beneficial effect of PBT compared to conventional physiotherapy. Therefore, we aimed to investigate the effects of PBT on reactive stepping in people with chronic stroke compared to conventional physiotherapy. METHODS: In an ongoing open-label randomized control trial, participants in the chronic phase after stroke were randomly allocated to PBT or to conventional physiotherapy. Both groups received training for five weeks, two times a week, for 60 minutes. Physiotherapy consisted of regular functional exercises to promote balance during standing and walking. PBT was delivered with the C-Mill, an instrumented treadmill challenging reactive and adaptive balance control while walking. Pre and post training, clinical assessments were performed, including the MiniBESTest, the Trunk Impairment Scale (TIS) and the 6-item activities-specific balance confidence score (6-ABC). Reactive step quality was assessed using multidirectional platform translations, with five stepping directions (20 trials each) for both paretic and non-paretic leg. We calculated the leg angle to quantify reactive step quality, defined as the angle between the vertical and a line connecting the mid-pelvis and the second metatarsal of the stepping foot. RESULTS: 11 participants within PBT and 10 participants within physiotherapy have currently completed training. MiniBESTest scores improved between pre and post training in both groups (PBT: 2.5 points, 95% CI [1.7 3.3] $p<0.01$, Physiotherapy: 2.5 points, 95%CI [0.1 4.9] $p<0.05$). TIS scores improved in the PBT group (2.6 points, 95% CI [1.7 3.5] $p< 0.01$) but not in the physiotherapy group (1.3 points, 95% CI [1.0 3.5] $p=0.2$). Yet, time*group interaction effects were not significant (MiniBESTest, $p=0.97$, TIS, $p=0.22$) . No significant time or group effects were observed for the 6-ABC. For step quality, we observed an improvement in paretic steps in diagonal forward direction ($\beta=1.17$, 95% CI [0.10 2.24] $p<0.05$), and a trend towards improvement in forward and sideways direction (forward: $\beta=1.42$, 95% CI [0.04 2.87] $p<0.06$, sideways: $\beta=0.98$, 95% CI [0.07 2.05] $p=0.06$). For non-paretic stepping we observed improved side steps ($\beta=0.91$, 95% CI [0.01 1.82] $p=0.05$). We did not observe between-group differences in training effects. CONCLUSION: Our preliminary results indicate beneficial effects of both PBT and conventional physiotherapy involving balance training in people with chronic stroke, including improvements on clinical balance scales and improvements in reactive stepping quality, yet

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without evident between-group differences in training effects. Final results will be available at time of the conference.

P2-O-57: Expecting the unexpected: adaptation to postural responses during repeated discrete platform perturbations with expected and unexpected support surface displacement amplitudes: preliminary results

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BACKGROUND AND AIM: Postural responses have been shown to adapt after repeated support surface platform translation oscillations. However, in such cases, platform translation amplitude and/or frequency typically is constant, so the expectation of perturbation effects could underpin postural response adjustments over time. Thus, the purpose of this study was to evaluate postural response adaptation in young adults when subjected to repeated discrete platform translations that varied in amplitude and timing. We hypothesized that postural response adaptation would occur within the first 10 consecutive expected perturbations, but not subsequent unexpected perturbations. METHODS: Twenty-two participants (11M/11F; 25±5yrs) with no recent history of injury or neuromuscular disorder stood on a moving platform that translated antero-posteriorly at a frequency of 0.75Hz in either 'big' (6cm) or 'small' (5cm) expectation conditions (counterbalanced order). In each condition, a majority of perturbations (75%) were congruent with condition type (e.g. 'big' perturbation in expected 'big' condition), with the remaining 25% of trials being incongruent (e.g. 'small' perturbation in expected 'big' condition; presented quasi-randomly following first 10 congruent perturbations). Participants faced 60 perturbations in total per condition (45 congruent, 15 incongruent). 3D kinematics, surface EMG of lower limb postural muscles, and force plate kinetics were recorded. Centre of Pressure amplitude, velocity, and time-to-peak displacement (COPamp; COPvel, COPttp, respectively) were obtained for each perturbation. Data were analysed using custom Matlab scripts. Initial adaptation to the condition was assessed by comparing postural responses at the 1st, 5th, and 10th congruent perturbations. Adaptation of responses to incongruent perturbations were evaluated across the subsequent 1st, 8th, and 15th interweaved incongruent perturbations. NB: Kinematics and EMG results are currently being analysed. RESULTS: Preliminary data presented here represent 15 of 22 participants (8M/7F; 26yrs). No recovery steps were taken by any participants at any time. COPamp, COPvel, and COPttp all decreased from the 1st to 10th congruent perturbation; COPvel and COPttp also decreased from 1st to 15th incongruent perturbation (COPamp also decreased, approaching significance). An overall effect of size was observed for COPamp only in both congruent and incongruent perturbations. CONCLUSIONS: As expected, participants showed rapid initial adaptation to postural responses across the first ten congruent perturbations, with adaptation plateauing by the 5th perturbation. Contrary to our hypothesis, participants also displayed adaptation when incongruent and congruent perturbation sizes were interweaved. This suggests that participants can flexibly shift between feedforward and feedback modes of postural control when expecting perturbations of varying amplitudes and timings.

Sensors (e.g. IMUs, activity monitors, machine learning)

P2-P-58: Gait stability changes over consecutive stride windows during load carriage

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[1]La Trobe University

Introduction: Load carriage can affect gait stability leading to falls and injuries, a common problem in the military. Recent studies have explored how load affect gait stability using non-linear measures, e.g. local divergence exponent. However, current methodologies have not considered that stability may evolve over time and that using data from shorts trials or from the first "n" strides may affect the results when comparing load conditions. The aim of this study was to determine how gait stability is affected as time progresses when carrying a heavy military load. Methods: Eleven healthy trained soldiers (3f/8m, 27.2 ± 5.6 years, 80.4 ± 15.6 kg, 1.76 ± 8.7 m) walked for 12 minutes on a treadmill at their self-selected speed while carrying a 35 kg load (16kg vest, 14kg backpack, 3.2kg replica rifle and 2kg boots). Four accelerometers (128 Hz) were placed on the sternum, sacrum and feet. Gait stability was assessed using the local divergence exponent (LDE) over the 0-0.5 stride range. We calculated stability for the sternum and sacrum over four non-overlapping stride windows (windows 1 to 4; W1-W4) each containing 100 strides. Feet sensor data were used to determine heel contacts and extract stride data. To calculate the LDE we first normalized 3D accelerations to 10000 samples and reconstructed a 9D (3D x 3 delayed copies) state-space with a delay of 6 and 10 for the sternum and sacrum, respectively. These values were calculated using the median values of the first minimum of the average mutual information function across all planes. Analyses were conducted in Matlab R2022b. A linear mixed model with participants as a random factor was used to determine differences in sacrum and sternum LDE (LDESAC and LDESTR, respectively) across the four stride windows. Post-hoc tests (Bonferroni corrected) were conducted to determine between windows LDE differences ($p < .05$). Results: The mean speed across all participants was 4.9 ± 0.3 km·h-1. There was no effect of time window on LDESAC ($p = .083$) but there was for LDESTR ($p < .001$). Post-hoc analysis showed that stability at the sternum during W1 was significantly lower than that during the other windows ($p < .001$). Discussion: These results indicate that stability at the sacrum remained relatively unchanged over the four stride windows of treadmill-based marching. However, stability at the sternum increased after 300 strides. Increased stability at the trunk may have occurred as an adaptive mechanism to contribute to the overall stability. Our results suggest that stability at the upper trunk during load carriage should be measured after the first 100 strides. Further studies should explore if stability is affected similarly in longer trials covering similar distances as field marching. Conclusion: Gait stability at the upper trunk increased after 300 strides of marching while carrying a 35 kg load, whereas stability at the pelvis was not affected.

P2-P-59: Proprioceptive quotient of postural complexity can discriminate people with very mild disability

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Background/Aim: People with MS (pwMS) with mild to moderate disability demonstrate impaired postural control, often leading to injurious falls. Postural sway over short time periods is highly influenced by individual biomechanical properties, whereas measures which characterize sway over longer time scales are more closely associated with neural control of movement. We recently showed that a nonlinear measure of postural sway, which assesses self-organized sway complexity over time (Sample Entropy), discriminated between healthy controls (HC) and pwMS with low Expanded Disability Status Scale (EDSS 0-2) better than

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linear spatiotemporal measures of sway, such as Sway Range and Jerk. Given the importance of monitoring MS progression in the earliest stages to optimize disease-modifying treatments (DMTs) and prevent accumulation of disability, this study aimed to further probe the discriminative validity of Sample Entropy (SampEn) by comparing the Romberg Quotient and the Proprioceptive Quotient from SampEn measures in people with very mild disability (EDSS 0-1). We hypothesized that Quotient values, which eliminate the influence of individual biomechanics (e.g. body mass index) would be more sensitive to postural control impairment than simple SampEn values. Method: 21 PwMS (relapsing-remitting, EDSS 0-1) and 21 healthy controls (HC) stood quietly (heels 10cm apart and 100 toe-out) wearing inertial sensors (APDM, Portland, OR, USA) at Sternum and Lumbar in four conditions: eyes open (EO) or closed (EC), on firm or foam surface. SampEn in the sagittal and frontal planes was calculated from 3D acceleration data in Matlab (Natwick, USA) using vector length (m=2) and tolerance ratio (r=0.15). Romberg Quotient was ECfirm/EOfirm. Proprioceptive Quotient was EOfoam/EOfirm. ANCOVA was used to determine group differences, controlling for age. Post-hoc Benjamini-Hochberg adjustments were made to account for multiple comparisons, with False Discovery Rate set at 5%. Result: SampEn, in the sagittal direction only, was significantly lower in pwMS under two out of four conditions, ECfirm (Eta2 Lumbar 0.262, p<.001; Sternum 0.244, p =.001) and EOfoam (Eta2 Lumbar 0.455, p<.001; Sternum 0.252, p<.001). The Romberg Quotient showed significant between-group differences in the sagittal plane from Lumbar only (Eta2 0.209, p<.001). However, the Proprioceptive Quotient in the sagittal direction was most sensitive to group differences (Eta2 Lumbar 0.532, p<.001; Sternum 0.429, p<.001). Conclusion: Sagittal SampEn demonstrated excellent known-group validity with large effect sizes, when eyes closed or on a compliant surface. The Romberg Quotient was not more sensitive than raw SampEn, however the Proprioceptive Quotient did show much greater discriminative validity. The Proprioceptive Quotient reflects the vulnerability of an individual's system to perturbation of proprioceptive sensory inputs, independent of individual variation in potential confounders, such as BMI, age or fitness. This ability to detect postural impairment in early stages of MS signals important new opportunities to fine-tune clinical management such as DMTs and/or rehabilitation. Funding: MSRA

P2-P-60: Can machine learning techniques reduce the number of inertial sensors in real life gait analysis?

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BACKGROUND AND AIM: The optimal number of inertial sensors for real-life gait analysis is a trade-off between data quality and patient convenience and feasibility. One-sensor systems have proven to deliver reliable information for average values of gait speed or step length. However, for the ataxic-sensitive measures of spatio-temporal gait variability, these systems reported less reliability and less sensitivity compared to 3 sensor systems including two sensors at the feet. Here, we investigate the potential of machine learning techniques to predict gait features based on 1 sensor only, which could increase the clinical feasibility of instrumented gait analysis in real-life recordings of cerebellar ataxic patients. METHODS: We recorded gait data from 44 healthy controls and 55 cerebellar patients at baseline, 1-year and 2-years follow-up assessments by 3 Opal APDM inertial sensors. These data successful identified longitudinal changes in gait variability measures for cerebellar patients (e.g. stride length variability, effect size: 0.53) Utilising 1D convolutional neural networks (1D-CNN) we predicted 14 gait parameters from stride based triaxial IMU data in two conditions with different

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input dimensions: using raw data from the pelvis sensor only (1S) in comparison to the complete set of all three sensors (3S). Thus, in the supervised training phase of both conditions, we used stride based gait features previously determined by the 3 sensors algorithm from APDM as ground truth. Aim in both approaches is to individualize the learned mappings for a new unseen patient based on a small amount of recorded gait samples with 3 sensors in the lab and to use transfer learning for the characterisation of real-life data. RESULTS: First results deliver a low (<5%) absolute mean error for gait speed, stride length, stride duration and foot pitch at TO using pelvis raw data only. In comparison, using the complete set of sensor data shows similar results (e.g. stride duration abs. err: 3.2% (3S),2.9% (1S)). Predicting sway of the upper body reveals moderate absolute mean error (~10%) in both conditions (e.g. coronal sway abs. err.: 8.6% (1S), 10.7% (3S)). CONCLUSIONS: 1D-CNN are able to predict gait features from pelvis raw data with low absolute errors. Further machine learning techniques such as transfer learning, explainability methods and prediction of foot raw data from pelvis data will be used in the future to surpass clinically necessary effect sizes compared to traditional methods based on one sensor only.

Sensory (e.g. vision, vestibular)

P2-Q-61: Movement processing in central visual field loss is linked to improved head stabilization while turning

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BACKGROUND & AIM: Individuals with central visual field loss (CFL) often limit their physical activity due to poor vision and a fear of falling. Mobility difficulties have been documented in this population though their extent is not well characterized. Further, as CFL often occurs in older age, age-related comorbidities can confound observations. Head stabilization is an essential skill, critical for providing a stable visual and vestibular reference and maintaining stable gaze. Suboptimal head stabilization manifests in more rigid head-trunk coordination and occurs in those who are visually dependent, have vestibular deficits, higher fall risk and fear of falling, and often in older adults engaged in challenging activities (e.g., turning). Our recent finding that individuals with CFL are more visually dependent, along with others' reports of increased fear of falling in CFL, and potential for age-related vestibular deficits suggest that head stabilization may be degraded in CFL. Studies also show that older adults with greater fall risk may alter how they think about their movements during walking: heightened conscious movement processing and fall-related ruminations are both linked to increased fall-related anxiety and movement errors when walking. Here, we investigate head stabilization in individuals with CFL during the Timed Up and Go (TUG) test and how it relates to changes in movement-related cognitive processing. In addition to its clinical relevance as a common measure of functional balance, the TUG includes straight and turning segments, i.e., locomotor sub-tasks of increasing difficulty. METHODS: Nine individuals with CFL (3F, age: 71.2 ± 8.5) and 4 visually healthy older adults (3F, age: 75.8 ± 4.1) performed the TUG three times with wireless inertial measurement units on their head, chest, and right ankle (latter used for step detection). We examined acceleration of the head and chest in the frontal plane. Pitch, roll, and yaw rotation angles in world coordinates were computed with respect to a reference posture

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and used to calculate anchoring indices to assess the stabilization strategy used: head articulated in space or rigid on the trunk. We used the Gait-Specific Attentional Profile (G-SAP) to assess movement processing. RESULTS: In those with CFL, we saw modest improvement in head stabilization during turns in pitch and roll, and a slight worsening in yaw. Improved head stabilization in yaw during turns was positively correlated with higher conscious movement processing, fall-related ruminations and processing inefficiency G-SAP sub-scales, only in the CFL group ($p<0.01$, $0.83<r<0.89$, partial correlations, controlling for age). CONCLUSIONS: Higher movement processing in the CFL group may be an adaptation to the more challenging task of turning. Recent work in our lab suggests that movement processing increases with CFL severity and is proportional to participants' functional balance. A larger sample and the use of more challenging tasks is needed to further examine these relationships. ACKNOWLEDGEMENTS AND FUNDING: This study was supported by NIDILRR Rehabilitation Engineering Research Centers Program grant 90REGE0018 and The Smith-Kettlewell Eye Research Institute.

P2-Q-62: A novel approach to EVS sway thresholding

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Background and Aim Electrical Vestibular Stimulation (EVS) is a technology which uses trans-mastoidal electrical currents to evoke vestibulospinal reflexes and probe central vestibular processing. Recently, biotech companies have been investigating the use of EVS to compensate for peripheral vestibular deficits. Currently there are 2 main electrode configurations used in the literature; monopolar binaural (4 electrodes; causes anterior-posterior sway) and bipolar binaural (2 electrodes; causes medial-lateral sway). A novel approach to bipolar stimulation is to use 4 electrodes, which allows the investigator to switch on-the-fly to evoke both anterior-posterior and medial-lateral sway with the same device and electrode configuration. Little is known about the minimum thresholds of EVS stimulation required to evoke sway in these different configurations. Stochastic EVS (SVS) was used to determine minimum sway thresholds for 4-electrode monopolar (2 channel), 4-electrode bipolar (2 channel) as well as 2-electrode bipolar (1 channel). Methods 10 healthy young adults (5 male, 5 female) between the ages of 18-24 stood on a force plate, with a 3-axis accelerometer attached to their right mastoid process and were given 14x 3 minutes SVS stimulation from 0.00625-2.1 mA, for all three electrode configurations. Cumulant density analysis was run using Neurospec 2.0- MATLAB between the SVS stimulation and force plate sway. Thresholds were determined visually by 2 significant peaks on the cumulant density plot. Results 2-electrode bipolar and 4-electrode bipolar had comparable thresholds. Thresholds for 4-electrode monopolar were significantly higher than thresholds for either bipolar electrode configurations. Conclusions It is likely that 2 electrode and 4 electrode bipolar configurations could be used interchangeably. Investigators wishing to use both bipolar and monopolar stimulation may need to increase monopolar stimulation amplitude by a significant factor in order to evoke the same amplitude of sway as bipolar stimulation.

P2-Q-63: Comparing the effects of different circular vection stimuli on upright stance

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BACKGROUND AND AIM: Upright quiet stance is maintained through the integration of sensory information from the visual, vestibular, and somatosensory systems [1]. Virtual reality (VR) is a well-established technology that has been used to assess sensory contributions to balance and induce visual perturbations. Previous assessments of virtual environments have suggested that VR can be used to produce various visual stimuli that affect balance [2], but there is limited work examining which dynamic visual stimulus, in the form of circular vection (CV), is the most effective at inducing postural sway. Therefore, this study utilized two different visual stimuli presented using VR to better understand their effects on postural control. METHODS: 29 healthy young adults between the ages of 18-40, free of neurological and vestibular impairments, stood quietly on a force plate while wearing a head-mounted display (Oculus Rift, 110° field of view). While standing upright for 30s, participants were exposed to a visual scene with a three-dimensional field of random white dots (DOTS) or a black and white striped tunnel (TUNNEL) that rotated in the roll plane at 60°/s clockwise or counterclockwise; the order of these two conditions was counterbalanced. Vizard python programming was used to custom design the two visual scenes. Amplitude was calculated from the mean position of head position data recorded from a head-mounted display, and from centre of pressure (COP) calculated from ground reaction forces and moments recorded from a force plate. RESULTS: Postural sway induced by both visual stimuli was in the same direction as the stimulus. Main effects of stimulus were observed, where the DOTS stimulus increased Head mean position ($p<0.02$) and COP mean position ($p< 0.01$) compared to the TUNNEL stimulus. There was no significant main effect or interaction with direction for Head mean position ($p<0.65$) or COP mean position ($p<0.74$). CONCLUSIONS: When comparing the type of stimulus during circular vection effects on upright stance, a DOTS stimulus was most effective at inducing direction-modulated postural sway as evidenced by an increase in Head and COP mean position. This study builds on our understanding of the destabilizing effects on postural control from VR-related visual stimuli and shows evidence that a DOTS stimulus has a stronger effect than a TUNNEL stimulus. Overall, it is important to consider the design of visual stimuli when examining effects on upright stance. REFERENCES: [1] Luo et al. (2018) Frontiers in neurology; [2] Tossavainen et al. (2003) International Journal of Medical Informatics. ACKNOWLEDGEMENTS AND FUNDING: Funded by NSERC.

P2-Q-64: Vestibular semicircular canal stimulus estimation during the video head impulse test

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BACKGROUND AND AIM: Dysfunction of the vestibular system, particularly the semicircular canals (SCCs), causes disequilibrium and increases fall risk. The video head impulse test (vHIT) is a commonly used assessment of SCC function, with purported ability to test all three SCC planes. Impulsive head movements are applied by the clinician, and reflexive eye movements are analyzed. VHIT is a reliable assessment tool for horizontal SCC function, but its reliability for assessing the vertical SCCs is questionable. Vertical head impulses require a complex head movement, making it difficult to provide a purely rotational stimulus to a single SCC plane without stimulating SCCs in other planes. A better understanding of the resulting head and vestibular end organ kinematics is necessary to improve the delivery of vertical head impulses and interpretation of vertical vHIT results. The purpose of this study is to provide descriptive kinematics of the vestibular stimuli during vertical plane impulses. METHODS: Six subjects received vertical SCC head impulses applied by an experienced physical therapist

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(RH) targeting the right anterior (RA) and left posterior (LP) SCC plane. Head kinematics were collected using a Vicon motion capture system. Vestibular end organ kinematics were derived from head kinematics based on the location and orientation of the SCCs and otolith organs using anatomical landmarks. Peak rotational velocity magnitudes in SCC planes and peak-to-peak gravito-inertial accelerations at the otolith organs were calculated. RESULTS: The largest rotational velocities occurred in the target SCC plane for RA impulses (186.6 ± 35.6 deg/s) and LP impulses (197.5 ± 24.0 deg/s). Non-negligible velocities occurred in non-target SCC planes for both RA impulses (horizontal SCC plane: 43.2 ± 16.4 deg/s; non-target vertical SCC plane: 33.9 ± 12.6 deg/s) and LP impulses (horizontal SCC plane: 40.0 ± 13.4 deg/s; non-target vertical SCC plane: 45.2 ± 15.5 deg/s). Larger vertical peak-to-peak gravito-inertial accelerations occurred in the right otolith organs compared to the left otolith organs for RA impulses (right: 0.30 ± 0.16g; left: 0.08 ± 0.14g) and LP impulses (right: 0.34 ± 0.13g; left: 0.09 ± 0.12g). CONCLUSIONS: These results show that typical vertical SCC plane impulses stimulate non-target SCC planes approximately 20% as much as the target SCC plane. The data also demonstrate that translation of the head during vertical impulses stimulates the otolith organs, with the right and left otolith organs experiencing different stimulation. Future work will investigate how to minimize stimulation to non-target SCCs and/or otolith organs, and the spatial accuracy required for vertical impulses to be useful clinically. ACKNOWLEDGEMENTS AND FUNDING: Thanks to Ricky Smith for data collection/processing. NIDCD/NIH: F31DC020110.

P2-Q-65: Feedforward control of arm position during object transport with altered sensory information

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Background and Aim: Vision plays an important role to stabilize the movement of an object relative to the trunk during transport in order to compensate for impact forces that result from heel contact. It is likely that somatosensory information from the hand and arm also play an important role in this control, however these contributions have received little attention. The purpose of this study was to determine the kinematic adaptations that occur during transport when somatosensory and visual information of the object are altered. Methods: To date, six healthy young adults performed treadmill walking while transporting a baseball-shaped massage ball in their dominant hand. The massage ball could be set to vibrate and alter the somatosensory information of the hand and arm. A set of goggles with the bottom half of the visual field covered were used to remove visual information of the transported object. Participants walked on the treadmill for two minutes during five experimental conditions (a control condition whereby participants placed their arm at a 90° angle without transporting an object, walking with full vision without the object vibrating, walking with the lower visual field removed without the object vibrating, walking with full visual information and the object vibrating, and walking with the lower visual field removed and the object vibrating) which were presented in a randomized order. Full-body kinematic data were analyzed and averaged over the final ten strides of each condition. Upper arm/forearm ranges and variabilities were determined from the sagittal plane angular trajectories of each segment. Arm damping was quantified using a ratio of the vertical trajectories of the trunk and the transported object. Coordination was analyzed using vector coding of the upper arm/forearm angle-angle plots to determine the percentage of the gait cycle whereby the segments moved in-phase and anti-phase. Results: Upper arm angle range did not differ statistically between conditions. However,

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there was a trend for forearm range, as well as upper arm and forearm variability to be lower during the vibration/lower visual field removed condition. Analysis of arm damping suggested the vertical range of the arm was more similar to that of the trunk in the vibration/lower visual field removed condition ($p = 0.008$). The coordination of the upper arm and forearm segments was predominantly in-phase and did not differ between conditions. Conclusions: During transport, healthy young adults adapt to the combination of absent visual information of the object and disruption of somatosensory input by fixing vertical movement of the transported object to that of the trunk. These results suggest that a feedforward control mechanism may be employed to reduce the available degrees of freedom in the presence of altered sensory information to stabilize the object during transport.

P2-Q-66: Difference of influence of intermittent blocking of visual information on walking parameters and cortico-muscular coherence between young persons and old persons

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BACKGROUND AND AIM: The automaticity of walking is a feature in healthy and well-functioning adults. However, it is still being determined how the automaticity of walking will be affected when visual information is interrupted intermittently. Therefore, this study aimed to clarify the influence of intermittent blocking of visual information on walking parameters and cortico-muscular coherence (CMC) in healthy young and old persons. METHODS: Twelve healthy young persons (age: 21.2 ± 0.8 years) and twelve old persons (age: 70.6 ± 3.2 years) living in the community participated in this study. Subjects walked a 20m 8-shaped walking path comfortably for 10 minutes. Measurement conditions were the following three conditions. The liquid crystal shutter goggle blocked the subjects' visual information with a 10 Hz blinking frequency under two conditions with 30% and 70% duty ratios. The control condition did not block visual information. Walking parameters of speed, walking rate, and step length were evaluated above the three conditions. EEG and EMG were measured during walking using a 4-channel Ganglion Board (Open BCI) at the 200Hz sampling frequency. EEG activity was recorded through unipolar silver electrodes placed at Cz by the international 10-20 system. Surface EMG electrodes of Ag/AgCl (Kendal H124SG) were placed at the proximal 1/3 of the tibialis anterior (TA) muscle of the right leg. EEG and EMG electrode impedances were kept below 5k Ohm. The Welch algorithm calculated EEG-EMG coherence (Cz-TA coherence) for Cz-TA in theta (4-8Hz), alpha (8-13Hz), beta (13-30Hz), and gamma (30-40Hz) bands (window width: 256 points, overlapping 128 points, resolution 0.78 Hz). Walking parameters and peak values of Cz-TA coherence in the four bands were evaluated in the above three conditions. Using repeated-measures ANOVA, the evaluation parameters compared no blocking and intermittent blocking with 30% and 70% duty ratios. Statistical significance was given for P-values smaller than 0.05. RESULTS: There was no significant difference in walking parameters during intermittent blocking of visual information with 30% and 70% duty ratios in young and old persons. The peak value of Cz-TA coherence in the beta band significantly decreased in young persons at intermittent blocking of visual information with a duty ratio of 70% compared to no blocking. On the other hand, the peak value of Cz-TA coherence in the beta band with the duty ratio of 30% and 70% in old persons significantly increased compared to that of no blocking. CONCLUSIONS: The peak value of Cz-TA coherence in the beta band decreased significantly in young persons and increased significantly in old persons under intermittent blocking of visual information. The difference was considered to have arisen from attentional

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demands during walking. Therefore, the peak value of Cz-TA coherence in the beta band might be a useful index for evaluating the attentional demands of walking.

P2-Q-67: Asymmetric visual cue increases gait asymmetry in healthy adults

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BACKGROUND AND AIM: Gait asymmetry--the bilateral difference of the lower extremities during walking--is commonly exhibited by people with a history of stroke or Parkinson's disease, and can lead to increased fall risk. Gait (a)symmetry is commonly altered using a split-belt treadmill--equipment that can be financially prohibitive, especially in clinical settings. As a more cost effective option, we explored the extent to which asymmetric visual cues may increase gait asymmetry in healthy adults, which could then serve as a proof-of-concept to inversely assist clinical populations. It was hypothesized that the asymmetric visual cue would increase gait asymmetries in healthy adults. METHODS: Adults (N=37, 23.82 ± 7.04 years) with no neurologic, musculoskeletal, or cognitive injuries or impairments were enrolled. Participants were quasi-randomized into a small (1.4-to-1 ratio) or large (1.9-to-1 ratio) asymmetric visual cue group, with a sample size of n=19 and n=18, respectively. The dependent variables used for symmetry index (SI) calculations were single limb support %, stance and swing %, step duration (s), and stride length (m). Opal wearable sensors (APDM) were placed on the feet, shins, lateral thighs, and low back. Participants walked at a self-selected pace on a treadmill for 10-minutes (baseline phase), then 5-minutes of rest, followed by 10-minutes of attempting to synchronize their gait to the asymmetric visual cue provided on a screen in front of the treadmill (adaptation phase). SI at the 10th minute of baseline was compared to SI at the 10th minute of adaptation for this analysis via a paired-samples t-test. RESULTS: For the small asymmetric ratio group, an increase in asymmetry was observed during the adaptation phase for the following variables (presented as M±SD): single limb support % SI (baseline: 2.95±0.72; adaptation: 3.94±1.69; p=0.014), stance % SI (baseline: 1.91±0.47; adaptation: 2.41±1.13; p=0.038), swing % SI (baseline: 3.17±0.87; adaption: 3.92±1.74; p=0.042), and step duration SI (s) (baseline3.33±1.14; adaptation: 4.35±1.80; p=0.020). A similar observation was made for the large asymmetric ratio group: single limb support % SI (baseline: 3.29±1.45; adaptation: 4.49±2.51; p=0.004), stance % SI (baseline: 1.99±0.78; adaptation: 2.69±1.28; p=0.003), swing % SI (baseline: 3.41±1.50; adaptation: 4.44±2.26; p=0.005), step duration SI (s) (baseline: 3.48, ± 1.43; adaptation: 4.78±3.15; p=0.026), and stride length SI (m) (baseline: 2.88±0.95; adaptation: 3.77±1.65; p=0.007). CONCLUSIONS: Asymmetric visual cuing can be used to alter gait symmetry in healthy adults. Further research should examine whether the increases in gait asymmetry remain once the visual cue is removed. This proof-of-concept study affords the opportunity to examine if the inverse (i.e., a symmetric visual cue leads to more symmetric gait) is adopted by clinical populations exhibiting an asymmetrical gait pattern.

P2-Q-68: Links between lifetime noise exposure, head stabilization, and conscious movement processing

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BACKGROUND & AIM: Reduced vestibular function significantly elevates fall risk. In addition to its known effects on hearing, noise exposure can damage the vestibular periphery, though it is often overlooked as a potential source of vestibular damage and thus increased fall risk.

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Three classes of vestibular afferents have been described: bouton-only, calyx-only, or dimorphic. Calyceal afferents exhibit irregular firing rates with phasic responses related to head acceleration and velocity and which tend not to saturate, even with high acceleration. The physiological properties of these afferents suggest that they are well-suited to play a role in maintaining postural stability. Indeed, these irregular afferents largely project to the spinal cord, with approximately 2/3 of inputs controlling descending vestibular reflexes arising from irregular vestibular afferents. Prior literature suggests these afferents are sound sensitive and may thus be susceptible to noise overstimulation. Recent work has shown that those at an increased risk of falls often alter their movement processing strategies, increasing their conscious movement processing (CMP), which is linked to greater attentional demands of walking and increased movement errors. In this preliminary study, we examined the effects of lifetime noise exposure on head-stabilization and CMP. METHODS: We assessed the extent of noise exposure in twenty-three individuals (11 M, age: 49.8±17.7) using the Noise Exposure Structured Interview (NESI). Each person also completed the Timed Up and Go test (TUG, clinical measure of functional balance) and was assessed for the degree of movement processing using the Gait-Specific Attentional Profile (G-SAP). During TUG, twelve of our participants we also instrumented with wireless IMUs attached to their head, chest, and right ankle (latter used for step detection) to measure head and trunk acceleration in the horizontal plane. Pitch, roll, and yaw angles were computed with respect to quiet stance and used to calculate anchoring indices (AI) to assess the stabilization strategy used: head articulated in space or rigid on trunk. RESULTS: When accounting for age and functional balance (TUG time), we found that the degree of noise exposure (NESI score) was a significant predictor of CMP ($p=0.01$, least-squares multiple linear regression). We also observed a significant interaction between NESI score and TUG time ($p=0.04$). In the subset of participants who were instrumented for the TUG, we also found that CMP was a significant predictor of head acceleration, when accounting for age, noise exposure, functional balance, and the other subscales of the G-SAP (anxiety, rumination, processing inefficiency, $p=0.04$). While not significant, we saw trends for higher head-in-space acceleration and more en bloc head stabilization strategy in pitch (lower AI) with greater lifetime noise exposure. CONCLUSIONS: Noise exposure is associated with greater conscious movement processing during walking, which in turn may lead to worse head stabilization in pitch (higher head-in-space acceleration). Additional data are needed to establish a clearer link between movement metrics and noise exposure history. ACKNOWLEDGEMENTS & FUNDING: This study was supported by NIH grant R01AG073157

P2-Q-69: Assessing balance in patients with bilateral vestibulopathy with the Mini-Balance Evaluation Systems Test (Mini-BESTest)

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Background and aim: Bilateral Vestibulopathy (BVP) leads to unsteadiness when walking which worsen in darkness and/or on uneven ground and oscillopsia when movement. A previous review concluded that clinical balance tests that challenge multiple aspects of balance should be investigated, since simple tests struggle to distinguish between BVP and healthy participants1. Our aim was (1) to test if the more comprehensive Mini-BESTest is feasible in BVP, (2) to examine how patients perform in terms of their overall and subcomponent scores and (3) to compare these scores with healthy reference data from the literature. Methods: 50

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participants with BVP completed the Mini-BESTest as part of a larger study. The Mini-BESTest has 4 components: anticipatory, reactive postural control, sensory orientation and dynamic gait. It comprises 14 items and each is scored from 0 (unable to perform) to 2 (normal performance) with a maximum score of 28. To compare the overall and sub-scores between our patients with BVP and those of healthy participants from the literature (n=327)2-9, Mann-Whitney U tests were used. Spearman correlations were used to investigate the relationships between Mini-BESTest score and age. Results: Patients with BVP had significantly lower Mini-BESTest total scores than the healthy group (BVP mean=20.8, Healthy mean=24.2, U(NBVP=49, NHealthy=327)=4564.00, p<0.001). 3 subscores of the Mini-BESTest (anticipatory, reactive postural control, sensory orientation) were significantly lower in BVP (U(NBVP=50, NHealthy=190)=2364.50, p<0.001, U(NBVP=50, NHealthy=190)=3737.00, p=0.028 and U(NBVP=50, NHealthy=190)=1223.50, p<0.001, respectively), while the dynamic gait subscores were not significantly different (U(NBVP=50, NHealthy=190)=4374.50, p=0.367). A stronger negative correlation between age and Mini-BESTest total score was found in the BVP group (ρ = -0.67; 95% CI: -0.74 to -0.35; p < 0.001) than in the healthy group (ρ = -0.32; 95% CI: -0.32 to -0.11; p < 0.001). Conclusions: Our findings illustrate that the Mini-BESTest can be used with patients with BVP and confirm the commonly reported balance deficits in BVP, specifically deficits related to anticipatory, reactive postural control and sensory orientation Mini-BESTest subscores. The negative association between age and balance was stronger in BVP, perhaps related to the age-related decline in the remaining functional sensory systems with which people with BVP compensate. References: 1.Herssens et al. 2020. doi: 10.1093/ptj/pzaa083 2.Naghdi et al. 2020. doi: 10.1007/s40120-020-00207-2 3.Santos & Duarte 2016. doi: 10.7717/peerj.2648 4.Harro et al. 2019. doi: 10.1519/JPT.0000000000000175 5.Akizuki et al. 2018. doi: 10.1589/jpts.30.1086 6.Dominguez-Olivan et al. 2020. doi: 10.1186/s12877-020-01724-3 7.Godi et al. 2021. doi: 10.1093/ptj/pzab180 8.Kim et al. 2017. doi: 10.1186/s12984-017-0225-2 9.Nakhostin-Ansari et al.2022.doi:10.1080/09593985.2020.1822967

P2-Q-70: Towards postural control simulation using a sensorimotor enhanced musculoskeletal human model

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BACKGROUND AND AIM: Dysfunctions in postural control are a typical symptom of neurodegenerative disorders like Parkinson's disease. Simulating postural control with biomechanical human models can help to investigate human body's internal processes to maintain balance. We aim to develop a neuromusculoskeletal model on a physiologically plausible basis to simulate postural control during walking and standing that represents control of healthy persons, as well as persons suffering from Parkinson's disease. METHODS: Current literature shows various approaches to simulate postural control for standing and walking, where for the control P- (e.g. [1]), PD- (e.g. [2]), PID-controlled models (e.g. [3]), reflex-based models (e.g. [4]), or models using optimal control methods like linear quadratic regulators (e.g. [5]) are used, while model predictive control [6] is applied as well. Reflex-based and PD-controlled models are prevalent when the body is represented using a musculoskeletal model. RESULTS: The concept of our new postural control model uses body's sensory information to describe sensible body's self-perception. Our model concept includes proprioceptive as well as vestibular and visual information and a central processing of this information. A controller

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uses this processed sensory information to initiate movements that keep the body in balance. During walking movements balance control is combined with a predefined motion plan. To be able to show characteristic postural control of persons suffering from Parkinson's disease as well, the model has to be able to simulate an impaired self-perception. CONCLUSION: To characterize postural control and to determine free control parameters of our model we use experimental motion capture data we are conducting at the university hospital Erlangen, Germany, including healthy subjects and persons suffering from Parkinson's disease. The next step is the implementation and validation of our new postural control model by comparing predicted with these experimentally assessed human motions. Parameters have to be found that differ between physiological and pathophysiological postural control. For this identification we apply machine learning algorithms. Such models on a physiological plausible basis could subsequently give insights into the differences of physiological and pathophysiological postural control behaviour enabling us giving therapy recommendations or optimizations to patients suffering from postural control disorders in the future. ACKNOWLEDGEMENTS AND FUNDING: This work was funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) - SFB 1483 - Project-ID 442419336, EmpkinS. REFERENCES: [1] M. Günther, H. Wagner, 2016. Comput. Methods Biomech. Biomed. Engin. [2] V. Joshi, M. Srinivasan, 2019. J. R. Soc. Interface. [3] A.D. Goodworth, R.J. Peterka, 2009. J., Neurophysiol. [4] H. Geyer, H. Herr, 2010. IEEE Trans. Neural Syst. Rehabil. Eng. [5] H. Van Der Kooij, et al., 1999. Biol. Cybern. [6] Z. Aftab, et al., 2016. PLoS One.

P2-Q-71: Assessment of proprioception with deep learning based motion capture (DeepLabCut)

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BACKGROUND AND AIM: Sensory deficits are common in neurological disorders. Proprioception is an example of a sensory system that could be impaired. In clinical populations, proprioception is preferably assessed as easily as possible. Techniques based on deep learning to precisely track body landmarks in simple video recordings are promising to analyze movement in clinical settings, outside the laboratory and without the need to attach markers. This study aims to validate deep learning based motion capture (DeepLabCut) with respect to laboratory-based 3D optoelectronic motion capture (gold standard) to assess proprioception by measuring the Joint Reproduction Error (JRE) during a knee joint position sense test[1]. METHODS: Proprioception was assessed with the eyes closed during 58 knee position sense tests of 12 typically developing children (5 girls, 7 boys, mean age 8.7 ± 1.1 years old, mean BMI 16,8 ± 2,6 kg/m2) by determining the absolute difference between the criterion and reproduced angle (JRE, in °). The joint angles were determined with 2 setups; 1) 3D optoelectronic motion capture (Vicon, 10 cameras) using the ISB lower limb marker model[2] (26 markers), and 2) 2D deep learning based motion capture (DeepLabCut[3,4]) in sagittal video files using the pre-trained human model (MPII) with 10 manually labeled frames. Negative knee JREs correspond to a greater reproduced angle compared to the criterion angle. Linear mixed models were used to assess differences in JREs between DeepLabCut and Vicon. In addition, the mean knee JRE was calculated per subject and compared between Vicon and DeepLabCut using an paired t-test. RESULTS: There was no significant difference in the knee JRE measured with Vicon (-4,54°) and the knee JRE measured with DeepLabCut (-4.20°) ($F=0.09$, $p = 0.77$) (Figure 1). The mean JRE over repeated trials per subject determined by using Vicon was not significantly different from the mean JRE determined by

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using DeepLabCut (t(11) = -1.19, p = 0.26). CONCLUSIONS: Measuring the knee JRE with DeepLabCut seemed valid with respect to the gold standard in typically developing children. Further research is needed and ongoing to assess the validity of DeepLabCut to measure the JRE in other joints than the knee (such as the ankle and the hip) and assess the reliability of measuring the JRE with DeepLabCut. Furthermore, we are working on validation of DeepLabCut to assess proprioception using the joint position sense tests in children with Cerebral Palsy (CP). Deep learning based motion capture techniques could facilitate the implementation of proprioception assessment in clinical settings as there are no markers and no laboratory setting needed. REFERENCES: 1. Baert I. et al. 2013. 2. Wu G. et al. 2002 3. Mathis A. et al. 2018 4. Nath T. et al. 2019

P2-Q-72: Vestibular and visual impairments and the associations with walking and movement limitations in people with Multiple Sclerosis

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Background and aim: Vestibular impairments in people with Multiple Sclerosis (MS) are often reported as symptoms of dizziness, and/or visual symptoms and can have a marked negative impact on quality of life. Vestibular dysfunction and visual symptoms in MS have been associated with reduced balance while walking. However, detailed vestibular function has not been linked to gait and balance performance and the majority of studies have investigated a heterogenous population with wide-ranging disability levels. The aim of this study was to investigate vestibular and oculomotor manifestations in people with MS and explore relationships with measured and self-reported gait parameters, balance confidence and MS impact, in a whole cohort and high and low gait disability subgroups. Methods: A prospective observation study was conducted with 41 people diagnosed with MS by a neurologist who were ambulant. All participants attended one test session. Oculomotor and vestibular function was recorded for post viewing, using a binocular video capture system embedded within the micromedical visualeyes V505, video frenzels (Interacoustics). This included oculomotor (eye-movements) and vestibular (Dynamic Visual Acuity, semi-circular canal gain, subjective visual vertical) measures. Vestibulo-ocular reflex (VOR), function (gain) was captured for the 6 semi-circular canals using the Video Head Impulse Test digital assessment tool (ICS Impulse) and dizziness with the DHI. Gait speed (Timed-10m-walk), gait balance (Timed Up and Go), endurance (6-Minute walk test) and self-reported gait (Multiple Sclerosis Walking Scale-12), balance confidence (Activity Balance Confidence Scale) and MS impact (Multiple Sclerosis Impact Scale-29) were recorded. Gait disability was rated using the Disease Step Rating Scale (DSRS), dividing participants into high and low disability subgroups (DSRS 0-2 vs 3-5). Correlations were explored for the whole cohort and subgroups. Results: Few significant relationships were identified-for the full cohort, however the less disabled subgroup showed more and stronger correlations for dizziness and semi-circular canal gains to gait speed and balance (r2 range -0.39 to -0.49; $p<0.37$), oculomotor to gait measures (r2 range 0.40 to 0.58; $p<0.05$) and dizziness to self-reported gait, balance and impact (r2 range -0.68 to 0.50; $p<0.05$). Different and stronger correlations were identified for the more disabled subgroup for the semi-circular canal gain to gait balance (r2 range -0.53 to -0.61; $p<0.42$) and self reported balance confidence (r2 0.54 & 0.70; $p<0.03$). Conclusion: Disability level had an effect on the correlations between vestibular and oculomotor function to clinical/self-reported gait and balance. Vestibular and oculomotor impairments are important to measure in people with MS

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as they vary by disability level. Addressing these impairments may influence gait/balance function as they are often related.

Tools and assessment methods

P2-R-73: Gait kinematics of Sarcoma patients at 1 year post-operative internal hemipelvectomy surgery: A retrospective study

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Background and Aim: Gait deviations are commonly seen in clinics in sarcoma patients who undergo internal hemipelvectomy (IH). To assess the effectiveness of the surgery and rehabilitation, the objective examination of gait deviations is crucial, but lacking. The Gait Profile Score (GPS) and the Gait Variable Score (GVS) were developed in order to summarize the kinematic gait data. The main purpose of this study was to investigate the feasibility of capturing these scores in this patient population and understand its clinical value. Methods: This is a retrospective cross-sectional pilot and feasibility study (Ethics approval: 21/WA/0027) of 10 patients who underwent IH for a sarcoma diagnosis one year ago. Data from Gait Real-time Analysis Interactive Laboratory (GRAIL) was analysed to measure GPS, GVS and gait speed. A normative GPS score was calculated using the kinematic data of controls, whereas individual scores were quantified for patients. GPS and gait speed were compared between patients and controls using Mann-Whitney U test. Spearman's correlations were used to study relationships between GPS and gait speed and GPS and the disease-specific 'Toronto Extremity Salvage Score (TESS)' scores. Results: The mean age of our patients were 41.5±11.77 years. Median GPS values for the patients and healthy individuals were 10.36˚ (8.15˚ to 14.62˚) and 1.22˚ respectively (Fig. 1) and these differences were statistically significant ($p<0.01$*), indicating gait abnormalities can be identified using the GPS, a single score. The GVS further helped this understanding by emphasising that the hip, pelvis, knee, and ankle were compensating. Gait speed was also found to significantly affected in patients [0.70 m/s (0.62 to 0.91 m/s)] compared to controls [1.2 m/s] ($p<0.05$*). Although correlations between the GPS and gait speed and GPS and TESS were not found to be statistically significant ($r= -0.465$, $p= 0.176$), the negative correlations were clinically sensible. Conclusion: This is the first study showing that GPS and GVS is feasible to capture in patients who underwent IH for a sarcoma. GPS identified patients struggling with gait abnormalities, whereas GVS identified compensations during gait. These objective scores can guide rehabilitation assessments and management in busy clinics. GPS and TESS scores can be used in combination to provide clinicians with objective as well as subjective prognoses of a patient and further studies with a larger sample size will be needed to confirm the usefulness and clinical applications of GPS and GVS.

P2-R-74: Assessing the effect of relevant and irrelevant visual information during visual feedback tasks in relation to the base of support width

Lucas Michaud[1], Alexandre Perreault[1], Anne-Sophie Mayer[1], Marc-Olivier Sauvé[1], Renée Desjardins[1], Yves Lajoie[1]

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BACKGROUND AND AIM: Visual feedback (vFb) of one's centre of posture (COP) displacement generally tends to improve postural control. Typically, when using vFb, participants are explained how it can help them improve their posture. However, in a recent publication looking at trunk sway in a seated position, Goodworth et al. (2020) found that, without explicit information about the vFb (i.e., what it was), an accurate vFb reduced sway while an erroneous vFb (i.e., random motion) increased sway. More recently, we found similar results (unpublished) in a feet together standing position. Considering that this feet position might be unnatural and more difficult due to the reduced base of support, the objective of this experiment was to assess the effect of accurate and erroneous vFb in a wider (and easier) stance. METHODS: Eighteen young adults (22.06 ± 2.34 years) were asked to stand on a force platform (100 Hz) for 60s trials while looking at an eye-leveled screen. Trials were performed in a randomized fashion with feet together and feet at shoulder width, under three visual conditions (no vFB, accurate vFB and erroneous vFB). Each condition was performed five times. At no time in the experiment, participants were told what they were looking at. They were told that the visual information "could or couldn't help them stand as still as possible". In the accurate vFb condition, their COP displacement was displayed in real time on the screen while in the erroneous condition, the COP from a previous trial was displayed on the screen. Nonlinear (sample entropy) and linear (area of the 90% confidence interval and standard deviation) measures of the COP were assessed. Two-way repeated measurements ANOVAS (feet position / visual tasks) were performed. RESULTS: After questioning, 7/18 participants did realize that vFb were sometimes non-accurate. Results suggested that a wider stance reduced sway in mediolateral, but only sample entropy in mediolateral showed a significant interaction. Erroneous vFb increased postural sway (higher variability and area) compared to an accurate vFb or no vFb. The COP signal was also, in general, more irregular (higher sample entropy) during the good vFb condition compared to the other conditions. CONCLUSIONS: Results suggest that even without the knowledge of what the visual feedback represents, participants exhibit worse control (higher sway) with an erroneous vFb compared to an accurate vFb. These effects were also present with a larger stance width (i.e., feet at shoulder width). These results might suggest that the central nervous system unconsciously uses the visual cues available to control our posture, whatever the meaning of the visual information. These results could eventually provide useful information in our understanding of the visual system in the control of someone's posture. ACKNOWLEDGEMENTS AND FUNDING: Primary author has the NSERC Postgraduate Scholarship.

P2-R-75: Modifying gait with mixed-reality cues: a greater field of view improves interaction with nearby obstacles and stepping targets

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BACKGROUND AND AIM: The HoloLens, a wearable mixed-reality headset, can be used to provide holographic visual context in the real environment. We have used it to help alleviate freezing of gait in individuals with Parkinson's disease by presenting 2D and 3D holographic cues onto the ground with the very first generation of HoloLens [1]. Although effective for individuals with long and/or many freezing episodes, we also noted that excessive head rotations were required to get holographic cues nearby the feet into view, related to the limited mixed-reality field of view (FOV) of HoloLens 1. The second-generation HoloLens, HoloLens 2, has an enlarged mixed-reality FOV (Figure 1). In this study we aimed to investigate the effects

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of mixed-reality FOV on head orientation and gait-modifying effects when interacting with nearby 2D holographic stepping targets and 3D holographic obstacles. METHODS: 16 healthy middle-aged adults walked over a walkway with 2D stepping targets and a 3D obstacle, both real (using a projector and hurdle, as in [2]) and holographic (using comparable digital images presented with HoloLens 1 or 2) while wearing either HoloLens 1 or 2 to measure headset orientation and position. They also looked at nearby and far real and holographic 2D stepping targets from a standing position. In addition, a pilot study was performed with 11 individuals with Parkinson's disease on the gait-modifying effects of holographic stepping targets with different inter-target distances, and differences therein between headsets. RESULTS: Middle-aged adults oriented their heads more downwards with HoloLens 1 compared to HoloLens 2 when looking at nearby holographic stepping targets, a difference not found for holographic stepping targets farther away. A greater initial downward head orientation was observed for walking on holographic stepping targets with HoloLens 1 compared to HoloLens 2. A greater overall downward headset orientation was observed when approaching a single holographic 2D stepping target or 3D obstacle with HoloLens 1 than with HoloLens 2. During all tasks, greater downward head orientations were found when interacting with nearby holographic objects than with comparable real objects. No differences in gait-modifying effects were observed between headsets: individuals with Parkinson's disease varied their step length with intercue distances, yet with more natural head orientations when holographic cues were presented through HoloLens 2. CONCLUSIONS: Mixed-reality glasses are evolving in the right direction for interacting with holographic objects nearby the feet, for which we observed required head orientations getting closer to the head orientations seen when interacting with comparable real objects. This will probably enhance the efficacy of applications utilizing holographic content nearby the feet, such as cueing applications to assist gait in individuals with Parkinson's disease or gait-and-balance training with holographic obstacles or stepping targets onto the ground. References: [1] Geerse DJ, Coolen B, van Hilten JJ, Roerdink M. Holocue: a wearable holographic cueing application for alleviating freezing of gait in Parkinson's disease. Front. Neurol. 2022;12:628388. [2] Coolen B, Beek PJ, Geerse DJ, Roerdink M. Avoiding 3D

P2-R-76: How many trials and participants do we need to assess gait variability?

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BACKGROUND AND AIM: This study aims to provide recommendations for the number of trials and participants to achieve a statistically robust assessment of gait variability, which is commonly used as an index of consistency or stability of locomotion. While previous studies have used variance and standard deviation to quantify variability, statistical power analysis has only been applied to determine the number of subjects. Here in this study, we seek to establish a statistical framework that combines the number of trials and participants needed to achieve adequate statistical power for gait variability assessment. METHODS: Through numerical simulation, we calculated the statistical power required for assessing gait variability by considering the number of trials, number of subjects, and expected differences in variability. First, we assumed that the data distribution for each trial followed a normal distribution with specified variance values for each group or condition. Then, the distribution of the unbiased variance can be modeled as the chi-squared distribution with n-1 degrees of freedom, where n is the number of trials. When conducting between-group comparisons, such as young versus elderly, we used the Mann-Whitney U test to compare the observed variances for the two

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groups. For within-subject between-condition comparisons, such as single-task versus dual-task, we compared the proportion of variances for both conditions, which followed the F distribution, with 1. We set a population variance of 1.0 for one group/condition and 1.05, 1.1, 1.2, 1.5, or 2.0 for the other group/condition as an alternative hypothesis. We conducted 10,000 simulations and defined statistical power as the proportion of trials in which the statistical test revealed a significant difference. Finally, we report the minimum number of combinations of the number of trials and participants required to ensure statistical powers of 0.8, 0.9, or 0.95. RESULTS: The recommended numbers of trials and participants were in a trade-off relationship. For example, if we assume the population variance (i.e., variance in step length, width, duration, or other measures) is 1.2 times larger in the elderly group than in the young group, a research design that measures 100 steps during treadmill walking for 12 subjects in each group would be feasible. On the contrary, overground gait tasks or postural tasks might pose a practical constraint that limits the maximum number of trials to 20. In such cases, 55 subjects per group would be needed to detect a 1.2 times difference in variance, or instead, 13 subjects per group would be sufficient to detect a 1.5 times difference in variance with a power of 0.8. CONCLUSIONS: Our study provided the recommendation of the number of trials and the number of participants that will satisfy an expected power to detect an expected difference in gait variability.

P2-R-77: Advances in mobility aid use reporting: situational context and objective measurement improve understanding of daily aid use in older adults

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Background: Understanding mobility aid use has implications for falls risk reduction, therapeutic intervention, and aid prescription. However, it is typically measured as a yes or no self-report which limits understanding of aid use and the ability to improve utility of mobility aids. This study examined two novel approaches to evaluate mobility aid use and dependence among older adults using an augmented self-report questionnaire and wireless inertial sensors. Methods: Data from two cross-sectional observational studies of mobility were used. Within the first study, 190 older adults (86 ± 5 years) completed an aid use questionnaire that detailed aid dependence by reporting situations in which aids were utilized. Performance on tests of standing, sit-to-stand, walking, grip strength, and self-reported fear of falling, were compared to self-reported aid dependence levels anchored to situational use (0= no aid to 4= high dependence). In the second study, a group of 20 older adults (90 ± 4 years) living in retirement care had walking behaviours monitored continuously for seven days with accelerometers mounted to their ankle, wrist, and aids to compare objective (total time using aid, aid use per walking bout length) and subjective aid use. Results: Physical performance scores and fear of falling, differed between aid and non-aid users (yes/no report) (all $P<.05$). However, comparisons between levels of situational aid dependence highlighted heterogeneity between aid users. Continuous monitoring revealed significant differences in daily walking behaviour and objective aid use when categorized by subjective aid dependence and walking bout length ($P<0.05$). The frequency of walking bouts (rho=-0.47, P=0.038) and proportion of aid use time (rho=.72, P=0.002) were significantly associated with reported aid dependence. Conclusions: Binary aid use reporting fails to identify important individual differences in walking and aid use behaviors. Enhanced subjective aid use reporting and objective measurements of walking and aid use can improve aid prescription and inform intervention to support safe and effective mobility in older adults.

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P2-R-78: Comparison of marker- and markerless-derived lower limb joint angles in unimpaired children during overground gait

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BACKGROUND AND AIM: The recommended clinical assessment of a child's gait pattern requires expert placement of markers in accurate anatomical locations, applied with double-sided tape on the skin. This assessment is time consuming, requires minimal clothing, can be uncomfortable for the child and might lead to unnatural gait patterns. Markerless technologies have the potential to resolve these known limitations. Theia3D is a deep learning algorithm-based approach to markerless motion capture which uses deep convolutional neural networks for feature recognition (humans and human features) within collective 2D camera views [1]. Previous findings in unimpaired adults demonstrate comparable Theia3D-derived and marker-derived gait patterns [1], but it is not known if there is a good match in unimpaired children. The aim of this study was to determine whether Theia3D-derived lower limb gait patterns in unimpaired children are closely comparable to traditional marker-derived gait patterns. METHODS: Ten unimpaired children (age 6-13 yrs) completed three barefoot overground gait trials at a self-selected speed along an 8-metre walkway. Reflective markers were attached to the skin of children according to the conventional Helen-Hayes model [2]. A 10-camera marker-based system (Oqus, Qualisys) and 7-camera markerless system (Miqus, Qualisys) captured synchronized data at 85Hz using Qualisys Track Manager (Qualisys AB). Video data were processed using Theia3D (Theia Markerless Inc., v2022.1.0,2309), from which 4x4 pose matrices of each body segment were generated. Subsequently, the tracked marker trajectories and the markerless-derived data were exported for analysis in Visual3D (C-Motion, USA). Kinematic-based gait events were used to obtain multiple time-normalized gait cycles per trial. Lower-limb sagittal plane joint angles at the hip, knee and ankle were then compared for matching marker- and markerless-derived gait cycles, by calculating the average root-mean-square deviation (RMSD) across all children. RESULTS: Data from all children were included in the analysis, using a mean of 17 gait cycles per child (range 10 to 25). Comparable patterns and ranges for flexion/extension were observed for each joint. The average (±1SD) RMSD between corresponding sagittal plane joint angles at the hip (5.5±2.6°), knee (6.1±2.5°) and ankle (6.1±2.7°) indicated the estimates from both systems were very similar. CONCLUSIONS: Our findings comparing marker- and markerless-derived gait patterns in unimpaired children are promising, and similar to or better than previously reported differences at the hip (11°), knee (3.3°) and ankle (6.7°) in unimpaired adults [1]. Future comparison of frontal and transverse plane joint angles will help to determine whether Theia3D can be a suitable alternative for capturing 3D gait patterns in unimpaired children. Markerless motion analysis has the potential to be beneficial to clinical, patient-focused assessments because it removes the need for placing markers and thus reduces the time and expertise required. It could allow children to walk more naturally while their joint movements are captured, which is vital for valid clinical assessment. REFERENCES: [1] https://doi.org/gmjfr8, [2] https://doi.org/b2bdww

Poster Session 3

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Affect (e.g. Fear of falling, depression)

P3-A-1: Trait anxiety can predict gait behaviour under conditions of postural threat

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BACKGROUND: Under conditions of postural threat, individuals experience state anxiety which often manifests as heightened fear and nervousness. Prior research has shown that both young and older adults tend to adopt a "cautious" walking pattern as exhibited through slower and smaller steps during postural threat. Interestingly, stable aspects of one's personality, such as trait anxiety, even in the absence of threat, have been shown to reduce gait speed in clinical populations. However, little work has been conducted studying whether this same effect is observed on young, healthy adults. While trait anxiety has been noted to increase feelings of nervousness when under conditions evoking state anxiety, there remains a gap in the literature regarding its impact on gait behaviour. AIMS: This study investigated whether trait anxiety levels predict gait behaviour while walking in i) a virtual reality (VR) environment in the absence of threat; and ii) a VR environment under conditions of postural threat. METHODS: This study used a repeated measures design where thirty neurotypical adults aged 19-28 completed five walking trials across a 6m ZENO pressure sensor carpet under two different VR-stimulated threat conditions. Double limb support %, step length variability (%CV), and velocity were the primary outcome measures. All participants started in the low threat condition (walking across a plank located on flat ground) and then completed the high threat condition (walking across a plank elevated over a deep pit) to maximize perceived effects of threat. Trait anxiety levels were determined using the State Trait Anxiety Inventory prior to commencing walking trials, while self-reported situational (state) anxiety was monitored after each trial using self-assessment manikins. RESULTS: Related samples Wilcoxon signed rank test showed that self-reported anxiousness was increased in the elevated condition (score: 3.1 ± 1.9) compared to the ground condition (score: 1.5 ± 1.0) ($p<0.001$). Univariate linear regression models revealed that trait anxiety was not a strong predictor of velocity ($p=0.860$), time in double support ($p=0.310$), or step length variability ($p=0.226$) when walking under conditions of low threat. However, higher trait anxiety levels predicted reductions in velocity ($p=0.007$) and an increase in time spent in double support ($p=0.014$) when walking at elevation compared to the ground. CONCLUSIONS: Threat manipulations were successful in inducing state anxiety due to increased ratings of self-perceived anxiousness in the high threat compared to low threat conditions. Overall, under conditions of postural threat, individuals with higher trait anxiety may adopt a cautious gait pattern to avoid falling. However, when simply walking in the absence of threat, trait anxiety does not predict gait behaviour in young, neurotypical adults. These findings highlight the impact of state anxiety on mediating trait anxious gait behaviours potentially through an increased cognitive load from arousal. Future studies should further examine how cognitive load may be altered under conditions of postural threat in trait anxious individuals to improve gait efficiency.

P3-A-2: Emotional intervention affects fluctuation of the ankle joint

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BACKGROUND AND AIM: Previous studies revealed that emotional state could influence postural control using affective pictures or movies. Most of them reported smaller postural sway using center of pressure (COP) while facing unpleasant contents. COP is proportional to the ankle joint torque; therefore COP can provide the postural strategy of the ankle joint. However, movements of the hip and knee joints are not negligible in quiet standing. In the current study, we aimed to clarify differences of quiet standing control in terms of multi-joint movements during the emotional intervention and focused on the fluctuation of the joint angles and torques of the ankle, knee, and hip joints. METHODS: Twenty-two healthy males (20-37 yr) participated in this study. Emotional states can be represented as a two-dimensional model of valence and arousal. We set six conditions composed of three valences (pleasant, neutral, and unpleasant) and two arousals (high and low). The participants were asked to stand on a force plate with their feet shoulder-width and to look at a monitor placed at 1 m in front of them. The experiment consisted of 6 blocks, and each block started with a 60 s fixation cross followed by a 72 s intervention. In the intervention, the monitor displayed 12 affective pictures for 6 s each. Kinematics data were collected with motion capture. The angle in the sagittal plane of the ankle, knee, and hip joints during the intervention phase were calculated. Standard deviations (SDs) of each joint angle and torque were evaluated as the amplitude of angular displacement and fluctuation of the joint torque. RESULTS: The SD of the ankle joint angle was significantly affected by valence. The mean±sd of unpleasant, neutral, and pleasant were 0.209±0.16, 0.221±0.13, 0.254±0.19 [deg], respectively. The post-hoc tests revealed that the value was significantly lower in unpleasant than that in neutral ($p<0.05$) and pleasant ($p<0.05$). In addition, the SD of the ankle joint torque was significantly influenced by valence. The mean±sd of unpleasant, neutral, and pleasant were 1.851±0.99, 2.144±1.48, 2.209±1.24 [N・m], respectively. The post-hoc tests revealed that the value was significantly lower in unpleasant than that in pleasant ($p<0.05$). CONCLUSIONS: Our results suggest that smaller postural sway in the unpleasant state observed in previous studies is mainly attributed to the smaller fluctuation of the ankle joint. Also, the ankle joint torque in unpleasant was more constant than that in unpleasant. The current study would lead to a better understanding of the association between emotion and motor functions.

P3-A-3: Postural misperception: a biomarker for persistent postural perceptual dizziness

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BACKGROUND AND AIM: Persistent postural perceptual dizziness (PPPD) describes a persistent sensation of dizziness and/or unsteadiness (without vertigo) aggravated by upright posture that generates increased postural sway. Here, we introduce a novel measure of perceived instability to investigate the relationship between observed sway and perceived instability in patients with PPPD compared with patients with persistent 'objective' instability due to bilateral vestibulopathy (BV). METHODS: 19 individuals with PPPD, 10 disease controls with BV (confirmed with objective vestibular function testing) and 10 healthy controls were recruited. PPPD patients were randomly allocated to an 'intervention' (n=7) and 'no intervention' group (n=12). Observed sway was measured over three 20s trials of quiet standing with eyes closed on a force plate. Controls stood on foam to increase instability. Participants firstly verbally rated their perceived instability during the observed sway measurements using a 0-10 ranked scale (0='completely steady'; 10='so unsteady that I would

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fall'). Second, participants replicated their perceived instability by moving their body how they thought they were swaying during the observed sway measurements ('move your body how you felt you were moving during the trial'). This perceived (termed 'reproduced') instability was quantified in an identical manner to the observed sway measurements except with eyes open. We computed the observed:reproduced sway ratio and reasoned it should equal one if perceived instability was accurately replicated. PPPD participants in the intervention group were shown a video recording of themselves during the observed sway measurements, plus their CoP trajectories. The discordance between perceived and actual sway was highlighted and an explanation for this in relation to PPPD given. The observed, perceived and reproduced instability measurements were then repeated. RESULTS: Observed sway tended to be less in PPPD than BV patients ($p=0.077$) but, despite this, PPPD patients perceived significantly greater instability than BV ($p=0.003$; Fig 1A). Reproduced sway was proportionate to observed sway in healthy controls and BV (ratio v one: $p>0.375$, i.e. ratio=1; Fig 1B,D-F) but not in PPPD where reproduced sway was on average double observed sway (ratio v one: $p<0.001$, i.e. ratio>1; Fig 1B,C,F). The intervention reduced perceived and reproduced instability ($p<0.031$; Fig 1A,C,F). CONCLUSIONS: Individuals with PPPD perceived instability incongruent with observed sway that represented a twofold misperception and was not apparent in patients with objective instability due to BV and healthy controls, made unstable by standing on foam. Our simple intervention suggests it is possible to reduce, at least transiently, the perception of sway in PPPD by providing visual feedback of actual sway. Future biomarkers of PPPD should include measures of perceptual impairment, rather than only observed sway, where differences between PPPD and even healthy controls are inconsistent.

Ageing

P3-B-4: Age-related changes to the contribution of plantar flexion strength and velocity as determinants of gait speed

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BACKGROUND AND AIM: The plantar flexion function is central to the push-off during gait and contributes significantly to forward propulsion. However, age-related changes in the mechanical output of gait result in a distal-to-proximal shift and a decrease in ankle plantar flexion work. Hence, the significance of plantar flexion function as a determinant of gait speed may decrease with aging in older adults. This study investigated the age-related changes in the contribution of plantar flexion function to gait speed. METHODS: A total of 527 community-dwelling older adults were classified into two age groups: the young-old group (aged 65-74 years) and the old-old group (aged≥75 years). The maximum gait speed and plantar flexion function (maximum muscle strength and maximum movement velocity) were assessed. The maximum isometric muscle strength was evaluated using a handheld dynamometer. The angular velocity measured using the gyroscope when the participant performed plantar flexion as quickly as possible under a no-load condition in a seated position is considered the maximum movement velocity. The differences in gait speed and plantar flexion function

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between the groups were analyzed using the unpaired t-test. Furthermore, we conducted multiple regression analyses separately for each group, with gait speed as the dependent variable and plantar flexion strength and velocity as the independent variables. RESULTS: The young-old group comprised 321 individuals (98 males and 223 females), and the old-old group included 206 individuals (101 males and 105 females). Gait speed (young-old: 1.88±0.28 m/s, old-old: 1.75±0.28 m/s), plantar flexion strength (young-old: 51.7±18.0 kgf, old-old: 48.0±15.7 kgf), and plantar flexion velocity (young-old: 721.2±139.2 °/s, old-old: 655.6±124.3 °/s) were significantly higher in the young-old group than in the old-old group. In the young-old group, plantar flexion strength (standardized β=0.31) and plantar flexion velocity (standardized β=0.26) accounted for 19% of the variance in gait speed (adjusted R^2=0.19, $p<0.01$). In the old-old group, plantar flexion strength (standardized β=0.47) and plantar flexion velocity (standardized β=0.26) contributed to 29% of the variance in gait speed (adjusted R^2=0.29, $p<0.01$). CONCLUSIONS: This study highlights that the plantar flexion function determines the gait speed more significantly in the old-old group than in the young-old group. These findings indicate that despite the decline in the plantar flexion work rate in forward propulsion generation with aging, the plantar flexion function remains an important determinant of gait speed. Moreover, the study revealed that the significance of plantar flexion muscle strength increases substantially in the old-old group as compared to the young-old group. Therefore, we conclude that interventions to improve the plantar flexion function, particularly muscle strength, are crucial to maintain and enhance gait speed in old-old adults.

P3-B-5: Gait phase-specific linear and angular momentum generation during 90-degree left turns in healthy older adults

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BACKGROUND AND AIM Turning while walking requires managing two transverse-plane mechanical objectives: changing direction of travel and changing body-facing direction. These are accomplished via control of transverse-plane linear momentum and angular momentum about the vertical axis, respectively. We recently found that young adults performing straight-line gait and turns generated leftward linear momentum more during right single support, and generated leftward angular momentum about vertical more during left double support [1]. However, it is not known if healthy older adults use this pattern of momenta generation. Therefore, the purpose of this study is to understand how healthy older adults generate linear and angular momentum within each gait phase during 90-degree left turns. We hypothesized that, similar to young adults [1], older adults will generate more linear momentum in the new direction of travel (leftward) during right single support, and more angular momentum to rotate the body (leftward) during left double support vs. each other gait phase. METHODS Nine (2 m 7 f) healthy older adults (mean (s.d.); 71 (6) yrs) with no falls in the prior 6 months participated in this study. To record their whole-body kinematics, reflective markers were affixed to 15 segments (250 fps, Optitrack). Participants performed 10 m straight-line gait 5 times and left turns 10 times (Fig 1A). We computed the change in linear momentum in the new direction of travel, global -X (ΔPx), and the change in angular momentum about the global vertical axis towards the turn (ΔHz) in each of four gait phases (left and right single and double support). For trials where more than one occurrence of a gait phase occurred (as in Fig 1A), the average ΔPx and ΔHz were computed for each gait phase. Sign tests were used to compare ΔPx and ΔHz at a group-level between gait phases for straight-line gait and turns (alpha=0.05). RESULTS Right single support phase generated the largest ΔPx compared to each other gait

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phase in straight-line gait and turns ($p<0.04$, Fig 1B). Left double support phase generated the largest ΔHz compared to each other gait phase in straight-line gait and turns ($p<0.04$, Fig 1C). CONCLUSION Linear momentum was generated more in the new direction of travel during right single support, and angular momentum was generated more in the direction of the turn during left double support. Thus, despite young and older adults using a varying number of steps for a 90-degree left turn (3-5 and 3-6 steps, respectively), both age groups may leverage momenta generation strategies during turns that are used during straight-line gait [1]. Future work will focus on identifying the advantages of linear and angular momenta generation during right single and left double support phases, respectively. This understanding can lead to targeted treatments for balance impaired populations. REFERENCES 1. Tillman et al., 2023. Sci Reports. In press.

P3-B-6: The influence of motion data filtering methods in gait analysis

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Background: Gait analysis is vital for balance assessment, fall risk prediction, disease diagnosis, and rehabilitation. However, the raw motion data always contains artifacts created and data filtering is necessary before gait analysis. A fourth-order low-pass Butterworth filter with a cutoff of 6 Hz is optimal for the filtering of motion data, and this filter could be considered a "standard" for gait analysis. While other studies suggested different parameters (order and cutoff) for the Butterworth filter. Chebyshev filter, which is another classic low-pass filter, has also been used in previous studies with different orders and cut-offs. Due to the discrepancy in filtering methods, it is necessary to investigate the influence of filter parameters on calculated gait parameters. Method: This study compared Butterworth and Chebyshev filters with different filter parameters for gait characteristics (step length, step width, toe clearance, and gait speed) in 66 trials from 33 healthy older adults, motion data were collected on a 7m walkway using motion capture system. Filters (n=48) with three orders (2, 4, and 6) along with eight cutoffs (4 to 18; increment by 2) were selected. Two-way ANOVA was used to determine the effect of order and cutoff on different gait characteristics, the intra-class correlation coefficient (ICC) was then used to evaluate the reliability across different orders and cutoffs. To compare the difference between standard filter and others, ICC was used to detect the similarity between each pair of filters. Results: The effect of filter parameters were only found on step length, which significantly increased along with decreasing order ($p<0.01$) and increasing cutoff value ($p<0.01$) for both Butterworth and Chebyshev filters. Similarly, only the step length showed a lower ICC across different orders ($ICC\leq0.82$) and different cutoffs ($ICC\leq0.66$) for both filters, while the ICC across orders and cutoffs was larger than 0.96 for other gait characteristics. The ICC between the standard filter and others showed that most (95%) of the filters selected in this study showed a high similarity ($ICC>0.9$) with the standard method for step width, toe clearance, and gait speed, while only a few (16.7%) filters showed a high similarity with standard filter for step length. Among all the filters, the sixth-order Butterworth filter with a cutoff of 8 Hz and the fourth-order Chebyshev filter with a cutoff of 6 Hz showed the highest similarity with the standard one. Conclusion: This study revealed that the selection of filter parameters has a significant effect on computed gait characteristics. Among all the variables analyzed in this study, step length was the only variable that was significantly affected by the filter parameters. However, if the filter parameters are selected from a certain range, there would be a very limited effect on the calculated gait characteristics. However, more gait characteristics should be verified in future studies.

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P3-C-7: Effects of age on cognitive-motor interference in curvilinear walking: an explorative study using functional near-infrared spectroscopy

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Background Musculoskeletal and executive functions, the latter linked to prefrontal cortex (PFC) activity, show a significant decline after the age of 60 (1). Tasks with increased cognitive load, like simultaneous cognitive and motor tasks (dual task-DT), induce more pronounced locomotion deficits (2,3), possibly due to gait automaticity loss (4). Wearable neuroimaging techniques, as functional near-infrared spectroscopy (fNIRS), maps the cortical activity measuring the concomitant increase in oxyhemoglobin (O2Hb) and decrease in deoxyhemoglobin (HHb) at level of cortical microcirculation blood vessels (1-3, 5). Studies on the effect of cognitive decline were limited to straight walking (10-meter walk test, 10mWT), while curvilinear paths, like the Figure-8 walk test (F8WT), requiring fine coordination of body segments' movements (6), have not been investigated. Therefore, the study aims at investigating age-related cognitive-motor adaptations during curved walking. Methods Fifteen young elderly (YE, 10F, 69.6±2.8 yrs) and 15 old elderly (OE, 11F, 80.6±3.3 yrs), without full-blown neurological conditions (Montreal Cognitive Assessment≥26), randomly performed 10mWT and F8WT in both single-task (ST, only motor task) and DT conditions. Cognitive task consisted in reporting how many times the letter "a" was present within a listened sequence of letters. As reference, the sequence was administered while subjects did not perform motor tasks (cognitive). Data were simultaneously acquired using a BRITE 24 fNIRS system, (Artinis Medical Systems, The Netherlands) and 4 body-worn sensors (Opal, APDM, USA, 128 Hz) to quantify gait parameters. Results Between groups: No PFC activation difference was found in the five tasks between YE and OE. OE showed worse motor performance in both the 10mWT and F8WT with respect to YE. Within groups: YE showed similar PFC activation levels in all performed tasks (Fig. top panel), but the DT condition impaired both the 10mWT and F8WT motor performances. Besides, different PFC activation was observed in the OE group (Fig. bottom panel), and a worse motor performance in the 10mWT DT. Correlations: several correlations among O2Hb/HHb and gait parameters referred to stability were observed in both groups during the 10mWT ST and DT, while for the only OE also in the F8WT ST and DT. Discussion OE requires additional cognitive resources to perform even simple walking modalities (10mWT) and higher instability is associated with increased PFC activation, especially when performing the F8WT. Understanding the motor-cognitive interference in aging is pivotal to determine function deviations that may signal early stages of neurodegenerative diseases. References 1.Nóbrega-Sousa Neurorehab&Neural Repair 2020;34:915-24 2.Koenraadt NeuroImage 2014;85:415-422 3.Holtzer J Gerontol Biol Sci Med Sci 2011;66:879-887 4.Clark Front Human Neuro 2015;9:246 5.Korivand Front Neurosci 2017;17:1051500 6.Godi Front Neurol 2019;10:532

P3-C-8: Facilitation of corticospinal excitability through functional electrical stimulation with observation and imagination of walking

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BACKGROUND AND AIM: Functional electrical stimulation (FES) has been used in gait rehabilitation for patients with gait deficits. Several clinical studies have found that FES gait training significantly improves gait function for these patients compared to gait training without FES. However, FES gait training is not suitable for patients with severe lower limb paralysis. We have previously shown that action observation combined with motor imagery (AO+MI) of walking induces walking-related cortical activity. Based on the findings, we combined the AO+MI with FES for dorsiflexion and plantar flexion as an alternative to gait training. Therefore, we aimed to investigate its transient effect on corticospinal and spinal reflex excitability, which is related to gait functions. Methods: Ten able-bodied individuals with no history of neurological disorders participated in the present study (two females, age: 24-34 years). They participated in an experiment with two conditions on different days. In the AO+MI+FES condition, they were asked to observe a video of a male walking and to imagine walking and were given FES for dorsiflexion and plantar flexion. The FES consisted of electrical stimulation to the common peroneal and tibial nerves, and FES timing was synchronized with the electromyographic activity of the walker in the video. In the FES only condition, the participants were asked not to imagine anything and were given FES as in the AO+MI+FES condition. We recorded motor evoked potentials (MEPs) in the tibialis anterior (TA) and soleus (SOL) muscles and SOL Hoffmann-reflex (H- reflex) at rest to assess corticospinal and spinal reflex excitability before, 0 and 30 min after the 20-min FES with and without the AO+MI. All procedures, except for the AO+MI part, were identical between conditions. The peak-to-peak amplitudes of MEPs and H-reflexes were calculated. Results: Friedman tests revealed significant differences in MEPs between time points in the AO+MI+FES condition in TA ($p<0.001$), but not in SOL ($p=0.273$). Friedman tests revealed no significant differences in MEPs for both muscles in the FES condition (TA, $p=0.150$; SOL, $p=0.497$) nor in H-reflexes in either condition (AO+MI+FES, $p=0.905$; FES only, $p=0.670$). Wilcoxon signed-rank tests revealed that, in the AO+MI+FES condition, MEPs in TA significantly increased 30 min after the intervention (283±148%), compared to those before (100%; $p=0.015$) and 0 min after the intervention (146±71%; $p=0.015$). There was no difference in MEPs before and 0 min after the intervention ($p=0.077$). Conclusions: Our results show that FES only did not change excitability, while FES with AO+MI facilitated corticospinal excitability. This facilitation likely occurred due to the synchronization of sensory inputs from FES and cortical activity during AO+MI. Our findings demonstrate the effectiveness of combining FES with AO+MI for neurorehabilitation strategies.

P3-C-9: Relationship of turning difficulties to cognitive function and brain activity in stroke patients: preliminary results

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BACKGROUND AND AIMS: Turning is a movement that often leads to falls in stroke patients. Turning seems to require higher cognitive demands than walking straight, but there has been a lack of furfur analysis of the correlation between turning performance and specific cognitive domains in stroke patients. Additionally, studies on brain activity in the prefrontal lobes of the brain to support the role of cognitive function in turning were scare. METHODS: Twenty chronic stroke patients were required. They were assessed their turning performance, cognitive

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function and brain activity during turning. Turning performance was evaluated by time (s) and angular velocity (°/s) using APDM Opal wireless sensors and Mobility Lab software (APDM, Portland, OR, USA). Global cognition was measured by Montreal Cognitive Assessment (MoCA) while specific cognitive domains such as visuospatial, attentional and executive function were assessed by Corsi block-tapping test (CORSI), Trail making test (TMT) and Stroop color and word test (SCWT) respectively. Pre-frontal brain activity was recorded by MindWave Mobile 2 (NeuroSky, USA) during straight-walking and turning towards affected and unaffected sides. Absolute power in alpha and beta waves was used to calculate attention index. RESULTS: A total of 20 chronic stroke patients were recruited (16 males, mean age 54.50±11.06, onset time 59.65±58.85 months, 10 ischemic stroke, 10 right hemiplegia). Turning performance was significantly associated with visuospatial ($r=-0.455$, $p=0.044$) and attentional function ($r=0.482$, $p=0.031$) but not executive function ($p=0.390$). Increased brain activity, presented by attention index, in pre-frontal lobe was observed when turning towards unaffected side ($p=0.001$) while unchanged brain activity was found when straight walking ($p=0.435$) and turning towards affected side ($p=0.984$). CONCLUSIONS: Our preliminary results showed that poor turning performance was associated with visuospatial function and attention. Higher pre-frontal activation during turning indicates a greater level of executive-attentional control was required to complete a successful and safe turn.

P3-C-10: Modulation of corticospinal excitability with balance task difficulty and cognitive dual task

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BACKGROUND AND AIM: The neural control of standing balance control can shift between subcortical and cortical circuits depending on the context of the task, as well as in aging and disease. Cortical engagement in balance control is thought to increase as balance task difficulty increases. Prior studies have inferred that cognitive resources are allocated to balance when motor performance degrades in the presence of a cognitive dual task. However, few studies have directly measured cortical inputs to balance control. Here, our goal is to quantify changes in motor cortical contributions to standing balance control in healthy young adults (YA) using single pulse transcranial magnetic stimulation (TMS) to assess corticospinal excitability (CSE). We hypothesize that more difficult balance tasks engage cortical mechanisms for balance control, and that a concurrent cognitive dual task will reduce motor cortical contributions to balance control. We predicted that both postural sway and CSE would be larger in tandem (TS) compared to quiet (QS) stance. We predicted that postural sway and CSE would decrease when a cognitive task was performed during TS vs QS. METHODS: We plan to collect data on 10 YA (18-35 years) during standing balance tasks with lower (QS) and higher (TS) levels of difficulty. QS was performed with feet hip width apart, and TS was performed with the right (dominant) foot placed directly behind the left foot. Participants stood with arms to the side, facing forward with eyes open, while standing on a force plate which measured center of pressure (COP) displacement in the mediolateral (ML) and anterior-posterior (AP) directions. QS and TS trials were performed both alone and during a concurrent Serial 7 cognitive math task. Trials lasted for 60s each and trial order was randomized. Additionally, during task performance, we used TMS targeted to the soleus and tibialis anterior M1 hotspot to assess CSE. 20 motor evoked potentials (MEPs) were collected per trial, and peak-to-peak amplitude was quantified for each MEP. RESULTS: Preliminary COP analyses

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without TMS (n=8) show significantly larger ML COP displacement ($p<0.05$) during all TS conditions vs QS alone. However, no differences in ML COP displacement were seen between single and dual-task conditions. Additionally, no significant differences were found in the AP direction. Consistent with our hypothesis, preliminary data (n=1) show TS MEP amplitudes were more 2-3x variable with 3-7x larger means than QS MEPs. No differences in MEP amplitude were seen between single and dual-task conditions. CONCLUSIONS: Preliminary results suggest YA balance is sufficiently challenged with in TS to engage cortical mechanisms for balance. However, the engagement is highly variable and may therefore be intermittent. Additionally, YA have sufficient neural resources to perform both cognitive and balance tasks with little interference. Further, in TS, there is a possible ceiling effect on measuring ML COP displacement due to the narrow base of support. This work will establish an experimental paradigm for investigating cortical control of balance in aging and cognitive impairment. ACKNOWLEDGEMENTS AND FUNDING: Laney Graduate School Fellowship NIH R01 AG072756 NIH R01 HD095975

P3-C-11: Neural mechanisms of motor rehabilitation through serious games using virtual reality in Parkinson's disease

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Background and aim: Physiotherapy approaches have been shown to improve gait and balance disorders in Parkinson's disease (PD) patients. Recent data highlighted the potential additional benefit of combining physical activity with virtual reality paradigm, such as serious games training. The effects of such training on anatomical and functional brain imagery has been little studied. Here, we aimed to assess the changes in brain volumes and functional connectivity (FC) induced by training with the serious game 'Toap Run' specifically built to treat gait and balance disorders of PD patients. Methods: We enrolled 24 PD patients with gait and balance disorders unresponsive to levodopa treatment in a randomized controlled study, aiming to assess the effects of full-body movements training with the 'Toap Run' game (Active group) vs playing the game with a computer (Control group), for 18 sessions at home. Clinical assessments, gait recordings, and a structural and resting state FC brain MRI, were done before and after the 18 sessions. We examined the link between severity of parkinsonian motor disability before surgery and brain MRI, and the changes in brain MRI after training relative to before, in both groups. Results: The data obtained in 19 PD patients were included in the MRI analysis: 11 from the Active group and 8 from the Control group. Before training, motor severity correlated with grey matter volume (GMV) of fronto-parietal cortices; and gait and balance disorders severity with the FC between motor-locomotor and associative brain areas. After Active training, we found a significant decrease in gait and balance disorders clinical severity, with no significant changes for the Control group. After Active training, the brain GVM increased in the motor and associative areas of the vermis, cerebellum and cortex, with no significant changes for the Control group. We also found significant shifts in the FC between cueing, locomotor, associative circuits and basal ganglia in both groups. For Active group, increases were found in cerebello-thalamic FC along with pallidal FC with motor and locomotor regions, putamen and thalamus, and between the prefrontal cortex and the primary motor cortex, as well as between STN, thalamus and the precuneus. Active group also showed decreased FC between fronto-parietal regions and the basal ganglia. In the Control group, we

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found increased mesencephalic locomotor region FC with premotor cortex and putamen, along with intra-cerebellar FC, and between cerebellum and visual processing regions, and decreased FC between cerebellum and the basal ganglia and premotor regions. Conclusion: These data indicated that Active training with the serious game Toap Run induced structural and FC brain changes, notably in the cerebello-thalamo-basal ganglia cortical locomotor and postural network. Further investigation are needed to examine the links between training-specific neural plasticity and effects of such approaches on disability.

Cognition (e.g. dual tasking)

P3-E-12: Variability and fractal dynamics of joint coordination according to walking speed and cognitive task

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BACKGROUND AND AIM: Stride time is considered a variable that reflects the final results of the neuromusculoskeletal system, and is generally used for group comparisons such as age, neuropathy, and body balance through analysis of gait variability and fractal dynamics [1]. Joint coordination is also widely used in studies to examine body balance [2]. From the point of view of the lower extremity link system, changes in joint coordination have a very close relationship with the control of stride time and may represent changes in body balance control more directly. Therefore, in this study, the variability and fractal dynamics of joint coordination variables according to walking conditions were confirmed. METHODS: A total of 8 subjects were subjected to a treadmill walking experiment according to 5 walking speeds (80~120% of preferred speed) and cognitive tasks. Subjects walked for 10 minutes in each condition. The lower extremity joint angle and gait event data were extracted using a 3D motion analysis system during walking. For the analysis, 6 minutes of data were used, excluding 2 minutes of each at the beginning and end. A 2-back test to memorize the alphabet presented on the screen while walking was used as a cognitive task. Joint coordination was quantified by the area and perimeter of the cyclogram realized by hip and knee joint angles. Gait variability and fractal dynamics were compared using the area and circumference of the cyclogram and the stride time, and CV (coefficient of variance) and the scaling exponent of DFA (detrended fluctuation analysis) were used, respectively. RESULTS: The average and CV of all variables were not affected by the cognitive task, and only the change according to the speed showed a statistical difference. In the case of DFA, there were differences according to cognitive task performance in all variables, and statistical differences according to speed were also found only in the case of stride time. CONCLUSIONS: According to the results, the variability of the walking time and joint coordination variables was affected only by the change in speed, but the fractal dynamics were affected by the performance of the cognitive task. In particular, while the effects of the cognitive task and the speed were simultaneously shown in stride time, only the effects of the cognitive task were shown in the area and perimeter, which are joint coordination variables. From the perspective of fluctuation, it can be inferred that stride time and joint coordination have a very close relationship, and further research is needed on the relationship between body balance according to subjects and conditions. REFERENCES: [1] Hausdorff JM, Gait dynamics, fractals and falls: Finding meaning in the stride-to-stride

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fluctuations of human walking. Hum Mov Sci 2007;26(4):555-89. [2] Park J, Lee H, Cho J, Kim I, Lee J, Jang S. Effects of knee osteoarthritis severity on inter-joint coordination and gait variability as measured

P3-E-13: The impact of multi-sensory information on cognitive-motor dual-tasking in young adults

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BACKGROUND and AIM: Sensory, cognitive, and motor systems are interconnected and increasingly draw from executive function networks in the prefrontal cortex with aging. It has been shown that, compared to unimodal presentation, audiovisual presentation of cognitive stimuli is facilitative for working memory; however, a systematic comparison of unimodal versus multimodal presentation conditions has not yet been examined in the context of cognitive-motor dual-tasking. We investigated the impact of multi-sensory integration on dual-task performance in a sample of healthy young adults. METHODS: Eighteen participants (Mage = 21.39, SD = 1.82) completed a 2-back working memory task under three sensory conditions: Auditory (through speakers), Visual (projected on a large screen), or Audiovisual (both modalities in synchrony). The stimuli were objects commonly seen during a neighbourhood walk (e.g., car, house, tree). The objects were presented in synchrony with the participants' belt speed. These three conditions were assessed under full attention (while standing) and dual-tasking (while treadmill walking) and order was counterbalanced across participants. Functional near-infrared spectroscopy (fNIRS: Artinis Brite MKIII) data from the prefrontal cortex were acquired to assess relative changes in oxyhemoglobin concentrations (HbO: measured at absorption peak of 850nm; nmol/L) compared to baseline resting data and between sensory and attentional conditions. RESULTS: Accuracy ($p = .038$, $\eta^2p = .334$) on the 2-back task was significantly better for the audiovisual compared to the auditory condition. Oxyhemoglobin concentrations also reflected the facilitative effect of the audiovisual presentation: in the dual-task conditions, it was observed that dual-tasking in the audiovisual condition (M = -9.87 E-06 nmol/L, SD = 5.02 E-05) had significantly lower mean HbO levels compared to the visual and auditory conditions, $t (15) = -1.78$, $p = .095$. Contrary to our prediction, cognitive response times were fastest while dual-tasking ($p = .006$, $\eta^2p = .371$), possibly due to increased physiological arousal when walking. CONCLUSIONS: The study results demonstrate the alleviation of cognitive load when stimuli are presented in two modalities instead of a single modality during dual-task walking. The inclusion of fNIRS acquisition in prefrontal cortical regions provides convergent evidence for the facilitative effects of audiovisual presentation. The use of sensorially rich immersive environments for studies of gait and posture may be informed by the consideration of whether individual differences in multi-sensory integration impact physical performance. Future inclusion of an older adult sample in the same experiment will elucidate if audiovisual presentation also alleviates dual-task costs during walking.

P3-E-14: Lower neurovascular coupling is associated with worse dual-task postural sway capacity during the N-back task in older adults

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Background: Senescence is associated with reduced standing postural control, particularly when dual-tasking (i.e., standing while simultaneously completing an unrelated cognitive task). The ability to dual-task depends upon the timely recruitment of related brain networks. Neurovascular coupling (NVC) has been defined as the change in cerebral blood flow velocity (CBFv) in response to the execution of one or more tasks. Previous research has demonstrated that NVC, as measured using transcranial Doppler ultrasound of the middle cerebral artery (MCA), is typically reduced in older adults. Moreover, in this population, lower NVC has been linked to both executive dysfunction and slowed walking speed. The role of NVC in dual-task standing postural control, however, remains largely unknown. We hypothesized that in relatively healthy older adults, lower NVC will be associated with worse dual-task capacity, as defined by relatively greater disruption of postural control when performing a cognitive dual-task. Methods: Twenty-seven older adults (aged=76 ± 6 years) were asked to complete multiple trials of standing while completing the n-back of executive function. The n-back consisted of a control (blank screen) and two experimental conditions (i.e., Identify X, [IdX] and 2-back) presented on a screen. CBFv of the MCA and postural sway were simultaneously recorded with transcranial Doppler ultrasound and a lumbar motion sensor. According to previous studies, NVC was quantified by calculating the percent change in mean CBFv between the IdX and 2-back conditions. For each trial, the degree of complexity associated with the anterior-posterior (AP) and medial-lateral (ML) acceleration time-series was computed using the multiscale entropy approach. The dual-task cost to AP and ML complexity was quantified as the percent change from the control to each experimental condition (i.e., IdX, 2-back). Performance was determined by the percentage of accurate target detections. Results: NVC was correlated with the dual-task cost to AP and ML sway complexity during the 2-back condition (AP: r=-0.19, p=0.02 and ML: r=-0.17, p=0.03). Specifically, those with lower NVC displayed higher dual-task cost to AP and ML sway complexity during the 2-back. After adjusting for age, sex, and BMI, this association remained significant for AP sway complexity (p=0.02) and trended towards significance for ML sway complexity (p=0.06). In contrast, these associations were not significant during the IdX task. There were no associations between IdX or 2-back performance and 1) NVC, or 2) dual-task cost to AP or ML complexity during either condition. Conclusion: In older adults, lower NVC was associated with higher dual-task cost to sway complexity during the n-back, particularly when standing while performing the more challenging 2-back component. Functional neural activation of CBF may provide novel insight and serve as a therapeutic target for impaired dual-task capacity in older adults.

P3-E-15: Repulsive vibrotactile biofeedback is more beneficial for balance control during an auditory Simon task

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BACKGROUND AND AIM: Vibrotactile biofeedback (VTF) during standing leads to decreased body sway for both an instructed attractive (move towards vibration) and repulsive (move away from vibration) feedback encoding. In terms of cognitive interference and balance control benefit, repulsive encoding has been shown to be less demanding and more efficient. However, during balance-cognitive multitasking, repulsive feedback still increased response time in a secondary cognitive task imposing working memory demands indicative of cognitive interference. This study aimed to assess whether either of the encoding modes impose

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interference with processes of cognitive conflict resolution due to their intrinsic processing demands. The encoding mode with a weaker incongruency effect in a Simon task could be considered cognitively less conflicting in nature. METHODS: 40 healthy young adults (25♀, 28,4±9.3 years) stood upright with eyes closed both during single-task balancing and balance-cognitive multitasking each with and without VTF (block-randomized, 5 repetitions each). During a multitasking block, an auditory Simon task was performed with 3 stimulus-response congruency levels (in/congruent, neutral), randomly presented 24 times each. For statistical analysis mixed model ANOVAs were computed for multitasking with Group (attractive, repulsive) as between-subject factor and Feedback (on, off) as well as Congruency (in/congruent, neutral) as within-subject factors. As a measure of cognitive performance, the linear integrated speed accuracy trade-off score (LISAS) was used, and RMS total tilt angle at L5 (RMS L5) as a measure of balance control. RESULTS: LISAS significantly increased from Feedback off to Feedback on ($F(1,38)=39.97$, $p\leq0.001$; mean diff.=0.11s (12%), $p\leq0.05$). This indicates cognitive demands of VTF. During incongruent trials, LISAS was significantly increased ($F(1,38)=7.04$,$p=0.012$), compared to the congruent trials (mean diff.=0.85s (9%), $p=0.024$) as well as compared to the neutral trials (mean diff.=0.10s (1%), $p=0.035$). However, there was no main effect of Group or interaction between any factors such as Group and Feedback and Congruency (for all $p>0.05$). Regarding balance control, a lower RMS L5 was found during Feedback on than off ($F(1,12)=535.65$, $p\leq0.001$; nrepulsive=17, nattractive=18). A significant Feedback-Group interaction, however, showed that sway was more reduced due to feedback in the repulsive vs. attractive group ($F(1,12)=45.96$, $p\leq0.001$). CONCLUSIONS: Attractive and repulsive VTF encoding demonstrated comparable performance in the Simon task during balance-cognitive multitasking. However, as body sway was only reduced in the repulsive group due to feedback, it can be concluded that repulsive encoding is more efficient for balance control particularly in a multitasking setting. Further analyses are required distinguishing between active and inactive feedback during Feedback on.

Dementia and cognitive disorders

P3-F-16: Identifying gait differences between Alzheimer's Disease and dementia with Lewy bodies: Mayo Clinic study of aging

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BACKGROUND AND AIM: Early accurate diagnosis of Dementia with Lewy Bodies (DLB) and Alzheimer's disease (AD) is important for early intervention and proper disease management, however, misdiagnosis is still common. Gait analysis has been suggested as a potentially useful tool in differentiating dementia subtypes due to links between gait characteristics and different cognitive domains. There is early evidence that gait characteristics are different between these dementia subtypes. However, previous research has reported conflicting findings. This study aimed to compare gait characteristics between AD, DLB, and cognitively unimpaired (CU) individuals. METHODS: This study used data collected in the Mayo Clinic Study of Aging and the Alzheimer's Disease Research Center. Gait was analyzed with GaitRITE and ZENO instrumented walkways. The gait outcomes of interest in this paper include the gait

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characteristics in the Lord et al (2013) model, under pace, rhythm, variability, asymmetry, and postural control, as well as cadence and double support percentage. AD (n = 70), DLB (n = 70), and CU participants (n = 280) were matched by age, sex, and education. Gait outcomes were compared using one-way ANOVAs or Kruskal-Wallis tests, followed by posthoc testing with Bonferroni correction. RESULTS: Compared to the CU group, both dementia groups had lower stride velocity, step length, cadence, and higher double support percentage ($p < 0.01$). The DLB group additionally had higher step length variability compared to the CU group ($p < 0.001$). Between AD and DLB, the DLB group had lower stride velocity, step length, and swing time, as well as higher step length variability and double support percentage ($p < 0.01$). CONCLUSIONS: This study demonstrated there are differences in gait between AD and DLB, particularly in pace, rhythm, variability, and postural control. This provides evidence that gait differs between these dementia subtypes, suggesting a potential for gait analysis to aid in the diagnosis of DLB and AD.

P3-F-17: Patients with mild cognitive impairment display altered kinetics patterns during obstacle-crossing

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BACKGROUND AND AIM Mild cognitive impairment (MCI) with memory loss as the predominant symptom is the intermediate stage between healthy older people and dementia. With impaired cognitive functions and abnormal gait performance [1], older people with MCI may have greater difficulty than their healthy peers in dealing with the neuromechanical challenges during obstacle-crossing. The biomechanical methods employed during obstacle-crossing and the accompanying risk factors for falling, toe-obstacle clearance above the obstacle and the associated kinematics and kinetics of the lower extremities have been used to measure and are important for identifying the biomechanical risk factors for falling. The purpose of the study was to quantify the change of kinetics in individual joints in older adults with MCI during obstacle-crossing as compared to healthy controls. METHODS Twelve patients with MCI were recruited in this study. Twelve older healthy with age, height and body mass matched to the MCI group were assigned as the Control group. Thirty-nine infrared retro-reflected markers were placed on specific landmarks of the body to track the motion of the segments [2]. Each subject walked at their preferred speed on a 10-meter walkway and crossed a tube-like obstacle placed horizontally across a height-adjustable frame. With the measured ground reaction forces, inter-segmental forces and internal moments at the joints of the lower limbs were calculated using inverse dynamics analysis. Spatio-temporal parameters, end-point variables and values of the kinetic data when the leading toe was above the obstacle, called crossing moments, were extracted for subsequent statistical analysis. RESULTS During obstacle-crossing, there were no significant between-group differences in spatio-temporal parameters and end-point variables. The two groups showed quantitative differences in some kinetic components. When the trailing toe was above the obstacle, the MCI group showed significantly decreased hip extensor and increased knee abductor crossing moments during early stance phase of the leading stance limb (Figure 1). CONCLUSIONS The current study identified the kinetic changes in patients with MCI during obstacle-crossing. The patients were found to cross obstacles of all tested heights with altered joint kinetics, but normal toe-obstacle clearance. It is suggested that patients with MCI should also be targeted for fall prevention. Possible therapeutic interventions to decrease falls may include strengthening the hip extensors and knee abductors, together with cognitive and motor training. Further study on

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patients with different severities of MCI may be needed for a complete picture of the biomechanical strategies adopted. ACKNOWLEDGEMENT Financial support: MOST 110-2628-B-038-025- REFERENCES [1] Verghese J. et al. (2008). Journal of the American Geriatrics Society, 56: 1244-1251 [2] Lu HL. et al. (2017) Gait & Posture, 51: 109-11

P3-F-18: Kinematic and kinetic data during sit-to-stand in older adults with and without mild cognitive impairment

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BACKGROUND AND AIM: Mild cognitive impairment (MCI) is an intermediate stage of declining cognitive function related to aging. Previous studies showed that the decline of cognition functions in older adults with MCI might be linked to a decrease in lower-extremity function, postural control, gait speed, and joint angle during walking. Although there is a broad description of motor function in older people with MCI in the literature, most studies assess walking. However, one of the simplest functional activities that an individual often performs daily is standing up from a chair or sit-to-stand (STS), which still needs the necessary information. Therefore, this study aims to study the differences in movement time, kinematic, and kinetic data in older adults with and without MCI while performing STS task. METHODS: Thirty-five older adults with MCI and thirty-five age and gender-matched control older adults without MCI participated in this study. All participants performed STS movement with their preferred speed and self-selected pattern from an adjustable chair. A three-dimensional motion analysis system was used to capture STS movements. In the present study, STS movement was separated into four phases by five transitional points as follows: phase I (flexion-momentum phase), phase II (momentum-transfer phase), phase III (extension phase), and phase 4 (stabilization phase). Data from this system was further used for calculating the total movement time, movement time in each phase, kinematics, and kinetics. RESULTS: The results showed that total movement time and movement time in each phase during STS in older adults with MCI were not significantly different from older adults without MCI. However, older adults with MCI presented with more trunk flexion and less anterior pelvic tilt during STS (T1 and T2) than older adults without MCI. For all kinetic data, there were no significant differences between older adults with and without MCI during STS. CONCLUSIONS: This study concluded that during STS, older adults with MCI had a different movement pattern when compared with older adults without MCI. Hence, the rehabilitation program should emphasize the interventions that could promote the movement pattern of STS in older adults with MCI. ACKNOWLEDGEMENTS AND FUNDING: This research is supported the scholarship from Human Movement Performance Enhancement Research Unit, Department of Physical Therapy, Faculty of Allied Health Sciences, Chulalongkorn University.

Exercise and physical activity interventions

P3-G-19: Effects of a sedentary life style on coordination of anticipatory locomotor adjustments for circumvention

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Inactivity and sedentary lifestyles have been linked to a notable decrease in muscular abilities, compromised proprioception, reduced social interactions, and an increased risk of social anxiety. The acquisition of motor skills is acknowledged to be task-specific, suggesting that sedentary and inactive lifestyles may negatively impact an individual's circumvention abilities. The objective of this study was to compare the impact of sedentary behaviour in young adults on anticipatory locomotor adjustments and related muscle activations during a pedestrian circumvention task. To date, two groups of young adults have been analyzed. Eleven participants in the active group (AG) engaged in at least 3 sessions of high-intensity physical activity per week, while nine participants in the sedentary group (SG) had a sedentary lifestyle for more than 8 hours per day and did not engage in any physical activity, according to the International Physical Activity Questionnaire. All participants were exposed to a virtual environment simulating a public park and were equipped with 11 EMG sensors placed on targeted muscles previously shown to be responsible for directional changes as well as with reflective markers to record body kinematics. Participants' objective was to walk to a panel placed 10 metres ahead of the starting point and to read a text written on the panel. After a period of familiarization to the virtual environment, experimental conditions included 5 unobstructed trials, 10 trials with a virtual pedestrian walking straight towards the participant and requiring circumvention to the right and 5 catch trials with the virtual pedestrian turning to the left after 3 steps forward to prevent participants from pre-planning their path. The dependent variables were the distance of initial path deviation from the pedestrian, maximum medio-lateral (ML) displacement velocity, and minimal clearance. For the preliminary analyses, the non-parametric Mann-Whitney U test was used to compare between groups. The first results indicate that SG deviated from their trajectory earlier than AG (mean difference= 1.05, p=0.003). Furthermore, the maximum ML displacement velocity was lower for SG compared to AG (mean difference= 0.093m/s, p= 0.004). However, no significant minimal clearance difference was observed between the two groups (mean difference= 0.035m, p= 0.876). These findings demonstrate that SG individuals may exhibit a more cautious behaviour during obstacle avoidance tasks when compared to AG individuals. Analysis of lower limb electromyographic data is underway to reveal related muscle coordination strategies.

P3-G-20: Pre-frontal lobe activation and gait speed during dual-task walking in people with multiple sclerosis: insights from a treadmill training intervention

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Background and Aim: Pre-frontal lobe activation (PFLa) during usual walking(UW) has been reported to be increased in people with MS (pwMS), compared to healthy controls. Furthermore, walking under dual-task(DTW) conditions is highly demanding and requires both motor and cognitive resources. Yet, little is known about the role of PFLa on motor performance in pwMS. Here we aimed to investigate the role of the pre-frontal cortex by evaluating the effects of treadmill training on PFLa activation under UW and DTW conditions, alongside other symptoms in pwMS. Further, we aimed to explore the associations between PFLa, gait speed and other symptoms. Methods: People with relapsing-remitting MS underwent supervised treadmill training for six weeks (3 sessions weekly). PFLa (HbO2 levels) during UW and DTW (while subtracting serial 3s) were evaluated using an fNIRS device. Gait speed was assessed using OPAL wearables placed on lower back and legs. Paired t-tests, Wilcoxon test and Mixed

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Models examined the interventions. Fatigue was assessed via the MFIS questionnaire and cognitive processing speed via the Symbol Digit Modalities Test (SDMT). Results: 19 subjects who completed the intervention were 46.9±1.9 years old, 58.6% females, with a median EDSS score of 3.5 (2-6). At baseline, the subjects walked faster (p=0.001)(107±23 cm/sec) under UW condition compared to DTW (99±25 cm/sec). HbO2 levels were similar under DTW and UW conditions (p=0.126). Higher HbO2 levels during the UW conditions were associated with higher physical fatigue (rs=0.460, p=0.018), and negatively with weekly walking time (rs=-0.360, p=0.014). Higher HbO2 levels during the DTW were moderately associated with medication intake (rs=0.500, p=0.010), but not with gait speed or cognitive performance. After six weeks of the intervention, gait speed under DTW, but not under UW condition, improved (Mean difference -9.06 ±2.6 cm/sec, p=0.002). HbO2 levels did not change following the intervention (p>0.05) under UW or DTW conditions (Figure 1). However, the improvement in DTW speed post-training (delta) was negatively associated with the delta of DTW HbO2 levels (Estimate =-39.4, 95% CI -65.8 to -13.1, p=0.007). Additionally, subjects reported less fatigue (p=0.044) and higher cognitive processing speed (p=0.028) following the intervention, yet these changes were not associated with delta DTW speed or HB02. Discussion: Our results among pwMS with a wide range of disease severity show that a treadmill training intervention program improved DTW speed, cognitive performance, and reduced fatigue but did not change PFLa. The idea that the DTW speed change was negatively associated with the HbO2 levels delta suggests that there may be less reliant on attentional mechanisms while performing complex motor-cognitive task after the intervention. Studies on a larger number of participants should further explore PFL activation in various walking conditions and as a response to interventions in pwMS.

P3-G-21: Control of pelvic and lumbar spine motion during walking with single-tooth wooden clogs (geta)

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Introduction Geta, also referred to as Japanese wooden clogs, are a type of footwear traditionally favored by the Japanese and are extremely unique in their shape and can be said to be a uniquely Japanese type of footwear that has no parallel in the world. Geta are basically a wooden board, called a 'tooth', that stands vertically to the ground with a wooden board placed horizontally over it that usually has a toe strap attached. Typical geta have two-teeth but there are also single tooth geta (Fig. 1). Although geta are rarely used in modern daily life, they are a familiar footwear for Japanese people, who often wear them when dressing in kimono (traditional Japanese clothing). There are very few examples of kinematic studies using single-toothed geta, and there is little kinematic knowledge about how geta affect humans and whether they are useful in physical exercise. Methods Nine healthy males participated in this study. Their mean (standard deviation) age, height, and weight were 23.2 (2.3) years, 166.4 (7.2) cm, and 58.2 (6.6) kg, respectively. Prior to measurements, the purpose and procedure of this study were explained in detail, and informed written consent was obtained from all subjects. The subjects went barefoot and wore two different pairs of geta. Before the measurements were taken, subjects were allowed to practice walking with each pair of geta to achieve a comfortable gait. A VICON system was used to capture three-dimensional movements. VICON data were recorded while subjects walked, from the time of heel contact to the completion of the walking cycle. Data were recorded throughout the right stance phase of the walking cycle. We defined the stance phase of the walking cycle, before and after the

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partial pressure of foot floor reaction, as the 'braking phase'. The latter phase was defined as the 'acceleration phase'. Statistical analyses were conducted using one-factor ANOVA and the Tukey-Kramer correction test. Results and Discussion Significant differences were found in the angle of anterior pelvic tilt and muscle activity of the erector spinae muscles in single-tooth geta compared to bare feet ($p<0.05$). Narrow, unstable base of support and upward deviation of center of gravity cause trunk abnormalities in walking. At that time, muscular activity of the erector spinae muscles increases to suppress abnormalities in the trunk. The resultant forced anterior pelvic tilt was thought to absorb internal shock.

P3-G-22: Does dog ownership impact physical activity levels and fall risk in older adults?

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BACKGROUND AND AIM: Ameliorating physical inactivity and fall risk among older adults is an urgent public health challenge. Unfortunately, many existing physical activity (PA) interventions for this population have poor long-term efficacy due to unsustained interest. Though the causal pathway remains unknown, reduced PA, impaired gait performance, and elevated fall risk are common in older adults. Increased gait variability in older adults is understood to predict future falls. Dog ownership may comprise a novel solution to the high attrition rates of PA interventions among older adults. Further, increased PA through dog walking could potentially confer gait performance improvements, leading to reduced gait variability and thus fall risk. This cross-sectional pilot study aimed to compare PA levels and gait performance of older adult dog owners to non-dog owners. METHODS: Twenty-two participants (10 dog owners, mean age 74.5[3.2]yrs; 12 non-dog owners, mean age 75.3[4.7]yrs) were recruited over 2 months. Participants wore an activPAL accelerometer 24hrs/day for 7 days, while also logging any dog walking PA. Gait measures were quantified by 6 body-worn, inertial sensors (APDM, Portland, OR) during a 2-minute walk over a 7m walkway, with 180° turns. Owing to the preliminary nature of this study, group differences are described by Cohen's effect sizes. RESULTS: Moderate effects of dog ownership on PA levels were observed (daily step count d = 0.59; daily stepping time d = 0.67; overall activity score d = 0.62). Compared to non-dog owners, dog owners averaged 2808 more daily steps and 32 more daily stepping minutes. A large effect of dog ownership on stride time variability was observed (d = 0.85), along with a moderate effect on stride length variability (d = 0.66), both suggesting decreased gait variability among dog owners. CONCLUSIONS: Our preliminary analyses indicate that older adult dog owners exhibit higher PA levels and less gait variability than non-dog owners. Greater gait variability implies instability and is an established fall predictor for older adults. These preliminary data therefore suggest that dog ownership may be associated with decreased fall risk in this population. While a fully-powered, follow-up randomized controlled trial will help to unravel this relationship, these preliminary findings point to dog ownership as a potential mechanism for both improving PA levels and reducing fall risk in older adults.

P3-G-23: Neuromuscular control of balance unchanged in children with developmental coordination disorder following a novel exergaming training intervention

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BACKGROUND AND AIM: Children with Developmental Coordination Disorder (DCD) have reduced motor competence and coordination in the absence of other competing neurological disorder. They often exhibit balance deficiencies due to poor muscle activity regulation predisposing them to trips and falls due to the inability to appropriately respond to postural disturbances. To our knowledge, no previous studies have examined how neuromuscular mechanisms controlling balance might be improved through training in children with DCD. Thus, this study assessed the effects of an exergaming intervention on postural control in this population. METHODS: Eleven of seventeen children with DCD (9±1yrs; <5th percentile balance component of MABC-2; "training") completed a 6-week at-home exergaming intervention consisting of pre-selected Nintendo Switch games challenging balance. Games were played for a minimum of 30 minutes, 3 times per week. Adherence to the training programme was monitored via logbook and console activity checks. The remaining six children formed the control group ("controls") and were asked to maintain regular levels of daily activity. Balance assessment pre-/post-intervention consisted of standing on a platform that translated antero-posteriorly at three frequencies (0.1Hz, 0.25Hz, 0.5Hz; 12cm peak-to-peak). Whole-body 3D kinematics, surface EMG of lower limb postural muscles, and force plate data were recorded. Centre of mass variability in the anteroposterior (COMap) and mediolateral (COMml) directions, muscle onset latencies and excitation times, and Centre of Pressure metrics were obtained. The number of children who stepped and the number of cycles in which steps were taken were counted. Onset latencies were determined by identifying bursts respective to platform changes of direction. Data were analysed using a linear mixed model with follow-up pairwise comparisons. RESULTS: Post-intervention, the training group improved MABC-2 balance scores, however remained below the 5th percentile. Both groups showed reduced COMap variability at 0.25Hz, while controls (but not training group) also showed reduced COMap/ml variability at 0.5Hz. At 0.25Hz, no significant differences were observed for onset latencies, however the training group reduced excitation times, appearing to behave more like typically developing children. No group differences were found for EMG metrics at 0.5Hz. CONCLUSIONS: Despite the improvements in MABC-2 scores, reductions in stepping responses and muscle excitation times, the lack of adaptation across the other measures suggests no significant, lasting changes in neuromuscular control strategies used for this task as a result of the exergaming intervention. Improvements being observed in both groups suggest these are likely due to a learning effect between test sessions and/or small sample sizes with large intra-group variability; the highest frequency (0.5Hz) remained challenging for both groups.

P3-G-24: Promoting safe mobility of frail older adults in care homes through a multicomponent exercise program: protocol of a cluster randomized controlled trial

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BACKGROUND AND AIM: Mobility allows older adults to maintain independence. Nearly 50% of older adults in care homes are frail. They routinely rely on armrests, walkers, and handrails for support. Our previous studies showed that over 20% of falls in care homes occur during transferring owing to poor trunk control [1]; people often use upper limbs to protect themselves from hitting their head during a fall [2]. Therefore, upper limb and core strength training is

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essential for older adults to safely perform daily activities and prevent injury. However, existing exercise programs mainly focus on lower limb strength. Moreover, most programs are not designed or delivered to suit people with different functional capacities. In this study, we aim to examine the effects of a multicomponent exercise program, Mobi-Fit on mobility and frailty in older adults living in care homes. METHODS: We previously developed the Mobi-Fit program that targets functional mobility with multiple exercise components, including postural strength, balance and core strength, agility, lower limb strength, wrist strength, and triceps strength [3]. The Mobi-Fit has been tested for feasibility [3]. We currently conduct a cluster randomized controlled trial (CRCT). 144 participants will be recruited from eight care homes for the intervention (3 times/week, 45 min/session for 12 weeks). Participants within each home will be randomly assigned to Mobi-Fit (intervention group) or a regular facility-based lower-limb strengthening program (control group). Outcome measures include upper and lower limb strength, trunk stability assessed by a portable force plate, mobility measured by SPPB, FRAIL-NH scale, and fall efficacy. Meanwhile, daily physical activity level and performance will be measured by an IMU worn on waist for consecutive four days. Two way mixed ANOVA and GEE models will be used to compare changes in outcomes between and within the two groups. In addition, subgroup analyses will be conducted to examine benefits of Mobi-Fit for older adults with different degrees of frailty, physical and cognitive function. RESULTS: Our pilot study showed that participants practicing Mobi-Fit decreased 3 seconds in 5-time sit-to-stand($p=0.04$) and decreased 0.05 seconds in reaction time($p=0.02$). In contrast, participants with usual care decreased hand grip strength by 1.3 kg($p=0.003$). In our CRCT study, we anticipate that participants in the Mobi-Fit group will show improvement in the measures of muscular strength, trunk stability, frailty, and daily physical activity performance. CONCLUSIONS: Results from this study will guide future scale-up implementation of our Mobi-Fit program to promote safe mobility in older adults in care homes. FUNDING: Research Grants Council of Hong Kong (CUHK 24618722). REFERENCES: [1] Robinovitch et al. Lancet, 2013. 381(9860): p.47-54. [2] Yang et al. J Head Trauma Rehabil, 2017;32(3):168-177. [3] Yang et al. Int. J. Environ. Res. Public Health. 2022; 19(9):5453.

Experimental

P3-H-25: Trade-offs in lateral foot placement regulation on curvilinear paths

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BACKGROUND AND AIM: People's ability to adapt their gait to meet specific task goals is essential for safe locomotion. On straight paths, people prioritize maintaining their step width (w) over lateral body position (zB) (Dingwell et al., 2019) but can make w and zB regulation trade-offs to adapt to a given task (Render et al., 2021; Desmet et al., 2022). However, curvilinear paths could require greater zB control that introduces competition between w- and zB-regulation. We hypothesize that to navigate curvilinear paths, people increase zB-regulation at the cost of decreased w-regulation. METHODS: Twenty-four adults (aged 18-35) walked on continuous paths projected onto the belt of a motorized treadmill. Paths differed in width (wide=0.6m and narrow=0.3m) and curvature (none, low, and high). We calculated w and zB at each step in a path-defined local coordinate system that's tangent to the point on the path

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closest to the mid-point between the two feet. We computed error-correction slopes (Mw and MzB) to quantify the degree to which deviations from the average w & zB were corrected on the next step where slope values of -1 indicate perfect correction (Dingwell et al., 2019). To quantify how these step-to-step error corrections give rise to stepping distributions relative to w & zB Goal-Equivalent Manifolds, we plotted left (zL) and right (zR) lateral foot placements in the [zL, zR] plane and constructed 95% prediction ellipses (Desmet et al., 2022), computing aspect ratio (λ1/λ2) and area of each ellipse. RESULTS: Both path width and curvature significantly affected all dependent measures ($p<0.001$). On narrower paths, steps were less variable (ellipse areas decreased), and people corrected their zB more (MzB toward -1.0) and their w less (Mw toward 0), thereby trading off some w-regulation for increased zB-regulation (λ1/λ2 decreased). On low curvature paths (compared to straight), steps were more variable (ellipse areas increased), and people corrected their w more (Mw toward -1.0) and their zB less (MzB toward 0), thereby further reducing zB-regulation for increased w-regulation (λ1/λ2 increased). On high curvature paths (compared to low), steps were more variable (ellipse areas increased), and people corrected their zB more (MzB toward -1.0) and their w less (Mw toward 0). CONCLUSIONS: Here, we quantified how people adapt their steps to negotiate real-world-like contexts that simultaneously challenged both w and zB. On both narrow and high curvature paths, people traded off controlling w for greater control of zB. This enabled greater maneuverability to walk on the continuously winding paths. This complementary inverse coupling between w and zB extends our previously developed lateral stepping regulation framework (Dingwell et al., 2019; Render et al., 2021; Desmet et al., 2022) to walking tasks beyond straight line walking. ACKNOWLEDGEMENTS AND FUNDING: NIH R01-AG049735 & R21-AG053470, & Sloan Foundation G-2020-14067

P3-H-26: Corticomuscular-coherence in Experimental Mal de Debarqument

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BACKGROUND AND AIM: Motion-triggered Mal de Debarquement Syndrome (MdDS) is a poorly understood neurological disorder, in which the affected experience a constant sensation of rhythmic self-motion (mixed rocking, bobbing, swaying; Hain et al., 1999, Van Ombergene et al., 2016). These phantom sensations can manifest pathologically after prolonged passive travel on water or non-pathologically after passive motion stimulation on an experimental platform (Schepermann et al., 2019). This is most prominently reflected in a patients' or subject' low-frequency body sway (patients: 0.2-0.3 Hz; Cha et al., 2020, experimental MdDS: 0.1-0.4 Hz; Schepermann et al., 2019). It is still unverified whether these symptoms originate cortically or from the periphery. So far, findings of an abnormal, persisting synchronization of baseline brain network activity in the brain scans of MdDS patients exhibiting symptoms (Cha et al., 2012, 2013) speak to a central origin. This could be confirmed if functional coherence exists between the brain and lower-leg muscles responsible for the postural sway when symptoms characteristic of MdDS are present. Thus, the aim here was to examine corticomuscular interactions (CMC) before and after the induction of transient MdDS-like aftereffects. METHODS: Non-pathological, MdDS-like dizziness was induced in 17 healthy volunteers (9 females, 31±8 years) after they passively stood, eye open for 30 minutes on a Hexapod platform simulating the low oscillating motion of a cruise ship (Schepermann et al., 2019). A 64-channel resting-state electroencephalogram and surface electromyograms from the gastrocnemius (GM) and soleus (SOL) muscles were recorded simultaneously before and up to 60 minutes after passive motion exposure, noting subjective dizziness at each time-point.

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Data from the subjects were pooled for the calculation of CMC between the cortical Cz and lower leg muscles to a resolution of 0.1 Hz. Significant coherence values were based on 95% confidence limit (0.011). RESULTS: Average subjective ratings of dizziness peaked at 15 minutes after exposure to the motion stimulus, corresponding to previous reports (Schepermann et al., 2019). The CMC between the Cz-GM and Cz-SOL significantly increased from 0.004 (before) to 0.015 at 0.4 Hz, and 0.003 to 0.012 at 0.3 Hz, respectively, when symptoms peaked. CONCLUSIONS: We were able to reproduce MdDS-like aftereffects in another cohort of healthy individuals and reveal significant corticomuscular coupling between the cortex and lower leg muscles in the low delta frequency band that corresponds to the typical body sway observed in MdDS patients. This points to a likely cortical origin of the MdDS-like symptoms. Further application of source analysis on the data collected may allow the localization of the brain activity coherent to the peripheral EMG signal.

Falls and fall risk

P3-I-27: A method for simulating forward falls and controlling and predicting impact velocity.

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Background and aim: Protective arm reactions in response to an unavoidable fall are thought to reduce the likelihood of injury. Assessment of protective arm reactions are typically performed by dropping participants from a height onto a landing surface and the impact velocity is generally predictable to participants. This contrasts with an actual fall where the fall velocity is dependent on several factors and not likely predictable at the onset of the fall. The FALL simulator For Injury prevention Training and assessment (FALL-FIT) uses a counterweight and pulley system to modulate the fall velocity in simulated forward falls in a manner that is not predictable to study participants. However, predicting the fall velocity based on participant height and weight and counterweight mass is not straightforward. The aim of this work is to develop a dynamic model of the FALL-FIT and fit the model to experimental data so that impact velocity may be predicted and controlled in future experiments. Method: A schematic of the FALL-FIT is shown in Figure 1A. The angular velocity of the FALL-FIT can be shown to be a function of the 'pendulum' length, L, the mass of the pendulum, m1, the counterweight, m2, the radius of the gear attached to the support platform, r, and the force acting on the gear attached to the support platform, FP. The force acting on the gear attached to the support platform is a function of the counterweight mass, m2, the number of pulleys, and the drag friction on the pulleys. Data from two previous studies were used to fit the dynamic model1,2. The angular velocity of the FALL-FIT prior to participants contacting the ground, initial lean angle, and counterweight load were used as input to a custom Matlab script to determine the effective length of the pendulum and drag friction of the pulleys that maximized the variance accounted for between predicted and measured angular velocity prior to impact. Results: The angular velocity predicted by the dynamic model equation and experimental data from experiment with varying initial lean angle are shown in Figure 1B and for varying counterweight in Figure 1C. The pendulum length that maximized the variance accounted for by the initial lean angle was L=1.21 m and for counterweight load was L=1.30 m. Initial lean

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angle predicted 72% of the measured variance in angular velocity and counterweight load predicted 60% of the variance with an associated drag friction of 0.18 [unitless]. Discussion: We have developed a dynamic model that predicts the angular velocity at impact in forward falls in a manner that is unpredictable to participants and controllable. The feasibility of using the FALL-FIT in laboratory-based experiments has been demonstrated previous, however the utility of the FALL-FIT system in reducing fall injury risk and deployment as a clinical tool remains to be determined. 1. Borrelli, Human Movement Science. 81, 2021 2. Borrelli, Journal of Biomechanics. 150, 2023

P3-I-28: Investigating the effects of visual delay in human balance and stability using VR

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BACKGROUND AND AIM: The study of human postural instability and its mechanism is critical for understanding the fall mechanics and the underlying factors engendering the instability in human postural balance. In this study, we analyze the postural instability of upright human stance and the mechanisms responsible for the induction of this instability through artificial manipulation of the visual sensory feedback through the application of Virtual Reality (VR). Previous studies have established the existence of instability via limit-cycle oscillations (LCOs) when the combination of neuromuscular gain and delay is excessive in a mathematical model, but experimental proof remains elusive. Through the manipulation of the visual sensory feedback in VR, we try to understand and evaluate specific neuromuscular mechanics such as delay in feedback and its effects on muscle strength resulting in instability. Also, we try to observe the existence of compensating behavior in upright balance in subjects after the time period of sustained delay. METHODS: For this study, we are testing the prediction of the mathematical models by manipulating the neuromuscular feedback gain through visual system in VR. For this study, we are looking to recruit around 50 participants, all above the age of 18, not suffering from any neurological disorders, weighing less than 400 lbs., and not having any uncorrected visual defects. The participant is then asked to stand on the AMTI optima BS400600 force plate while looking forward for 23 trials. The first two trials are preliminary data where the participants' data of CoP is taken with their eyes open and closed and serve as a baseline for the rest of the study. From trial 3 through 17, the participant is asked to wear Oculus Rift S VR headset where the delay is increased consistently from 0ms to 700ms with each time the delay being increased by 50ms. The last six trials are conducted as residual trials with participants having to take mandatory timed breaks in between. RESULTS: Attached as the plot. CONCLUSIONS: From the initial analysis of raw data, it can be observed that the rise in delay which is introduced from trial 3 to trial 17 in VR environment gives rise to postural instability. In figure 1, it can be observed that the COP elliptical area increases as the number of trial increases, peaking at trial 17 which coincidentally is when the delay time through VR is maximum. Similarly, this is reinforced by the fact that LCO arise with the increase in delay (through trials 3 to 17). Based on this observation of the preliminary data, we can draw an early conclusion of the existence of LCOs experimentally with the increase in visual delay. However, future trials specifically in the age group of people over 60 will be analyzed for definitive conclusion on the existence of LCOs during human postural instability and subsequent compensating mechanism of the body.

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P3-I-29: Longitudinal associations between physical and cognitive declines and falls in older people with and without mild cognitive impairment

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Background and aims: Falls are associated with impaired physical function, such as slow gait speed, impaired mobility, and poorer balance in people with MCI. However, longitudinal physical and cognitive declines and their associations with falls remain unclear. We examined longitudinal changes in physical and cognitive function, as well as the associations between change in function and falls, in people with and without mild cognitive impairment (MCI). Methods: Prospective cohort study with physical and cognitive assessments every 2-years (for up to 6-years) were conducted. Four hundred and eighty-one community dwelling older people classified into three groups: those with MCI at baseline and MCI or dementia at follow-up assessments (n=92); those who fluctuated between cognitively normal and MCI throughout follow-up (cognitively fluctuating) (n=157), and those who were cognitively normal at baseline and all re-assessments (n=232). Number of falls were collected in the year following participants' final assessment. Mixed-effects regression models with random intercepts were used to determine the main effects of cognitive group and time on cognitive and physical performance over 6 years follow-up. The associations between change in cognitive and physical performance and multiple falls (≥2 falls) were assessed using binary logistic regression in Generalized Linear Models (GLM). Results: In summary, 27.4%, 38.5% and 34.1% of participants completed 2, 4 and 6 years follow-up of cognitive and physical performance, respectively. The MCI and cognitive fluctuating groups demonstrated cognitive decline over time whereas the cognitively normal group did not. At baseline, the MCI group had worse physical function than the cognitively normal group but among three groups showed similar decline in physical performance over time. In the cognitively normal group, decline in global cognitive function and sensorimotor performance were associated with multiple falls. In the whole sample, decline in mobility (timed-up-and-go test) was associated with multiple falls. Conclusions: Cognitive declines were not associated with falls in people with MCI and fluctuating cognition. Physical function decline was comparable across all groups, but a decline in mobility was associated with falls in the whole sample. The study suggests that exercise, which multiple health benefits including maintaining physical function should be recommended for all older people. Additionally, programs aimed at mitigating cognitive decline should be encouraged specifically in people with MCI.

P3-I-30: Inadvertent obstacle contacts in older adults when a preferred foot placement target is available during the approach to the obstacle.

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BACKGROUND & AIM When stepping over a stationary, visible obstacle, participants occasionally trip on the obstacle [1,2]. Trips result from inadequate limb elevation, and the error may result indirectly from inappropriate foot placement before the obstacle (green trajectory, Fig 1B), or the error may result directly from incorrect joint angles of the lower limbs despite appropriate foot placement (red trajectory, Fig 1B) [1]. Appropriate foot placement is reflected

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in reduced foot placement variability during the approach to the obstacle [1]. Thus, contacts may be reduced with visual foot placement targets on the walkway that facilitate the reduction in foot placement variability. To determine if placing a target on the walkway at the preferred foot placement affected inadvertent trips in OA, we conducted a secondary analysis of an obstacle crossing study with one foot placement target and compared it to published data on inadvertent trips without targets [1,2]. METHODS 32 older (OA, 69+8 years) adults walked on an 8 m walkway and stepped over a stationary, visible obstacle (~22 cm) for 140 trials. To match published research [2], trials were truncated to 100 trials. Either no target (20% of trials) or one target (80% of trials) was present in the walkway (green rectangle, Figure 1). RESULTS In this section, results are reported first for the current study (with a target at preferred foot placement) vs the previous studies (no targets) [1,2]. The percentage of OA that had ≥1 obstacle contact was lower with a target than without (19% vs 37% [2]). The percent of trials with contact was lower (1% vs up to 3.5% [1,2]). The percent of contact trials where the cause was foot placement error was substantively lower (14% vs 100% [1]). The percent of contacts in the first vs second half of trials was 23% vs 77%. CONCLUSION The lower percent of people who tripped and the lower foot placement errors support the idea that the stepping target enhanced correct foot placement during the approach to the obstacle [3], which may have led to fewer trips. These observations are consistent with the argument that OA with higher fall-risk prioritize planning of future steps over accurate execution of ongoing steps which may contribute to trips and falls [3]. Safer community ambulation may be possible through the placement of visual cues in front of hazards, such as a curb or staircase, to alter gaze behavior, leading to more accurate foot placements. Lastly, fatigue likely increased the frequency of trips in the later trials, consistent with [2], and highlights the importance of endurance training for fall prevention programs. REFERENCES [1] Muir et al. (2020). Gait & posture, 77, 100-104. [2] Becker et al. (2022). Braz. J. Mot. Behav, 16, 385-399. [3] Chapman & Hollands (2007). Gait & posture, 26(1), 59-67.

P3-I-31: Can volleyball landing technique be learned to minimise injury risk from a fall? A proof-of-concept study

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Background: The aim of this proof-of-concept study was to investigate the use of an adapted volleyball landing technique to reduce impact forces and improve safety during a forward fall in young healthy adults. We examined if the safe landing techniques adapted from volleyball can be learned in a single training session in young healthy adults. Methods: This was a randomised controlled experiment involving 32 young healthy participants with a mean age of 22.2 ± 2.7 years old. Participants were randomly assigned intervention (N=17) or control (N=15) group. The intervention group undertook a 45-minutes chest-landing training protocol with objective motor skill learning goals in seven training steps (from 1 bracing with elbow flexion, 2 chest landing from a kneeling position, to 7 safe landing from standing falls). The control group was provided with sham general physical exercise including push-ups and squats fatigue levels. Prior to and following the single training session, each participant underwent fall impact assessments using a tether-release method (release from a holding force of 30% at random timing) onto two force plates and Vicon 3D motion capture. Results: Half of the intervention participants (N=8) achieved all learning goals in a single training session. Both groups were similar at baseline with no significant difference in fall impact measures. Following the training, the intervention group decreased the initial impact force exerted on the hand and

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wrist by 20% (P<0.05) whereas the control group did not change. Only the intervention group increased in their fall duration (time between onset of fall to rest) by 9.41% and impact duration (time from initial/hand impact to main/body impact) and 28.97% (P<0.05). A larger range of motion in the hip and knees were observed when the intervention participants were falling compared to the controls (P<0.05) (Figure 1). Compared to the controls, the intervention participants reported reduced pain during a fall and increased confidence to avoid injury following the training. Conclusion: Young healthy participants who undertook the Volleyball chest landing training relied less on their arm strength to brace the fall impact, took longer impact duration by landing sequentially with their hands, upper and lower bodies. These changes also resulted in reduced pain during falls and they increased confidence to avoid injuries from falling. Half of young healthy adults could learn the volleyball chest landing technique in a single training session but other half would benefit from additional training sessions.

P3-I-32: Impact of physical feedback during virtual obstacle avoidance training in older people

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Background: Falls in older people often occur with trips and slips. Traditional exercise interventions focus on improving standing balance and muscle strength but do not address interacting with environmental hazards that can lead to falls in daily life. This may be achieved by use of virtual reality (VR) which has been successfully used to engage older people. We have developed a VR obstacle avoidance training on a treadmill that can provide physical feedback (treadmill belt accelerations/decelerations) when feet collided with a virtual obstacle. This study aimed to examine impact of physical feedback on motor adaptation to avoid obstacles using virtual reality in older people. Methods: This is a crossover randomised experiment involving 20 older people living in the community. Participants wore an immersive VR head-mounted display (Oculus S Rift), a safety harness and walked on a split-belt treadmill (M-Gait) for 8 minutes for two sessions/conditions in a random order. They walked on a footpath in a virtual suburban while collecting apples with hand controllers and avoiding hazards such as a glass bottle and muddy puddle (Figure 1). In a perturbation (P) condition, any foot-obstacle collision resulted in immediate physical feedback via treadmill belt accelerations/decelerations. In a non-perturbation (NP) condition, no physical feedback was provided. Obstacle collision rates (primary outcome) and subjective measures were collected and compared between the P and NP conditions. Results: No between-condition difference was seen in obstacle collision rate in all participants (N=20). However, among those who started with the NP condition (N=12), there was a significant reduction in obstacle collision rate in the P condition (NP 36.7 ± 15% to P 28.7 ± 19%, P < 0.05). Among those who started with P condition (N=8), obstacle collision rate was relatively low from the beginning and stayed low in the subsequent NP condition (P 26.2 ± 12% and NP 23.7 ± 9%, P = 0.472). Obstacle collisions occurred frequently by the heel of the leading foot and the toe of the trailing foot. The most collided obstacles were raised concrete slabs (69.4%) and the least collided obstacles were cans and bottles. Conclusion: Physical feedback during VR obstacle avoidance training may facilitate motor skill learning among older people. Obstacle avoidance skills learned during the VR training with physical feedback may be retained even when the physical feedback is removed in a subsequent session. Daily-life obstacles in low contrast as raised concrete slabs require

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particular attention. Older people also need particular attention with heel of the leading foot and toe of the trailing foot which are most often collided with stepping over an obstacle.

P3-I-33: Muscular responses to repeated simulated trips on a treadmill vs walkway

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Background and Aim To address the issue of falls, perturbation-based balance training (PBT) is a task-specific approach utilising repeated exposure to postural perturbations. Overground PBT delivered on a walkway has high ecological validity but lacks feasibility for use in clinical settings. In contrast, PBT using a surface perturbation treadmill offers a feasible alternative but its ecological validity and training mechanisms are not well understood. Thus, this study aimed to compare the proactive and reactive muscular adaptations during PBT delivered as walkway trips and treadmill belt accelerations in older people. Methods This was a randomised crossover trial involving 38 healthy, older adults (65+ years). Participants were randomised to begin with PBT on the treadmill (T-W) or walkway (W-T), followed by a short break then the other mode of PBT. Each PBT session included a total of 11 simulated trips (via a pop up obstacle or treadmill belt accelerations) interspersed with 18 normal walks in a randomised order. Trips occurred on both legs, with the first (T1), fourth (T4), seventh (T7) and eleventh (T11) trips occurring on the left leg and the first full recovery step (rec1) executed by the right leg used for analysis. Muscular responses were measured using 8-channel wireless surface electromyography (1000Hz), with electrodes placed bilaterally over the rectus femoris (RF), tibialis anterior (TA), semitendinosus (ST) and gastrocnemius medial head (GM). As reactive adaptations, changes in muscle activation onset latency, peak magnitude, time to peak and co-contraction index (CCI) in rec1, and proactive adaptations, as changes in pre-trip muscle activity were measured. Results No significant time-based changes were observed in proactive pre-trip muscular activity levels with repeated trials for both walkway and treadmill PBT. PBT on the walkway resulted in significant reductions with repeated trials in onset latencies of the right TA and ST from T1 to T11 ($P<0.05$). No significant time-based changes were observed for peak magnitude, time to peak or CCI with repeated trials on the walkway. Treadmill PBT resulted in significant reductions in peak magnitude for the RF, TA and ST on the left leg and ST and GM on the right leg from T1 to T11 ($P<0.05$). No other significant time-based changes were evident with repeated trials during treadmill PBT. Conclusions PBT using repeated obstacle trips and treadmill belt accelerations elicit different muscular adaptations. Walkway PBT resulted in faster initiation of muscles responsible for ankle dorsiflexion and knee flexion during the first large recovery step. In contrast, treadmill PBT resulted in a decline in peak muscle activity of major leg muscles responsible for ankle dorsiflexion, knee flexion and hip flexion/knee extension. Further research determining the transferability of these treadmill PBT muscular adaptations to an obstacle trip will provide a better understanding of the value of treadmill

P3-I-34: Do novel instrumented cognitive-motor assessments increase the ability to identify older people who fell? Preliminary findings

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BACKGROUND: Falls are a major cause for injuries in older adults and are associated with motor and cognitive impairments [1]. Thus, sensitive assessment tools capturing subtle changes in motor and cognitive functioning are crucial for the prediction of falls. Aim of this study was to test the ability of a novel instrumented, cognitive-motor assessment battery to distinguish older people who experienced a fall in the past 12 months (fallers) from people who did not (non-fallers) as well as its added value to predict fall status compared to gold-standard clinical fall risk assessments. METHODS: This is a secondary analysis using baseline data of an international RCT study. Participants (>60 years old, categorized in two groups: fallers and non-fallers) performed five instrumented tests (Reaction time test (psychomotor speed), Flexibility test (mental flexibility), GoNogo task (inhibition), Sway test (postural control), and Coordinated Stability test (dynamic balance control)), as well as the Timed-up and Go (TUG) test as a gold standard assessment. A correlation analysis was performed to identify test variables correlating with the group assignment which could then be included in a logistic regression analysis. Furthermore, an ROC AUC analysis was performed. RESULTS: Preliminary results of n=42 showed that only TUG showed a significant association with the fall status (Spearman's ρ=.34, p=.028). Of the instrumented assessments, only the inhibition assessment was close to the significance level (ρ=.30, p=.0503). Similarly, the ROC analysis showed significant AUC values only for TUG (AUC=.750, p=.029). The instrumented cognitive-motor assessments presented AUC values of .287-.706 (p=.073-.677). CONCLUSIONS: This preliminary analysis showed that, in line with previous research [2], fallers tended to exhibit lower performance on TUG, but also on a novel inhibition task. However, only TUG had significant discriminative properties in respect to categorizing people who fell in the past or not. The study is still ongoing, and thus, the complete results (n=180 people) will be presented on the poster. REFERENCES: [1] Hsu CL, Nagamatsu LS, Davis JC, et al. Examining the relationship between specific cognitive processes and falls risk in older adults: A systematic review. Osteoporos Int. 2012;23:2409-2424.; [2] Schoene D, Wu SMS, Mikolaizak AS, et al. Discriminative ability and predictive validity of the timed up and go test in identifying older people who fall: Systematic review and meta-analysis. J Am Geriatr Soc. 2013;61:202-208.

P3-I-35: Differentiating characteristics of adult populations with varied living support needs before, during and after an attentional focus training intervention, using a smartphone-based data collection

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BACKGROUND AND AIM: Managing fall risk in the older adult population remains a concern, since fall rates escalate as adults grow older. With the serious consequences of falls for injury, loss of independence or early death, identifying strategies to help vulnerable populations is critical. A test for balance was previously used with a group of adults that had sustained a fall, to see if a balance training intervention with attentional focus instructions would give measurable benefit. When the training groups had similar results, it was then posited that the adults may have differed by living location before training occurred. It was hypothesized that adults in different living support situations (single family homes, independent living, and assisted living facilities) would have different results with the variables of a smartphone based balance test with a stepping in place task, which would potentially explain the lack of training differences in the balance intervention. METHODS: 79 adults were randomly assigned to three training groups: Control (N= 22, 74.3 ± 4.6 yrs), Internal focus (N= 26, 80.5 ± 6.3 yrs) and External focus (N= 31, 80.7 ± 6.0 yrs), with six separate training sites. The groups were tested

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at baseline, after 6 weeks of training, at 12 weeks training, and then after training completed up to 20 weeks. The phone test app cued a series of two stepping trials each in three conditions: eyes open (EO), eyes closed (EC), and headshake (HS). The phone data was analyzed for mean thigh angles and timing of thigh movement, as well as SD and CoV. A Pearson correlation was then created for all the phone variables at each site. RESULTS: The training groups did not have differentiating spatial or temporal phone variables. By site, there was a difference at baseline for several locations. Pairwise comparisons show only the following sites were similar: mean stride time (.93 seconds, .035s difference, p= .567) for the assisted living (ALF) and community IL, for SD stride time between SFH and ALF (.13 seconds, difference 0.35 s, p=.11), between ALF and SFH for CoV (18.2, difference 2.01, p=.49), between ALF and IL SD peak flexion (5.2 deg, difference 1.6 deg, p=.104), between ALF and SFH Cov peak flexion (45, diff .694, p=.92). In the Pearson correlation for headshake condition only, there were stronger site related differences from baseline for the settings with mean stride time (-.362), SD stride time (.248), CoV stride time (.338), SD peak flexion (.428), and CoV peak flexion (.374), all at p=.01. CONCLUSIONS: While training balance with attentional focus did not deliver benefits by group, there were site differences between the ALF and the others. The ALF group had more variability at baseline than most other groups, but then improved from training. The ALF received external focus training, considered to be superior in the literature, which may explain the results.

P3-I-36: A stair fall pandemic: Impact of COVID-19 lockdown on home stair falls in older adults

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BACKGROUND AND AIM: Stair falls in older adults can have severe consequences for the faller, their carers, and health and social care services. The COVID-19 pandemic brought about a national lockdown, confining people to their homes for a substantial amount of time. Amongst the consequences of these lockdowns, physical inactivity, social isolation, and loneliness may have impacted the occurrence of and outcomes from stair falls (Montero-Odasso et al., 2022). Particularly so in older adults from socio-economically disadvantaged areas, as they are more likely to have chronic conditions and live in a home that poses risks to their health and safety (Ryu et al., 2017). Therefore, this study investigated the effect of the COVID-19 pandemic on stair falls in the home environment. METHODS: An online and telephone survey was conducted with UK residents aged ≥ 50 years between June and October 2021. The survey captured stair falls in the home environment before (June 2019 - 23rd March 2020) and during (23rd March 2020 - October 2021) COVID-19. Additional outcome measures included Indices of Multiple Deprivation (IMD) quintiles based on postcodes, and perceived activity levels. RESULTS: There were 164 responses. Twenty participants reported at least one stair fall, of this 60% (n=12) reported a stair fall before and 75% (n=15) during the COVID-19 UK lockdown. Nighty percent of stair fallers were in IMD quintiles 3 (20%, n = 4), 4 (30%, n =6) and 5 (40%, n = 8) and 10% were in quintiles 1 (5%, n = 1) and 2 (5%, n = 1). In addition, 40% of stair fallers reported being less physically active, 35% reported no change in physical activity levels, and 25% reported being more physically active during the COVID-19 lockdown, respectively. However, there was no significant difference in the rate of stair fallers across IMD quintiles, indicating that older adults from socio-economically disadvantaged areas were not at a greater

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risk of a stair fall. CONCLUSION: The survey revealed that more stair falls occurred during the COVID-19 pandemic lockdown, but there was no evidence to suggest people living in socio-economically disadvantaged areas were more likely to experience a stair fall. This may be related to the low number of responses from socio-economically disadvantaged areas. Instead, a decrease in physical activity levels during the COVID-19 lockdown may have increased the risk of a stair fall during the pandemic. A reduction in physical activity during lockdown likely resulted in physical deconditioning and muscle atrophy. Further research is needed to establish the specific circumstances under which the stair falls occurred, including changes in behaviour on stairs, and assess the impact of individuals staircase features on these falls. Understanding living conditions and stair falls can identify at-risk individuals and hazards, facilitating targeted interventions or community-based fall prevention programs and prevent stair falls in vulnerable older adults.

P3-I-37: The (cost-)effectiveness of an implemented fall prevention intervention on falls and fall-related injuries among community-dwelling older adults with an increased risk of falls: protocol for the In Balance randomized controlled trial

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Background and aim: Falls and fall-related injuries among older adults are a serious threat to their quality of life and result in high societal costs. In this study, we will investigate the effectiveness and cost-effectiveness of In Balance, a fourteen-week, low-cost group fall prevention intervention, that is already widely implemented in the Netherlands for community-dwelling non- and pre-frail older adults with an increased fall risk. We expect the In Balance intervention to be (cost-)effective in comparison with standard care in reducing the amount of falls and fall-related injuries in non- and pre-frail older adults. Methods: This study is a single-blinded, multicenter randomized controlled trial. The target sample will consist of 256 community-dwelling non-frail and pre-frail adults of 65 years or older with an increased risk of falls. The intervention group receives the In Balance intervention as it is currently widely implemented in Dutch healthcare, which includes an educational component and physical exercises. The physical exercises are based on Tai Chi principles and focus on balance and strength. The control group receives general written physical activity recommendations. Primary outcomes are the number of falls and fall-related injuries over 12 months follow-up. Secondary outcomes consist of physical performance measures, physical activity, confidence during walking, health status, quality of life, process measures and societal costs. Mixed model analyses will be conducted for both primary and secondary outcomes and will be stratified for non-frail and pre-frail adults. Results: No results can be presented since this is an overview of a study protocol. Conclusions: This trial will provide insight into the clinical and societal impact of a widely used Dutch fall prevention intervention and will have major benefits for older adults, society and health insurance companies. In addition, results of this study will inform healthcare professionals and policy makers about timely and (cost-)effective prevention of falls in older adults.

Neurological trauma (e.g. Stroke, TBI, concussion)

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P3-J-38: Development of a new Artificial Intelligence-based dimensionality reduction using kinetic and kinematic data of healthy adults and patients with hemiplegia

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BACKGROUND AND AIM While an increasing number of elderly people suffer from various movement disorders, it is getting more difficult for clinicians to find and provide effective personalised rehabilitation timely. Artificial Intelligence-based data analysis could be helpful for clinicians to evaluate different aspects in patients and thus discover new approaches for more timely and effective rehabilitation. While a machine learning based biomechanical gait analysis has been proposed, it still requires an adequate number of samples for dimensionality reduction. We aimed at developing a new method of dimensionality reduction with a small sample. METHODS 44 patients with hemiplegia and 110 healthy adults were recruited. Both kinetic and kinematic data were measured during walking, using force plates (MG-1120, ANIMA Corp.) and 3D motion capture system (MA-3000, 12 cameras, 100Hz, ANIMA Corp.). 180 parameters were investigated as explanatory variables. Gait speed was used as a response variable due to significant difference between the two groups. We implemented the Mahalanobis Distance (MD) algorithm with ten dimensions and Markov Chain Monte Carlo (MCMC) method to reduce the dimensionality even with a small sample. One calculation cycle consists of 1) first random selection of 10 parameters out of 180, 2) calculation of the MD and correlation coefficient, and 3) adjustment of the 10 parameters based on the calculated coefficient and MCMC algorithm. The cycle was repeated to finalise the 10 parameters that were the most relevant to gait speed. To avoid the bias due to the first selection of 10 parameters, the whole process above was repeated by changing the first 10 parameters. Finally, we estimated the frequency of each explanatory parameter to investigate which parameters were frequently detected in the process of dimensionality reduction. RESULTS The new method of dimensionality reduction revealed 13 parameters with the probability over 0.12: 8 Trailing Limb Angle (TLA) parameters on sagittal plane, 3 hip flexion (HF) parameters, and 2 ground reaction force (GRF) parameters in forward direction (Table 1). The results suggest that the proposed dimensionality reduction approach would be promising since critical parameters for hemiplegia were selected. In addition, TLA could be one of the important elements that we would attend to in the hemiplegia rehabilitation. CONCLUSIONS The proposed method found that TLA, HF, and GRF parameters would be a good indicator to classify people with hemiplegia. Since these parameters are relevant to hemiplegia, the new method would be useful to reduce the dimension regardless of small sample size. The results of this study warrant further research to compare the parameters derived from the conventional approach (e.g., principal component analysis), and those found in this study to inspect whether the new approach is valid. Acknowledgements This work was supported by JSPS KAKENHI Grant Numbers JP20K21775 and JP21H03311.

P3-J-39: Blast exposure leads to changes in dynamic balance performance in Service Members

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BACKGROUND AND AIM: In the military community, there is growing concern about potential neurological deficits from repeated sub-concussive blast exposure (RSCBE) that can occur in training/operational environments. While these neurological insults are sub-clinical (i.e., not diagnosed as a concussion), data suggest RSCBE may impede neurological function. While most studies in this space have small sample sizes, the Investigating Training Associated Blast Pathology (INVICTA) Study is enrolling a large cohort of blast exposed service members, along with a control cohort. Balance tests are commonly used to assess neurological function and this abstract presents preliminary data from INVICTA examining dynamic balance changes after RSCBE in U.S. Service Members. METHODS: This repeated-measures longitudinal study design enrolled participants who received RSCBE as part of a training program, which included Special Operators (or trainees) who shot heavy weapons as part of their training and Range Safety Officers (RSOs) present when the heavy weapons were shot. Special Operators (or trainees) and RSOs were combined into a single "blast exposed" group. Participants completed a dynamic balance task--consisting of two stepping-in-place trials with a custom smartphone app collecting data from the participants' thigh movement--before (baseline) and after (6-hr, 72-hr, 2-wks, and 3-months) RSCBE. Special Operators (or trainees) who participated in the training, but did not shoot heavy weapons and active-duty Service Members who did not participate in the training were enrolled as the "control cohort". Variability in stepping (i.e., neuromotor performance) was quantified as the Coefficient of Variation (CV) of the peak thigh flexion angle (CV PeakFlex %). A linear mixed effect model and F-test was used to examine group differences. RESULTS: A total of 110 participants qualified for analysis (i.e., two or more timepoints): 83 blast exposed Service Members and 27 controls. A significant time by group interaction was observed, $F(4,382.94) = 4.32$, $p < 0.01$. For the blast exposed group, change across timepoints was significant, $F(4,291.23) = 4.41$,$p < 0.01$. Pairwise comparisons showed that the baseline (est M = 6.77, SE = 0.171) and 6-hr (est M = 6.07, SE = 0.173) timepoints were different ($p < 0.01$), with no other significance after adjusting for the type I error. For the controls, no difference across timepoints was observed, $F(4,91.405) = 1.6143$, $p = 0.17$. CONCLUSIONS: A short-term (6-hr) decline in balance control variability was observed after blast exposure, reflecting a shift toward more robotic (and less adaptable) movement. These findings are consistent with previous neuromotor research following a nervous system insult. The shift toward robotic movement is thought to reflect a reduction in the functional degrees of freedom within the nervous system, thus reducing the body's ability to make micro-adjustments as needed to optimize movement.

Other clinical pathologies (e.g. musculoskeletal disorders)

P3-K-40: Dynamic balance and gait outcomes after 1-year post-operative hemipelvectomy surgery

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Background and aim: Currently, the focus when considering post-operative functional assessment in patients with musculoskeletal cancer (sarcomas) is to measure their disability,

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while balance (postural stability) issues and their investigation is lacking in most sarcoma research. Static balance (during standing) has been investigated in two pilot studies (De Visser 2001, Furtado et al 2020) respectively, but there are no studies that look at dynamic balance (during walking) even though people with musculoskeletal cancers present with significant balance problems and falls in the long-term. This study aimed to investigate the feasibility of assessing dynamic balance after hemipelvectomy surgery for a sarcoma. Methods: This is a retrospective cross-sectional pilot and feasibility study (Ethics approval: 21/WA/0027) analysing existing datasets from the Gait Real-time Analysis Interactive Laboratory (GRAIL) database at RNOH for 10 sarcoma patients who underwent hemipelvectomy one year ago and 10 healthy participants (controls). The margin of stability (MOS) was used to quantify dynamic balance ability in all participants during treadmill walking. MOS in the anterior, posterior, lateral and medial direction, stride length and stride width of the patients and controls at heel contact or during the swing phase were compared using the Mann-Whitney U-test. Results: 10 patients (nine males and 1 female) with pelvic sarcomas of mean age, weight and height of 41(±13) years, 78.4(±16.9)kg, 1.77(±0.10)m were enrolled into this study. No statistically significant differences were seen in patient MOS between the operated and non-operated side during the swing phase ($p>0.05$), but it was found that the patient's stride length was usually longer on the operated side than on the non-operated side ($p<0.05$*). Furthermore, it found that patients had significantly smaller values of posterior MOS during the swing phase ($p<0.05$*) and smaller values of medial MOS during heel touch compared to controls ($p<0.05$*) (Fig. 1). Conclusion: This is the first study demonstrating that it is feasible to quantify dynamic balance in the sarcoma population. It is pertinent to note that, MOS identified struggling the patients with balance issues during walking. However, no differences were found between the balance of the operated and non-operated side of the leg during the swing phase and the stride length of the operated leg was longer than the non-operated leg in patients after hemipelvectomy. Encouraging balance training using physiotherapy and rehabilitation strategies when walking in the posterior and medial directions, may help to improve overall body balance.

P3-K-41: The balance control feedback system in transfemoral amputees

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BACKGROUND AND AIM: Lower limb prosthesis users have diminished and different sensory feedback for balance. Typical proprioception and cutaneous cues are absent below the level of amputation and only partially transmitted through cutaneous feedback within the socket on the residual limb. Despite the important role of balance in daily life, very few mechanistic studies quantify feedback postural control in prosthesis users. Our project examines above-knee prosthesis users in both planes of motion and includes clinical scores of mobility and balance. We describe above-knee amputees' balance control system and test the hypothesis that amputees shift weight away from their prosthetic side to compensate for balance perturbations. METHODS: Five transfemoral amputees (24-74 yrs) with a broad range of walking ability participated in 4 eyes closed balance tests. Each test was 4.5 minutes of continuous pseudorandom surface tilts: small (2 deg) anterior-posterior (AP), large (6 deg) AP, small medial-lateral (ML), and large ML tests. Subjects responded naturally to the perturbations while the trunk, pelvis, and greater trochanter were measured. Postural sway of the center of mass were analyzed through root-mean-square (RMS) sway, frequency and step response functions. A feedback model was used to describe the underlying control processes for each subject. The inverted pendulum model was controlled through torque generation in

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proportion to body sway (stiffness), sway velocity (damping), and slower acting time-integrated sway (integral control). The model also had a time delay between sensory feedback and corrective toque and had sensory weights (vestibular and somatosensory contributions). The clinical tests included the ABC, PROMIS Function and Fatigue, and PEQ. RESULTS: Amputees completed the tests with notable exertion and fatigue. There were instances of knee buckling and spotting required to prevent a fall. One subject strongly shifted toward his sound side, two did so slightly, and two subjects shifted toward their prosthesis side on several tests. Subjects who shifted toward their sound side typically had the lowest sway responses and their neural control system had large integral gains (limiting slower lower frequency sway) and large damping. Despite the increased exertion in amputees, many of the averaged sway metrics and model parameters were similar to previous reports of healthy adults. Across all amputees, when stimulus amplitude increased, there was a statistically significant increase in stiffness and vestibular feedback, and a significantly shortened time delay. CONCLUSIONS: This is the first characterization of the balance control system in transfemoral amputees. When responding to surface tilts, amputees who shifted away from their prosthetic side generally reduced sway by increasing torque in response to sway velocity (damping) and sway summed over time (integral feedback). FUNDING: DoD Award: W81XWH-19-1-0870

P3-K-42: Effects of posterior spinal fusion surgery on gait biomechanics in patients with severe adolescent idiopathic scoliosis

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BACKGROUND AND AIM: Scoliosis is a complex multidimensional spinal deformity which affects spinal anatomy, quality of movement and walking, and trunk symmetry. Posterior spinal fusion (PSF) is usually performed to stop curve progression, reduce back pain, and to restore asymmetric upper body [1]. Previous studies indicate that there is an alteration of gait patterns in patients with Scoliosis and this gait pattern is substantially altered after surgical intervention. In India, these deformities are often neglected and present at a very late and much more deformed state (mean cobb angle ≥60 Degrees). So, we have planned a study to investigate the effects of posterior spinal fusion surgery on spatio-temporal, kinematics, kinetics, and Electromyography (EMG) in severe Adolescent Idiopathic Scoliosis (AIS) patients during gait. METHODS: This clinical prospective study after written informed consent included 60 AIS subjects and 20 healthy controls (mean age 16.3 Years) diagnosed with thoraco-lumbar/lumbar AIS (cobb angle MT 78.62 ± 8.10, TL/L 60.52 ± 7.42). Spatio-temporal parameters, kinematics, kinetics, & EMG were evaluated preoperatively and after 1 Year of surgery for AIS subjects and one time for healthy controls using instrumented 3D gait analysis (BTS, Italy) (Figure-1). Student T test, & two way annova were performed to find significant differences between pre and post operative AIS and healthy controls. RESULTS AND DISCUSSION: Gait speed (p= 0.001), cadence (p= 0.001), and step length (p= 0.01) were improved significantly after 1 Year of surgery. Trunk tilt range (p= 0.53), pelvis tilt range (p= 0.79), gait profile score (GPS) (p= 0.56), and gait deviation index (GDI) (p= 0.89), were not changed significantly postoperatively. No significant changes in the mean angle of spine flex extension (p= 0.78), Peak during loading and propulsion phase of the gait cycle (p= 0.12), EMG activity of erector spine (p= 0.14)& gluteus medius (p= 0.19)were observed postoperatively. A comprehensive study involving long-term post-operative follow-up is needed to draw decisive conclusions regarding the alteration in the gait of scoliosis patients postoperatively. CONCLUSIONS: The results of our study suggested that Surgical intervention did not cause any significant changes in the upper

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and lower limb kinematics during gait, despite of large part of spinal fusion. Postoperative significant improvements in spatio-temporal parameters explain the well functioning in the daily life of subjects with Adolescent Idiopathic Scoliosis.

P3-K-43: Assessment of ankle joint quasi-stiffness in individuals with incomplete spinal cord injury

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BACKGROUND AND AIM: The ankle joint plays a critical role in regulating standing balance. Partial paralysis in the ankle musculature in individuals with incomplete spinal cord injury (iSCI) causes deteriorated standing balance, characterized by larger postural sways and increased fall risk. We previously demonstrated that individuals with iSCI exhibit unique control in their ankle musculature compared to able-bodied (AB) individuals (Fok et al., J Neurophys 123:2343, 2020; Fok et al., Scientific Reports 11:19599, 2021). Here we investigated the ankle joint quasi-stiffness to evaluate the mechanical role of the ankle joint in controlling standing balance in individuals with iSCI. The quasi-stiffness encapsulates torque-producing mechanical properties of the joint and represents its ability to resist angular displacement. METHODS: 15 individuals with iSCI and 14 age- and sex-matched AB participants performed quiet standing under eyes-open (EO) and eyes-closed (EC) conditions. Since the level of impairment in the iSCI group ranged widely, we excluded high-functioning iSCI participants using a clinical score in our analysis (CB&M score of 75/96). Our analysis was therefore based on 13 iSCI and 14 AB participants. We used two methods for evaluating ankle quasi-stiffness, as a secondary aim to compare the correlation between them. The first method, proposed by Winter et al., estimates the ankle quasi-stiffness (Kqs1) by approximating quiet standing as a single-link inverted pendulum governed by a mass-spring-damper model (Winter et al., J Neurophsiol 80: 1211-, 1998). The second method, by Loram and Lakie (Loram and Lakie, J Physiol 540: 1111-, 2002), decomposes postural sway during quiet standing into a series of unit sways and calculates the slope of the torque and angle plots (Kqs2). RESULTS: There was a high correlation between the quasi-stiffness calculated using the two methods (EO: r=0.966, EC: r=0.919). From the mixed analysis-of-variance, we found Kqs1 to be significantly greater in individuals with low-functioning iSCI than the AB participants (EO: 1426.2 Nm/rad vs 903.03 Nm/rad; EC: 1532.2 Nm/rad vs 1058.4 Nm/rad, p = 0.023). There was no statistically significant difference between the two groups for Kqs2, while there was a tendency for stiffness to be greater in the iSCI group compared to the AB group (EO: 1273.9 Nm/rad vs 851.75 Nm/rad; EC: 1340.9 Nm/rad vs 976.23 Nm/rad, p = 0.051). CONCLUSIONS: We demonstrated that the ankle quasi-stiffness is larger in individuals with iSCI than in AB individuals during quiet standing. Muscle atrophy probably causes reduced intrinsic stiffness in individuals with iSCI, while they use co-contraction strategy as a compensatory mechanism which may cause the larger quasi-stiffness. The high correlation between Kqs1 and Kqs2 suggests that the stiffness parameter from the modelling of quiet standing as an inverted pendulum captures similar stiffness attributes as the direct measurement of quasi-stiffness.

P3-K-44: Postural control following COVID-19 infection: differences in average center of pressure velocity

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BACKGROUND AND AIM: Declared a global pandemic in March of 2020, coronavirus disease 2019 (COVID-19) continues to impact our world. Initially thought to exert acute effects primarily on the respiratory tract and lungs, there are increasing reports of long-term symptoms following infection, regardless of the severity or presentation of initial symptoms. Such evidence indicates a more expansive disease course than previously thought. Many of the long-term symptoms illustrate involvement of the central nervous system (CNS). Interestingly, the presentation of long-term symptoms and evidence of CNS involvement is similar to that incurred from mild traumatic brain injury (mTBI). An area of impairment that may present following mTBI includes dysfunction in postural control, particularly alterations in postural sway. Given the similarities between long-term COVID-19 symptomatology and CNS involvement with that of mTBI, it is pertinent to explore the potential impact of COVID-19 infection on postural control. The purpose of this study is to investigate the effects of COVID-19 infection, both acute and long, on postural control through the assessment of postural sway. We hypothesize that significant differences in center of pressure (COP) velocity will be seen between individuals who have experienced a COVID-19 infection and whose symptoms resolved within 4 weeks (acute-COVID), those who had COVID-19 and had at least one symptom persist longer than 4 weeks (long-COVID), and those who have no known history of COVID-19 infection (non-COVID). METHODS: COP velocity was measured during quiet standing on a force plate during eyes-open (EO), eyes-closed (EC), and a virtual reality balance challenge consisting of a VR baseline measurement (VR), visual perturbation with a "moving room" (MR), and a recovery period (RC) following cessation of movement of the moving room. RESULTS: The following results were obtained from our ongoing work with this study. Significant reductions in average COP velocity were seen in the MR condition in the anteroposterior direction ($p = 0.003$) between the acute-COVID ($M = 7.273$ mm/s) and non-COVID groups ($M = 11.461$ mm/s). Significant decreases in average COP velocity were also seen in the MR condition in the anteroposterior direction between the long-COVID ($M = 7.058$ mm/s) and non-COVID groups. In addition, significant reductions in average COP velocity ($p = 0.021$) were seen in the mediolateral direction in the MR condition between the acute-COVID ($M = 4.075$ mm/s) and non-COVID groups ($M = 5.508$ mm/s). During the RC condition, average COP velocity ($p = 0.046$) for the mediolateral direction significantly decreased in the acute-COVID ($M = 4.403$ mm/s) group compared to the non-COVID group ($M = 5.687$ mm/s). CONCLUSIONS: Our data from this ongoing study indicates that those with a history of COVID-19 infection display significantly slower COP velocities in response to a balance challenge than those with no history of COVID-19 infection.

Other neurological disease (e.g. Multiple sclerosis)

P3-L-45: Correlation between gait spatiotemporal parameters and dynamic arm swinging in patients with Multiple Sclerosis

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BACKGROUND AND AIM. Gait and balance disorders are marked functional deficits in people with multiple sclerosis (MS) [1]. Although it is known that upper limbs play a crucial role in maintaining balance and stability [2], their contribution is often neglected both in gait analysis and rehabilitation programs for people with MS. Thus, little information is available about the relationship between standard spatiotemporal parameters of gait and upper limb function in MS. This study aims at investigating this relationship in patients with MS using wearable sensors during gait. METHODS. Sixty patients with MS (20M, age 50±10 years) were enrolled and, based on their disease severity, further divided into two groups (Expanded Disability Status Scale (EDSS) score [MS1=1<EDSS<4, mild-moderate impairment; MS2=4.5<EDSS<6, severe impairment)]. Participants performed three times a 10 m walk test while wearing four inertial sensors (APDM Opal, 128 Hz) on both wrists and lateral malleoli. Average walking speed (WS) was estimated by measuring each participant's task completion time. Gait cycles were segmented based on sensor data [3] and temporal parameters were estimated. The upper arms' oscillation frequency, the peak-to-peak angular velocity during arms oscillation, and the symmetry [4] between the wrists' peak angular velocity were calculated for each stride (both left and right). For all parameters, the median value of all strides was obtained and the mean of the three trials was calculated and used for statistical analysis. After checking for normality, the relationship between spatiotemporal and upper limb parameters was explored using Pearson's correlation coefficient (α=.05) for the whole sample and for both MS1 and MS2 groups separately. RESULTS. The values of the temporal parameters were in agreement with the existing literature on MS [1]. WS ranged from 0.27 to 1.83 m/s. The results of correlation analyses are reported in Table 1. DISCUSSION. Many significant correlations were found between standard spatiotemporal parameters, including WS, and metrics describing the upper limb function for the whole MS group and for MS1 and MS2. Upper limb oscillation frequency and angular velocity increase with WS and, thus, exhibit inverse correlation with stride, stance, swing, and double support durations. Interestingly, in MS1, upper arms oscillation frequency does not correlate with any spatiotemporal parameters, suggesting that, in patients with mild to moderate disability, coordination between lower and upper limbs movement may represent an issue to be addressed. This information could be used in defining tailored rehabilitation programs that incorporate arm movements in patients with MS. REFERENCES [1] Vienne-Jumeau A et al. Ann Phys Rehabil Med 2020;63(2):138-47 [2] Stephenson J et al. Gait Posture 2009;29(1):11-6 [3] Trojaniello D et al. J NeuroEng Rehabil 2014;11:152 [4] Zifchock RA et al. Gait Posture 2008:27(4):622-7

P3-L-46: Radial distance between foot and center of mass at touch down determines the asymmetry in generating centripetal impulse while running on a curved athletic track

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BACKGROUND AND AIM: Change of direction during locomotion needs centripetal impulse in contact. Left contact generates more centripetal impulse than right in sprinting on an athletic track (Churchill et al., 2016). However, when running on a track with a smaller curvature radius (1-5m), the asymmetry in centripetal impulse is reversed (Chang and Kram, 2007), and we observed individual variations in the degree of asymmetry in 200 m race (unpublished). The purpose of this study was to clarify the cause for the asymmetry in the generation of centripetal impulse. We hypothesized that the degree of asymmetry in generating centripetal impulse is explained by the degree of asymmetry in leg inclination if leg inclination decides the direction

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of ground reaction force. As it is difficult that we control the degree of participants' leg inclination on the experimental test, we adjusted leg inclination by radial distance right and left foot contact positions. A wider step width would increase the degree of asymmetry in leg inclination (left < right), but a narrower step width decreases it. METHODS: Six healthy adults run on a curved path with 42 m radius curvature for wide and narrow step width conditions. We instructed participants to run step across the 0.3 m wide parallel lines under wide condition and to run step inside the lines under the narrow condition. Three-dimensional marker trajectories on the bodies and ground reaction forces are measured by a motion capture system and four force plates. We assessed leg's inward inclination at touchdown by calculating the angle between the center of pressure and the hip of the contacting leg, normalized centripetal impulse with body weight and the average centripetal impulse by dividing the centripetal impulse by the contact time. We then compared the results for each condition between right and left legs. RESULTS: There was no difference in running speed between the two conditions (wide, 6.98±0.95m/s; narrow, 7.01±1.0m/s). The radial distance between foot and center of mass (CoM) expressed relative to leg length at touchdown was a significant difference between right and left at touchdown in wide (left, -0.01±0.04 ; right, 0.26±0.07; $p<0.01$) and narrow conditions (left, 0.06±0.04; right, 0.13±0.07; $p<0.01$). The angle of inward inclination of the leg was a significant difference in wide condition (left, 1.85±3.23deg; right, 7.47±5.96deg; $p<0.01$) but not a significant difference in narrow condition (left, 7.38±1.23deg; right, 0.89±5.33deg). The centripetal impulse was also a significant difference in wide (left, 0.11±0.09Ns/kg; right, 0.43±0.12Ns/kg; $p<0.01$) and narrow conditions (left, 0.37±0.11Ns/kg; right, 0.11±0.06 Ns/kg; $p<0.01$). There were no differences in contact time and average centripetal impulse in both conditions. CONCLUSIONS: The results do not support our hypothesis but suggest that the radial distance between foot and CoM at touchdown determines the asymmetry in generating centripetal impulse.

P3-L-47: Identifying modifiable gait risk factors for fall prevention in neurodegenerative Cerebellar Ataxia, SCA3: Preliminary study results

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Background & Aim:Gait disturbances are the most disabling feature of cerebellar ataxia (CA) resulting in significant morbidity due to high fall rates. CA patients require tailored rehabilitative programs to prevent falls. With the advent of disease-modifying drugs, sensitive digital monitoring biomarkers (DMOs) for the detection of emergent ataxia and disease progression are crucial. We performed deep phenotyping of gait in CA patients with SCA3, the most common of rare autosomal dominant CA, in order to ascertain potential therapeutic candidates for fall prevention. Methods:We examined 10 SCA3 (mean age: 48±12 yrs,SARA score 8.4±3.6,4/10 fallers,5 males,MoCa ≥26) and healthy subjects (mean age: 39±11 yrs, 22 males, MoCa≥26). Patients completed the Mini-BESTest. Gait mat (PKMAS, ProtoKinetics) recordings were made while subjects walked in 5 conditions: usual speed walking (UW), slow speed walking (SW), fast speed walking (FW), walking while subtracting 3 (DT) and walking in an obstacle (ObN) course. Derived measures included velocity, average and variability of step and stride length and duration and average and variability of stride width. Correlations between clinical CA severity (based on SARA score and falling rate) and gait variables were compared along with UW and DT gait measures of CA vs. HC and DT cost (DTC) comparison, defined as the difference between the DT measures vs. the UW, normalized by UW. Results: Average TUG(14.6+/-3.1SD vs. 8.9+/-2.8SD) with DT and total Mini-BesTEST (20.3+/-SD vs. 26.3+/-

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1.1SD) scores among the patients were higher than reported norm. Clinical severity significantly correlated with stride width in all gait conditions except ObN and variability of temporal measures in UW, SW and DT and of spatial measures in FW (Pearson correlation coefficient: 0.65- 0.87). CA group demonstrated increase in temporal and variability measures and decrease in spatial and speed measures compared to HC ($p<0.05$). All spatial-temporal and variability cost analysis indicated performance reduction under DT conditions in the CA group with largest DTC effect size in velocity, step time and stride length variability. Conclusion:Clinical severity correlates with step width. The CA group and HC differ in locomotor constructs under single and DT conditions, with slower gait, shorter and wider strides, and excessive variability. These objective markers shed light on different CA aspects such as rhythmicity, regularity, and compensation abilities that are difficult to quantitate by visual gait analysis or clinical rating scales and further support their application as potential DMOs. We demonstrate for the first time that SCA3 patients have less coping abilities during challenging walking conditions. We plan to complete cerebellar cognitive affective syndrome scale evaluation to assess motor-cognitive interactions and expand the cohort size to further study modifiable gait risk factors, including variability and stride width.

P3-L-48: Inertial sensors on the feet, rather than lumbar sensor only, increase sensitivity of spatio-temporal gait measures to longitudinal progression in ataxia

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BACKGROUND AND AIM: The optimal number of inertial sensors for gait analysis is a trade-off between data quality, patient convenience and feasibility. 1-sensor systems (1S) have proven to deliver reliable information for average values of gait speed or step length. However, for measures of spatio-temporal gait variability which are sensitive measures of ataxia, 1S systems often showed less reliability and sensitivity compared to 3-sensor (3S) systems which include two sensors at the feet. Here, we compare specificity, reliability and longitudinal sensitivity of ataxic-specific gait variability assessed by 3S vs 1S with state-of-the-art algorithms1,2,3. METHODS: We captured longitudinal gait data of 55 ataxia subjects and 44 healthy controls, using a constrained walking condition (2*25 m straight in self-selected speed) and assessed at baseline, 1-year and 2-years follow-ups using 3 Opal APDM Sensors (1 lumbar spine, 2 feet). For 1-sensor analysis, only the pelvis OPAL sensor was used, analysed with algorithms validated in older adults, people with Parkinson's disease and ataxia patients2,3. We analysed spatio-temporal gait variability (stride length, stride duration) in terms of specificity, test-retest reliability and sensitivity to longitudinal change in both sensor conditions. RESULTS: Specificity in discriminating healthy controls and ataxia subjects reveals higher effect sizes with 3S, which is caused by generally increased variability of healthy subjects with 1S (effect sizes: stride duration var: (3S) δ=0.75; (1S) δ=0.55; stride length var: (3S) δ=0.82, (1S) =0.35). In addition, test-re-test reliability reveals higher values for 3S (stride duration var: ICC=0.73; stride length var: ICC=0.81) compared to 1S (stride duration var: ICC=0.43; stride length var: ICC=0.61). In 1S, longitudinal changes are not detectable in temporal, but in spatial gait measures after one year (stride length variability: effect size r=0.31) and increased after two years (e.g. stride length variability: r=0.46). However, longitudinal analysis in 3S shows higher effect sizes in 1-year and 2-years follow-up (stride length variability: effect sizes

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rprb=0.34; r=0.53). CONCLUSIONS: While at least a part of the variability measures are sensitive to longitudinal change also in the 1S condition, effect sizes of change as well as reliability are higher in the 3S condition. This indicates an additional benefit from feet sensors - at least with current algorithms - to determine spatio-temporal gait variability in ataxia, given the necessity of high effect sizes and test-re-test reliability in upcoming intervention trials in this rare disease. 1. Ilg et al. Neurology 2020, 95(9):e1199-e1210. 2. Del Din, et al IEEE J Biomed Health Inform 2016 May;20(3):838-847. 3. Hickey et al Physiol Meas 2016;37(11):N105-N117.

Paediatric (e.g. Cerebral Palsy)

P3-M-49: Differences in anticipatory postural control during an alternating stepping task between children with typical development, developmental coordination disorder and cerebral palsy

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[1]University of Antwerp, [2]Hasselt University

BACKGROUND AND AIM: Balance control deficits are common in children with developmental coordination disorder (DCD) and cerebral palsy (CP). In both conditions, some evidence points towards movement planning issues that might result in motor and balance control deficits. Prior to movement execution, postural muscles are activated by feedforward control reflecting anticipatory postural adjustments (APA). By comparing APA between children with typical development (TD), DCD and CP more insights can be gained in the relation between movement planning and balance control. METHODS: Children aged 5-10 years with DCD, CP and TD were recruited. All children performed 5 repetitions of an alternating stepping task. Surface electromyography (sEMG) of Erector Spinae, Gluteus Medius, Tibialis Anterior and the Gastrocnemius (lateral head) was recorded bilaterally. On both feet 3D accelerometers (TrignoTM, Delsys Inc.) were placed to detect foot off and foot contact. Movement execution is characterized by the time between foot-off and foot contact. Raw sEMG data were filtered (4th order Butterworth bandpass 20 - 250 Hz.), rectified and low-pass filtered (4th order Butterworth 10 Hz.). Muscle onset latencies and time-to-peak (TTP) were calculated (MATLAB R2022a). Analyses were performed on the mean of 5 repetitions per child and standard deviations characterize intra-individual variation. A Kruskal-Wallis test with post-hoc analysis identified group differences ($p < 0.05$). RESULTS: In this ongoing study, 10 children with DCD (6.8-10.9 years), 7 with CP (6.4-8.7 years, GMFCSI:3/II:4) and 10 with TD (6.0-10.5 years) were analyzed. Children with DCD show an increased movement execution time compared to TD children (Q1-Q3: 0.31-0.47s in DCD versus 0.26-0.33s in TD; P = .026). Children with CP showed an earlier onset of muscle activation in Erector spinae of the standing leg compared to TD (P = .009) and DCD (P = .003). No other differences in onset latencies were observed but intra-individual variation in onset of Erector spinae was increased in DCD compared to TD (P = .037) and CP (P = .017). DCD children also showed an increased TTP in Tibialis Anterior of the standing leg (P = .011) and in Gluteus medius on the swing leg side (P = .004). Group results are illustrated in a figure. CONCLUSION: Our preliminary results seem to suggest that movement planning is mainly affected in DCD children since they show a slower execution of the task, with deviant APA and increased intra-individual variability. The earlier onset of muscle

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activation in Erector spinae in the CP group might reflect an increased muscle tone. The observed deficits in APA are consistent with the internal modelling deficit (IMD) hypothesis of DCD. This IMD hypothesis needs to be explored in a larger sample. ACKNOWLEDGEMENTS AND FUNDING: Thank you to all the children participating in the study. CJ was supported by the Research Foundation - Flanders (FWO) (43498).

P3-M-50: Dynamic margin of stability when stepping to a target is altered in children with cerebral palsy

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Background: Postural control is essential while taking a step. Before lifting the foot, anticipatory postural adjustments (APAs) move the Centre of Mass (CoM) toward the stance leg[1]. In children with cerebral palsy (CP), anticipatory postural control is affected[2,3]. This potentially limits their ability to control CoM during stepping and thereby, result in poor stepping performance[4]. However, to date, knowledge on dynamic control of CoM, especially during stepping, is still scarce in CP. Methods: Children with CP and typically developing (TD) children aged 6-10 years performed a stepping task: i.e., alternate stair touch as fast as possible until four successful touches for each foot. Postural control was assessed by (1) clinical Kids-BESTest item scores[6] (four-point Likert scale) and (2) Margin of Stability (MoS) at foot touch on the stair. The MoS was calculated as the difference between extrapolated centre of mass (XCoM)[7] and anterior (distal phalanx I) and lateral (malleolus) base of support boundary of stance foot, determined from 3D motion capture data (VICON, Biometrics, UK). For dominant/less affected [dMoS] and nondominant/most affected leg [ndMoS] leg, the mean and variability of MoS in antero-posterior (AP) and medio-lateral (ML) directions were calculated and used as an outcome. Between-group differences (CP vs TDC) in (1) item scores and (2) MoS-related variables were analysed using Mann-Whitney test. Results: Figure 1 shows preliminary data from 11 TD (8.55±1.06 years; 5boys) and 8 CP children (8.01±1.38 years; 2boys; GMFCS-I:4/II:4; 4 bilateral). During alternate stair touch, AP MoS was significantly larger (dMoS:$p=0.013$; ndMos:$p=0.048$) and more variable (dMoS:$p<0.001$; ndMos:$p<0.001$) in CP compared to TD. Along ML direction, the (variability in) MoS did not significantly differ ($p>0.05$). Also, significantly lower item scores were observed in CP (1.00±0.76) than in TD (2.91±0.30, $p=<0.001$). Conclusions: Postural control during alternating stepping is affected in children with CP. While taking a step, CoM accelerates less efficiently toward or even away from base of support. This poor control of COM could be due to poorly modulated APAs before lifting the foot[2,3]. APA control also depends on the position of step target (anterior versus lateral)[1,4], which might explain the relatively unchanged ML MoS in CP. These postural control deficits are also clinically identifiable (compared to TD). However, a range of MoS values was still observed within CP (approximately -44mm [backward lean] to +11mm [forward lean]), suggesting that alterations in MoS might reveal control mechanisms underlying these postural control deficits. Ongoing research will further investigate this hypothesis in a larger sample. [1]Lyon I.(2005); [2]Tomita H.,et al.(2013); [3]Stackhouse C.,et al.(2007);[4]Rapson R.,et al.(2023); [5]Dewar R., et al.(2020); [6]Chakraborty S., et al.(2020); [7]McCrum C., et al.(2019)

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P3-N-51: Muscle co-contraction and its role in people with Parkinson's disease suffering from freeze-of-gait

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BACKGROUND AND AIM: Freezing of gait (FOG) is a phenomenon that affects individuals with advanced Parkinson's disease (PD) and is characterized by the inability to complete a step despite the intention to move forward. Muscle co-contraction (CC) refers to the simultaneous activity of agonist and antagonist muscles crossing the same joint and is an adaptive strategy that strengthens joint stability during different activities thus enabling mobility during the performance of different activities. Increased CC occurs in several neurological conditions that impair gait and mobility. Some previous work suggested that FOG is associated with CC, however, the studies tested EMG characteristics during FOG episodes whereas this study aims to investigate CC differences during walking without freezing. Moreover, disposable wearables can theoretically be used, in the next stages, to study CC during daily living. It is not yet clear if CC differs between PD who have FOG (PD+FOG), compared to PD patients who do not (PDnoFOG). The aim of this study was first, to test the feasibility of novel disposable EMG electrodes and second, to evaluate whether muscle CC is higher in PD+FOG, compared to PDnoFOG during walking. METHODS: We used a wireless system of 16-channel EMG and accelerometers at tibialis anterior and gastrocnemius muscles. Electrode arrays were based on carbon and silver traces screen-printed on a soft PU film developed at xtrodes.com. Data was recorded via a miniature wireless unit and transferred continuously to an Android app via Bluetooth. We used Independent Component Analysis to remove motion artifacts and crosstalk. EMG was segmented based on a pattern-matching algorithm on accelerometer data. We evaluated 14 PD patients, 8 without FOG (age=70 yrs [65-77]; 6 men; UPDRS-3=40.5 [22-56]; Moca=26 [24-29]; H&Y=2[2-3], all medians) and 6 with FOG (age=69.5 yrs [48-83]; 6 men; UPDRS-3=34 [15-57]; Moca=27 [24-29]; H&Y=2 [2-3], all medians), using a 2-min walk test. CC was analyzed from the stance phase as it is more relevant to freezing. RESULTS: We obtained measures for CC of the two muscles from the cleaned and segmented EMG data, i.e., a percentage value of co-contraction for each gait cycle. These percentages are calculated both in the area under the curve measure and fraction of the cycle based on the (figure 1a,b). PD+FOG (25.41% [12.28-38.33]) patients showed a higher percentage of CC during a step cycle compared to PDnoFOG patients (10.5% [3.11-18.39]) with a confidence $p<0.001$ (figure 1c). CONCLUSIONS: We can reliably measure EMG from the TA and GS muscles in the stance. our results show CC was significantly higher among PD+FOG patients compared to PDnoFOG patients in stance. Second, we showcased that this disposable wearable technology is feasible and can be used to detect CC. Finally, these findings encourage further monitoring of FOG in daily-living settings.

P3-N-52: Cognitive function associations with daily life gait and turning in people with Parkinson's disease

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Background and Aims: Parkinson's disease (PD) is responsible for more mobility disability and cognitive disability than most other neurological diseases. It is increasingly recognized that gait and turning are not pure motor tasks, but that cognition is also essential for safe mobility during daily life. In fact, recent laboratory studies are revealing important relationships between cognition and mobility (gait and turning) in people with PD. Here, we used body-worn, body-worn inertial sensors to quantify gait and turning in daily life, as well as tablet-based cognitive assessments to investigate whether cognition and daily-life mobility are associated in people with PD. Methods: A total of 48 individuals with idiopathic PD (age= 69.8 years, disease duration: 7.7, SD:5.8; MoCA: 26.6, SD:1.9) participated in the study. Participants were screened over the phone, and consent was obtained during virtual study visits. Cognitive testing was performed with a Tablet-based Cognitive Assessment Tool (TabCAT) tests on an IPAD, developed by UCSF Memory and Aging Center. Specifically, visuospatial function was assessed with a Line Orientation task modeled after the Benton Judgement of Line Orientation task and executive function was assessed with a Set-Shifting task as well as Flankers task. At home, subjects were instructed how to wear two specialized socks with inertial sensors embedded, on each foot, and a sensor on the waist (Opals, APDM Wearable Technologies) for a week of continuous monitoring for an average of 8 hours per day. We analyzed 2 measures of gait and turning quantity (# of strides and # of turns) as well as 2 metrics of turning quality (duration and peak velocity) and 5 metrics of gait (gait speed, angle at heel strike, double support time, stride duration, and cadence), plus the variability of each metric, across all strides from the week of passive monitoring. Results: All participants were able to complete the TabCAT cognitive assessment and the week of home monitoring with an average of 7.2 (SD:1.05) days of recording and an average of 63.3 (SD:12.5) hours. Executive function, and specifically set-shifting, was significantly associated with average gait, but not turning, metrics during daily life. Specifically better set-shifting ability was associated with faster gait speed (rho=0.32, p=0.03), bigger angle at heel-strike (rho=0.29, p=0.04), shorter double-support time (rho=-0.39, p=0.005), shorter stride duration (rho=-0.32, p=0.03), and faster cadence (rho=0.29, p=0.05). Visuospatial function was not significantly associated with any gait or turning measures, and no association was present between quantity of gait and turning and cognitive function. Conclusions: Our preliminary findings support a relation between executive function and multiple domains of gait during daily life. Specifically, better performance in set-shifting, the component of executive function related to cognitive flexibility, was related to better gait performance in daily life suggesting the importance of successfully shifting back and forth between multiple tasks for safe gait in daily life in people with mild to moderate PD.

P3-N-53: Association between pre-frontal cortex activity and objective gait measures in people with Parkinson's disease

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BACKGROUND AND AIMS: People with Parkinson's disease (PD) have mobility impairments, reduced automaticity and increased pre-frontal cortex (PFC) activity even for simple tasks like walking. This is thought to be more pronounced in people with PD who have freezing of gait (FOG). FOG is characterized by absence/marked reduction of forward progression of feet. Here we used functional near infrared spectroscopy (fNIRS) data to measure activity in the

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PFC and body-worn sensors to derive gait metrics to determine (1) the effect of freezing status on PFC activity during single-(ST) and dual-task (DT) walking, and (2) whether the PFC activity and gait metrics are associated in people with PD. METHODS: In this ongoing study, 29 individuals (11 freezers, 18 non-freezers) with idiopathic PD (age 68.2, disease duration 9.07, MDS-UPDRS 34.19) were included and tested while On Levodopa (~ 1 hour from last dose). Participants were classified as freezer if they scored > 0 in the new freezing of gait questionnaire. Objective gait metrics were measured during 2-minute ST and DT walking using inertial sensors (Opals, APDM Wearable Technologies) worn on head, sternum, lumbar, bilateral wrists and feet. PFC activity was measured using a continuous wave, portable fNIRS system (OctaMon, Artinis Medical systems) with 50 Hz sampling frequency. The walking tasks included 20 s quiet stance, followed by 120 s walking and turning, and end with 10 s quiet stance. We derived 5 metrics of gait (foot-strike angle, double support time, cadence, stride length, gait speed) along with the variability measure for each metric. Effect size was calculated accounting for the sample size (Hedge's g). Pearson correlation was computed for association between fNIRS and gait metrics. RESULTS: The PFC mean oxygenated hemoglobin (HbO2) levels while walking were higher in freezers (0.145 microM/L) compared to non-freezers (-0.031 microM/L) with a Hedge's g effect size of 0.62 (CI: -0.23 to 1.47) during the DT walking condition. Increased variability in foot-strike angle during ST was significantly associated with increased PFC HbO2 level with r = 0.49, p = 0.01. No other ST measures or DT measures were associated with the PFC activity. CONCLUSION: Our preliminary results confirm the involvement of pre-frontal cortex in people with PD. People with PD and freezing of gait exhibit increased pre-frontal cortex activity supporting the literature findings. We also found that variability in foot-strike angle and pre-frontal cortex activity are significantly associated. While the effect size of freezing on pre-frontal cortex activity was high, it was not statistically significant, likely due to the limitation in sample size. With availability of more data towards the end of the study we may be able to confirm the findings in a larger sample size. However, the preliminary findings could guide treatments options for improving freezing of gait. ACKNOWLEDGEMENTS AND FUNDING: We thank the participants and the R01 Turning (R0 1HD100383).

P3-N-54: Asymmetry of gait and turning with regard to symptom laterality in Parkinson's disease

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Background and aim: Asymmetric representation of motor symptoms is very common in people with Parkinson's disease (PD). Furthermore, other motor behavior like gait and turning can be asymmetric as well, especially in those individuals with Freezing of Gait (FOG). To date there is limited information about how different domains of asymmetry are associated in PD. Therefore, the aim of this study was to investigate how asymmetry of gait and turning are interrelated with regard to symptom laterality. We hypothesize that the more affected side in terms of PD symptoms assessed with the Movement Disorder Society-Unified Parkinson's disease rating scale Part III (MDS-UPDRS-III) is also more affected during gait and turning. Methods: In this cross-sectional sub-analysis of a larger trial (ID: NCT04176263) 92 participants with PD (n=67 with FOG) from two centers (CAU Kiel, Germany & KU Leuven, Belgium) were assessed. Gait and turning parameters were recorded using 3D motion capture systems and inertial measurement units. Gait and turning outcomes were computed using a

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customized Matlab script. Additionally, the MDS-UPDRS-III was assessed to quantify PD symptoms. The selected outcomes were step length, swing time, stance time, turning time, turning steps and side-dependent subscores of the MDS-UPDRS-III (total and lower-limb items). Furthermore, asymmetry scores were calculated for all outcome parameters and scores were correlated with each other using Pearson and Spearman correlation coefficient. Results: We found that the more affected side (as assessed with the MDS-UPDRS-III subscore) was the side with the shorter step length in 62%, the shorter stance time in 62% and the longer swing time in 59% of participants during gait. Those percentages were slightly reduced when determining the more affected side with lower limb items only. For turning we found that 55% of participants took more time for turns when turning towards the more affected side. Conversely 35% of participants took more steps when turning towards the more affected side. Additionally, we found that MDS-UPDRS-III, gait and turning asymmetries were mostly uncorrelated between each domain, except for turning steps asymmetry with UPDRS-III asymmetry ($p<0.01$, $r=-0.24$). Conclusions: We neither found consistent laterality agreement according to our hypothesis for the different outcomes, nor relevant correlations between the asymmetry scores of each domain. The findings suggest that overall disease laterality, gait and turning only partially share the same neural pathways. Those differences could be attributed to the varying involvement of postural control components for each outcome. Acknowledgements and funding: This project was funded by the Jacques and Gloria Gossweiler Foundation (Switzerland).

P3-N-55: The effects of isolated axial thorax rotational movement practice on motor symptoms and mobility in patients with Parkinson's disease - a pilot study

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BACKGROUND AND AIM: The "turn en bloc" phenomena in Parkinson's disease (PD) is associated with multiple negative outcomes. Turn en bloc may partially be the result of an impaired axial coordination movement between the head, thorax and pelvic segments during turns. This phenomena can be a trigger for freezing of gait and falls and lead to reduced independence. Previous interventions have not specifically focused on axial movement and rotation to address turn en bloc. The aim of the study was to examine the influence of practicing an isolated thorax axial rotational movements during different sitting and standing positions while encouraging weight shifting between legs and stability, using the recently developed Rotacher device (see Figure 1). Methods: A pilot, open-label study was conducted in eight patients with PD (all were "freezers"). Participants used the device twice a week over 2 months (for about 40 minutes of exercise in each session). Exercises were conducted during sitting and standing; the difficulty level was adjusted with progression in a pre-specified manner The MDS-UPDRS part III (motor score) and MiniBest tests were video-taped and scored offline. The new freezing of gait questionnaire (N-FOGQ) and Geriatric Depression Scale (GDS15), also evaluated pre and post intervention. A wearable sensor placed on the lower back and worn for at least 72 hours was used to assess axial rotation velocity during sleep (Axivity AX6, UK, 100Hz). Results: No adverse events related to the intervention were seen and there was a high level of compliance (e.g., 100% of all sessions were attended). MDS-UPDRS part III scores were 34.5 (IQR: 28.75 - 44.50) before the intervention and were reduced ($p=0.012$) to 26.50 (IQR: 21.50 -33.00) after the intervention (median change: 9.5; IQR: 4.5-12.8), for a median

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improvement of 26.8% (IQR: 15.5-42.1%). Scores on the MiniBest 19.00 (IQR: 16.00-26.00) tended to increase (improve) (p=0.078) to 25.00 (IQR: 20.00 - 26.00). N-FOGQ 16.00 (IQR: 7.25 - 24.75) was reduced (improved) (p=0.018) to 9.50 (IQR: .00 - 21.75). Depressive symptoms were lower (p=0.034) after the intervention, going from 3.00 (IQR: 1.00 - 6.25) to 2.00 (IQR: 1.00 - 4.50). The speed of axial rotation during sleep tended to increase after the intervention (p=0.068; pre: 9.45 degrees per second, IQR: 4.98-12.97; post: 10.58 degrees per second, IQR: 6.78-13.26). Conclusions: These preliminary findings demonstrate the feasibility and safety of using a recently developed device designed to focus on axial rotation. Initial results, especially the motor part of the MDS-UPDRS, are promising. The minimal clinically important difference for the MDS-UPDRS part 3 is 4.8 points. The median improvement that we observed was about twice that. Follow-up studies in larger cohorts are needed to confirm these findings and the potential of this new approach.

Perturbation

P3-O-56: Neural drive underlying transient muscle activity during postural control associated with external perturbations

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BACKGROUND AND AIM: In perturbed stance conditions, the central nervous system utilizes anticipatory and compensatory postural adjustments (APAs and CPAs respectively) to maintain the body's stability. The dynamics of muscle activity during APAs and CPAs are well characterized by the time-domain analysis of electromyographic (EMG) signals, but the underlying neural drive (information at motor unit (MU) level) is unknown. Such information is useful in identifying potential mechanisms of impaired neuro-motor control and in aiding targeted rehabilitation, therefore it has been investigated. METHOD: 12 healthy adults (28.9±2.3 years; 6 males; written informed consent obtained) were exposed to external predictable (eyes open- EO) and unpredictable (eyes closed- EC) perturbations (magnitude- 3% of subject's body weight) at shoulder level in standing. Surface EMG signals from leg muscles were recorded. Normalized integrals, median frequency (MDF, in Hz) and fractal dimension (FD) of EMG envelopes were computed for background (BGD), APA, and CPA phases of postural control. Conduction velocities (CV, in m/s) of distal muscles were also computed. Repeated measures ANOVAs followed by post-hoc tests with corrections were performed. Further, the EMG signals were decomposed to obtain MU discharge patterns using a custom-designed algorithm. RESULTS: A significant ($p<0.05$) increase in EMG integral (Tibialis anterior- BGD-EO:~0, APA-EO:0.23±0.1, CPA-EO:0.41±0.2; BGD-EC:~0, CPA-EC:0.99±0.1) was accompanied by a significant ($p<0.05$) decrease in MDF (BGD-EO:63.1±8.9, APA-EO:45±15.8, CPA-EO:18.5±4.3; BGD-EC:63.1±6.5, CPA-EC:16±4.4) and FD (BGD-EO:1.6±0.03, APA-EO:1.5±0.05, CPA-EO:1.5±0.03; BGD-EC:1.6±0.03, CPA-EC:1.5±0.04) over the control phases. This pattern was consistent across the muscles and conditions. However, in unpredictable condition where APAs were absent, a pattern of greater decrease in MDF and FD with greater increase ($p<0.5$) in integral, and a trend of increase in muscle CV (EO:2.7±1.3, EC:3.2±0.9) were observed. In addition, the obtained MU discharge patterns showed an occurrence of MU synchronization for increasing muscle activity in APA and CPA

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phases. CONCLUSION: The pattern of decreasing MDF and FD with increasing integral of EMG is indicative of a predominant occurrence of synchronous firing of the MUs, as was affirmed by the obtained MU discharge patterns. Although this key neural drive underlying transient muscle activity remained the same across conditions, the trend of greater decrease in MDF and FD, and the increased muscle CV in unpredictable condition probably imply a greater synchronization of the MUs and more recruitment of the large MUs respectively, resulting in a larger CPA magnitude in the absence of APAs. Thus, these findings provide an overview of the possible neural drive underlying dynamic postural control and lay the groundwork for future research into altered neural drive in individuals with impaired postural control.

P3-O-57: An adaptive staircase procedure to estimate compensatory stepping thresholds

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BACKGROUND AND AIM: The majority of falls experienced by at-risk populations occur following external perturbations, underscoring the importance of reactive balance assessment. Stepping threshold (ST), defined as the largest perturbation an individual can recover their balance from without consistently taking a step, is a valuable predictor of fall-risk in clinical populations. Furthermore, ST can be used to individualize perturbation magnitude when assessing fixed support strategies in research settings, during which responses with steps are routinely excluded from analysis. ST is often assessed by incrementally increasing one or more parameters of perturbation magnitude until a step is consistently elicited. These protocols can be time-consuming, but precise if small increments are used, or quick and imprecise if large increments are used. To overcome this trade-off, the present study describes an adaptive staircase procedure for the assessment of ST. The primary objective is to determine the within- and between-session reliability of ST using this adaptive staircase procedure. METHODS: Five healthy young adults underwent five ST assessments over 2 days. On the first day, three ST assessments were performed with 5 min rest between them, with the fourth ST assessment performed after ~45-minutes of rest. The fifth ST was performed on a second day, at least 24 hours later. Each ST assessment was performed using a split belt treadmill programed to provide 500 ms perturbations over a range of belt velocities following an adaptive staircase procedure (4-2-1 steps). Each staircase started with peak velocity of 0.2 m/s, which was initially incremented at 0.1 m/s. Increments were halved (0.05 m/s) after the first 4 perturbations for each direction (forward and backward), and again after another 4 perturbations (0.025 m/s). Seven perturbations in each direction were completed at the smallest increment (30 perturbations total; 15 each direction interleaved). Peak velocities were either increased or decreased at the respective increment depending on whether a step occurred during the previous perturbation of the same direction. ST for each direction was calculated as the mean of the smallest incremented reversal points. RESULTS: STs were substantially smaller for forward (mean: 0.240 ±0.050 m/s) than backward (0.437 ±0.049 m/s) perturbations. Subtle order effects were present across the first 3 consecutive assessments, with ST increasing ~0.02 m/s for both directions. However, ST was reliable when re-assessed within- and between days. CONCLUSIONS: An adaptive staircase procedure provides a reliable estimate of ST that can implemented easily in both clinical and research settings. Single assessments may be appropriate for cross-sectional studies, while order effects should be accounted for when examining the effects of clinical and experimental interventions.

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P3-O-58: Keeping balance with tied arms

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Background and aims: Loss of balance and falls are a major health concern for older adults and people with neurological disorders. Arm responses to loss of balance have mechanical benefits that aid to regain stability. However, the contribution of arm movements to dynamic stability when recovering a lateral loss of balance during gait is unclear. We aimed to 1) quantify the effect of arm restriction on gait stability and upper body kinematics; 2) test the association between gait stability and upper body kinematics; 3) test whether upper body kinematics differ between anterior-posterior and mediolateral directions in response to lateral perturbations. Methods: Fourteen young adults (age 35±2.3; 7 female) were introduced to random lateral surface translations while walking on a treadmill (Balance Tutor, MediTouch) in three conditions: 'arms free', '1-arm restricted' and, '2-arm restricted'. Full body kinematics were collected using a motion captured system (Vicon Motion Systems). Outcome measures included dynamic stability (i.e., margin of stability (MoS) in medio-lateral and anterior-posterior directions, MoS_ML, MoS_AP) and velocity profiles of the head, trunk and shoulders (measured as the area under the curve (AUC)) for the 1st step after perturbation. To test the effect of 'arm condition' on dynamic stability and upper body velocities we used 6 mixed-effect models (one for each outcome variable) with 'participants' as the random effect. To test the association between dynamic stability and upper body kinematics we used the Spearman's rank correlation coefficient. Finally, to compare the upper body velocities in the AP and ML directions we used Wilcoxon Rank Sum tests. Results: We found a significant effect of arm condition on MoS_AP and upper body velocity measures, with significant differences between 'free arms' and '2-arm restricted'. Significant correlations between dynamic stability and upper body velocity measures were found. Specifically, positive correlations between MoS_ML and trunk and shoulders were found in the '1-arm restricted' condition ($0.29 < R < 0.34$, $p<0.05$). Negative correlations between MoS_AP and upper body velocity parameters were found for both 1- and 2-arm restricted conditions ($-0.38<R<-0.62$, $p<0.014$). Finally, the head and trunk showed greater maximum velocity in the ML vs. AP direction while the shoulders demonstrated greater velocities in the AP vs. ML direction in the 2-arm restricted condition. Conclusions: Greater arm restriction has led to increased AP instability and greater compensation in the head, trunk and shoulder movements. Additionally, AP instability was compensated by greater upper body velocities in 3-d space when the arm movement was restricted. Finally, when responding to a loss of balance, the head and trunk velocities were more pronounced in the ML direction while the shoulder velocities in the AP direction.

P3-O-59: Postural control deficits on a continuously moving platform in participants with chronic ankle instability

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BACKGROUND AND AIM: Individuals with chronic ankle instability (CAI) have deficits in postural control in static or dynamic unilateral weight-bearing exercises, showing CAIs have significant alterations to lower extremity movement mechanics, during eyes-closed standing, drop landing and lateral stepping down. However, postural control in CAI on a continuous moving platform is unknown. We hypothesized that individuals with CAI would demonstrate

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deficits in the Time-to-boundary (TTB) measure of postural control on a moving platform; CAI would exhibit greater changes in postural stability from static standing to a moving platform or when closing their eyes, compared to healthy controls. METHODS: Four physically active participants with CAI and five healthy controls participated in this study. Each participant performed four conditions of 30-s single-leg standing, including standing with eyes open and closed on a stable surface, and with eyes open and closed on a moving platform on one leg (affected in CAI; side matched in control). The platform motion follows a mediolateral sinusoidal pattern with an acceleration at 1m/s2, and the amplitude of its displacement at 5 mm (peak-to-peak displacement at 10 mm). The TTB measures were absolute minimum TTB, mean of the minimum TTB samples, and standard deviation of the minimum TTB samples. All measures were calculated in the mediolateral (ML) direction from the centre of pressure. RESULTS: To compare the effects of group, platform motion and eye condition on TTB measures, a series of 2 (group) × 2 (platform) × 2 (eyes) mixed analyses of variance (ANOVA) were computed. Significant group main effects were observed and pairwise comparisons revealed that the CAI group demonstrated significantly less TTBML absolute minima ($p=0.016$; $\eta p2 = 0.59$; mean difference=-0.149; 95% CI=-0.26 to -0.038), TTBML mean of minima ($p =0.011$; $\eta p2 = 0.62$; mean difference=-1.33; 95% CI=-2.23 to -0.04) and TTBML SD of minima ($p=0.030$;$\eta p2 =0.51$; mean difference=-1.33; 95% CI=-2.23 to -0.04) compared to the control group regardless of vision or moving condition. Moving platform decreased postural stability in both groups, especially in healthy control in TTBML absolute minima ($p = 0.020$; ES=0.17) and TTBML mean of minima ($p=0.030$; ES=2.07), which violated our hypothesis. This may reflect the possibility that people with CAI use a variety of compensatory mechanisms to maintain balance on a moving platform. For more difficult postural tasks, alternative biomechanical variables, such as time to stabilization, torque, and ankle stiffness could be computed to comprehensively measure the postural control in CAI. However, this abstracts reflects progress of PhD work, which renders the authors' findings tentative. CONCLUSIONS:CAI demonstrated deficits in postural control on continuous moving platform compared to healthy control. The effect of visual disturbance on postural stability during continuous perturbation is not significant.

P3-O-60: Sensory integration for sway perception and postural control may differ

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Background and Aim Visual motion directly influences postural sway even when visual motion stimuli fall below perceptual thresholds. Body sway increased when subjects perceived that visual perturbations increased their ongoing body sway. Body sway is variably influenced by environmental context, emotional state, sensory weighting, and disease processes. It is unclear whether detecting perception of a change in body sway is influenced by any of these factors. Methods Healthy adults (n = 7, age 26.6 ±10.8, 4 females), stood wearing a virtual reality (VR) head mounted display (HTC Vive) and experienced 2 interleaved adaptive staircases of virtual sinusoidal pitch rotation of the visual scene (0.2 Hz) about the ankle axis. Virtual sinusoids ranged in amplitude adaptively from 0.1 degrees to 10 degrees. In separate blocked conditions, subjects indicated if their perceived body to sway changed (more/less) during the trial. This was repeated in pseudo random order for two conditions (floor and foam). Binary response data fit with psychometric curves determined the point of subjective equality (PSE) separately for visual motion or sway motion perception. Head sway area was calculated from the VR HMD position. Paired t-tests compared sway area, the PSE, and the sway area ratio during the visual perturbation from "less" to "more" sway responses between conditions.


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Results Sway area was significantly larger during the visual perturbation when standing on foam (2.83 mm^2) compared to standing on the floor (0.92 mm^2) [t(1,11) = -39.9, p < 0.0001]. The PSE for detecting change in body sway was not different on the floor (3.3 degrees) compared to on the foam (3.1 degrees) [t(1,11) = 0.1052, p = 0.9179]. The ratio of sway increase from "no" responses to "yes" responses was not different on the floor (1.1) compared to on the foam (1.4) [t(1,11) = -0.6870, p = 0.5051]. Conclusions Despite larger baseline sway when standing on foam, PSEs were similar across conditions. When more sway was perceived, the increase in sway was proportional to the amount of sway present when perturbations resulted in undetectable sway increase. Although sensory reweighting for postural control (standing on foam) may lead to less precise control of balance, this appears to have minimal influence on detection of whole body multi-sensory sway perception.

Sensors (e.g. IMUs, activity monitors, machine learning)

P3-P-61: Monitoring gait variability and statistical persistence in the wild

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BACKGROUND AND AIM: Human gait exhibits stride-to-stride fluctuations that may reflect gait adaptability; estimated with nonlinear measures such as statistical persistence. Decreased statistical persistence towards disorder suggests diminished gait adaptability with age[1], and such measures are more sensitive to age-related changes in gait. However, nonlinear measures require hundreds of strides, restricting data collection to laboratory settings (e.g., treadmill), which may misrepresent normal gait. Smartphone accelerometer systems (SPAcc) have reliably estimated gait variability and statistical persistence during treadmill walking[2] and have captured traditional measures such as gait speed in the free-living environment[3]. However, no study has investigated statistical persistence estimated from a SPAcc, nor age-related differences, during free-living walking. This study investigated the SPAcc as an accessible tool for remote monitoring of gait patterns. METHODS: Thirteen young adults (YA) (7F; 28.3±3.7yo) and 11 older adults (OA) (7F; 68.7±2.8yo) completed four laps of a shopping mall during a two-hour period while walking at their comfortable speed with a SPAcc placed in their right front pants pocket. Each lap was ~12mins. Right heel contact events were determined using the SPAcc vertical axis signal; inter-stride interval was calculated as the time difference between ipsilateral heel contact events. Walking bouts were defined as ≥24 consecutive strides. The first and last two strides were removed from each bout. Stride time SD (s) and coefficient of variation (COV) (%) were calculated on all bouts. Statistical persistence, estimated with the fractal scaling index (FSI), was calculated on bouts >255 strides. One-way repeated measures analysis of variance compared the effect of age for each measure. RESULTS: A significant difference between age groups (mean:YA, OA; p-value) was found for stride time SD (0.04s, 0.05s; <0.04) and COV (3.4%, 4.2%; <0.03). FSI (0.95, 0.93; 0.45) did not differ between groups. CONCLUSIONS: The SPAcc placed in the pant pocket revealed age-related differences in gait variability during free-living walking. The OA demonstrated greater gait variability compared to YA, as expected. Statistical persistence did not differ between groups, which was unexpected, and was greater than typically observed in laboratory-based studies, suggesting a more structured stepping strategy, perhaps related to

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increased challenge during walking. These results may provide a representation of statistical persistence while walking within an ecologically valid setting, which includes obstacle navigation and changes in walking speed to avoid collision with other walkers. Further research is required to explore what aspects of environment may have affected statistical persistence. [1]Hausdorff JM, et al. JApplPhysiol 1997;82(1):262-9 [2]Di Bacco VE, Gage WH. JBiomech 2023;151,111527 [3]Lugade V, et al. JAgingPhysAct 2021;29,1026-1033.

P3-P-62: The validity and reliability of a self-administered, smartphone-enabled, 4-meter gait speed test in older adults

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BACKGROUND: Gait speed is commonly tested by using a stopwatch to record the time to walk four meters. This 4-meter test, while meaningful, requires staff assistance and is subject to human error and bias. Our team developed an iPhone-based Application (App) allowing older adults to complete the 4-meter gait test without supervision, in non-laboratory settings, by walking with the phone placed in their front pants pocket. The aims of this study were to (1) determine the validity of the App-based assessment, and (2) establish the test-retest reliability of the App-based assessment when used unsupervised by older adults within their home. METHODS: Fourteen older adults (13F,77.2±6.3y) completed five study sessions in their home. On the first two sessions, the study team traveled to the participant's home, gathered validity data, and ensured the participants could self-administer the 4-meter test with the App. For the following three unsupervised sessions, the participants used the App to administer the 4-meter test alone at home. The initial two sessions followed the same protocol. A 4-meter strip of ribbon was first placed on the ground. The smartphone provided verbal instruction and was placed in the participant's pocket during the test. Once the participants heard "Go" from the App, the participants walked along the line and made a turn at the 4-meter mark. Concurrently, a staff member used a stopwatch to record the time and a video camera to confirm start and finish timing of each trial. Gait speed was calculated by dividing 4 meters by the time captured using the video camera, stopwatch, and App. Pearson correlation coefficients were used to examine measurement agreement. The magnitude of error was calculated and visualized using Bland-Altman plots. The test-retest reliability of App-based 4-meter test was analyzed for the three unsupervised assessments using the intra-class correlation coefficient. RESULTS: All participants completed the two supervised sessions. Two participants did not complete the three unsupervised sessions due to smartphone malfunction. Gait speed derived from App data was highly correlated with gait speed as determined by video recordings ($R=.92$, $p<.001$). This correlation was noticeably stronger than that observed between gait speeds derived from the stopwatch and video recording ($R=.83$, $p<.001$) (Fig. A1, A2). Bland-Altman plots revealed that gait speed derived from the App and stopwatch both demonstrated excellent validity as compared with the video (Fig. B1, B2). Among three unsupervised home sessions, the smartphone App showed excellent test-retest reliability under normal and dual-task walking conditions, which was .90 and .75, respectively. CONCLUSIONS: Older adults were able to use the App to administer the 4-meter gait speed independently at home. The gait speed derived from our smartphone App is valid, reliable and appears to be more accurate than using a stopwatch for the 4-meter gait speed test in older adults.

P3-P-63: Age effects on patterns and variability of com-to-COP inter-plane coordination during gait using a waist-worn IMU with machine learning techniques

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[1]National Taiwan University

INTRODUCTION Dynamic gait balance has been quantified using the inclination angles (IA) of the body's centre of mass (COM) relative to the centre of pressure (COP) and their rates of change (RCIA) [1]. Dynamic balance needs integrated COM-COP control in both the frontal and sagittal planes. Inertial (IMUs) have become more widely used for gait monitoring in domestic environments [2]. For IA and RCIA, several IMUs would be needed, so monitoring gait balance via the sagittal and frontal COM-COP inter-plane coordination using a single IMU is challenging. Machine learning techniques can potentially reduce the number of sensors [3]. The current study aimed to quantify the age effects on the COM-COP inter-plane coordination in terms of continuous relative phase (CRP) [2] using a waist-worn IMU with machine learning techniques. METHODS Thirteen healthy young and thirteen older adults wearing 50 skin markers and an IMU on the waist walked while the ground reaction forces were measured with four forceplates and marker data by a motion capture system. These data were used to calculate gold standard IA and RCIA [1] and, together with the IMU data, were used to train a hybrid LSTM model. The accuracy of model predictions was described by relative root-mean-squared errors (rRMSE). With the LSTM-predicted IA and RCIA, phase plots of normalized IA and RCIA for frontal and sagittal planes were generated to give the phase angles [2]. Continuous relative phase (CRP) was obtained by subtracting the frontal phase angles from the sagittal angles. A CRP close to 0° indicates in-phase coordination, while a CRP close to ±180° is anti-phase. The deviation phase (DP) of the CRP curves described the variability of the coordination. A lower DP value indicates a smaller variability. Independent t-tests compared the variables between groups (α=0.05). RESULTS AND DISCUSSION The means (SD) of the rRMSEs of the LSTM-predicted sagittal IA, RCIA, frontal IA, and RCIA were 3.73 (0.90), 4.39 (1.40), 6.10 (2.20), 5.20 (0.90), respectively. The LSTM model accurately predicted IA and RCIA data for studying inter-plane coordination. The older and young groups had different patterns of inter-plane COM-COP coordination (Fig. 1). The older group showed significantly greater coordination variability during SLS (Old: 5.14 (0.21), Young: 4.84 (0.33), p=0.012) and Swing (Old: 5.22 (0.26), Young: 4.88 (0.23), p=0.001). CONCLUSIONS This study showed the feasibility of quantifying gait balance via inter-plane COM-COP coordination using a waist-worn IMU with an LSTM model. The proposed system has reasonably high accuracy and great potential for real-life monitoring of dynamic balance in people with fall risks. REFERENCES [1] Hong, S.W., et al. Gait Posture 42(4): 523-528, 2015. [2] Atrsaei, A., et al. NPJ Parkinsons Dis. 7(1), 24, 2021.

P3-P-64: Estimation of human spine orientation with inertial measurement units (IMU) at low sampling rate: How low can we go?

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BACKGROUND AND AIM Studying people in their daily life is important for understanding conditions with multi-faceted aetiology such as chronic low back pain. Inertial measurement units can be used in conjunction with specialized filters to reconstruct the posture and motion of the body outside of laboratories to enable this research. The battery life of these sensors strongly affects the usability of the system, since recharging them frequently is inconvenient


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and can lead to additional errors. A major determinant of the battery life for these sensors is sampling rate, but the relationship between low sampling rates (which would extend battery life) and accuracy in motion reconstruction is not well documented. The overall objective of this study was to develop a model that could output suggested minimum sampling rates for common activities of daily life, along with filter parameters optimized for that sampling rate. METHODS We measured spine movement of 12 participants using inertial measurement units across a variety of tasks such as sitting, sit-to-stand, walking, and jogging. The orientation of the spine was reconstructed using several filters, including a novel filter developed specifically for high performance at low sampling rates. This proposed filter is a Gradient Descent Filter upon which we made a series of modifications focused on increasing accuracy at low sample rates. Benchmarking against optical motion capture, we developed models for predicting error and optimal filter parameters as an exponential function of sampling rate. Using the model of error, we developed a criterion for recommending minimum sampling rates for accurate motion estimates for each task. We also compared the performance of our proposed filters against 4 other state-of-the-art filters. RESULTS The error of all tested tasks increased exponentially as sampling rate was lowered (Fig. 1A). The optimal accelerometer and magnetometer gains also exponentially increased as sampling rate was lowered, whereas the optimal gyroscope gain exponentially decreased. To meet our error criterion, walking tasks on average required a sampling rate of at least 20.3 Hz, while non-locomotory tasks required 17.8 Hz, and jogging required 34.5 Hz. Our proposed filter performed better than most other tested filters, especially at low sampling rates (Fig. 1B). CONCLUSIONS Sampling rate is an important factor in experiments with IMUs and has not been previously systematically examined. We developed a model for estimation of error as an exponential function of sampling rate that was applicable to all types of filters used with IMUs attached to the spine across static and dynamic daily life tasks. Using these error models along with the models for optimal filter parameters, minimum sampling rates can be recommended for a task, thereby optimising the trade-off between accuracy and battery life. Our proposed filter exhibited increased accuracy which enabled lower required sampling rates compared to existing filters. ACKNOWLEDGEMENTS AND FUNDING This work is supported by grants from the National Health and Medical Research Council of Australia (APP1091302; APP1194937).

P3-P-65: Gait event detection in cerebellar ataxia: A single vs. multiple sensor approach

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Background and Aim Monitoring gait in the real-world using wearable sensors presents an exciting opportunity for improving access to healthcare and delivering timely interventions[1]. Sensor configuration (number and location) may influence the accuracy of gait event detection and calculation of subsequent gait outcomes. Using a wearable sensor on each foot is considered the most robust approach for detecting gait events, such as initial and final contacts, which are used to segment stance and swing phases. Using a single sensor on the lower back has advantages including; reducing data footprint (processing and storage), minimising patient burden by removing the need to move sensors between shoes thereby ensuring uninterrupted continuous data acquisition, as well as prolonging battery life[2]. Ataxic gait is characterised by uncoordinated movements with high movement variability[3]. This

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study evaluated the accuracy of a single sensor for detecting gait events compared to multiple sensors in a diverse group of patients with cerebellar ataxia and controls. Methods 98 participants (control: n=43, 44% female, age=41.8±14.3y; pre-symptomatic: n=19, 74% female, age=38.1±12.4y; symptomatic: n=36, 36% female, age=49.1±11.9y) walked two 25m straight walks at their self-selected preferred pace in a laboratory setting. The Scale for the Assessment and Rating of ataxia (SARA) was used to define pre-symptomatic (SARA<3) and symptomatic (SARA>3) participants. A wearable sensor (APDM, Opal 128Hz) comprising accelerometer, gyroscope and magnetometer was affixed to the lower back and the dorsum of both feet (over the metatarsal bones). Two approaches were taken to identify gait events (initial contact-IC, and final contact-FC); a single sensor (lower back) using algorithms validated in older adults, people with Parkinson's disease and ataxia patients[4,5] vs. multiple sensors (feet) using manufacturer algorithms. The positive predictive value (PPV) was calculated with a tolerance window of 0.5s and the median absolute error (MAE) for both ICs and FCs were calculated[6]. Results A total of 9050 IC's and 8660 FC's were identified. PPV revealed minimal false positives for the detection of ICs for all participant groups with a median PPV of >90% (Fig.1A-C). False positives were higher for the detection of FCs with a median PPV of >80% for all participant groups. The MAE (Fig.1D) were similar for controls (IC=0.03s, FC=0.06s) and pre-symptomatic participants (IC=0.04s, FC=0.06s), and slightly higher for symptomatic participants (IC=0.06s, FC=0.07s). Conclusions There was a strong agreement between the single and multiple sensor approaches for gait event detection in controls and participants with cerebellar ataxia. Greater differences observed between the two approaches for the identification of FCs in symptomatic patients would influence the calculation of gait outcomes. Further efforts are required to determine whether the algorithm may be optimised for patients with cerebellar ataxia of moderate disease severity. References [1] Del Din 2019 Annals Neurology. [2] Czech 2020 NPJ Digital Medicine. [3] Ilg 2020 Neurology. [4] Del Din 2015 IEEE. [5] Hickey 2016 Phys Measurement. [6] Bonci 2022 Front Bioeng & Biotec.

Sensory (e.g. vision, vestibular)

P3-Q-66: Does postural instability inhibit rapid visually-guided reaching movements?

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BACKGROUND AND AIM: Express visuomotor responses (EVRs) are muscle activity bursts that occur ≈100ms after visual stimulus onset and aid in rapid movement execution. We recently found that during initiation of rapid visually-guided steps, a posturally unstable situation yielded suppression of lower-limb EVRs, greatly enhanced expression of ensuing anticipatory postural adjustments, and delayed step reaction times compared to the stable condition. These findings implicate a postural control system that can contextually suppress EVRs in the lower limbs at the expense of movement speed. Here we tested the hypothesis that this would also hold for upper-body EVR expression during reaching in an unstable situation. METHODS: 22 healthy participants made right-arm reaches towards visual targets presented to the left or right. Surface EMG of pectoralis major (Pec) and posterior deltoid (Delt) was recorded, two muscles that are either involved in leftward reaches (Pec) or rightward reaches away from the body (Delt). To manipulate postural stability, participants were either

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seated on a stable chair with the feet firmly placed on the ground ('Stable'), or seated on a 'wobble stool' with a rounded base, requiring continuous stabilization ('Unstable'). To further increase postural demands, the participants' feet were placed on top of two tennis balls. Outcome measures were EVR presence, magnitude (M) and latency (L), postural responses following EVRs, and reaction times (RTs). RESULTS: All participants had strong EVRs in Pec during leftward reaches, with no differences between the stable (L = 92ms; M = 0.52) and unstable (L = 93ms; M = 0.54) conditions. There were no RT differences between the stable (RT = 206ms) and unstable (RT = 211ms) condition. Further analysis showed a sudden and significant increase in Pec activity during rightward reaches in the unstable condition, occurring shortly after the EVR window but before movement onset (129ms after target onset, lasting ~20ms), despite inhibition being appropriate in this context. This sudden activation coincided with an increase (126ms) in Delt activity, relative to the stable condition. CONCLUSIONS: The lack of differences in EVRs suggests that our manipulation of postural demands may not have been sufficient to engage the contextual suppression of EVRs on the upper limb. However, our manipulation of postural stability revealed contextual engagement of a strategy of co-contraction of antagonistic muscles in the upper limb immediately after the EVR. These results support previous notions that EVRs are mediated by a neural circuit that is distinct from that governing subsequent recruitment patterns. Further, the postural control system can flexibly and rapidly engage muscles after the EVR to counteract recruitment that might otherwise compromise postural stability.

P3-Q-67: Effect of peripheral visual noise on the completion of a central task in young adults with ADHD

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BACKGROUND AND AIM: Safely passing through a closing aperture requires one to accurately couple their rate of approach to that of the closing aperture, and to allow the central executive to make a correct decision. Populations with altered executive function, such as individuals with ADHD, score poorly on tests on visual perception and collide frequently with obstacles. Individuals with ADHD use suboptimal decision-making strategies, which may impact their ability to make correct aperture passability judgements. The current study compared decision-making abilities of young adults (YA) with and without ADHD during a closing aperture crossing task while immersed in different Virtual Environments (VE). We expected aperture crossing decisions between groups to be different based on environmental complexity. METHODS: Six YA with ADHD (female=3; 22.2±3.7yrs) and 13 age-matched Controls (female= 8; 21.5±1.2yrs) were immersed in a VE using an HTC Vive Pro2 head mounted display (HMD). Participants approached a set of doors from 6.5m. The initial aperture of the doors was 4m and when the participants were 4m from the doors, they began to close at a rate ranging from 0.6-1.2m/s*participant's preferred walking speed. There were 3 different VE: 1. Plain; 2. Static Virtual Pedestrians; and 3. Moving Virtual Pedestrians (Fig. 1). Participants were instructed to approach and walk through the closing aperture if they deemed it passable without acceleration or shoulder rotation otherwise stop. Using the position of the HMD during the approach phase, the position at slowdown and stop were calculated to determine each participant's critical point (i.e., switch point from passible to impassible). RESULTS: A significant main effect of door closing speed on position at stop [$p<0.001$, $f=1.856$] and position at slowdown was observed [$p<0.001$, $f= 1.835$]. The critical point for door speeds deemed passable versus impassable for both groups, in all conditions was 0.9m/s*walking speed. There

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was a significant 3-way interaction between group*VE*door speed for position at slow down [p=0.036, f=0.376] where YA with ADHD (M0.8=6.5±1.0, M0.9=6.02±1.0, M1.0=5.41±0.84) slowed down significantly sooner than the Controls (M0.8=6.97±0.55, M0.9=6.54±1.02, M1.0=5.98±1.15) in the Moving Virtual Pedestrian VE at door speeds 0.8, 0.9, and 1.0m/s*walking speed. CONCLUSIONS: Findings indicate that YA with ADHD compared to Controls: 1. make the same aperture passability decisions; 2. stop at the same location on trials deemed impassable; but 3. slow down sooner in the most complex VE. Slowing down sooner may be a strategy to compensate for the increased attentional demand of the dynamic environment to allow them more time to process necessary information to make the correct decision.

P3-Q-68: Visual re-weighting during walking

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Background and Aims: Sensory re-weighting is the process of changing reliance on a sensory system to facilitate the estimation of the body's motion state in space (i.e., position and velocity). We used a novel method that applied a continuous visual motion perturbation at frequencies below the stepping cadence during walking. The reliance on vision was determined by measuring the influence on body motion of visual stimuli applied at different amplitudes. It is currently unknown if adults re-weight visual information with changes in visual amplitude to maintain stable balance and how these changes could differ in healthy young versus older adults. Methods: A pilot cohort of 14 healthy young and 15 healthy older adult participants walked on a self-paced, instrumented treadmill inside a virtual reality dome. The virtual display presented a pseudo-random rotation of the virtual scene around the anterior/posterior axis of the horizon. Three different amplitudes of the visual stimulus were presented: 6, 10, and 15 degrees peak-to-peak. We calculated response gain as the ratio of medial-lateral center of mass movement to the visual stimulus amplitude as a measure of visual sensory reliance. Gait variability measures including step width, step length, stride length, and stride time were compared in younger and older adults. Results: Our preliminary analysis indicated that older subjects showed greater reliance on vision for balance during walking. Additionally, in both young and old, visual dependence decreased while step width variability increased with increasing visual stimulus amplitude. Remaining measures of gait variability did not change as visual stimulus increased. Conclusion: Our preliminary analysis indicated that visual system dependence decreased with increasing stimulus amplitude, implying that the nervous system down-weighted vision as it became a less reliable indicator of self-motion. The effects of the visual down-weighting on gait variability were minimal, suggesting that alternative sources of sensory information may have been upweighted to compensate.

P3-Q-69: The effect of circular vection on the subjective postural horizontal in the pitch plane

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BACKGROUND AND AIM: Balance control is maintained through the integration of sensory information from the visual, vestibular, and somatosensory systems [1]. Previous assessments of postural orientation and balance, including the subjective postural horizontal (SPH) test, have suggested that multisensory integration during a postural task is dependent on the

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direction of visual cues [2]. Dynamic visual stimuli, in the form of circular vection (CV) in the roll plane, were found to significantly affect the perception of platform horizontal and alter body position during upright stance [2]. However, CV in the pitch plane has been shown to provide a different form of visual stimuli and elicits distinctly different postural strategies compared to roll stimuli [3]. Therefore, by altering the support surface and visual information during upright stance, this study aims to understand how applying dynamic visual stimuli, in the form of circular vection in the pitch plane, influences balance behavior and perception of the support surface horizontal. METHODS: 20 healthy young adults were asked to stand on a platform while wearing a head mounted display. While standing upright for 30s, participants were exposed to A) a visual scene rotating in the pitch plane at 60°/s forward (FW; downwards) or backward (BW; upwards), B) the platform rotating ~3° at 15 seconds (SPH, FW or BW), C) a combination of both rotating congruently, or D) neither rotating. During SPH task, participants used a controller to adjust the pitch position of the platform until they perceived it to be level, or "horizontal". Body pitch angles were calculated from kinematic markers. RESULTS: Participants mean perceptions of platform horizontal deviated from true horizontal by 0.57° during SPH-only collapsed across FW and BW platform rotations, and were biased by CV in the combined conditions increasing to 1.00°. Body lean was larger for CV conditions compared to SPH, and greatest for combined congruent conditions compared to the CV or SPH. Body lean was greatest for FW compared to BW conditions during CV. However, during SPH and combined conditions, pelvis angular displacement was largest for BW, while head and trunk angular displacements were largest for FW. CONCLUSIONS: Pitch CV significantly effects SPH of the support surface and body position during postural tasks. Body angular displacements were larger when perturbed forward compared to backward. This study demonstrates a direction specific effect of CV, and supports the hypothesis of weighted multisensory integration during a postural task being dependent on the direction of additional visual cues. This could be useful for future work when examining body orientation tests with older adults who have increased reliance on vision, for example, after vestibular loss. REFERENCES: [1] Luo et al. (2018) Front. Neurol.; [2] Cleworth et al., (2018) ISPGR; [3] Carpenter et al. (2001) Exp. Brain Res. ACKNOWLEDGEMENTS AND FUNDING: NSERC.

P3-Q-70: 3D GRF estimation using LSTM model and shoes with three uniaxial load cells

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Ground Reaction Force (GRF) is the force exerted by the ground on a body in contact with it. GRF is crucial for estimating muscle strength and joint torque in inverse dynamics analysis [1]. Conventional measurement methods employ force plates, which present spatial limitations. As gait studies often involve numerous steps, they necessitate an extensive array of force plates, posing a significant disadvantage. To overcome these, we developed a deep learning model for estimating three-axis GRF utilizing shoes with three uniaxial load cells.

The study encompassed 81 healthy young participants (40 men (age: 23.44 ± 2.18) and 41 women (age: 23.33 ± 2.21)). The research protocol was approved by the University's Ethics Committee (IRB No. 7001355-201507-HR-066). Each participant walked on a force plate (Fs: 120 Hz) while wearing shoes fitted with three uniaxial load cells (Fs: 100 Hz). The experiment was conducted twice. The three-axis GRF was calculated using a seq2seq approach based on long-short-term-memory (LSTM) [2] with load cell data during gait as input. The seq2seq

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model comprises three LSTM layers (number of nodes: 200, 50, 200) and estimates the uniaxial signal measured from each load cell to correspond to the 3-axis GRF obtained from the force plate. All data were resampled at 200 Hz for training. For learning, validation, and testing, subjects were randomly selected. Sixty participants were divided as follows: 37 in the training set, 12 in the validation set, and 11 in the test set. The root-mean-square-error (RMSE), correlation coefficient, and Bland-Altman plot between the measured and predicted GRFs for the test set were calculated to assess the trained model's performance [3]. Additionally, the GRF application point was determined by applying the equilibrium equation to the load cell coordinates and measured pressure in the shoe, a method comparable to force plate techniques for identifying pressure center coordinates.

The estimated GRF closely aligned with the force plate-measured GRF, exhibiting correlation coefficients of 0.97, 0.96, and 0.90 and root mean square errors of 65.12 N, 15.50 N, and 9.83 N for the vertical, anterior-posterior (AP), and medial-lateral (ML) directions, respectively. A Bland-Altman analysis demonstrated good agreement for the maximum vertical GRF. The application point calculation confirmed the trajectory from the heel to the 1st metatarsal, following the 5th metatarsal [4].

The AP and vertical axis predictions demonstrated a high degree of accuracy in all validations; however, the ML direction's accuracy was relatively lower. Generally, the change in the foot's center of pressure during walking starts at the heel, progresses through the lateral region to the metatarsal region, and terminates at the big toe [4]. In some participants in this study, simultaneous pressure occurred at the 1st and 5th metatarsals. The developed model did not accurately detect this intoeing gait, seemingly reducing the ML direction's accuracy. Additionally, the application point calculation using the equilibrium equation has some limitations. The load cell does not accurately represent the entire foot's pressure during walking, and as the load cell value is minimized during heel contact and toe-off, there is a possibility of error, making the moment when the foot disengages from the load cell sensitive.

Despite the limitations, the proposed shoe equipped with three uniaxial load cells and the seq2seq LSTM model can be employed for estimating 3D GRF in outdoor environments with level ground or for gait research where subjects take multiple steps at their preferred walking speed. Consequently, this approach can provide essential data for conducting basic inverse dynamic analysis.

Reference

[1] Winter, D.A. Biomechanics and Motor Control of Human Gait, Normal, Elderly and Pathological; University of Waterloo Press: Waterloo, ON, Canada, 1991.

[2] Sutskever, I.; Vinyals, O.; Le, Q.V. Sequence to Sequence Learning with Neural Networks. Adv. Neural Inf. Process. Syst. 2014, 27, 3104–3112.

[3] Bland, J.M.; Altman, D. Statistical Methods for Assessing Agreement between Two Methods of Clinical Measurement. Lancet 1986, 327, 307–310.

[4] Kim, K. Implementation of Gait Pattern Monitoring System using FSR (Force Sensitive Resistor) Sensor. J. Semicond. Disp. Technol. 2021, 20, 56–60.

ACKNOWLEDGMENTS

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P3-Q-71: Mutual avoidance behaviours of older and young adults passing through a doorway

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BACKGROUND AND AIM: Individuals constantly adapt their movements to avoid potential hazards and obstacles within an environment. Vision is the primary sensory system that allows individuals to perceive the time prior to colliding with an approaching object and determine when to avoid, as well as the future risk of a collision. When mutually avoiding another pedestrian, individuals will adopt role-dependent strategies whereby the person passing second will contribute more to the avoidance by slowing down or deviating from their original path. While these findings are consistent within the young adult population, aging may affect visuomotor processing. Therefore, the primary objective of the study was: 1) to further examine individuals' ability to use visual information to accurately avoid an approaching person while simultaneously negotiating a doorway; and 2) to identify the impact of age-related changes on mutual avoidance behaviour. METHODS: Nine young adults (Y; 24.4±2.3 yrs, 4 females) and 9 older adults (O; 69.6±2.2 yrs, 9 females) participated in the study. On any given data collection session, 2-3 individuals from each group participated, creating three possible interaction combinations (i.e., YY, YO, OO). Starting at one of two locations on opposite sides of a 10m pathway, two participants were instructed to approach one another and mutually decide who would pass first through a doorway located halfway along the path. Kinematic data was recorded using the Qualysis Motion Capture System and used to determine participant's location along the pathway and approach speed. This information was used to identify the predicted and actual crossing order of participants through the doorway. RESULTS: When two participants from the same age group mutually avoided one another, the predicted order of crossing matched the observed order of crossing (i.e., "proper" order) on 81.0% and 84.1% of the trials for YY and OO, respectively. However, when participants were instructed to mutually avoid the opposite age-group (i.e., YO), the proportion of trials where the "proper" crossing order was observed decreased to 75%. In other words, when the YAs and OAs were required to mutually avoid one another, there were more inversions (i.e., the actual crossing order did not match the predicted order of crossing). CONCLUSION: Findings suggest that both groups of adults can use visual information to predict and maintain proper crossing order. Yet, there appears to be a discrepancy in the ability to maintain proper crossing order when the pedestrians are of different age groups. Research has demonstrated that older adults have diminished visuomotor processing capabilities within a restricted timeline, which may cause YAs to contribute more to the avoidance (i.e., change speed or path). In addition, the larger proportion of inversions during the YO interactions may be due to social norms, whereby YAs allow the OAs to pass first regardless of their distance to doorway.

P3-Q-72: Examining the effects of radial and laminar optic flow gain on quiet stance

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BACKGROUND AND AIM: The visual system plays an integral role in maintaining quiet stance. When visual feedback is amplified by increasing the gain of optic flow, individuals develop a tighter control of upright stance [1]. The pattern of optic flow can also vary depending on the eccentricity of gaze, where looking to the side can increase the proportion of laminar, compared to radial optic flow [2]. Further, previous work has shown differences between visual motion perception when exposed to varying types of optic flow [2]. It currently remains unknown how the type of optic flow contributes to postural control while under the influence of modified gain. Therefore, this study aims to better understand how the gain of radial and laminar optic flow, manipulated by changing head orientation, contributes to balance control during quiet stance among healthy adults. METHODS: 23 healthy adults (mean age: 22.5, 10 female) were recruited to stand quietly with feet together on a foam pad placed over a force plate (AMTI, USA). Participants wore a virtual reality head mounted display (HMD) (Oculus Rift) exposing them to an approximately 110° photo-realistic environment. Three head orientations (forward, 45° left, 45° down) were used to expose participants to primarily radial (forward) or laminar (left and down) optic flow. For each head orientation, participants completed 3 trials, where the gain of optic flow was amplified to either 1x, 4x, or 16x normal optic flow. Each of the 9 experimental trials lasted 60-seconds. Mean power (MP) among four frequency bands (LOW: 0-0.1 Hz, MED: 0.1-0.5 Hz, MED-HIGH: 0.5-1.0 Hz, HIGH: 1.0-5.0 Hz), root mean square amplitude (RMS), and mean power frequency (MPF) for anteroposterior (AP)/mediolateral (ML) COP and AP head displacement (HeadPos) were used to quantify balance. RESULTS: Significant main effects of optic flow gain were observed across COP and HeadPos RMS, MPF, and MP. In general, an increase in optic flow gain decreased COP and HeadPos RMS, and shifted the power of COP and HeadPos displacements from low to higher frequencies (p's<0.05). In addition, significant main effects of head position were observed for AP COP MPF (p=0.004) and ML COP RMS (p<0.001). When looking to the left, ML COP and AP HeadPos RMS increased compared to looking forward or down. However, the effect of optic flow gain on COP and HeadPos were similar across head orientations. CONCLUSIONS: Postural stability appears to be significantly influenced by optic flow gain, where an increase in optic flow gain decreases the amplitude of COP and head displacement. However, this effect appears to be independent of head orientation and the type of optic flow (radial and laminar). Future work is needed to examine the influence of different types of optic flow gain under dynamic balance tasks, such as recovery from perturbations. REFERENCES: [1] Lavalle & Cleworth (2023) Neurosci Lett.; [2] Harris et al. (2012) J. Vis.

P3-Q-73: Is there a consistency in actions when passing through a narrow aperture?

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BACKGROUND AND AIM: Aperture crossing tasks are commonly used to test an individual's perception-action integration capabilities. Multiple studies have consistently demonstrated that aperture widths that are less than 1.3 times an individual's shoulder width (SW), will result in shoulder rotations to safely pass through the aperture. It is believed that the nervous system is controlling shoulder rotation magnitudes at the time of crossing, however, other behaviours may also be regulated. The purpose of the current study was to determine whether participants regulate their gait parameters prior to crossing through a narrow aperture. It was hypothesized that narrower aperture widths would lead to more consistent behaviours among individuals.

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More specifically, individuals will accurately and consistently place their nondominant foot in a similar location prior to passing through the aperture. METHODS: Eleven young adults (7 male; 21.33±1.15) walked along an 8-meter pathway towards an aperture created by two identical poles (8 inches in diameter) located halfway along the pathway. Participants were instructed to approach and pass through an aperture with one of five random aperture widths ranging from 0.8-1.2 times SW with 0.1 incremates. Participants were exposed to each aperture width 5 times for a total of 25 trials. The location of each participant's trunk and feet during the approach were recorded using the Optotrak camera system collected at 60Hz. Data analysis included step length variability during the approach, foot location prior to crossing the aperture, and proportion of trials in which participants placed their non-dominant foot prior to crossing. RESULTS: A significant interaction was observed between door aperture width and step length variability [p <0.001, f=0.45], such that as door aperture width became smaller there was an increase in the variability of step length. As well, significant main effects for door aperture [p= 0.01, f= 0.35] and step length variability [p <0.001, f= 0.70]. Likewise, final footfall location variability decreased as door aperture sizes became smaller [p = 0.02, f= 0.23]. Such that smaller apertures resulted in lower variability (increased consistency) of the final footfall location prior to crossing. There was a strong to moderate negative correlation between door aperture width and non-dominant final footfall placement [r=-0.66], such that the smaller the door aperture, the more likely participants placed their dominant foot prior to crossing the doors. CONCLUSIONS: Findings suggest that as aperture widths decrease, there is an increase in the consistency of behaviours to allow the individual to be successful. Participants are correcting step length errors earlier in the approach and are more likely to target their non-dominant foot just prior to crossing as aperture widths decrease.

P3-Q-74: The effects of enhanced plantar surface stimulation on neuromuscular responses during standing balance and gait in healthy and clinical populations: a systematic review

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BACKGROUND AND AIM: Enhanced sensory input applied to the plantar surface of the feet has the potential to improve standing balance and gait, by way of underlying changes in neuromuscular control. Innovative footwear devices that incorporate sensory-stimulating design components (e.g. texture, vibration) have been shown to improve balance and gait in healthy adults and clinical populations with metabolic and neurological disease. Thus, plantar sensory stimulation devices are emerging as a promising new rehabilitation technique to help improve balance and gait for individuals at risk of falls. However, the underlying mechanisms by which plantar stimulation devices alter balance and gait remains unclear. This systematic review aimed to investigate the effect of enhanced plantar surface stimulation on neuromuscular responses during standing balance and gait. METHODS: Four databases (PubMed, EMBASE, CINAHL, Cochrane Library) were selected to identify randomised controlled trials and observational studies of plantar stimulation devices designed to improve balance or gait in healthy and clinical populations. The primary outcome measure was neuromuscular responses during balance or gait. Studies from the searches were imported to Covidence with duplicates removed. The title and abstract of articles were screened to determine inclusion, and thereafter relevant full text articles were reviewed. Data was extracted from the included studies and quality was assessed using the Cochrane Risk of Bias 2 tool. RESULTS: 2770 articles were screened for title and abstract. Thereafter, 32 articles were

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screened for full text, and 22 articles were included in the review. Study participants included clinical populations with multiple sclerosis, diabetic neuropathy, Parkinson's disease, Charcot-Marie-Tooth disease, foot deformities, and healthy adults. Textured insoles were the most commonly reported intervention, followed by textured surfaces, electrical stimulation, and vibrating insoles. Amplitude of lower limb muscle activity was the most commonly reported neuromuscular measure, followed by onset of muscle activation. Enhanced plantar stimulation was reported to decrease amplitude and bring about earlier onset of lower limb muscle activation. Changes in neuromuscular responses were associated with improved balance (e.g. reduced sway) and gait (e.g. greater step length). CONCLUSIONS: Plantar surface stimulation appears to have the potential to alter neuromuscular responses and may be one underlying mechanism contributing to improved balance and gait in healthy and clinical populations. Greater knowledge of how plantar stimulation devices bring about their effect on balance and gait is critical to inform the development of new tailored treatment options for individuals at risk of falls. Enhanced balance and gait in older and clinical populations could help to prevent falls and injury, leading to enhanced quality of life, improved physical activity, and greater participation in social, domestic, and productive roles.

P3-Q-75: Investigating how aperture characteristics and goal location influence pathway selection

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BACKGROUND AND AIM: Although people tend to choose the shortest path, environmental features are also considered when navigating. People may choose a longer path if it provides a greater safety margin from obstacles. The purpose of the current study was to 1) determine when goal location or aperture characteristics dictate path selection when choosing competing apertures and 2) evaluate if an inward-facing pedestrian induces similar behaviours as a small aperture. It is hypothesized that goal location and the presence of a pedestrian will affect path selection. METHODS: Eight young adults (23yrs ±2.31) participated in the study. Participants walked along a 10m pathway toward 1 of 7 goal positions while passing through 1 of 2 apertures (Figure 1A). Three poles created two apertures presented as 1) equally sized (80cm); 2) unequally sized (80cm and 1.2 times shoulder width (*SW); or 3) equally sized (80cm) with the middle pole exchanged for a pedestrian facing left or right. Participants completed 69 trials organized into three blocks (Figure 1B). Participants' trunk positions in space were tracked using an Optotrak camera system collected at 60Hz to monitor aperture crossing behaviours. RESULTS: Participants' COM position at the time of aperture crossing was analyzed to determine path selection. A rmANOVA examined the proportion of trials when participants passed through the left aperture (i.e., 80cm, 1.2*SW, or left-facing pedestrian) when the goal was located on or to the left of the midline. Results revealed that when the goal was along the midline (position 4), participants chose to pass through the left aperture significantly more when it was 80cm or the pedestrian was facing left than when it was 1.2*SW ($p<.001$). For all other goal positions (i.e., to the left of the midline), participants were significantly more likely to pass through the left aperture ($p<.001$). Another rmANOVA examined the proportion of trials when participants passed through the right aperture (i.e., 80cm, 1.2*SW, or right-facing pedestrian) when the goal was in line or to the right of the midline. Similar results were observed such that participants were significantly more likely to pass through the right aperture ($p<.001$) when the goal was to the right of the midline. However, when the goal was located along the midline and the right aperture was 1.2*SW, participants

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were less likely to pass through than in the other two conditions (p<.001). CONCLUSIONS: Overall, goal position affects path selection more than aperture characteristics. When the goal is located away from the midline, participants will choose the shortest path however, when the goal is located along the midline, aperture characteristics affect path selection. Although an inward-facing pedestrian did not induce the same behaviours as a smaller aperture, these results could be due to the experimental design (i.e., presentation of certain goal locations relative to aperture characteristics).

Tools and assessment methods

P3-R-76: Reconceiving step lengths & step widths for non-straight paths

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BACKGROUND & AIM: People rarely walk straight ahead. Instead, we make frequent turns or other maneuvers. Spatiotemporal variables (e.g., step length, width, etc.) characterize gait and predict fall risk (Taylor et al., 2013). While well-defined for straight walking, these definitions are not straightforward for non-straight walking. Prior efforts (e.g., Huxham et al., 2006; Ho et al., 2023) did not account for walking paths. People follow paths imposed by their environment (store aisle, sidewalk, etc.) or choose stereotypical & predictable paths of their own (Moussaïd et al., 2011). People maintain lateral position on their path (Dingwell & Cusumano, 2019) and readily adapt their stepping when their path changes (Desmet et al., 2022). METHODS: We propose a conceptually coherent convention that defines step lengths and widths relative to known walking paths. Our convention simply re-aligns lab-based coordinates to be tangent to a walker's path at the mid-point between the 2 footsteps of each step. We hypothesized this would yield results both more correct and more consistent with notions from straight walking. We defined several common non-straight walking tasks: single turns, lateral lane changes, walking on circular paths, and walking on arbitrary curvilinear paths. For each, we simulated idealized step sequences denoting "perfect" performance in each task. We compared results to other path-independent alternatives. For each, we directly quantified accuracy relative to known true values. RESULTS: We show why anatomically-based coordinates cannot work because they conflate body segment motions with the walking task being performed. We show the main alternative convention (Huxham et al., 2006) produces large artificial errors for single-step turns, introduces artificial changes in movement direction for lateral maneuvers, generates both substantial errors and artificial asymmetries for walking around a circle, and excessively large errors for walking on general curvilinear paths. Conversely, our convention returns correct values for both single-step turns and lateral maneuvers, far smaller errors and no artificial asymmetries for walking around circles, and far smaller errors for curvilinear walking. Most importantly, across all tasks, our convention yielded results conceptually coherent with definitions and concepts from straight walking (Whittle, 2007). CONCLUSIONS: Multiple results strongly confirmed our hypothesis. Explicitly accounting for walking paths as important task goals (Cusumano & Dingwell, 2013) resolves conceptual ambiguities of prior approaches. Our work thus offers a conceptually coherent way to conceive important quantities beyond straight walking. This has important implications for studying falls that occur in complex non-straight walking tasks (Robinovitch et al., 2013) and for increasingly-important

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assessments of real-world walking (Twardzik et al., 2019). FUNDING: NIH R01-AG049735 & R21-AG053470

P3-R-77: BACK-me-UP: Validation of low BACK pain measurements Using mobile Phone technology

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Background and aims Altered postural control patterns have been found in asymptomatic individuals who are more likely to develop low back pain (LBP). Nonlinear analyses are able to identify those alterations and discriminate between pathological populations, such as, risks of falls in elderly people or the degradation of motor skills in Parkinson's disease. There is consensus that research should focus on preventing the persistence of LBP, however, there is a lack of tools to identify these subpopulations. The aim of this study was to investigate the concurrent validity of nonlinear measures of postural sway derived from a smartphone against the gold standard 3D motion capture system. Methods Twenty healthy young adults (age: 21.1 ± 3.36) completed four static balance tasks in random order. The data were simultaneously collected by the smartphone (Samsung Galaxy A3, Samsung, Seoul, South Korea) fixed on the sternum at 100 Hz and by an eight-camera SMART-D Motion Capture System (BTS S.p.A., Milan, Italy) at 250 Hz using twenty-five passive reflective markers. Concurrent validity was examined by comparison (Spearman's rank correlations) of nonlinear measures, quantified as complexity indexes of Multiscale entropy (MSE) of postural sway acceleration derived from the two systems. Results There were significant large correlations between MSE from the smartphone and the motion capture system during tandem stance (rho=0.535, p =0.018) and single leg stance (rho=0.698, p =0.001), but not during double leg stance with eyes open (rho=0.165, p =0.448) and closed (rho=0.142, p =0.481). Conclusions This study demonstrated that smartphones are valid to assess nonlinear measures of postural sway during challenging static stance with a small base of support. Smartphones have the potential to provide accessible, objective postural sway measures, to identify people at risk of LBP, which may have an impact on clinical practice, the development of mobile digital health, accessible (self-)assessment, and implementation of LBP preventive strategies.

P3-R-78: Physical therapists' rationales when rating balance exercise intensity

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BACKGROUND & AIMS: Balance rehabilitation programs involve a series of appropriately structured exercises over time that aim to improve individuals' ability to utilize available sensory information and reduce fall risk. A dose-response relationship drives the effectiveness of balance training with an emphasis on appropriate exercise intensity, but clinical recommendations do not provide concrete guidelines for balance intensity assessment or dosage. Balance exercise intensity is a complex metric to measure as the intensity of an exercise depends on the underlying physical and contextual factors affecting an individual's ability. Physical therapists (PTs) typically perform clinic-based outcome measures and observations of balance performance to customize rehabilitation programs to individuals and ensure appropriate challenge in the exercises prescribed. The goal of this study was to examine PTs' rationales when rating balance exercise intensity and qualitatively investigate inter-rater differences to better understand PTs' approaches to balance exercise evaluation.

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METHODS: 47 exercise participants (age = 51 ±18y; 30 female, 17 male) from a broad range of populations and balance abilities including healthy adults and individuals with balance-related disorders participated in a single-session study. Exercise participants were filmed performing exercises that included standing on firm/compliant surfaces, weight shifting, lifting a weight up and down, and walking under varying sensory conditions. 44 PT study participants participated in a survey-based study. Respondents were PTs licensed to practice in the US with experience in balance rehabilitation. PT participants were asked to watch videos of up to five exercise participants performing balance exercises, provide balance intensity ratings on a 1-5 scale, and reflect on their rationales for providing ratings following a think-aloud protocol. Think-aloud responses were transcribed and thematically analyzed to codify emerging rationales for balance ratings across exercise categories and intensity levels, and investigate inter-rater differences. RESULTS: The thematic analysis uncovered four main themes of rationales conveyed by PTs: task-specific factors relating to the demands of the exercise, individual-specific characteristics relating to the exerciser's perceived condition or age, performance-based factors relating to compensatory reactions observed, and factors relating to changes in performance across trials/exercises. Categories of factors considered under each theme were outlined and instances of rating differences between raters were explored through illustrative examples. CONCLUSIONS: This study provides qualitative descriptions of PTs' rationales when rating balance exercise intensity. Insights from this work could support the further development of balance intensity scales and clinically informed guidelines for exercise selection and progression in balance rehabilitation.

P3-R-79: Integrated measurement system for the postural disorders in the field of clinical rehabilitation

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BACKGROUND AND AIM: Postural disturbance accompanies various type of diseases and injuries. Center of pressure (COP) has been commonly utilized as an effective way to characterize clinical manifestation of postural disorders those largely differ among the type of disease and symptom. Although spatiotemporal parameters obtained from COP, such as sway area and velocity, have been regarded as feasible indicators for the assessment of static and dynamic postural balance, observation of whole-body alignment of body segments and measurement of muscle activities in the lower limb might provide useful information for the characterization of the postural disorders. We have been developed comprehensive assessment tool for the evaluation of postural disorders with the combination of COP, kinematics and muscle activities with less effort, space, and cost. We here describe our newly developed system and introduce how the system works effectively to characterize of postural disorders, and then discuss the potential benefits in the clinical situation. METHODS: In addition to CoP measurement using force plate platform (BASYS, TechGIHAN), we simultaneously recorded muscle activity in the soleus and tibialis anterior muscles (MuscleBIT, Plux) and whole-body kinematics. We utilized pose estimation based on point cloud data obtained from depth camera (Azure Kinect, Microsoft Inc.), and then calculate center of mass (CoM), position of head, and angle of each joint. Graphical user interface of our developed system based on C# (WPF) could integrate three independent sensors those have different sampling rates and connection paths. RESULTS: With the use of different modality of posture-related recording data, clinical manifestation of postural disorders could potentially be

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characterized. For example, displacement of the head and COP toward non-paretic side in stroke, specific flexion posture in Parkinson's disease, and unique forward leaning posture and excessive activity of the tibialis anterior muscle in spinocerebellar degeneration. We already recorded more than 450 patients with various type of postural disorders, including stroke, Parkinson's disease, spinal cord injury, and spinocerebellar degeneration. CONCLUSION: Characteristics of COP reflects as a resultant kinetic property of postural control. In order to examine detailed coordination strategy during standing posture, kinematic data and muscle recording would give us important information. These data might have a potential for elucidate multivariate analysis for understanding pathological structure of postural disorders. Our developed system has already been installed as a clinical tool and is being actually used to assess postural disorders at multiple hospitals. It is expected that the system will be used effectively to extract the characteristics of various postural disorders that have not been clarified by the accumulation of future data.

P3-R-80: Development of patient-tracking robotic gait measurement system: Feasibility test for 684 patients with various types of gait disorders

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BACKGROUND AND AIM: 10-meter walking test is commonly-used clinical gait assessment in the field of rehabilitation. While parameters obtained from 10-meter walking are just simple determination as required time and number of steps, it is important to be focusing on kinematic and kinetic parameters for the better understanding/characterization of gait disorders. Recently, novel techniques of human pose estimation with RGB image and/or depth camera has been developed. Such potential technologies expected to utilize as an alternative assessment tool in the field of rehabilitation. We have been developed a patient-follow modality of novel gait measurement system which enable us to capture kinematic data during 10-meter walking. The aim of this study was to test the feasibility and potential usefulness of our developed system based on the analysis obtained from various types of gait disorders. METHODS: In total, 677 subjects (20-96 years old) categorized as various types of disorders/symptoms (wide range of healthy, stroke, spinal cord injury, spinocerebellar degeneration, Parkinson's disease, orthopedic disease, etc.) were enrolled in this study. All subjects underwent two trials of 10-meter walking. Depth point cloud data during walking was recorded by Azure Kinect (Microsoft Corporation) which mounted on the motorized vehicle. Distance between subject and vehicle was constantly controlled as 3 meters by the detection of center of pelvis by the use of point could data. To identify gait events (heel contact and toe off), we used each of four FSR sensors attached on the both side of insole of shoes. Fundamental gait parameters of 10-meter walking (gait velocity, gait efficiency, step length, cadence, stance time, hip range of motion and angular velocity) were calculated. Mutual relationship between parameters were confirmed by Pearson's correlation coefficient with python package of statistical analysis (scipy.stats module). RESULTS: In addition to velocity, gait efficiency (summation of the CoM acceleration) was calculated as a kay valuable for gait behaviour. Relationship between gait velocity and efficiency could be well fitted as logarithmic function (R2=0.617), not merely liner, suggesting that those two parameters can be regarded as independent evaluation parameters for the characterization of gait behaviour. Gait speed has statistically significant correlation with cadence ($r = 0.682$, $p < 0.01$) and stride length ($r = 0.941$, $p < 0.01$), and hip angular velocity ($r = 0.62$, $p < 0.01$). CONCLUSION: Our developed

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system enables us to perform simple and easy gait measurement with high accuracy over entire range of 10 meters, which has been thought to be difficult in the common optical motion capture environment. These advantages of our system highly contribute to acquire accurate gait data. We will continue to correct plenty of data, and then perform detailed analysis to get better understanding of mechanisms underlying gait disorders.

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