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Keynote Speakers

K.1 – Daniel Ferris

Why use mobile brain imaging to study human movement?

Daniel Ferris, University of Florida

I used to be, and am still, skeptical of mobile brain imaging tools. How can mobile brain imaging increase our understanding of principles governing human movement? Does information about increased/decreased brain blood flow or increased/decreased electrocortical spectral power in certain areas of the brain give insight into why people move the way they do? Will it help clinicians diagnose or treat individuals with motor disorders? In 2008, I spent 6 months on sabbatical in the Swartz Center for Computational Neuroscience at University of California, San Diego, working with Scott Makeig and Klaus Gramann. There, I learned how to use high-density electroencephalography to record electrical brain activity while human research subjects walked on a treadmill. Over the last 15 years, the hardware and software technology for recording and deciphering high fidelity electrical brain dynamics has greatly improved. The Human Neuromechanics Laboratory at the University of Florida uses EEG-based mobile brain imaging to study humans during walking, running, and even playing table tennis. It is often difficult to separate brain electrical signals from motion artifacts, eye electrical signals, and muscle electrical signals when using scalp electrodes. However, there are ways to validate hardware and signal processing approaches, providing greater confidence in the results. I will present on the current state of the art in EEG-based mobile brain imaging and discuss how it has been, and will be, valuable to researchers studying human posture and gait. Mobile brain imaging with high-density EEG can provide insight into how different balance training modalities are perceived and processed. It can identify differences in younger and older brains attempting to achieve the same tasks (e.g. walking on uneven terrain surfaces). As the technology progresses in the coming decade, it is not difficult to envision a future with real-time streaming of electrical brain dynamics to your smart phone application. That information could help other applications assist you with directions, scheduling, or communications. It could be analyzed locally or in the cloud, and be sent to your health service along with data from inertial measurement units embedded in your clothes or accessories. Figuring out how to best use that information will require concerted efforts from many researchers in the coming decades.

K.2 – Kathyrn Sibley

Inquiry and Impact in Posture and Gait Research: Towards a Healthy Balance

Kathyrn Sibley, University of Manitoba

The pursuit of knowledge and understanding has long defined the human experience, and scientific inquiry offers great potential to positively impact society and our world. However, the extent to which the production of science-based knowledge has translated to societal impact has not been optimized due to a complex array of factors that influence contemporary research and evidence-informed decision-making. In this talk I will discuss some tensions between scientific inquiry and research impact, reflect on inquiry and impact in posture and gait research to date, and explore approaches for moving towards a healthy balance of inquiry and impact in posture and gait research. These approaches address both systemic and individual actions needed to foster a posture and gait research culture where inquiry and impact are shared priorities with meaningful investment in both advancing knowledge and improving health and well-being in our global community.

K.3 – Mark Carpenter

Standing up to our fear: the interaction of human balance and emotion

Mark Carpenter, University of British Columbia

Emotions of fear and anxiety have been shown to be strongly related to balance instability and falls, as well as altered performance on other motor control tasks. While traditionally, fear and anxiety are considered negative outcomes of balance dysfunction, recent evidence has shown that these factors may also directly contribute to altered balance performance in both animals and humans.

The short-term effects of fear and anxiety on balance have been investigated in healthy adults and individuals with balance deficits by experimentally manipulating the environmental threat (by changing support-surface height or the likelihood of a balance perturbation), social anxiety (including white-coat and first-trial effects) or viewing affective pictures designed to elicit different emotional responses.

The effects of emotion on quiet stance have been most well-defined, with changes in amplitude and frequency of sway found to scale relative to the level of postural threat. Some observed postural control changes such as shifts in mean centre of pressure (COP) position and changes in amplitude of postural sway, appear context-dependent, as they vary depending on the nature, or direction, of the threat, and persist even following repeated threat exposure. In contrast, other postural control changes, such as a shift to higher frequency COP oscillations and co-contraction, likely stem from a combination of physiological arousal and cognitive/attentional processes, as they are consistently observed across different sources of threat and postural tasks, adapt quickly to repeated exposure and distraction tasks, and are often correlated with the level of state-anxiety, attentional focus, and physiological arousal.

Fear and anxiety have also been found to contribute to significant neuro-mechanical 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.

Although postural changes with fear and anxiety are well-characterized, the underlying mechanisms remain unclear. Direct comparisons with upper-limb postural tasks suggests that some anxiety-related balance changes may be unique to upright stance, as opposed to more global motor control changes. Converging evidence suggests that anxiety and fear significantly influence sensori-motor reflex gain including increases in Ia and Ib spinal reflexes, and vestibulo-spinal reflexes, and to a lesser extent for visual and cutaneous reflex pathways. Cortical changes are also likely influenced by anxiety, based on observed changes in conscious perception of whole-body movements, sensory-evoked cortical responses, and cortico-muscular coupling.

We will discuss how these experimental results align with current theoretical models of emotion-balance interactions and implications for improving balance training in those with clinical or situational fear and anxiety.

K.4 - Caterina Rosano

Mobility resilience in older age: a story of high heels, music, and doughnuts

Caterina Rosano, University of Pittburgh

Some older adults function and move better than others even in the presence of similar locomotor risk factors and medical conditions, demonstrating mobility resilience. Work done by us and others suggests mobility resilience may be linked to distinct neurobiological characteristics. Most recently, the role of brain muscle-cross talk has been introduced as a driver of mobility resilience. Together, this evidence helps us tracing a logical link between long-term exposure to cardiometabolic and lifestyle factors, integrity of skeletal-muscle system and selected brain networks, and maintenance of physical function in older age. I will discuss how harnessing this pathway can be critical to promote mobility resilience and prevent or delay disability in older age.

K.5 – Bradford McFadyen

Constantly seeking Negentropy: Understanding Anticipatory Locomotor Adjustments and how we might assess and intervene in them

Locomotion is totally dependent on, in fact would not exist without, the physical environment which in turn can both sustain and threaten it. Without a continual effort to seek dynamic order, (i.e., negentropy), over body displacement mediated by a rich sensory interface, we become prone to mishaps such as slips, falls, and collisions with the potential for injury or worse. Proactive control is crucial to this negentropic endeavour allowing us to accommodate the parts of the environment that align with our intentions and to avoid those that do not. We have referred to this proactive control for locomotor navigation as Anticipatory Locomotor Adjustments (ALAs). I will present some of the evidence regarding the way we control ALAs to step over, on and around environmental constraints and share how I believe we can exploit this knowledge to assess and intervene on mobility deficits, and specifically executive dysfunction, following acquired brain injuries. More recent research on locomotion in general, and ALAs specifically, including work that I will present, has increasingly made use of immersive technology to control and manipulate factors related to the agent, the environment and the sensory interface. I will also share my views on the potential and the challenges of integrating such technology to study, to assess, and to intervene in ALAs and locomotor mobility.

Proming Scientist Award

Kaylena Ehgoetz Martens, University of Waterloo

From freezing to subtle prodromal gait impairments in Parkinson disease: What can be learned from going 'back to the future'?

Walking upright is an astounding human ability that we often take for granted until it starts to decline, and mobility becomes challenged. Freezing of gait represents a fascinating yet debilitating phenomenon that robs individuals with Parkinson's disease (PD) of their mobility. Several decades of research has advanced our understanding of freezing of gait by characterizing the situations that trigger it, investigating associated clinical symptoms, and probing brain network abnormalities. However, heterogeneity has made it difficult to fully realize the underlying mechanism of freezing of gait, halting major advances in clinical management. Our research has recently been focused on better understanding how transient episodes of anxiety may put an individual at-risk for freezing of gait, as well as exploring methods to better predict FOG and tailor therapies. More recently, we have started to re-imagine the possibilities if we could make use of the DeLorean and go back in time. However, this prompts the important question - what time period would yield the best results? Should we go back a few minutes to prevent that recent fall that landed someone in the hospital and led to a nursing home admittance? Or should we go back in time a few years before FOG onset and prescribe some interventions that preserve mobility? Another alternative may be to ultimately try to predict who will develop PD altogether by detecting subtle early signs in the prodromal period. Each of these options have benefits for a spectrum of individuals either currently living with FOG or destined to develop PD and FOG in the future. We will discuss our current work investigating what our gait can reveal about brain health and degeneration, and how this work might inform novel interventions that may vary depending on disease stage and trajectory.

Emerging Scientist

Ríona Mc Ardle, Newcastle University

Assessing mobility in dementia: the bridge between diagnosis and care

Approximately 55 million people are living with dementia globally, with numbers set to rise to 74 million by 2030. Dementia is regarded as a global health priority, with global policymakers calling for earlier, more accurate diagnostic practices and improved post-diagnostic care. Assessing mobility, such as gait and physical activity, may contribute to improved diagnosis, as mobility impairments reflect cognitive decline and may be clinical markers of disease. However, improving diagnosis of dementia increases the need for optimal care provision following diagnosis. Mobility assessment can play a role here, as real-world mobility monitoring may reflect disease progression and predict adverse post diagnostic outcomes, such as falls. Equally, the promotion of physical activity following dementia diagnosis can support people to remain mobile and independent for longer. This talk will follow Ríona Mc Ardle's research journey across the clinical dementia pathway, taking the clinical use of mobility assessments from diagnosis to care. She will highlight novel evidence that gait could be a supportive marker of differential diagnosis for dementia subtypes, using gold-standard gait analysis (i.e. instrumented walkway). To combat limited clinical resources, such as space and funding, she will demonstrate the feasibility of using inexpensive wearable technology to continuously monitor mobility in the clinic and real world in different dementia subtypes, which captures similar disease-associated signatures of gait. To bridge the gap between diagnosis and care, she will draw on participatory research conducted with people with dementia, carers and dementia care professionals, capturing their perspectives on the importance of mobility and physical activity following dementia diagnosis. Bringing together the voices of people affected by dementia and the mobility assessment techniques applied in her research into diagnostic markers, she will describe her new fellowship research which aims to establish socio-ecological predictors of physical activity and mobility loss in dementia. This talk will show how mobility research can contribute across the whole clinical care pathway for people with dementia, from acting as a clinical marker of disease to supporting people with dementia to remain independent and in their own homes for longer.

Symposium Sessions

S.1: Understanding heterogeneity in PD for personalized rehabilitation of gait & balance

S1.1: ***Optimizing rehabilitation strategies by understanding the neural circuitry of complex locomotion in Parkinson's disease with freezing of gait***

Caroline Paquette[1], Alexandra Potvin-Desrochers[1], Trina Mitchell[1], Dorelle Hinton[1]

[1]McGill University

Recent advancements in neuroimaging techniques have enabled the quantification of task-specific neural correlates of complex gait and posture. Particularly problematic in the context of complex walking, the dysregulation of supraspinal locomotor control, specifically in people with Parkinson's disease (PD) who have the freezing-of-gait (FOG) symptom. Adaptations in complex locomotor control may be present in PD with FOG. In fact, our recent neuroimaging studies using a glucose analog tracer with Positron Emission Tomography during real locomotion show that in participants with PD, who have FOG, have reduced metabolic activity in parietal regions and increased metabolic activity in the supplementary motor area compared to PD without FOG during upright complex walking. In addition, participants with freezing demonstrated activity in the mesencephalic locomotor region that correlated with severity of freezing. These results may demonstrate an alternate control mechanism used for complex locomotion in PD with FOG that could be linked to gait impairments. Finally, we will present how non-invasive brain stimulation has the potential to alter activity of both motor and non-motor regions involved in the control of complex gait with a special focus on the parietomotor circuitry. Evidence from neuroimaging studies guides us on the type of excitability change to induce in these cortical areas to improve FOG. The combination of non-invasive brain stimulation to prime the brain prior to rehabilitation interventions to promote the use of desirable circuitry will be discussed in the context of FOG.

S1.2: ***PD heterogeneity and its implications on rehabilitation strategies and individualized treatment***

Franziska Albrecht[1], Hanna Johansson[1], Philip von Rosen[1], Breiffni Leavy[1], Eric Westman[1], Joana Pereira[1], Erika Franzén[2]

[1]Karolinska Institutet, [2]Karolinska Institute

BACKGROUND AND AIM:Parkinson's disease (PD) is a heterogeneous neurodegenerative disease characterized by different subtypes. Clinical, genetic, neuroimaging, and pathological data support the notion that PD should rather be treated as a syndrome, divided into disease subtypes. Despite this, no consensus on a subtype classification, or guidelines, currently exist which are helpful for the field of exercise and rehabilitation. METHODS AND

RESULTS:My talk covers different approaches of PD subtyping and how this can potentially inform rehabilitation strategies. Traditional clinical phenotypes and data-driven PD subtyping will be discussed as well as behavioral and neuroimaging characteristics. First, we investigated the influence of cognitive status on dual task costs on gait and cognition during dual-task walking in people with PD (Johansson et al. 2021). People with PD were classified according to their cognitive status into cognitively normal and those with mild cognitive impairment (MCI). People with PD MCI had larger dual-task costs on gait than cognitively healthy PD. Interestingly, compensation strategies during dual-task gait were dependent on cognitive status. People with PD MCI applied a posture-second strategy, while people with PD healthy cognition used a posture-first strategy. Moreover, I will show how objective physical activity data in people with PD can inform subtypes of physical activity (von Rosen et al. 2021). Our data yielded three different subtypes differing in their time spent active: "Sedentary", "Light Movers", and "Steady Movers". Of note, these activity-based subtypes could be differentiated by a functional mobility test, which is easy to implement in clinical assessment - the Timed Up and Go test. Lastly, I will present our multimodal subtyping approach, which extends beyond the concept of clinical phenotyping as it is based on multimodal data of clinical, motor, cognitive, and neuroimaging variables that may potentially better describe specific PD syndrome-groups (Albrecht et al. in prep.). Using machine learning, we identified three PD subtypes: a "motor-cognitive subtype" characterized by widespread alterations in brain structure and function as well as impairment in motor and cognitive abilities; a "cognitive dominant subtype" mainly impaired in cognitive function that showed frontoparietal structural and functional changes; and a "motor dominant subtype" impaired in motor variables without any brain alterations. Motor variables were most important for the subtyping, followed by gray matter volume in the right medial postcentral gyrus. CONCLUSIONS:Gait and posture rehabilitation strategies informed by PD subtypes yield the potential to be more effective interventions. I will shed light on the heterogeneity observed within PD and advance our understanding and usage of PD heterogeneity described in subtypes.

S1.3: *Personalized rehabilitation of gait & balance in Parkinson's disease: easier said than done*

Moran Gilat[1]

[1]KU Leuven

Parkinson's disease (PD) is characterized by widespread pathology, progression and heterogeneity. Rehabilitation of PD-related gait and balance problems is complex and until now largely driven by clinical intuition. An important risk factor for immobility and falling in PD is freezing of gait (FOG), defined as an episodic reduction of forward progression despite the intention to walk. FOG not only constitutes a very important marker of fall-proneness, but also of treatment stratification, as it requires a specific rehabilitation approach that may depend on the severity of the symptom. A number of motor and non-motor determinants predict the emergence of FOG. These predictors reflect signs of higher disease burden and overlap with risk factors for falls. So far, only two rehabilitation trials have studied the association between disease profile, including FOG-severity, and effect size. Interestingly, in both studies, a worse baseline condition of the specific training outcome was found to predict a larger training effect, signifying more room to improve (1-2). However, in the second study, global profiles of milder disease and better cognitive capacity were also associated with better training outcomes, suggesting that baseline compensatory reserve could play an additional significant role. Finally, in response to a home-based fall prevention training, fall rates of freezers worsened after training in contrast to non-freezers (3). This may be ascribed to the increased mobility risks that freezers were taking after training. Hence, personalization of rehabilitation for PD and FOG does not only require careful profiling of symptom severity, but also possible risks of training as well as of the capacity to recover. Having prior knowledge of these components through clinical screening, possibly supplemented with imaging methods, holds promise for clinical decision-making tailored to the different subtypes of PD. References: 1 - Löfgren N, Conradsson D, Joseph C, Leavy B, Hagströmer M, Franzén E. Factors Associated With Responsiveness to Gait and Balance Training in People With Parkinson Disease. J Neurol Phys Ther. 2019 Jan;43(1):42-49. doi: 10.1097/NPT.0000000000000246. 2 - Strouwen C, Molenaar EALM, Münks L, Broeder S, Ginis P, Bloem BR, Nieuwboer A, Heremans E. Determinants of Dual-Task Training Effect Size in Parkinson Disease: Who Will Benefit Most? J Neurol Phys Ther. 2019 Jan;43(1):3-11. doi: 10.1097/NPT.0000000000000247. 3 - Chivers Seymour K, Pickering R, Rochester L, Roberts HC, Ballinger C, Hulbert S, Kunkel D, Marian IR, Fitton C, McIntosh E, Goodwin VA, Nieuwboer A, Lamb SE, Ashburn A. Multicentre, randomised controlled trial of PDSAFE, a physiotherapist-delivered fall prevention programme for people with Parkinson's. J Neurol Neurosurg Psychiatry. 2019 Jul;90(7):774-782. doi: 10.1136/jnnp-2018-319448.

S.2: Investigating the role of multisensory brain processes when walking in a virtual reality: How do we differ from virtual zombies in the Walking Dead?

S2.1: ***Association of self-paced treadmill walking speed and optic flow speed in a dynamic virtual environment***

Daniel Jacobs[1], W. Geoffrey Wright[1]

[1]Temple University

BACKGROUND AND AIM: Human locomotion relies on the complex interplay between the nervous system, the mechanics of the joints and tissue, and dynamics of the external environment. Information from the sensory (visual, vestibular, somatosensory), motor, and cognitive systems are integrated to coordinate movement and respond to perturbations. When information from the sensory systems is degraded, as a result of disease, aging, or external influence (e.g. unstable surface or visual perturbation), sensory reweighting may occur, whereby the contribution of each sensory system is modulated in response to the dynamics of the environment. When the walking environment is on a treadmill, visual cues with discordant velocity relative to physical movement, and diminished vestibular information compared to overground walking occurs, both of which may reduce skill transfer between treadmill therapies and overground performance. A fuller understanding of this process can help elucidate the relationships underlying effective movement and inform rehabilitation

protocols. We hypothesized that modulating visuospatial dynamics of a virtual environment could result in controlled modulation of the user's walking speed. METHODS: To investigate the relationship between the sensory input and motor performance, we use custom gait system (VRSPT) consisting of a self-paced instrumented treadmill (SPT) and a virtual reality (VR) headset (Oculus Quest). Our novel SPT algorithm updates speeds on heel-strike without incorporating a position control loop, allowing users to freely choose velocity and acceleration profiles (limited only by belt length) without regard to position. In the headset, subjects viewed an infinitely repeating hallway moving at speeds between 0.8 and 2.0 m/s, with 0.2 m/s grid spacing. Each target speed was displayed in VR for 30 seconds and the targets were repeated 3 times in randomized order. We collected motion capture data (Qualisys), force data (Bertec), EMG data (Delsys) from young adult subjects with no history of neurological or musculoskeletal impairment. Subjects were instructed to walk at the speed that best matched the speed of virtual scene. We characterized the dynamic relationship between input (constant speed of virtual scene) and output (physical walking speed of SPT). We inverted the characterized relationship and measured self-paced treadmill walking in response to our variable hallway speed. RESULTS: For all target speeds presented, subjects chose matching walking speeds on the SPT that were less than unity. The subjects' relationship between scene speed and treadmill speed were well characterized by a linear fit, with a slope near ~0.5-0.6. CONCLUSIONS:Our results suggest that controlled modulation of walking in a virtual scene can be done effectively by virtual visual input. Our results stress the importance of the SPT algorithm, acclimation time, and virtual avatar representation in setting up experiments in this paradigm.

S2.2: ***Seeing Gravity - effects of aging on sensory-locomotion integration while walking in virtual inclinations***

Meir Plotnik[1], Amit Benady[1], Adi Lustig[2], Sharon Gilaie-Dotan[3]

[1]Sheba Medical Center, [2]Tel Aviv University, Tel Aviv, Israel, [3]Bar-Ilan University

BACKGROUND: Using advanced virtual reality technology, we demonstrated that exposure to virtual inclinations simulating inclined walking induces gait modulations in a manner consistent with expected gravitational forces (i.e., acting upon a free body), suggesting vision-based perception of gravity. The force of gravity critically impacts the regulation of our movements. However, how humans perceive and incorporate gravity into locomotion is not well understood. We identified and described 'braking' and 'exertion' effects - locomotor adaptations accommodating gravito-inertial forces associated with physical inclines. We showed that purely visual cues (virtual inclinations) induce consistent locomotor adaptations to counter expected gravity-based changes, consistent with indirect prediction mechanisms. Specifically, downhill visual cues activate the braking effect in anticipation of a gravitational boost, whereas uphill visual cues promote an exertion effect in anticipation of gravitational deceleration. We also observed that gait speed effects can be parametrically induced by manipulating the discrepancy between virtual visual inclination and the actual surface inclination (aka visual incongruence). AIM: To measure the influence of the visual cues on these modulations in healthy older adults and compare it to healthy young adults. METHODS: We used a fully immersive virtual-reality system embedded with a self-paced treadmill and projected visual scene that allowed us to manipulate the inclinations of the treadmill and the visual scene in an independent manner. In addition, we measured the visual field dependency of each participant using the rod and frame test. RESULTS: The group of older adults (N=15) presented the braking (decelerating), and exertion (accelerating) effects, in response to downhill and uphill visual illusions, respectively, in a similar manner as the young group (N=12). Furthermore, we found a significant correlation between the intensity of the speed modulation and the visual field dependency for each group separately, however the visual field dependency was significantly higher in the elderly adults. Heart rate increased during acceleration ('exertion' effect), even when the treadmill remained leveled, to a higher extent than would have been anticipated by the mere increase of gait speed. CONCLUSIONS: These results suggest that with aging individuals maintain their reliance on the visual system to modulate their gait in accordance with surface inclination in the same manner as young adults. Our finding that walking in incongruent sensory conditions triggers sympathetic responses of the autonomic nervous system emphasizes the complexity of this process involving multiple components of the nervous system (i.e., somatic and autonomic).

S2.3: ***Dissociating cognitive and motor components of virtual reality-based Color Trails Test execution in older adults***

Meytal Wilf[1], Alona Korakin[1], Yotam Bahat[1], Jason Friedman[2], W. Geoffrey Wright[3], Meir Plotnik[1]

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BACKGROUND AND AIM: Normal human ageing entails in many cases a decline in cognitive and sensorimotor function. Evidence shows that impairments in either of these functions may lead to postural imbalance and eventually higher risk of falls. Although they are usually studied separately, most daily life activities are comprised of a combination of both cognitive and motor demands. Thus, in order to detect deficiencies in cognitive-motor performance in naturalistic conditions, we here address this notion using cognitive testing in virtual reality (VR) with simultaneous recordings of multiple motor signals. Specifically, our aim is to delineate the effect of motor versus cognitive components during cognitive task performance, in the context of fall-risk in older adults. METHODS: To this aim, a group of older adults (aged 65-90) performed our previously validated VR adaptation of a cognitive test assessing executive function - the 'Color Trails Test' ('CTT'; VR-CTT; Fig 1A,B). In this test, participants use their hand to follow a trail of numbered targets in either a sustained visual attention ('Trails A') or a more difficult divided attention ('Trails B') task, and their completion times are recorded. To isolate the motor component, participants performed also a 'low-cognition' version of the task, in which they had to manually track a visually-cued sequence of targets with no numbers (Fig 1C). To isolate the cognitive component, participants performed a 'gaze-only' condition, completing the VR-CTT task using only their eyes and not their hand (Fig 1D). We recorded simultaneously hand and head kinematics, gaze, and cognitive task performance. Additionally, each participant underwent a battery of standard cognitive tests (MOCA) and functional tests indicative of fall-risk (e.g., TUG; Fig 1E). RESULTS: We found that manually performed and gaze-only VR-CTT produced similar

completion times, with Trails B times significantly longer in both conditions ($p < 0.001$). However, the low-cognition condition was significantly faster for both Trails A and Trails B ($p < 0.001$). Correspondingly, when comparing hand-head coordination during the VR tasks, we found that the lag between the head and hand movement towards the target increased with cognitive load (i.e., VR-CTT Trails B > Trails A > low-cognition; $p \leq 0.003$). Additionally, we found that all VR test scores (including 'low-cognition') were correlated with participants' MOCA scores (i.e., higher MOCA scores corresponded to shorter completion times). Lastly, participants' fall-risk tests scores correlated with their MOCA scores (e.g., faster TUG performance corresponded to higher MOCA scores). CONCLUSIONS: This novel paradigm enables delineating the cognitive-motor interactions with respect to their sub-components. We posit that the findings of correlations between MOCA, fall risk-related functional tests and VR tests will pave the way for more accurate predictions of fall risk among older adults.

S2.4: ***Training Functional Gait Using a Virtual Reality Obstacle Course***

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BACKGROUND: Older adults have an increased risk of falling due to trips, decrements in balance, and poor mobility. Virtual reality (VR) has shown some success in training gait and balance; however, studies have been limited to non-immersive VR training on a treadmill. It is unknown how performance within an overground VR obstacle course may transfer to a real environment and how this transfer may vary by age. The purpose of this study was to examine the changes in real-world obstacle crossing patterns after a single bout of training within an overground VR obstacle course between older and younger adults. METHODS: Older adults (N=8; 67.0±4.4yrs) and younger adults (N=13; 22.1±2.5yrs) participated in a single bout of training within an overground VR obstacle course environment. The VR course was presented in a head mounted display and contained obstacles for participants to target and to avoid in all 3 directional planes. Virtual sneakers were mapped onto the participant's feet in real-time via integrated foot trackers. The Older Training (OT) and Younger Training (YT) groups completed 15 trials of the course with 30s of rest in between each trial. OT and YT groups completed 10 real-world obstacle crossings pre-training and post-training. Foot position before the obstacle (PBO), position after the obstacle (PAO), closest distance of the foot to the obstacle (radial clearance - RC), and peak elevation (PE) for both the lead and trail foot were measured. A series of Group (OT/YT) by Time (pre-training/post-training) RM-ANOVAs were calculated for each variable by foot. Additionally, Cohen's dz effect sizes were calculated. RESULTS: There was a significant group difference for RC ($p=0.043$) and PE ($p=0.033$) for the trail foot. RC and PE were significantly elevated for OT compared to YT. For foot position metrics, there was also a significant difference of time between pre- and post-training for PBO for the lead foot ($p=0.001$; YT Cohen's dz =1.190; OT Cohen's dz =0.661) and trail foot ($p=0.009$; YT Cohen's dz =0.938; OT Cohen's dz =0.418). PBO was significantly increased at post-training compared to pre-training. CONCLUSIONS: Our results suggest that training within a VR obstacle course may initiate an earlier obstacle crossing when encountering a real-world obstacle. Early crossing allows for more time to modify foot trajectory for optimal placement, stability, and decreased risk of obstacle contact. Contrary to

previous research, older adult trail foot clearance values were elevated compared to younger adults. This may suggest a relatively healthy older adult population was recruited due to restrictive inclusion criteria. Additionally, the VR obstacles may not have been challenging enough to induce larger changes as they were the same height as the real environment obstacle.

S.3: Is increasing muscle co-activation beneficial to balance control?

S3.1: ***Agonist-antagonist muscle co-activation does not improve reactive balance response but increases sensory feedback***

Giovanni Martino[1], Owen Beck[1], Rish Rastogi[1], Lena Ting[2]

[1]Emory University, [2]Emory University & Georgia Tech

BACKGROUND AND AIM: Agonist-antagonist muscle co-activation is a common neural mechanism in natural standing. Postural threat and fear of falling can increase muscle co-activation, suggesting that co-contraction is a motor control strategy to improve balance. Populations with impaired balance abilities show increased co-activation, but balance training reduces co-activation. Further, lower co-activation is associated with better balance in skilled populations as professional dancers or martial artists. Moreover, these studies investigate overall balance ability, and do not directly examine the role of muscle co-activation on balance control. As such, whether co-activation is a compensatory strategy to improve balance or a maladaptive behavior causing worse balance has yet to be clarified. METHODS: Here we performed a within-individual study with controlled ankle muscles co-activation levels using visual biofeedback to limit confounding factors, such as emotional states or underlying pathological effects other than co-activation. We studied reactive balance responses to backward support surface perturbation, allowing us to examine the effect of co-activation on both balance capacity, i.e. the largest perturbation that the participant could withstand without taking a step, as well as postural control strategies during reactive balance recovery. Finally, it is not known how muscle coactivation affects the sensory information induced by a balance perturbation. We therefore used a novel shear wave tensiometer to estimate Achilles tendon force during reactive balance control, as well as muscle fascicle length changes using ultrasound imaging. RESULTS: Consistently with the idea that increased joint stiffness increases resistance to passive movement, CoM acceleration due to the perturbation was reduced when muscle contraction increased. However, we found no effects of co-activation on biomechanical outputs such as stepping threshold and postural strategy. We show that tendon force increases, but muscle fascicle stretch due to the perturbation was not different with coactivation. However, the sensory-evoked muscle activity increased, suggesting that muscle coactivation increases the neural sensitivity to perturbations, possibly due to force feedback. CONCLUSIONS: As such, although muscle coactivation causes metabolically inefficient postural responses, it may increase sensory signals generated by postural responses, which could both increase the acuity to detect perturbation, as well as compensate for decreased sensorimotor feedback in motor impaired populations. This study was supported by NIH grant R01 HD90642.

S3.2: ***Effort minimization predicts co-contraction in the presence of sensorimotor noise***

Friedl De Groote[1], Tom Van Wouwe[1], Lena Ting[2]

[1]KU Leuven, [2]Emory University & Georgia Tech

BACKGROUND AND AIM: Agonist-antagonist co-activation is thought to help stabilize posture in the presence of noise through increasing joint impedance but is considered energetically costly. Musculoskeletal simulations that identify energetically optimal motor strategies in noiseless environments fail to predict experimentally observed co-contraction strategies. It is unclear whether this failure to simulate co-contraction is due to the performance criterion (energy minimization) or to the absence of noise. Previous simulations were not able to consider interactions between feedforward co-activation and feedback control in the presence of noise based on nonlinear models that capture activation-dependent muscle impedance. We developed a novel stochastic optimal control simulation method and used it to test the hypothesis that muscle co-activation contributes to a minimal effort strategy in sensorimotor control of balance in the presence of noise. METHODS: We simulated two types of support-surface perturbations to standing balance that benefit differentially from muscle co-activation: platform translations, where muscle co-activation provides joint torques that are congruent with the balance-correcting feedback torques, and platform rotations, where muscle co-activation provides joint torque opposite to the balance-correcting feedback torques. We modeled the body as an inverted pendulum actuated by a pair of antagonistic ankle muscles with activation-dependent impedance. Muscle were driven by constant feedforward activations and linear feedback of delayed proprioceptive and vestibular cues, which encode the angle between the body and the support surface, and gravity, respectively. Gaussian sensory and motor noise was additive to feedback signals and muscle inputs respectively. To simulate vestibular loss, we removed vestibular cues. We solved for feedforward activations and feedback gains that minimized expected effort. RESULTS: Stochastic optimal control predicted muscle co-contraction as a complementary strategy to sensorimotor feedback depending on the perturbation type and magnitude, and sensory acuity. During translations, muscle co-contraction was predicted with increasing perturbation magnitude in the presence and absence of vestibular information (Figure). In translations, increased joint impedance due to co-contraction reduced body sway, which in turn reduced the relative effort of feedback corrections. During rotations, moderate levels of co-contraction were predicted for vestibular loss subjects, but not for healthy controls (Figure). In rotations, increased joint impedance due to co-contraction opposes healthy balance-correcting responses. However, co-contraction contributes to maintaining a constant joint angle with respect to the platform, the strategy observed in vestibular loss subjects. CONCLUSIONS: A combination of co-contraction and feedback corrections may be energetically more efficient than feedback corrections only.

S3.3: ***Co-adjustment of stiffness and stretch reflexes***

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BACKGROUND AND AIM: When subjects stand in challenging balance conditions, such as on a narrow support, their ankle stretch reflex is decreased. This is interpreted as indicating an increased reliance on cortical rather than spinal control of balance. However, this ignores the role played by muscle co-contraction, which increases ankle stiffness during challenging balance conditions. METHODS: I developed a model of standing balance which integrates biomechanical and neural control aspects. I tested the model's balance response to perturbations when varying ankle stiffness, feedback gain and neural delay. RESULTS: According to this model, ankle stiffness plays a critical role for maintaining stability, as it slows down the fall of the body after a perturbation. However, increasing ankle stiffness only improves balance if it is combined with a decrease in neural feedback gain, to prevent overcompensation. Moreover, to prevent a deterioration of balance when the neural delay increases (such as occurs during ageing), ankle stiffness must be increased in combination with a decrease in feedback gain. CONCLUSIONS: Ankle muscle co-activation is beneficial for standing balance, particularly after an increase in neural delay. However, it only improves balance if it is combined with a decrease in ankle stretch reflex. The decrease in stretch reflex observed in challenging balance conditions should therefore be interpreted as an increased reliance on stiffness, rather than as an increased reliance on cortical control.

S3.4: ***Delayed and reduced intralimb muscular coupling during postural reactions in individuals with incomplete Spinal Cord injury***

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Background: When balance is compromised, postural strategies are induced to quickly recover from the perturbation. These postural strategies are critically dependent on rapid and precise sequential activation or de-activation of different muscle groups, and require the contribution of sensory information from visual, vestibular and peripheral limb afferents. After spinal cord injury (SCI), individuals show deficits in balance control and are at higher risk of fall. Muscular activations were shown to be delayed in individuals with SCI. However, the nature of the changes in the sequential muscular activations, giving rise to the postural strategies, are unknown. Furthermore, altered neuronal mechanisms underlying the deficits in postural strategies are not well understood. Aims: 1) Identify changes occurring in postural strategies by assessing intralimb muscular coupling in lower limbs following a perturbation in individuals with SCI; 2) Identify impairments in neuronal networks underlying the postural strategies by assessing soleus H-reflex. Methods: Ten men with incomplete SCI and eight age-matched controls (CTRL) stood on a force-platform that was randomly tilted forward or backward. Electromyographic (EMG) activity was recorded in soleus (SOL), tibialis anterior (TA), biceps femoris (BF) and vastus lateralis (VL). Coactivation or simultaneous facilitation/suppression between pairs of muscles was analyzed: Onset and duration of coupling latency, intralimb coupling delay, and amplitude ratios were measured. SOL H-reflex amplitude was assessed by stimulating the tibial nerve prior to and at 100, 150 and 200 ms following perturbation onset. Results: Aim1.In forward tilt, SOL EMG activity increased in both CTRL and SCI participants but occurred earlier in CTRL. The main coupling was TA-SOL co-contraction for both groups, but the latency was longer and the duration shorter in SCI participants. In backward tilt, SOL EMG activity decreased in both groups. TA-VL co-activation was the main coupling in CTRL (88 %), and it was expressed by 60 % of SCI participant with a delayed latency. In the SCI group, the main coupling was the facilitation/ suppression of TA-SOL (80 % vs 63 % in CTRL). Delayed coupling latencies were correlated with the strength of lower limbs. Aim 2. During forward tilt, an increase in SOL H-reflex amplitude was observed at 150 and 200 ms in the CTRL group, but no significant increase was observed in the iSCI group. During backward tilt, a decrease in SOL H-reflex amplitude was observed at all delays post-tilt in CTRL, but only at 200 ms in SCI, which is the latest delay tested. Furthermore, the decrease in H-reflex amplitude was smaller in SCI participants. Conclusions: Overall, delayed and reduced spinal reflex processing parallels delayed muscular couplings in SCI individuals, and might contribute to postural reaction deficits

S.4: Clinical feasibility of reactive balance training: from the lab to community

S4.1: ***Implementing reactive balance training in clinical practice: what are the gaps?***

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Reactive balance training (RBT) is a treatment approach that can improve control of balance reactions. While many RBT studies use custom equipment (e.g., walkways, moving platforms) or programmable treadmills to deliver the perturbations, clinicians often do not have access to this equipment, or the space or funding to acquire equipment. RBT methods that do not require specialized equipment are possible. This presentation will discuss results of our recent meta-analysis of randomized controlled trials, examining the effects and harms of RBT, and our work aiming to understand how RBT is implemented in clinical practice. Meta-analysis of 25 trials, found that RBT reduces the rate of falls in daily life by almost 40%, compared to other types of exercise. Studies using RBT methods that do not rely on equipment to provide perturbations were as effective in preventing falls in daily life as equipment-based RBT approaches. The prevalence of adverse events was higher for RBT (29%) compared to control interventions (19%), although most adverse events (>80%) were mild in severity. When examining different types of adverse events, fear and anxiety related to the perturbations seemed to be reported more frequently for participants assigned to RBT (2.6%) than control interventions (0%). Otherwise, the types of adverse events were typical of those reported during any exercise intervention (e.g., joint or muscle pain). Using an integrated knowledge translation approach, working collaboratively with clinical partners, we iteratively developed an RBT toolkit, describing equipment-free RBT methods, principles of training, contraindications and precautions, safety considerations, and training strategies based on underlying dyscontrol. Our previous survey found that RBT is reportedly used frequently in Canadian rehabilitation settings (used by >75% of respondents), but some implementation challenges remain. Interviews with healthcare professionals who report using

RBT in their practices have revealed: variability in training approaches; limited awareness of assessment approaches; conflicting rehabilitation priorities, which may prevent use of RBT; and perception of RBT as 'advanced skill' to only be practiced when other more basic motor and balance skills have been mastered. Clinicians reported that their clients frequently express fear and anxiety related to perturbations, in agreement with the findings of our meta-analysis, but also that fostering trust between the clinician and client can build client confidence. Given competing rehabilitation priorities and limited time that many clients have in rehabilitation, it is important to understand how RBT fits into current rehabilitation practices. Therefore, our ongoing and future work aims to determine the minimum dose of RBT to improve reactive balance control and prevent falls in daily life, and to understand the effects of RBT on other components of physical fitness (e.g., strength and cardiorespiratory fitness).

S4.2: ***Surface Perturbation Training in Older Adults: Results of a Highly Pragmatic Randomized, Controlled Trial***

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BACKGROUND AND AIM:Falls are the leading cause of injuries among older adults and trips and slips are major contributors to falls. We aimed to compare the effectiveness of adding a component of surface-perturbation training to usual gait/balance training for reducing falls and fall-related injury in high-risk older adults referred to physical therapy. METHODS: We performed a multi-center, pragmatic, randomized, comparative effectiveness trial at 8 outpatient physical therapy clinics. We enrolled 506 patients aged 65+ at high fall risk referred for gait/balance training. The experimental intervention was surface-perturbation treadmill training integrated into usual multimodal exercise-based balance training at the therapist's discretion versus usual multimodal exercise-based balance training alone. The main outcomes were falls and injurious falls, assessed with a prospective daily fall diary, which was reviewed via telephone interview every 3 months for 1 year. (Clinicaltrials.gov number NCT01006967) RESULTS: Overall, 211/253 (83%) of patients randomized to perturbation-training and 210/253 (83%) randomized to usual treatment provided data at 3-month follow-up. At 3 months, the perturbation-training group had significantly reduced chances of fall-related injury (5.7% vs. 13.3%; relative risk 0.43, $p < 0.01$) but no significant reduction in the risk of any fall (28% vs. 37% ST; relative risk 0.78 $p<0.07$) compared to usual treatment. Time to first injurious fall showed reduced hazard in the first 3 months, but no significant reduction when viewed over the entire first year ($p=0.67$). Limitations of this study include a lack of blinding and variable application of interventions across patients based on the pragmatic study design. CONCLUSIONS: The addition of some surface perturbation training to usual physical therapy significantly reduced injurious falls up to 3 months post-treatment. Further study is warranted to determine the optimal frequency, dose, progression and duration of surface perturbation aimed at training postural responses for this population.

S4.3: ***The effectiveness and acceptability of perturbation-based balance training in older adults: a mixed-methods study***

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BACKGROUND AND AIM: Perturbation-based balance training (PBT) is an emerging intervention that has shown to improve balance recovery responses and reduce falls in everyday life in older adults. However, perturbation interventions so far have been heterogeneous and clinical feasibility, including acceptability, should be improved. The aim of this study was to evaluate the effectiveness and acceptability of a PBT protocol designed to build on previous work. METHODS: This mixed-methods approach combined an RCT with interviews. Community-dwelling older adults (≥65 years) who visited the hospital outpatient clinic due to a recent fall received PBT as an add-on to usual care (physiotherapy referral), or usual care only. PBT consisted of three 30-minute sessions in three weeks. Treadmill and platform perturbations were applied during standing and walking on the Computer Assisted Rehabilitation Environment (CAREN, Motek Medical BV). This is a dual-belt treadmill embedded in a motion platform with 6 degrees of freedom, with a 180° screen on which virtual reality environments are projected. Duration and contents of the training were standardized, while training progression was individualized. Balance control (Mini-BESTest, primary outcome) and fear of falling (FES-I) were assessed at baseline and one week post-intervention. Falls in everyday life were assessed during a 6 months follow-up (fall calendars). Training acceptability was evaluated with semi-structured interviews using the Theoretical Framework of Acceptability and a template analysis approach. RESULTS: In total 82 participants were included (n=39 in the PBT group), with a median age of 73 years (IQR 8 years). Baseline Mini-BESTest score was 23 points (IQR 4 points) in both groups. Post-intervention Mini-BESTest scores were 24 (4) points in the control group and 25 (5) points in the PBT group. These scores were not significantly different between groups. FES-I scores did not change in either group. Fewer participants in the PBT group fell during follow-up, but this was not significantly different to the control group (28.2% vs 35.9%, relative risk 0.79, p=0.57). However, this study was not powered to detect between-group differences on this secondary outcome measure. Sixteen PBT participants were interviewed, which revealed that PBT is perceived acceptable. Enjoyment of the novel training and technology, being able to feel safe during training and perceived increased self-efficacy and balance confidence were identified as facilitating factors. CONCLUSIONS: The PBT protocol in this study was perceived acceptable and enjoyable by community-dwelling older adults with a recent history of falls. The addition of PBT to usual care did not yield significantly different results in balance control or fear of falling in this population. The proportion of fallers in everyday life decreased more in the PBT group compared to the control group, but these results did not reach statistical significance.

S4.4: ***Developing a task-specific and clinically feasible reactive balance training method***

Yoshiro Okubo[1]

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Reactive balance training (RBT) or perturbation-based balance training is an emerging training paradigm for falls prevention in older adults and people with neurological conditions. There have been various perturbation methods which have been used to train reactive balance in these populations. Our three randomised controlled trials using a boobytrap slip and trip walkway showed older adults, people with multiple sclerosis and Parkinson's disease can significantly improve balance responses to unpredictable trips and slips during gait. However, there are two major issues which have been found in such approaches. First, the clinical feasibility is often low because the training requires sophisticated perturbation and safety equipment such movable plates or obstacle pop-up systems embedded in the floor, multiple pully systems for waist-pulls and an instrumented treadmill. An instrumented treadmill that can provide belt accelerations and decelerations are a convenient tool, but their costs (e.g. USD 70,000) are not affordable to individual practitioners. Second, safety of exposing older clients to repeated perturbations is often a concern. Anxiety induced by unpredictability of the upcoming perturbations has been a cause of dropouts in some studies. To overcome these two issues, we have developed a novel reactive balance training program "ReacStep" that can achieve both the clinical feasibility and task-specificity required for fall prevention. ReacStep focuses on task-specificity to the most common daily life hazards i.e. trips and slips. This training requires low-cost equipment and can be conducted by one trained Physiotherapist or Exercise Physiologist in approximately 30 minutes per session. The primary components of ReacStep are i) manual tether-release reactive step training and ii) intentional slip training (Figure 1). Preliminary results from an ongoing survey to clinicians (e.g. Physiotherapists, Exercise Physiologists) working in balance and falls prevention have revealed that ReacStep has high perceived effectiveness and feasibility. Based on the survey using a 11-point Lickert scale (0 = strongly disagree, 10 = strongly agree), the clinicians felt that ReacStep could be safely conducted in clients without (8 ± 1.6) and with diagnosed neurological conditions (7.1 ± 1.8). Clinicians were open to implementing ReacStep (8 ± 1.8) and felt that clients will enjoy the training (7 ± 1.8). A pilot case study with a 78-year-old participant with balance instability, sarcopenia, chronic pain was conducted. The participant reported no adverse event, had high enjoyment (8 out of 10), training suitability (10), no concern about falling during training (0). These preliminary results suggest ReacStep is safe and clinically feasible but more studies are needed to confirm these results and examine its effectiveness to improve reactive balance and reduce falls.

S.5: The future is already here – using dynamic neuroimaging methods to identify biomarkers for disease detection, disease progression and effectiveness of treatments

S5.1: ***fNIRS during gait as marker for neurological diseases***

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Background and aim: Walking impairments are common in people with neurological diseases, such as Parkinson's disease (PD) and spinocerebellar ataxia (SCAs), and lead to reduced mobility, independence, and quality of life. Walking is controlled by multiple neural systems throughout the central nervous system including the spinal cord, brainstem, cerebellum, basal ganglia and motor cortex. Other forebrain regions, such as the prefrontal cortex (PFC) also plays a crucial role in adapting gait to changes in environmental conditions. PFC has also an important role in compensatory mechanisms, in fact, in PD PFC activation during gait may compensate for the impaired basal ganglia output that affects the automaticity of movement; whereas in SCAs PFC activation during gait may signal damage in the cerebellum and brainstem. Technological advancement has recently allowed monitoring of 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 gait, measured with fNIRS, in PD and SCAs. Methods and Results: 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. Participants walked for 2-minutes at a comfortable pace back and forth over a 10m distance, with a 180 degree turn at each end while wearing wireless inertial sensors to derive gait characteristics. Our findings showed increased PFC activity (HbO2) while walking in people with PD compared to age-matched healthy controls. Levodopa therapy normalized PFC activity during walking in PD while it improved objective gait parameters. Cholinergic therapy also improved objective gait parameters in PD but did not change PFC activity. Patients with genetically determined SCA were also studied as a second population with reduced gait automaticity. PFC activity (HbO2) while walking was increased in people with SCAs compared to healthy controls of similar age. Surprisingly, pilot findings showed that such increased PFC activity could be present even in the pre-manifest stage of SCA. Conclusions: In PD, the combination of dopaminergic and cholinergic drugs seems to be more effective, than levodopa alone, in improving gait, particularly with dual-task challenges, although annulling the reduction in PFC activity observed with levodopa alone. In SCAs, our pilot data suggest that PFC activity is increased in pre-manifest SCA, when clinical scores are normal. fNIRS techniques could be used to improve understanding of brain mechanisms associated with walking automaticity in multiple neurological disease and might be employed as an outcome measure in clinical trials for early treatments of these gait disorders. However, studies in larger population are needed to confirm findings.

S5.2: ***The effects of disease severity, freezing of gait and step training on cortical activity during stepping in people with Parkinson's disease***

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Background and aims: People with Parkinson's Disease (PD) have difficulties generating quick and accurate steps in anticipation of and/or in response to environmental hazards, which places them at increased risk of falls. We have previously reported that compared with healthy controls, people with PD perform poorly in stepping tasks requiring inhibitory control and show concomitant reduction in fNIRS-recorded cortical activity in frontal regions (Pelicioni 2020). Here we investigated: (i) the influence of disease severity and freezing of gait and (ii) the effects of a stepping training intervention, on cortical activity in people with PD during on a cognitively demanding stepping test associated with falls. Methods: Fifty-two people with PD (mild-moderate severity) mean (SD) age: 70 (8) years, 17 women, performed the stroop stepping test on a computerised mat, while "On" levodopa medication. Cortical activity in the prefrontal cortex (PFC), Supplementary Motor Area (SMA), and Premotor Cortex (PreMC) was recorded using fNIRS. Participants completed the New Freezing of Gait Questionnaire and the Movement Disorders Society- Unified PD Rating Scale (MDS-UPDRS) -part III (motor symptoms). Forty-four of these participants were also enrolled in a randomised control trial which compared the effects of a 12-week intervention involving cognitively challenging stepping games to usual care on markers of fall risk. Results: Participants with more severe motor symptoms (median split, MDS-UPDRS part III score >31, n=27) had slower decision and movement times in the stroop stepping test (mean difference (95%CI): 428 (139 to 716) ms, p=0.002; and 102 (17 to 186) ms, p=0.032), compared to those with less motor deficits (n=27). They also showed lower cortical activity in the PFC (mean (SD) [HbO2]: 0.001(0.007) vs. 0.005 (0.007) µmol/l, p=0.021). Participants who reported freezing of gait (n=17) showed more severe motor symptoms than those who did not (n=35) (MDS-UPDRS part III, mean difference (95%CI): 6.9 (1.0 to 12.8), p=0.024) and lower cortical activity in the PreMC during the stroop stepping test ([HbO2] mean difference (95%CI): 0.004 (0.000 to 0.007) µmol/l, p=0.046) but similar stepping decision and movement times. Compared to usual care, a 12-week home-based stepping intervention led to increased cortical activity in the PFC, SMA and PreMC in the stroop stepping test and fewer stroop stepping mistakes (p<0.05 for all). Conclusion: People with PD with increased disease severity and / or freezing of gait have reduced ability to compensate for their motor deficits during a complex stepping test as suggested by reduced PFC and PreMC activity. However, cortical activity in these regions (key to executive functioning, attention and motor planning) as well as complex stepping performance can be enhanced by 12 weeks of cognitive-motor stepping training. fNIRS data may be used to measure disease progression and rehabilitation intervention effects in people with PD.

S5.3: ***Mobile brain/body imaging (MoBI) to monitor brain activity response to walking interventions in Parkinson's***

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Background and aim: The study of the neural underpinnings of movement in neurological conditions has traditionally been conducted with associative studies that have used static imaging techniques, such as fMRI or PET. Previous work correlated movement outcomes

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with imaging or assessed assays of movement (virtual reality, mental imagery) during imaging, as imaging the brain during walking has previously been impossible due to the need to keep the head still. More recently, mobile brain/body imaging (MoBI) is a new imaging approach employing mobile brain monitoring devices such as functional near infrared spectroscopy (fNIRS) or electroencephalography (EEG), which can be synchronised with movement monitoring devices, such as wearable inertial sensors. MoBI can be used to investigate brain activity during functional mobile tasks (i.e., walking) and response to interventions, which allows examination of the brain activity accompanying natural human movement by overcoming the movement restrictions of established imaging modalities. Cueing interventions have been used to improve walking in neurological populations for many years, particularly Parkinson's disease. However, not all patients respond to cues and the neural mechanisms underlying response to different cueing modalities (internal, auditory, visual, tactile) are unknown. The aim of this presentation is to examine the changes in brain activity during walking with and without cues (internal, auditory, visual, tactile) using MoBI techniques in people with Parkinson's disease. Methods and Results: We have examined MoBI (fNIRS and EEG) signals during walking overground with and without various cueing strategies (internal, auditory, visual or tactile) in people with Parkinson's. Inertial sensors were synchronised with MoBI systems to monitor gait characteristics. We examine mobile EEG source localized independent component (IC) clusters and their power spectral densities; Delta (δ:1-4Hz), Theta (q:4-8Hz), Alpha (α:8-13Hz), Beta (β:13-30Hz) and Gamma (γ:30-50Hz). Additionally, we used mobile fNIRS to determine the oxygenated haemoglobin levels within specific brain regions; pre-frontal cortex, supplementary motor area, pre-motor cortex, primary motor cortex and occipital cortex. Findings reveal that selective brain regional activity is influenced by different cueing modalities during walking in Parkinson's, which may reflect the sensory components of the cues. In addition, changes in brain activity and gait with cues may be influenced by disease severity. Conclusions: The combination and simultaneous application of fNIRS, EEG and wearable sensors can provide important insights into the neural activity underpinning walking and response to interventions for walking impairments in neurological cohorts, such as Parkinson's disease. Use of MoBI techniques during performance of mobile tasks is a recent advancement, which is possible with technology and signal processing developments.

S5.4: *The role of EEG to elucidate alterations in electrical brain patterns during walking in different neurological diseases*

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Background and aim: Electroencephalography (EEG) is a promising tool to investigate alterations in neural processes during performance of cognitive and motor tasks. Its high temporal resolution can reveal important compensatory mechanisms that occur within a specific time window. With respect to studies of gait and dual tasking, EEG allows for the measurement of actual upright gait. The most commonly used EEG method in neuroscience is the event related potentials (ERPs), generated by external stimuli. The ERPs allow investigating specific windows that closely relate to repetitive events along the task and so reduces the accumulation of random noises to the EEG signal, an important advantage when examining gait. The ERP can reflect several aspects of electrical brain activity. Measures of ERP shape, such as peak amplitude, can reflect the amount of activated synchronized neurons, measures of power spectral analysis can quantify the power and time of different frequency bands, and measures of coherence can reveal functional connectivity between channels of interest. The aim of this presentation is to examine the changes in electrical brain activity during walking tasks using EEG in healthy young, healthy older adults, patients with Parkinson's disease (PD), and patients with epilepsy. Methods and Results: EEG signals during walking on a treadmill with and without cognitive task (single vs. dual task) were compared between groups and tasks. The findings revealed delayed cognitive ERPs during walking compared to sitting in all groups, however, changes in the ERPs amplitude differ between the groups mainly during walking. Patients with PD showed reduced P300 amplitude during walking compared to healthy older adults, while patients with epilepsy demonstrated reduced N2 amplitude during walking compared to healthy young. Furthermore, changes in the ERPs power spectral analysis revealed that patients with PD increase power of delta waves and decreased power of alpha waves during walking compared to healthy older adults. In another study, we found specific gait related potentials within a gait cycle that were altered with aging and type of task. Conclusions: Applying advanced EEG methods can reveal important neurophysiological changes during walking, setting the stage for developing electrophysiological markers for early detection of neurological diseases, evaluation of disease severity and progression, and assessment of pharmaceutical and non-pharmaceutical interventions. Changes in EEG have been well-studied in relation to cognitive function and resting state. However, the application of EEG to actual walking and dual tasking is limited, mainly due to the difficulty in removing movement noise from the EEG signal. The advance in technology makes the EEG test accessible in many disciplines and thus urges the need to overcome old barriers in terms of analytical approaches and include EEG tests during walking tasks that illustrate daily functions.

S.6: Maintaining Energy: A potential transformative power to promote mobility in aging

S6.1: ***Reduced Fatigue is Significantly Associated with Improved Mobility and Cognition in Chronic Stroke: Results from a 6-Month Randomized Controlled Trial***

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Background and Aim: Fatigue is a common consequence of stroke. Cross-sectional evidence suggests post-stroke fatigue is negatively associated with both mobility and cognitive function. We aim to understand the longitudinal relationship between fatigue, mobility, and cognitive function in community-dwelling adults with chronic stroke (defined as having a stroke = or > 12 months prior to study). Methods: A secondary analysis of data from a 6-month randomized controlled trial with 120 adults with chronic stroke who were randomized to group-based, supervised: 1) exercise training; 2) complex social and mental activities; and 2) stretch and balance exercises with general education sessions. We constructed linear regression models to assess the contribution of changes in fatigue to changes in usual gait speed (over 4 meters) and to changes in cognitive function. Cognitive function was measured by the Alzheimer's Disease Assessment Scale - Cognitive Subscale (ADAS-Cog) Plus. Higher ADAS-Cog Plus scores indicate greater cognitive impairment. Fatigue was assessed using: 1) Fatigue Severity Scale; and 2) Visual Analogue Scale. The Fatigue Severity Scale measures fatigue severity and its impact on daily activities global fatigue The Visual Analogue Scale asks individuals to rate their global fatigue. Higher Fatigue Severity Scale and Visual Analogue Scale scores indicate greater severity and degree of fatigue, respectively. In the regression models, we controlled for experimental group, age, and biological sex. Results: Reduced severity of fatigue over the 6 months was associated with improved gait speed ($p = 0.02$). Reduced global fatigue was associated with improved cognitive function ($p = 0.04$). Specifically, a reduction of 25 points on the Fatigue Severity Scale was associated with an increase of 0.1 m/s in gait speed (R-square = 5%). For the Visual Analogue Scale, a reduction of 3.3 points in global fatigue was associated with a reduction of 0.1 point (i.e., improvement) in the ADAS-Cog Plus (R-square = 4%). Conclusions: Given the prevalence and consequence of fatigue on function in chronic stroke, future work is needed to identify effective interventions.

S6.2: ***Perceived Energy, Fatigue, and Physical Function in Older Adults***

Rebecca Ehrenkranz[1], Xiaonan Zhu[1], Nancy Glynn[1], Caterina Rosano[1]

[1]University of Pittsburgh

BACKGROUND AND AIM: Older adults may report high energy alongside fatigue or vice versa. Although energy is often conflated with fatigue, evidence suggests energy and fatigue have different underlying physiology. We investigated whether previously established associations between high self-reported energy and decline in mobility were significant among those reporting co-occurring fatigue. We hypothesized that higher self-reported energy would be associated with less declines in gait speed among those reporting fatigue. METHODS: We examined energy and fatigue states among community-dwelling older adults from the Health, Aging and Body Composition Study, a population-based cohort study with active follow up starting in 1997 and ending in 2011. At baseline, self-reported energy was captured on a 0-10 scale (dichotomized at the median), and fatigue was categorized as present or absent. Participants were stratified by fatigue status and all analyses were conducted separately in the fatigued group and the fatigue-free group. Generalized linear mixed models were created to evaluate changes over eight years by energy status within fatigue stratum for usual and rapid gait speed. RESULTS: There were 2,613 total participants included; 724 (27%) were fatigued and 1,889 (73%) were fatigue-free at baseline. Of those who reported fatigue, 240 (33.2%) also reported high energy (9.2% of the sample). The subset of fatigued participants co-reporting high energy was more likely to be Black, had less post-secondary education, and fewer depressive symptoms. Among fatigued participants, those reporting high energy had lower average annual declines in rapid gait speed over time than those reporting low energy, independent of demographics and comorbidities ($ß = 0.007$, p = 0.03). No significant changes in usual gait speed were found in fatigued participants. Amongst the fatigue-free participants, high energy was associated with less decline in rapid gait speed over time (ß =0.004, p = 0.04), but not with usual gait speed. CONCLUSIONS: In this sample, participants with fatigue who reported high energy comprised around a third of the fatigued group. These participants showed less decline in rapid gait speed during the following eight years. Our results suggest that participants with higher self-reported energy may be protected from gait speed decline, especially due to fatigue. The protective effects of energy in fatigued participants in the context of rapid gait may be because the rapid gait condition pushes participants out of their comfort zones. Higher self-reported energy may reflect an underlying physiologic compensatory mechanism, such as better bioenergetic reserves or dopamine availability, even in the presence of fatigue. If so, lower self-reported energy independent of fatigue may be an indicator of impending mobility impairment and may be a candidate for inclusion into an algorithm to identify older adults at risk of developing impaired functional capacity.

S6.3: ***Association of walking energetics with amyloid status: Findings from the Baltimore Longitudinal Study of Aging***

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BACKGROUND AND AIM: Higher energetic costs for mobility predict gait speed decline. Slow gait is linked to cognitive decline and Alzheimer's disease (AD). Whether the energetic cost of walking is linked to AD pathology is unknown. We investigated the cross-sectional association between the energetic cost of walking, gait speed, and amyloid beta (Aβ) status (+/−) in older adults. METHODS: One hundred forty-nine cognitively normal adults (56% women, mean age 77.5 ± 8.4 years) completed customary-paced walking assessments with indirect calorimetry and 11C-Pittsburgh compound B positron emission tomography. Logistic regression models examined associations adjusted for demographics, body composition, comorbid conditions, and apolipoprotein E ε4. RESULTS: Each 0.01 mL/kg/m greater energy cost was associated with 18% higher odds of being Aβ+ (odds ratio [OR] = 1.18; 95% confidence interval [CI]: 1.04 to 1.34; P = .011). These findings were not observed when investigating gait speed (OR = 0.99; 95% CI: 0.97 to 1.01; P = .321). CONCLUSION: High energetic cost of walking is linked to AD pathology and may be a potential target for therapeutic intervention.

S6.4: ***Energy Predicts the Incidence of Subsequent Falls: Results from a 12-Month Randomized Controlled Trial***

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BACKGROUND AND AIM: To understand the role of self-reported energy in predicting subsequent falls in at-risk community-dwelling older adults and whether self-reported energy can be modified, using data acquired from a 12-month randomized trial of exercise, we examined: 1) whether baseline self-reported energy predicted subsequent falls using a negative binomial regression among the full sample; and 2) whether self-reported energy can be improved by exercise using an analysis of covariance (ANCOVA). METHODS: Three-hundred and forty-four older adults aged 70 years and older with a recent history of a fall were randomized to either a home-based exercise program plus usual care or usual care only (i.e., care provided by a geriatrician). Self-reported energy was acquired from the "Vitality" dimension of the SF-6D, which asked how often one feels energetic (i.e., all of the time, most of the time, some of the time, a little of the time, and none of the time); higher score indicate lower frequency of energy. Falls were tracked prospectively using monthly calendars. The negative binomial regression model was adjusted for group, age and functional comorbidities. The ANCOVA was adjusted for instrumental activities of daily living. Missing data for the SF-6D at 12-months were imputed using available data at 13-months. RESULTS: Lower self-reported energy predicted the prospective rate of falls (IRR=1.16; 95% CI: 1.00-1.34; p=0.046). At trial completion, there was a non-significant trend in the exercise group for improved self-reported energy vs. usual care (p=0.125). CONCLUSION: The frequency in which older adults feel energetic may be an overlooked risk factor for falls that can be modified by exercise.

S.7: Perception and self- evaluation of gait and balance performance

S7.1: *Self-perception of physical ability; a factor for falling in older adults?*

Mirjam Pijnappels[1], Nick Kluft[1], Roel Weijer[1], Sjoerd Bruijn[1], Marco Hoozemans[1], Jaap van Dieën[1]

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BACKGROUND AND AIMS Discrepancies between physical ability and self-perceived physical ability are suggested to increase the risk of falling in older adults. We performed a series of studies in which we explored the quantification of such discrepancies for stepping and gait in older adults. Moreover, we investigated whether self-perceived physical ability modulates the relationship between physical ability and future falls. METHODS In a cohort of 255 community dwelling older adults (65 to 94 years old), we assessed self-perceived and actual stepping ability by explicitly asking and testing for older people's stepping ability to cover high and far steps, or by implicitly monitoring their behaviour in a stepping down paradigm. We monitored for falls during 12-month follow-up. We used a factor analysis on all self-perceived and actual physical ability measures and structural equation modelling to test if self-perceived physical ability factors modulated the relation between the physical ability factors and falls. RESULTS Our results showed that self-perceived physical ability, as well as actual ability can be consistently and reliably measured across tests, whereas the degree of misjudgment appeared less reliable and consistent within individuals [1]. When predicting future falls, adding a discrepancy term derived from performance in the stepping down paradigm did not improve prediction models based on actual physical ability [2]. Finally, we also showed that self-perceived physical ability did not modulate the relation between physical ability and falls that were assessed during follow-up in community dwelling older adults [3]. CONCLUSION Overall, our studies showed that discrepancies between physical ability and self-perceived physical ability may be context specific and seem not to be a factor in predicting falls in healthy older adults. REFERENCES [1] Weijer et al. Consistency and test-retest reliability of stepping tests designed to measure self-perceived and actual physical stepping ability in older adults. Aging Clin Exp Res. 2019;31(12):1765-1773. https://doi.org/10.1007/s40520-018-01112-3 [2] Kluft et al. Does misjudgement in a stepping down paradigm predict falls in an older population? R Soc Open Sci. 2019, 3;6(11):190786. http://dx.doi.org/10.1098/rsos.190786 [3] Weijer et al. The relation between falls, physical ability, self-perceived physical ability and physical activity in community dwelling older adults: a structural equation modeling approach. Submitted.

S7.2: ***Perception of temporal gait asymmetry in neurotypical adults and people with stroke***

Kara Patterson[1], Lucas Crosby[1], Joyce Chen[1], Jessica Grahn[2]

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Background: Inaccurate perception of motor performance may prevent people with stroke (PwS) from benefiting from augmented feedback during gait training. A common target of gait rehabilitation is temporal gait asymmetry (TGA) exhibited by nearly 60% of PwS. Augmented feedback and rhythmic auditory stimulation (RAS) are two promising interventions, but it is not known whether inaccurate perception of TGA influences their effectiveness. We conducted two studies to investigate the accuracy of perception of TGA and the influence of a metronome cue (RAS) on perception. Methods: We compared perception of the presence, direction, and magnitude of TGA with actual TGA measured with a pressure sensitive mat during self-paced gait in two studies with neurotypical adults (NT; n=29) and people with stroke (PwS; n=28). PwS were categorized as asymmetrical (PwS+TGA; n=20) or symmetrical (PwS-TGA, n=8) at baseline. TGA was induced in NT using unilateral ankle cuff weights. NT walked with induced TGA for 15min. Actual and perceived TGA was measured before and after 15min, immediately after load removal and again at the point NT reported gait had returned to preloading status. Both NT and PwS walked over-ground with and without an auditory metronome cue (RAS) and perceived and actual TGA were measured after each trial. Actual TGA was calculated as a symmetry index. Perceived TGA was recorded as responses to 2 questions: 1) Which limb did you spend more time on while walking (presence and direction)? and 2) Estimate how much time you spent on each limb while walking (magnitude). The answer to question 2 was reported as a percentage of 100 and converted to a symmetry index. Actual and perceived TGA were compared, the number of true and false positives and true and false negatives were tallied, and accuracy was calculated for the perception of TGA presence and direction. Magnitude of perceived and actual TGA were compared with scatterplots. Results: TGA was induced and maintained in NT after 15min of walking. PwS and NT both accurately perceived the presence of TGA during baseline walking, but RAS made perception worse. PwS +TGA were

more accurate and perceiving the direction of TGA compared to NT. Conversely, PwS-TGA were poor at detecting the absence of TGA but their perception improved with RAS. Finally, TGA magnitude was grossly overestimated for baseline and RAS conditions. Conclusions:The results suggest that perceiving the symmetry of timing of gait events is a difficult task even for neurotypical adults. Rather than serving as a useful reference, external auditory cueing may worsen perception of TGA. Future work should investigate whether the use of self-evaluation in combination with augmented feedback about TGA is appropriate to train symmetrical gait post-stroke.

S7.3: ***The impact of anxiety and attention on older adults? perceptions of stability***

Elmar Kal[1], William Young[2], Toby Ellmers[3]

[1]Brunel University London, [2]University of Exeter, [3]Imperial College London

Background: When balance is threatened, it is key that our perceptions of stability are appropriately scaled to the level of instability experienced, to ensure that we adopt protective behavioural adaptations (e.g., walking slower and more cautiously). However, many older adults experience distorted perceptions of instability, whereby they perceive themselves to be more unstable and at greater risk of falling than they actually are. In this presentation I will present some recent experimental and observational work to illustrate how anxiety-induced excessive conscious monitoring of balance ('hypervigilance') may underpin such distorted perceptions of instability. Further, I will discuss how we may use this knowledge in management of balance issues that are closely linked to anxiety, such as 'unexplained' dizziness. Methods and Results: First, I will discuss a recent lab-based study in which we measured the effects of postural threat on actual (measured using a force plate) and perceived postural sway (determined through self-report). A group of 26 healthy older adults performed 60-second static balance trials in three different conditions: standing at ground level (low-threat) standing at height (0.6 m; high-threat) and standing at height but while doing a simple yet distracting cognitive task (threat+distraction). Significant increases in fear and conscious monitoring of balance were evident during the threat vs low-threat condition. This was accompanied by a substantial reduction in perceived stability (~20%), even though actual sway amplitude was unchanged. Yet, when people were distracted while at height, perceptions of stability significantly increased, while fear and actual sway remained similar. This is proof of concept that threat-induced 'hypervigilance' can drive distorted perceptions of instability. Second, I will discuss the role of balance hypervigilance in older adults with unexplained dizziness. I will present our recent work on the development of a Balance Vigilance Questionnaire. Early results from a sample of 240 older adults show that the questionnaire is reliable and valid. Most importantly, we found that older adults with high balance vigilance scores have significantly higher odds (OR=1.07, 95%CI=[1.011, 1.130]) of experiencing dizziness in daily life, even when corrected for other key risk factors (e.g., anxiety, depression, medication use). Discussion: Overall, our results suggest that hypervigilance (excessive conscious monitoring of balance) can negatively bias older adults' perceptions of stability. This may be a potential mechanism that underpins unexplained dizziness in older adults, but could also potentially explain distorted perceptions of instability in older adults with excessive fear of falling. I will close with some guidance as to how certain

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clinical interventions that specifically aim to normalise vigilance may help improve perceptions of stability in these populations.

S.8: Multisensory contributions to mobility in older adults

S8.1: ***Listening and postural control as multi-tasking challenges for middle-aged and older adults***

Ralf Krampe[1], Nathan Van Humbeeck[1], Mira van Wilderode[1], Astrid van Wieringen[1]

[1]KU Leuven

Participating in spoken conversation constitutes a multitasking situation with concurrent demands on sensorimotor (auditory, postural) and cognitive functioning (storing and retrieving content in and out of memory). As aging affects multisensory integration and cognitive control, these higher-order processes are likely to put accumulating constraints on listening as we grow older. However, little is known about the interplay of listening and postural control, and its potential importance for the treatment of age-related hearing impairment (presbycusis). In an age-stratified field study and different experiments we investigate the interplay between postural control and auditory processing under ecologically relevant listening conditions. To this end we use stabilogram-diffusion analysis (SDA) and other measures of stability to analyze posturography data from young, middle-aged and older adults. A focus of our experimental approach is the systematic manipulation of posture (e.g., stable stance vs sway-referenced) and listening demands (early phoneme recognition vs speech understanding with alternating speakers) to determine at which age/level of hearing impairment multitasking leads to costs and/or prioritization.

S8.2: ***The Impact of Multisensory and Cognitive Load on Younger and Older Adults? Cognitive-Motor Dual-Task Performance***

Berkley Petersen[1], Caitlin Murphy[1], Ross Clark[2], Aaron Johnson[1], Karen Li[1]

[1]Concordia University, [2]University of the Sunshine Coast

Background: Maintaining postural control efficiently is dependent upon the coordination of motor, sensory and cognitive systems, all of which are subject to decline with healthy aging. Compared to younger adults, older adults demonstrate increased cognitive resource sharing, and secondary cognitive tasks, and sensory loads from hearing and vision loss demand similar attentional resources as postural control. However, few experimental designs have considered how a combination of sensory and cognitive loads impact postural control. To address this omission, we investigated how younger and older adults' single- and dual-task postural control was impacted by increased cognitive load, simulated vision impairment, and hearing loss. Methods: We recruited 32 younger (M = 23.03 SD = 3.53 yrs.), and 27 older adults, 16 with mild or moderate hearing loss, (M = 77.13 SD = 7.53 yrs.) and 11 without hearing loss (M = 71.27 SD = 11.30 yrs.). Data collection took place in a public mall

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setting to increase inclusivity and participant diversity. Using a Nintendo Wii Balance Board, and simulated low vision goggles, participants underwent five balance conditions: Eyes closed, single-and dual-task normal and low vision simulated impairment. Single and dual-task cognitive assessments involved backwards serial 7s counting for 30 seconds. Results: As task complexity increased (i.e., presence of a visual and/or counting task), postural control decreased. Younger adults outperformed older adults on all tests of postural control. There were minimal variations in postural performance between older adults with and without hearing loss. Older adults with hearing loss had greater medial-lateral sway in single-task normal and low vision conditions. Considering that those with hearing loss are older than those without hearing loss suggests the decline in medial-lateral amplitude is more pronounced with increasing age and compensating for low vision is more challenging for those with hearing loss. Positive dual-task postural costs were evident among all three groups, but no group differences existed. Under normal and low vision conditions, older adults without hearing loss displayed positive dual-task cognitive costs, while those with hearing loss experienced no costs, suggesting differences in task prioritization, which may be attributed to cohort effects. The prioritization of the cognitive task over the postural task may be an ineffective dual-task strategy putting older adults with hearing loss at a higher risk of falling. Conclusions: Our results illustrate how aging, sensory loss and increased cognitive load can affect postural control in younger and older adults. The notable age-related declines in postural control are likely attributed to musculoskeletal declines and reduced attentional capacity. Taken together, understanding the interconnections between sensory, cognitive, and motor functioning is critical in reducing falls, and preserving healthy aging and mobility.

S8.3: ***Multitasking in virtual scenarios - aging, influencing factors and neuronal correlates***

Claudia Voelcker-Rehage[1], Robert Stojan[1]

[1]University of Münster

BACKGROUND AND AIM: Cognitive-motor multitasking is an integral part of our daily lives. Driving a car while talking to a passenger or walking down the street while using a mobile phone are typical examples of everyday behavior in which we perform multiple actions simultaneously. In older adults, that ability to perform two or more tasks concurrently often is compromised. This age-related decay in multitasking has been attributed to an interrelated decrement in sensory, motor, and cognitive functions, which is associated with structural and functional deteriorations in the aging brain. The effects of aging on multitasking performance and the underlying mechanisms have been studied mainly in laboratory experiments probably limiting the transferability of findings towards behaviors in everyday life. Therefore, our aim was to study multitasking in older adults in more ecologically valid, virtual environments. METHODS: We conducted a series of multitasking studies in different virtual scenarios (driving, street crossing, normal walking) with older adults assessing different behavioral and neurocognitive outcome parameters. Neural correlates of multitasking were assessed via functional-near-infrared spectroscopy (fNIRS) applied over frontal (and parietal) brain regions. In addition, potential moderators/mediators such as physical activity/fitness and executive functions were investigated. RESULTS: Results from two driving simulator and one walking study will be reported. Findings consistently indicate the effects of aging on various outcomes of multitasking and neuronal correlates. However, these effects varied considerably between task types, conditions, and other experimental manipulations, and seemed to be associated with lifestyle factors like physical activity behavior. CONCLUSIONS: Virtual scenarios are feasible to detect the effects of aging on multitasking under more naturalistic conditions. Results are discussed against different dual-tasking models and in line with current perspectives and conceptual advances in neurocognitive and motor aging. Current challenges and opportunities in studying human behavior under more natural conditions will also be highlighted to advance this emerging area of research.

S8.4: ***Dual-task performance in hearing-impaired older adults***

Bettina Wollesen[1], Anna Wunderlich[2]

[1]University of Hamburg, [2]TU Berlin

Background: Hearing impaired older adults exhibit a reduced walking performance under dual-task (DT) conditions compared to healthy controls or younger adults. The Mobile Brain/Body Imaging approach (MoBI) allows for the parallel analysis of brain and body during unrestricted movement. Applying this method during different DT conditions in this target group enables to gain deeper insights into the interaction of cognitive and motor processes and the neuronal correlates. More detailed comparisons of the performance decrements of older adults with hearing impairments can be gained by utilizing different stimulus modalities in the discrimination task (visual and auditory) and the control for age. Methods: Aiming for a sample size of 96 (48 healthy and 48 mildly hearing impaired) community-dwelling older adults (50-70 years) and 48 younger adults (20-30 years), a first subset of participants has been recruited so far. The ongoing study has a multifactorial mixed-measure design comparing three groups. One between-subject factor is age (younger vs. older adults) and the second for the older age groups is hearing impairment (mild vs. not hearing impaired). Within-subject factors are task complexity (single- vs. DT) and cognitive task modality (visual vs. auditory). Besides stimulus modality, stimuli of the discrimination task differed according to presentation side (left vs. right), and presentation-response compatibility (ipsilateral vs. contralateral). Different gait parameters were captured with the OptoGait system and EEG activity was recorded using 64 active electrodes (LiveAmp, BrainProducts). Results: As part of the symposium, the final setup for the interdisciplinary measurements will be introduced, and the preliminary results of the recorded data will be presented. Cognitive-motor-interference (CMI) was analyzed by dependent variables of task performance (accuracy and response time) and gait parameters (Gait speed, step length, double support phase) as well as stimulus evoked brain potentials during single and dual task. The gait- and cognitive function-related dual task costs, as well as the interferences between both measurements will be summarized. Discussion: Cognitive-motor interference varied between the groups of young and older adults as well as older adults with hearing impairment. Differences representing the interference of motor and cognitive tasks were revealed at a behavioral and neurophysiological level by the comparison of task complexity and auditory versus visual discrimination task. Assumingly, performance decrements were associated with different cognitive-motor processes, i.e., stimulus input, resource allocation, and movement execution.

When dual-tasking, performance was more compromised in the auditory condition, especially for older, hearing-impaired adults. The results allow first conclusions about task-specificity and general mechanisms of CMI (ST vs. DT walking) in dual-task performance while over ground walking.

S.9: Emerging interventions for rehabilitation of mild neurocognitive disorders: Evidence from neuromodulatory and cognitive-motor training approaches

S9.1: ***Motoric Cognitive Risk syndrome: overview***

Joe Verghese[1]

[1]Albert Einstein College of Medicine

Background: Motoric cognitive risk syndrome is a pre-dementia syndrome characterized by the presence of self-reported cognitive complaints and slow gait. Individuals with Motoric cognitive Risk syndrome are at higher risk of developing dementia and also for other geriatric outcomes such as falls, disability and mortality. Methods: This presentation will review the epidemiology of Motoric cognitive risk syndrome in different populations. Risk factors for Motoric cognitive risk syndrome will be discussed with a focus on modifiable risk factors. Results: Globally Motoric cognitive risk syndrome is present in one in ten older adults. A number of modifiable risk factors such as low physical activity, depressive symptoms and obesity are associated with the presence and risk of developing Motoric cognitive Risk syndrome. Potential interventions for Motoric cognitive risk syndrome will also be described. Conclusions: Motoric cognitive risk syndrome has high utility in clinical and research settings to identify individuals at risk of dementia, and offers opportunities for introducing interventions early to prevent cognitive decline.

S9.2: ***Cognitive Training for Chronic Vestibular Hypofunction***

Brooke Klatt[1]

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BACKGROUND AND AIM: Spatial cognitive impairment is prevalent in people with vestibular disorders. In other populations, cognitive training programs that specifically target spatial skills show that those skills can improve post-training, demonstrating that this cognitive ability is modifiable. It is unknown whether a training program aiming to improve this domain of spatial cognitive function might help people with vestibular disorders with commonly reported subjective cognitive complaints and/or balance and gait performance-based outcomes. METHODS: In a novel clinical context to individuals with vestibular impairment, we plan to evaluate the preliminary efficacy and feasibility of a cognitive training program in a sample of participants with chronic vestibular impairment, who report symptoms of spatial disorientation. The cognitive training program will focus on spatial cognitive skills and will be used as an adjunct to traditional vestibular physical therapy. RESULTS: Data collection is anticipated to be completed at time of the 2022 ISPGR World Congress. Results will include findings from analysis of pre- to post-training change in cognitive and dizziness symptoms (Dizziness Handicap Inventory) and balance and gait performance (Modified Clinical Test of Sensory Interaction in Balance and Dynamic Gait Index). CONCLUSIONS: We hypothesize that addressing both cognitive as well as physical manifestations of vestibular loss will lead to better objective and subjective outcomes.

S9.3: *Dual-task Exergaming for improving anticipatory and reactive fall-resisting skills.*

Tanvi Bhatt[1], Lakshmi Kannan[1], Shuaijie Wang[1], Olusola Ajilore[1]

[1]University of Illinois at Chicago

Older adults with mild cognitive impairment (OAwMCI) experience subtle balance control and gait deficits predisposing them to increased fall risk compared to cognitively intact older adults (CIOA). Such deficits have been associated with brain pathologies like impaired white matter integrity (WMI) and reduced gray matter volume (GMV). These results are during self-initiated activities (volitional balance control), however, their relationship with primary defense mechanism against falling, i.e., reactive balance control, has not been examined. Further, there is enough evidence that the deficits are more pronounced during dual tasking (DT, simultaneous performance of motor and cognitive task) resulting in increased cognitive-motor interference (CMI, deteriorated performance either motor and/or cognitive task) which could attribute to the > fall risk in OAwMCI. Alternate form of therapy like exergame training has shown promising results in improving balance control and cognitive function in CIOA but there is limited evidence in OAwMCI. This talk will discuss the differences in types of CMI patterns experienced for different tasks (gait and volitional vs reactive balance) in CIOA vs people with mild NCDs, present findings from series of studies examining neuromechanisms of balance control in OAwMCI and feasibility of novel exergaming and DT interventions to improve CMI and fall-risk in OAwMCI. Our first study examined reactive balance control in OAwMCI in response to external perturbations during standing. Results showed 2 folded increased number of falls among OAwMCI (66%) compared to CIOA (33%) and young adults (0%). We show that compared to healthy counterparts, OAwMCI exhibit exacerbated reactive instability and are unable to modulate their responses based on the intensity of balance threat. Our second study explored the underlying associations of balance recovery mechanisms (volitional balance assessed via limits of stability test and reactive assessed via external perturbations) with WMI and GMV (both assessed via MRI). Results indicated that the structural brain integrity influences stability control in OAwMCI during both volitional and reactive balance tasks, which may share similar cortico-subcortical motor pathways and relay centers. Further, the integrity of descending pathways from cortical attentional centers could influence stability control for both these tasks. Our last study determined the effects of 4 weeks of DT exergaming (combined cognitive and exergame training) on CMI during volitional and reactive balance tasks under attentional demanding conditions. Results indicated that while DT exergaming has the potential to reduce CMI during volitional balance control task, limited to no benefits were observed during reactive balance control task. These findings could be leveraged for designing protocols to enhance anticipatory and reactive fall resisting skills in OAwMCI.

S9.4: ***Transcranial direct current stimulation (tDCS) as a tool to understand and enhance dual task balance in older adults with and without mild cognitive impairment***

Brad Manor[1], Jounhong Zhou[1], On-Yee (Amy) Lo[2], Lewis Lipsitz[1], Alvaro Pascual-Leone[1], Jeffery Hausdorff[3]

[1]Harvard Medical School, [2]Hebrew SeniorLife / Harvard Medical School, [3]Tel Aviv Sourasky Medical Center and Tel Aviv University

BACKGROUND AND AIM: Standing and walking are controlled by complex systems that rely on the function of numerous cortical and subcortical brain regions and their connected neural networks. This reliance upon supraspinal elements of the motor control system increases with age and many age-related diseases, especially when an individual must stand or walk in unfamiliar environments and/or simultaneously perform additional cognitive tasks like talking, reading signs, or making decisions. Transcranial direct current stimulation (tDCS) is a form of non-invasive brain stimulation that can selectively modulate cortical excitability. Mounting evidence suggests that tDCS can augment cortical plasticity and thus holds strong promise as a stand-alone or adjunct treatment strategy to counteract age- and disease-related alterations in standing, walking, and daily-life balance and mobility. METHODS: This talk will first highlight the fundamentals of tDCS along with optimal methods for the rigorous implementation of tDCS within clinical research studies. It will then provide an overview of a series of studies we have conducted to examine the effects of tDCS on the neural control of standing and walking in older adults. RESULTS: In four separate studies focused on healthy younger adults, healthy older adults, older adults with mild cognitive impairment, and older adults suffering from Parkinson's disease, we have demonstrated that a single exposure to 20 continuous minutes of tDCS designed to facilitate the excitability of the left dorsolateral prefrontal cortex improves dual task standing and walking performance when tested immediately after stimulation. Subsequently, we have demonstrated in a pilot randomized controlled study of older adults with mild cognitive impairment that a two-week, ten-session tDCS intervention targeting the same brain region induced significant dual task walking improvements that persisted for at least two weeks following the intervention. CONCLUSIONS: Together, these results implicate the left dorsolateral prefrontal cortex as a critical brain region involved in dual task standing and walking, and further suggest that multi-session tDCS interventions may induce meaningful benefits in vulnerable populations of older adults.

S.10: Quantitative snobs no more! Integrating qualitative approaches into posture and gait research

S10.1: ***Development of a survey for characterizing real-world fall events in lower limb prosthesis users: Involvement of target respondents***

Andrew Sawers[1], Brian Hafner[2]

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[1]University of Illinois at Chicago, [2]University of Washington

BACKGROUND AND AIM: Despite their importance to fall prevention research, little is known about the details of real-world fall events experienced by lower limb prosthesis (LLP) users. This gap can be attributed to the lack of a structured, population-specific fall survey to document these adverse health events. The objective of this study was to develop a survey capable of characterizing the circumstances and consequences of fall events in LLP users. METHODS: Focus groups were conducted with a diverse sample of LLP users to solicit perspectives about their fall experiences. Terminology and themes that emerged from the focus groups were used to develop fall event definitions and construct a conceptual fall framework that guided the creation of candidate fall survey questions. Cognitive interviews, with retrospective verbal probing, were conducted to evaluate the clarity, comprehension, and applicability of definitions and candidate questions. Finally, the fall survey was administered to a national sample of 246 LLP users in a cross-sectional study to determine if survey questions operated as intended (i.e., yielded data consistent with expectations). Revisions to the survey were made at each stage of development based on investigators' analysis of participant feedback and data. RESULTS: Definitions for two overlaping yet unique fall events were proposed, tested, revised, and ultimately understood by LLP users; a fall is a loss of balance where your body landed on the ground or floor, and a near-fall is loss of balance where you caught yourself or recovered without landing on the ground or floor. A conceptual framework consisting of four modules (i.e., personal characteristics, fall circumstances, consequences, and recall) (Figure 1) was constructed based on six themes identifed in the focus groups, and used to guide the creation of candidate survey questions. Survey content focused on the activity, environment, situation, mechanics, and consequences of fall events. Cognitive interview feedback revealed that LLP users saw select response options as confusing, too broad, or too limiting. Revisions to the survey resolved these issues and improved survey clarity, applicability, and comprehension. Evaluation of data from the cross-sectional study revealed: i) additional response options were needed to fully characterize falls experienced by LLP users; ii) survey participants confidently recalled details of fall events queried by the survey, and iii) fall data obtained with the survey was consistent with expected patterns and associations. CONCLUSION: The structured 36-question population-specific fall event survey developed in this study offers clinicians and researchers the means to document, monitor, and compare fall details that are meaningful and relevant to LLP users in a standardized and consistent manner. The data that can be collected with the survey are essential to establishing specific goals for fall prevention initiatives in LLP users.

S10.2: *Through the lens of people living with spinal cord injury: integrating qualitative approaches to create more meaningful fall prevention initiatives*

Kristin Musselman[1], Hardeep Singh[1], Janelle Unger[2], Olinda Habib Perez[3]

[1]University of Toronto/University Health Network, [2]Western University, [3]University Health Network

Frequent falls is one of the many consequences of living with a spinal cord injury (SCI); 69-78% of those living with SCI fall at least once/year. Despite living with such a high fall risk, little was known about the causes and consequences of falls after SCI. This lack of knowledge resulted in the use of generic fall prevention interventions in SCI rehabilitation. Over the past eight years, we have integrated qualitative research methods into our posture and gait research to both understand the causes and consequences of falls after SCI, as well as develop effective fall prevention interventions specific to this population. First, to gain a comprehensive understanding of 1) the consequences of falling and fall risk and 2) the factors that influence fall risk, we used photovoice. Photovoice is a participatory research method that combines photo-taking with group dialogue. Thirty-six individuals living with SCI took photographs representing their experiences with falling and living with a high fall risk. Next, they participated in individual, semi-structured interviews and focus group meetings to discuss the content of their photographs and brainstorm potential strategies to prevent falls. Findings highlighted, for the first time, the significant psychosocial consequences of falls and fall risk after SCI. Participants described feelings of vulnerability, interference with parenting and paid work, as well as restriction of recreational activities, each strengthening the need for effective fall prevention initiatives in this population. Participants perceived falls to be caused by multiple interacting factors unique to each person. They also explained that experiencing falls and near-falls helped them learn how to prevent future falls. Altogether the findings from these initial studies informed the development and testing of balance training programs for individuals with SCI. For example, we created a perturbation-based balance training (PBT) program that provided safe opportunities to experience near-falls. We completed a single-blind, randomized clinical trial that evaluated the feasibility and efficacy of PBT compared to dose-matched conventional balance training in 20 individuals with chronic, motor incomplete SCI. To understand how each training program impacted participants' lives and fall risk, a semi-structured interview was completed with each participant three months post-training. No significant between-group differences on quantitative measures of balance, lower limb strength and post-training falls were found. However, the interview data indicated that participants of PBT were engaging in new activities and taking more balance risks in their daily lives. The inclusion of qualitative research methods in this clinical trial enabled us to evaluate the meaningfulness of training outcomes for participants; insight that is difficult to gain through quantitative measures.

S10.3: ***Incorporating Qualitative Description within Mixed Methods Research on Physiotherapist Balance Measurement Practices: An Evolving Approach***

Kathryn Sibley[1]

[1]University of Manitoba

Multiple research methodologies are recommended in research that aims to facilitate evidence-informed clinical practices to reveal the mitigating factors and effects of complex interventions and to better understand the nuances and realities of real-world clinical settings. Mixed methods research embraces the complementary contributions that both quantitative and qualitative data make to advancing understanding of a complex issue. In this presentation I will describe two projects focused on physiotherapist balance measurement practices, each using qualitative description, a naturalistic approach that attempts to understand an issue from the perspective of the people involved, within a distinct mixed methods approach. The first project involved a sequential mixed methods evaluation of the effects of a theory-based intervention to increase measurement of reactive balance among physiotherapists working in Canadian rehabilitation hospitals using a QUAN -> qual structure, in which we found increased measurement of reactive balance over a 12-month period and identified key factors mediating perceptions and potential adoption in practice. The second project involved a concurrent mixed methods study to describe and examine effects of an integrated knowledge translation research project on balance measurement with physiotherapists, with equal priority on quantitative and qualitative data components. In this project we demonstrated through both data components that adopting an integrated knowledge translation approach resulted in important effects on the research process and demonstrated an impact on the physiotherapists and clinical practice I will compare the sequential and concurrent analysis approaches, emphasizing the strengths and challenges associated with each. I will discuss the implications of using qualitative description within a mixed methods approach for understanding and advancing physiotherapist measurement of balance, and explore alternative approaches that could enrich future research.

S.11: Gait speed and balance control

S11.1: ***Balance control insights from gait behavior of healthy individuals at very slow speeds***

Amy Wu[1]

[1]Queen's University

BACKGROUND AND AIM: Individuals at an increased risk of falling may walk at very slow speeds, possibly as a strategy to maintain balance. It is unclear, however, how balance is affected by speed. Gait studies with healthy individuals are typically achieved at faster speeds (~1.25 m/s) and might not translate well to slower speeds. To help address this gap, we investigated healthy gait behavior at very slow speeds (less than 0.6 m/s) to provide a normative baseline for speed-related changes in gait behavior. METHODS / RESULTS: We examined gait kinematics, kinetics, and stability at very slow speeds (0.1 m/s to 0.6 m/s) with healthy, young adult subjects [1, 2]. Kinematics and kinetics were primarily focused on the sagittal plane while stability was investigated through lateral margin of stability. Like faster speed ranges, joint angles, torques, and powers and ground reaction forces decreased in magnitude as speed slowed, and known relations for spatiotemporal and work measures still held at very slow speeds. These findings suggest no clear delineation between normal or fast speeds and very slow speeds. While step width was unchanged, we observed increases in stance time variability and lateral center of mass magnitude, suggesting that additional balance control measures were needed at slow speeds. We determined that stability, measured through the minimum lateral margin of stability, decreased as speed slowed because the center of pressure could not compensate for an increased excursion of the extrapolated center of mass. At the minimum margin gait event, hip and ankle torques also increased as speed slowed, suggesting that lateral torques contribute more to balance than stepping. However, direct measurements of muscle activity are needed to draw firmer conclusions. CONCLUSIONS: How could these results translate to assisting the clinical population? Using scaled down normative gait kinematics and torques in controllers for lower-limb assistive devices seems appropriate for gait generation, but upper body controllers could be crucial to maintaining balance. Upper body controllers could limit lateral trunk movement to reduce center of mass excursions if center of pressure is limited. Likewise, active external assistance or targeted gait training of lateral ankle and hip muscles seems more important at slow speeds if trunk movement is inevitable. Although increased step width was not observed in our study, the stepping strategy might still be useful for balance. While it is uncertain how knowledge gained from healthy young individuals can be translated to clinical populations, normative studies at very slow speeds can offer insights into elucidating the relationship between walking speed and balance to reduce the risk of falling. [1] Wu et al. "Mechanics of very slow human walking," Sci Rep, 2019. [2] Best and Wu, "Upper body and ankle strategies compensate for reduced lateral stability at very slow walking speeds," Proc Royal Soc B, 2020.

S11.2: ***Walking speed affects the recruitment of different balance mechanisms***

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Humans walking on two legs are mechanically unstable and tend to fall over sideways unless actively balanced. To keep the body upright, the central nervous system must continuously regulate the body position by accelerating the body mass in a desired direction. There are two main biomechanical mechanisms to modify lateral acceleration of the body. (1) The foot placement mechanism shifts the location of the foot placement at the next step, which affects the moment arm of the gravitational pull. (2) The ankle roll mechanism uses ankle musculature at the stance leg during single stance to actively pull the body in a desired direction. The nervous system can flexibly shift between these balance mechanisms throughout the gait cycle, recruiting the one that is available and shifting between the legs dynamically. One difference between the two mechanisms is the source of the mechanical energy that accelerates the body mass. The foot placement mechanism changes the gravitational acceleration in a way that is beneficial for balance, whereas the ankle roll mechanism has to generate the acceleration actively by contracting muscles to pull the whole body. From a metabolic efficiency point of view it is surprising that humans use the ankle roll mechanism at all, electing to generate force actively instead of exploiting gravity. One limitation of the foot placement mechanism is that it can only be used when a foot is placed. When humans walk slowly, with a low cadence, the time to the next foot placement can be substantial and preventing loss of stability might require increased use of the less efficient ankle roll mechanism. We postulate that humans recruit these balance mechanisms to be as energy efficient as possible, but as stable as necessary. This predicts that humans use more foot placement at higher cadences, and more ankle roll at lower cadences to maintain balance. Using galvanic vestibular stimulation to induce small fall stimuli in healthy young adults, we show that this prediction is supported by experimental data. Responses to the vestibular stimuli used predominantly the ankle roll mechanism in slow walking, and a mix of foot placement and ankle roll in normal walking, while the whole-body balance response was almost identical. This finding is relevant for populations with neuromotor impairments, who tend to walk at slow speeds. Recent data indicate that people with Cerebral Palsy (CP) and Parkinson's Disease (PD) both tend to rely more on foot placement and make less use of the ankle roll mechanism for balance control than age-matched neurotypical control. We speculate that since ankle roll is a continuous and active balance mechanism, it requires more high-level control and integration of proprioceptive information from different joints. Impaired proprioception is a symptom of PD and CP, which might influence people with these conditions to rely more on the foot placement and, to accommodate this mechanism, to walk at higher cadences.

S11.3: *Walking speed and balance among people with chronic stroke*

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BACKGROUND AND AIM: Many individuals who experience a stroke exhibit reduced walking speeds and altered walking balance in comparison to neurologically-intact controls. Such speed and balance deficits are common targets of therapeutic interventions, although the link between these two deficits is not entirely clear. We explored several aspects of the relationship between walking speed and balance using a sample of 93 ambulatory individuals with chronic stroke (>6 months post injury). METHODS: First, we investigated whether treadmill walking speed influenced the step-by-step relationship between step width and mediolateral pelvis displacement at the start of a step (a metric related to mediolateral balance; quantified as a partial correlation ρdisp). Our focus on mediolateral balance was based on the many falls that occur toward the paretic side in people with stroke. Second, we investigated the dramatic decrease in walking speed that is often observed when individuals with stroke walk on a treadmill (compared to overground). This decrease in speed can complicate comparisons with young, healthy adults that often rely on treadmill walking, and has been suggested to be due to a lack of balance confidence. RESULTS: Across participants walking at their self-selected speeds, we found that ρdisp was significantly lower for paretic steps than non-paretic steps, and increased significantly with walking speed, paralleling prior results in neurologically-intact controls. However, when individual participants were asked to speed up (to their fastest-comfortable speed), ρdisp for steps taken with the paretic leg did not increase significantly. This combination of results is consistent with the proposal that a reduced ability to accurately control paretic step width can limit self-selected walking speed in people with chronic stroke. In our comparison between overground and treadmill walking, we found that overground self-selected walking speed was significantly correlated with treadmill self-selected speed, although the overground speed was substantially faster. Activities-specific balance confidence score (a common clinical assessment) was unrelated to the decrease in speed when on a treadmill. In contrast, participants who self-reported a fear of falling exhibited larger decreases in speed. The present results suggest that participant fear may limit our ability to compare clinical populations with young, healthy adults during treadmill walking. CONCLUSIONS: Overall, the

relationship between walking speed and balance among people with stroke is complex. Both balance deficits and fear may limit the walking speed achieved in this clinical population.

S11.4: ***The mechanisms of maintaining gait stability at different speeds.***

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[1]Vrije Universiteit Amsterdam

The effects of walking speed on gait stability are debated [1]. Mechanically, gait stability would be expected to increase with walking speed, as higher walking speed (step frequency) allows for more frequent corrections by foot placement. On the other hand, older adults and patient groups often walk slower, which is thought of as an adaptation to cope with (potential) instability, suggesting that slower walking is more stable [2]. However, it is unknown 1) whether other control mechanisms than foot placement (such as ankle and push-off mechanisms) play a larger role at slow walking speeds, and 2) how feedback contributions to gait stability change with gait speed. Thus, in a first study[3], we tested the effects of steady-state walking speed on the degree of foot placement control, and use of the ankle mechanism and push-off mechanism during steady state walking. We found that higher walking speed increased both the accuracy of foot placement and of the ankle mechanism, while there were no differences in the use of push-off (to maintain anterior-posterior stability). Taken together, these findings suggest that faster walking is more tightly controlled. In another study, we tested whether vestibular contributions to walking indeed are related to gait stability. We found that random electrical vestibular stimulation led to a decrease in gait stability, and less accurate foot placement, whereas coherence between stimulus and horizontal ground reaction forces decreased in stabilized walking [4]. These results indicate that vestibular information is indeed used to control gait stability. Work from others additionally showed that the vestibular contribution to gait decreased with increasing speed [2]. Taken together, these findings seem contradictory; on the one hand, they suggest that faster walking is more tightly controlled, while on the other hand they suggest that vestibular feedback for control of gait stability has a higher gain in slow walking. One could argue that during fast walking, visual information may play a larger role, but the evidence suggests the opposite [5, 6]. All in all, this indicates that at higher walking speeds, lower level (more reflexive?) control and passive stabilizing mechanisms may become more prominent. Given the delays associated with higher level control, such a switch to more "automated" (reflexive) mechanisms seems logical. At what speed such a change occurs and whether it is gradual or discrete remains to be investigated. References 1. Bruijn, S.M., et al., Is slow walking more stable? J Biomech, 2009. 42(10): p. 1506-1512. 2. Brandt, T., M. Strupp, and J. Benson, You are better off running than walking with acute vestibulopathy. Lancet, 1999. 354(9180): p. 746. 3. van Leeuwen, A.M., et al., Active foot placement control ensures stable gait: Effect of constraints on foot placement and ankle moments. PLoS One, 2020. 15(12): p. e0242215. 4. Magnani, R.M., et al., Stabilization demands of walking modulate the v

S.12: Watch your step! – Fundamentals and clinical applications of walking adaptability

S12.1: ***Positioning walking adaptability in a wider conceptual and technological context***

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A better understanding, identification, and prevention of falls due to walking is urgently needed as falls are a growing, common, expensive public health problem. Most falls are due to loss of balance caused by tripping, slipping and misplaced steps in environmental context (such as obstacles or uneven terrain), often attributed to situational context (such as rushing too much or being distracted). Unravelling the interplay between an individual and these contextual factors that contribute to walking-related falls is essential for understanding (limitations in) context-dependent walking (Figure 1a). Here a simple conceptual framework is introduced with two inputs for the reduction of walking-related falls: 1) reduction of the number of disturbances and 2) reduction of the fall probability per disturbance (Figure 1b and 1c). The framework includes walking-adaptability, walking-stability, and prioritization aspects, all of which are independently known for their contribution to walking-related falls. The first, walking adaptability, is a person's ability to adapt walking to environmental factors, such as obstacle avoidance and precision stepping. Improving walking adaptability can result in fewer falls by reducing the number of balance disturbances due to misplaced steps, trips, and slips (Figure 1e, center panel). The second, walking stability, is a person's ability to recover walking after a disturbance such as a trip or slip. Improving walking stability can result in fewer falls when exposed to disturbances (Figure 1e, left panel). Prioritization is one's ability to set the right priorities. Improving prioritization can result in fewer falls by positively impacting the relationships between walking-adaptability and falls and between walking-stability and falls (Figure 1e, right panel). Failure to prioritize adaptability and stability leads to more falls due to more disturbances and poorer recovery from disturbances, respectively. In recent years, new augmentation and perturbation technologies have become available to study certain aspects of context-dependent walking (for examples, see Figure 1d), all of which show promise for reducing the number of walking-related falls. Integrating such technologies with the proposed conceptual framework will allow for the development of encompassing methods and techniques to bridge conceptual and practical levels of research, with strong potential for even better understanding, identification, and treatment of persons prone to walking-related falls. Could such conceptual and technological solutions be the decisive step in reducing the incidence, costs, and health-impact of walking-related falls?

S12.2: ***Gaze Behaviour for Walking Adaptability: Fundamental and Clinical Insights***

Daniel Marigold[1]

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People must make several decisions while walking. They must decide how to direct gaze to acquire critical information about terrain and objects in the environment. Then, based on this visual input and their goal, they must decide the path to walk or safe locations to step. What factors influence these decisions? Two factors have recently emerged as driving gaze behaviour when foot-placement accuracy is important during walking: visual uncertainty and motor cost. We find that gaze time on targets increases with greater target visual uncertainty and associates with reduced foot-placement error (Dominguez-Zamora et al. 2018). We also find that when step width increases, gaze behaviour shifts from a strategy that focuses on planning future steps to one that results in continued visual feedback of the current step to ensure accuracy (Dominguez-Zamora & Marigold 2019). However, in these experimental paradigms, like most used in the field, people did not have a choice of which targets to step on; each foot simply had to step on the next target in a pre-defined sequence. In a recent study (Dominguez-Zamora & Marigold 2021), we designed a path that consisted of a series of targets, where in one "row", people had to choose which of two targets to step on. One of these targets varied in its blurriness, creating uncertainty in the location of its centre. The other target required a wider, more energy-demanding step, but its centre was easier to locate. Some people spent more time looking at both targets and tended to step onto the more energy-demanding but visually-certain location. Others usually ignored looking at the more energy-demanding target and chose to step to the more visually-uncertain target, thus minimizing energy. Gaze behaviour predicted step choice. This work suggests that acquiring environmental information, being certain of one's action, and the energy required to move are factors that interact to dictate how to direct gaze and decide where to step; how one assigns value to these factors differs across people. Is an understanding of gaze behaviour clinically relevant? Eye diseases, such as glaucoma, create visual uncertainty and increase the risk of obstacle collisions and falls. These eye diseases can also cause (maladaptive) changes in gaze behaviour. In people with glaucoma, for instance, this includes changes in timing of gaze shifts to and from step locations and obstacles (Lajoie et al. 2018; Miller et al. 2018). This suggests a potential avenue for intervention. Recent evidence from our lab shows that teaching these people general and task-specific gaze strategies can both alter gaze behaviour and lead to greater foot-placement accuracy and decreased obstacle collisions (Gunn et al. 2019). Thus, teaching people to use their vision more effectively through gaze training may serve to improve walking adaptability. Interventions of this nature should capitalize on our fundamental understanding of what drives gaze.

S12.3: ***Anxiety-related changes in perceptual and cognitive processes and their influence on adaptive gait***

William Young[1]

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Walking in our cluttered world relies on the ability to perceive the world around us (and our movements in it), make decisions, and both plan and execute appropriate actions. In some situations, like when anxious, walkers will tend to allocate visual attention differently (exhibit bias for environmental threats), consciously process their movements and also adopt more conservative movement strategies. The implications of these changes on balance safety are currently unclear. However, they are likely to depend on the dynamic requirements and complexity of the task. In the domain of motor performance, during simple/static tasks we might expect that conservative attempts to constrain movements (i.e. co-contract antagonistic muscle groups) will be somewhat beneficial. Yet, with increased task dynamics, these constraints are likely to become increasingly maladaptive. Similarly, in the cognitive domain, during simple tasks anxiety-related inefficiencies may not be clearly evident, as walkers compensate for such inefficiencies by increasing mental effort. However, this compensation will inevitably become more difficult during more demanding tasks and inefficiencies will eventually materialise as performance errors. Therefore, the implications of anxiety-related perceptual and cognitive processes are less likely to be revealed within simple, unconstrained, walking tasks. Instead, if we are to form meaningful interpretations about the efficiency of these processes, we must use tasks that are both ecologically valid and sufficiently challenging to drive significant errors in each process. We will discuss the benefits and drawbacks of studying highly dynamic and complex walking tasks in the context of a new protocol from the VSimulators facility at the University of Exeter (www.vsimulators.co.uk). This task comprises over-ground walking, feedforward planning (precision stepping) and reactive balance (recovery from unexpected surface perturbations across a 3.7 x 3.7m array of force plates capable of moving in six degrees of freedom). Suggestions are made regarding the development of outcome measures from such dynamic tasks that might: i) implicate specific underlying mechanisms, and ii) lead to targeted clinical interventions.

S12.4: ***Online step adaptations - how do balance and leg motor control interact?***

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People with upper motor neuron lesions (e.g. stroke) often experience difficulties adapting their walking pattern to environmental demands and constraints, which contributes to their elevated risk of falling. These deficits are most evident when step adjustments have to be made under high time pressure, involving online stepping corrections (e.g. to avoid a sudden obstacle). In the first part of this talk, experimental findings will be presented showing that both residual leg motor impairment and balance difficulties underlie the particular challenge that people with stroke encounter in making online step adjustments. Our recent findings demonstrate that this is also true for people with stroke who are very mildly affected. In this study that included sixty-nine minor stroke participants, we used a step-adaptability task that involved stepping forward onto a projected rectangular target. In 40% of trials, at the instant of foot-off, the target jumped 15cm in the anterior, posterior, lateral or medial direction, forcing the participants to adjust their steps during swing. We measured foot placement errors relative to the new target position and found that the associations between balance and leg motor control deficits on the one hand and foot placement errors on the other hand varied according to the direction of the target jump. To gain further mechanistic insight into the interplay between fast target-directed response expression and balance control, in the second part of the talk, a new experimental paradigm will be introduced where participants had to step to highly salient visual targets with either the left or the right leg. We contrasted the balance requirements of the task (i.e. the necessity of making an APA prior to stepping) by presenting the targets either laterally or medially in front of the feet. In our first experiment in healthy adults, we observed a consistent early (~100ms latency) target-directed burst of activity in contralateral hip abductor muscles. This activity was greatly suppressed when balance requirements were higher, in conjunction with a substantial delay in step initiation time. This finding leads us to suggests that people with poorer balance capacity (e.g. those with stroke) may inhibit the expression of 'automatic' visuomotor responses to avoid jeopardizing stability, yet at the expense of slower and less effective gait adaptations.

Oral Presentations

O.1 – Parkinson's Disease

O.1.1: *White matter connectivity associations with postural control and freezing of gait in Parkinson's disease*

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[1]KU Leuven

Background and aim: Freezing of gait (FOG) is one of the most important symptoms of Parkinson's disease (PD), which contributes to falls. People with PD and FOG (freezers) also have more impaired dynamic postural control, in particular for tasks that require mediolateral weight-shifting such as turning. Understanding the structural neural underpinnings of these problems is currently lacking. Our aim was to determine the association between white matter connectivity and objectively measured mediolateral weight-shifting and FOG severity in freezers, non-freezers and controls. Methods: Nineteen freezers, 16 non-freezers and 18 healthy controls performed a mediolateral weight-shifting task at increasing frequencies in a movement analysis laboratory when OFF medication and diffusion tensor imaging (DTI). Furthermore, the FOG-ratio during repeated 360° turning was used as an objective measurement of FOG-severity. DTI data were acquired and analyzed with a constrained spherical deconvolution method, using fiber bundle capacity (FBC) between regions of interest as a metric of biological connectivity. General linear models were employed to assess if the connectivity of the mesencephalic locomotor region and the cerebellum with subcortical and cortical hubs was associated with weight-shifting performance and FOG. Results: Freezers showed smaller weight-shifting amplitudes and higher FOG-ratios than non-freezers ($p<0.001$) and controls ($p<0.001$), and weight-shifting breakdown occurred earlier in freezers than in controls ($p=0.008$). Biological connectivity between the right MLR and right caudate was lower in freezers compared to controls ($p=0.009$), but not compared to non-freezers ($p=0.178$). Coinciding with this result, we also found that weaker connectivity in the same tract was associated with higher FOG-ratio values in freezers ($p=0.003$). Results for postural control involved different tracts and an incongruous pattern, as freezers and non-freezers showed an association between compromised weight-shifting breakdown and an increased fiber bundle capacity between the right MLR and left cerebellum ($p=0.006$ and $p=0.019$). This association was not found in controls ($p=0.563$). Conclusions: This study investigated structural brain abnormalities underlying postural control and FOG in PD. The involvement of the MLR appears 'shared' across both clinical problems, but the different targets to and from this structure are distinct between FOG and weight-shifting problems in PD. MLR-caudate connectivity was associated with FOG-severity, possibly reflecting a reduced ability of the cognitive circuit to take over impaired gait control in freezers. The stronger MLR-cerebellum connectivity found in those with impaired weight-shifting hints at a compensatory role of the cerebellum in postural control in PD, irrespective of sub-group.

O.1.2: ***Cortical correlates of compensation strategies for gait impairment in Parkinson's disease***

Anouk Tosserams[1], Vivian Weerdesteyn[2], Tess Bal[1], Bastiaan Bloem[3], Teodoro Solis-Escalante[4], Jorik Nonnekes[4]

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BACKGROUND AND AIM: Gait impairment in persons with Parkinson's disease is both common and debilitating. Affected individuals typically experience greater difficulties with automatic behavior, compared to goal-directed behavior. The application of compensatory gait strategies (such as external cueing) is an essential part of rehabilitation. Such strategies are postulated to improve gait by facilitating a shift from automatic to goal-directed motor control, but their exact underlying working mechanisms remain unclear. Through the use of high-density EEG recorded during actual gait, we explored the cortical correlates of three categories of compensation strategies: external cueing, internal cueing, and action observation. METHODS: Eighteen participants (8 women; aged 66.2±7.6 years) with Parkinson's disease and self-reported disabling gait impairment were included. We recorded EEG both during stance and while walking on a treadmill under four conditions: (1) uncued (without applying any strategies); (2) external auditory cueing (listening to a metronome); (3) internal cueing (silently counting in a rhythmic manner); and (4) action observation (observing another person walking). Treadmill speed was set at the participant's preferred comfortable speed and kept constant for all gait conditions. EEG data were acquired using a 126-channel electrode cap. Independent component analysis was performed to reduce artefacts. To control for the effects of sensory processing of the cues, we computed relative power changes as the difference in power spectral density between walking and standing for each condition. RESULTS: Relative to uncued gait, the use of all three compensation strategies induced a stronger decrease of beta band activity in the sensorimotor clusters, indicative of increased cortical activation. Parieto-occipital alpha band activity decreased with external and internal cueing (i.e., increased cortical activation), and increased with action observation (i.e., decreased cortical activation). Only internal cueing induced a change in cortical activation of the frontal cluster, by eliciting a stronger decrease of beta band activity compared to uncued gait. CONCLUSIONS: The application of compensation strategies during gait resulted in altered cortical activity compared to uncued gait that could not be solely attributed to sensory processing of the cueing modality. Our findings suggest that there is more than one route to control gait, and that different compensation strategies likely rely on different cortical mechanisms to achieve enhanced central motor activation in persons with Parkinson's disease.

O.1.3: ***Towards personalized gait rehabilitation in Parkinson disease: a prospective study on compensation strategies in 101 patients***

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BACKGROUND AND AIM: Gait impairment is common and disabling in Parkinson's disease (PD). The application of compensation strategies is an essential part of gait rehabilitation in PD. However, apart from external cueing, these strategies have rarely been systematically investigated. We studied the effects of five different types of compensation strategies. We aimed to: 1) quantify the efficacy of the different strategies on spatiotemporal gait parameters; and 2) explore whether the effect of specific strategies is associated with certain patient characteristics. METHODS: 101 participants (50 men; median [range] age: 66 [47-91] years) with PD and self-reported disabling gait impairment were included. An extensive battery of clinimetrics was performed, including: questionnaires (New Freezing of Gait, Vividness of Movement Imagery, adapted version of the Goldsmiths Musical Sophistication Index), cognitive assessments (Attentional Network Test, MoCA, Brixton Spatial Anticipation Test), and physical exams (MDS-UPDRS part III, Mini-BEST, tandem gait, rapid turns test). Gait assessment consisted of six 3-minute trials, in which participants walked continuously around a 6-meter walkway. Trials comprised: 1) baseline uncued gait (without applying any strategies); 2) external cueing (walking to a metronome); 3) internal cueing (counting); 4) action observation (mimicking another person); 5) motor imagery (visualizing and mimicking another person); and 6) adopting a new walking pattern (exaggerating the arm swing). Movement data was acquired using Vicon to determine the absolute difference in stride time variability between uncued gait and gait with each of the compensation strategies. The association between patient characteristics and the efficacy of the strategies was explored using univariable linear regression analysis, followed by stepwise regression analysis with forward selection. RESULTS: The efficacy of the different strategies on spatiotemporal gait parameters varied greatly among participants. For all strategies, the strongest predictor of efficacy was stride time variability at baseline (Figure 1). While participants with higher variability at baseline showed larger improvements when applying a compensation strategy, participants without freezing of gait, with lower MDS-UPDRS part III scores, higher balance capacity, faster Timed Up and Go times, and better performance in orienting attention, also showed greater improvements in gait variability. With respect to strategy-specific associations, higher MoCA scores were associated with higher efficacy of external cueing and male sex with higher efficacy of exaggerated arm swing. CONCLUSIONS: Our findings support the use of compensation strategies in gait rehabilitation for PD, but highlight the importance of a tailored, personalized approach. Even patients with high gait variability at baseline are able to improve gait quality through the application of compensation strategies. Associated patient characteristics may not be used in clinical practice yet to predict which patients would benefit most from a specific strategy, but do provide insight into the possible underlying mechanisms. Certain levels of cognitive and functional reserve seem necessary to benefit from compensation strategies.

O.1.4: ***Pointing in the right direction: improvements in objective measures of function using directional versus ring-mode deep brain stimulation in individuals with Parkinson's disease.***

Christopher Hurt[1], Daniel Kuhman[1], Melisaa Wade[1], Alyson Moll[1], Harrison Walker[1]

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Background and Aim Deep brain stimulation (DBS) is an effective treatment strategy for Parkinson's disease (PD). However, addressing declines in gait and mobility are a major unmet need in PD therapeutics. Emerging DBS technologies provide greater radial control over directionality of the electrical field, allowing clinicians to "steer" stimulation to minimize side-effects while maximizing functional outcomes. We have recently shown that optimized DBS programming can result in clinically important increases in walk speed. However, we did not assess how directionality could improve task performance on objective measures of function compared to traditional ring-mode stimulation. Here, we test the hypothesis that unilateral optimized directional DBS results in greater motor improvement than traditional ring-mode stimulation in patients with PD. Methods 31 individuals (57.8±7.5 years, MDS-UPDRS III off medication 49.2±12.8) completed a baseline data collection and a randomized monopolar review of this double-blind SUNDIAL Trial (NCT03353688). We assessed changes to gait function (10-m walk test), mobility (timed up and go), upper limb dexterity (9-hole pegboard), and lower limb dexterity (foot target test) at baseline and while programming the device one-month after implantation. Participants arrived at both visits off PD medication ≥12 hours. An experienced clinician conducted DBS programming. For each participant, we first subtracted baseline performance of each outcome and then rank-ordered performance on the motor battery for the directional contacts grouped by vertical location on the lead (i.e., dorsal or ventral contacts) and best to worst numerically for comparison with the ring contacts. Comparisons between location on the lead (dorsal vs. ventral) and contact (three directional and one ring contact) were compared using 2x4 repeated measure ANOVAs. Results For gait function the best directional contact resulted in a larger difference in walking speed than the best ring-mode (0.25±0.04 m/s vs. 0.20±0.04 m/s, $p<0.02$). For the timed up and go, the best directional contacts resulted in better performance relative to the best ring-mode (4.07±1.17s vs. 3.52±1.12s, $p<0.01$). For the 9-hole pegboard, task performance of the best ranked directional contact was significantly faster than the ring-mode (9.08±1.98s vs. 7.30± 2.00s, p<0.01p<0.01). For the foot target task, the performance of the best ranked directional contact was significantly faster than performance on the ring mode-mode (6.72±1.51s vs. 5.88±1.47s, $p<0.01$). Conclusions In this investigation, we show using quantitative, objective measures, that directional DBS stimulation results in functional improvements in upper and lower extremity tasks. While this data is acute in nature, resulting from a single data collection in a laboratory setting, these promising findings suggest that directional DBS can be optimized to target improved dexterity, gait function, and mobility.

O.1.5: ***Progression of gait disturbances in people with Parkinson's disease and REM sleep without atonia***

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BACKGROUND AND AIM: Approximately 30 to 40% of people with Parkinson's disease (PD) have REM sleep behavior disorder (RBD), a parasomnia characterized by increased muscle activity during REM sleep (termed REM sleep without atonia, RSWA) and dream enactment. The co-expression of PD with RBD is associated with increased motor and cognitive impairment, including postural instability and gait disturbances, compared to those without RBD. Little is known about the association between the presence and expression of RSWA (measured by the level of muscle activity during REM sleep) and the rate of progression of gait impairment in people with PD. This study examined the progression of gait impairment in people with mild-to-moderate PD, with and without RSWA, and healthy controls over three years. We hypothesized that: (i) people with PD with RSWA (PD-RSWA+) would show a significantly larger decrement in gait ability than PD without RSWA (PD-RSWA-) and controls and (ii) baseline RSWA scores would correlate with the progression of gait impairment. METHODS: Forty-one people with PD (22 PD-RSWA+; 19 PD-RSWA-) and 21 age- and sex-matched controls completed overnight sleep testing and gait assessments at baseline. Gait testing was conducted off PD medications. Spatiotemporal parameters of steady-state gait were obtained using a GAITRite Electronic Walkway (CIR Systems, Inc.) (31+ steps). Measures of RSWA were derived from EMG recordings during polysomnography testing. A linear mixed model tested for the effects of visit (baseline vs. follow-up), group, side (least vs. more affected), and their interactions. Spearman's correlations examined the relationship between baseline RSWA scores and change in gait metrics in the PD groups. RESULTS: Forty-nine individuals were re-tested at follow-up (16 in each PD group and 17 controls). Of the 13 individuals lost to follow-up, 43% were in the PD-RSWA+ group (PD-RSWA-: 21%, controls: 36%). The mean time between baseline and follow-up tests was 35.0 ± 6.7 months. Gait speed showed main effects of visit and group, with speed decreasing over time, and the PD-RSWA+ group walking slower than controls (Fig. 1A). Stride length (normalized to leg length) showed main effects of group and visit, and a group x visit interaction. Stride length was shorter in the PD-RSWA+ group compared to controls, decreased over time for both PD groups, but not for controls, and the decrement in stride length over time in the PD-RSWA+ group was greater than the PD-RSWA- group (Fig. 1B). There were no significant main or interaction effects for cadence (Fig. 1C). The change in MA and LA stride lengths were correlated with tonic and phasic chin RSWA scores at baseline ($p < 0.039$). CONCLUSION: These findings provide evidence that the presence of RSWA in early PD is a harbinger of a more rapid progression in gait impairment, characterized by a shortening of stride length. ACKNOWLEDGEMENTS: NIH RO1 NS070264, NS088679, P50 NS09857, 8UL1TR000114-02, UL1TR000114.

O.1.6: ***Predicting freezing of gait with mixed-reality technology: Timely, accurate and automatic cue activation is technologically feasible***

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BACKGROUND AND AIMS: Visual cueing applications for mixed-reality technology (Figure 1) have strong potential for alleviating freezing of gait (FOG) in people living with Parkinson's disease [1]. Mixed-reality technology maps one's environment (Figure 1C) as well as the position of the headset in the mapped environment, from which several features may be reliably parametrized [2]. The aim of this study was to examine if mixed-reality headset data allow for a fast and accurate FOG prediction, that is, before it occurs. METHODS: 24 people living with Parkinson's disease with ON-state FOG participated in the study, comprising two home visits. Participants walked around in their home environments and wore a HoloLens 1 to record movement and environment data. The mixed-reality display was turned off. In addition, sessions were videotaped. Two independent raters annotated the videos on a sample-to-sample basis for eight motor states, including FOG. A computationally efficient algorithm was trained, tested and cross-validated for FOG prediction, evaluated in terms of the area under the receiver-operator characteristics curve (AUC), sensitivity, specificity and accuracy. RESULTS: In total, 568 FOG episodes were observed, the vast majority of which were trembling FOG episodes (84%). The performance of the FOG prediction algorithm fed with movement and environment features was excellent (0.9<AUC<1) for 6, good (0.8<AUC<0.9) for 8 and fair (0.7<AUC<0.8) for 6 of the 24 participants. Deviant performance was attributable to demonstrably distinct data compared to the training dataset because of 1) dyskinesia of the head (AUC=0.63), 2) split-level home environment with many stairs (AUC=0.63), 3) fast walking (1.3m/s) with many short (mean 0.71s) FOG episodes (AUC=0.55). The remaining participant experienced no FOG. The algorithm was cross validated, with 0.89 sensitivity, 0.75 specificity and 0.76 accuracy and proved quite robust against feature combinations. The true-positive-rate of FOG predictions before they occur varied from 50% for episodes up to 1s to 62% for episodes longer than 5s. CONCLUSIONS: Automatic holographic cue activation to prevent FOG from happening is technologically feasible, with better performance for longer FOG episodes. About 50-60% of FOG episodes can be predicted before they occur with a computationally efficient algorithm fed with environment and movement features derived from mixed-reality headset data, with fair to excellent performance in 83% of the participants. ACKNOWLEDGEMENTS AND FUNDING: The Michael J. Fox Foundation for Parkinson's Research, Grant ID 16595. References Geerse, Coolen, van Hilten & Roerdink (2021). Front. Neurol. 12:628388. Geerse, Coolen & Roerdink (2020). Sensors 20, 3216. doi: 10.3390/s2011321

O.2 – Machine learning

O.2.1: ***Effects of Level of Central Sensitization on Physical Activity Patterns in Chronic Low Back Pain: Insights from A Machine Learning Approach***

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BACKGROUND AND AIM: Chronic low back pain (CLBP) is the leading cause of disability. Central sensitization (CS) is often present in a subsample of patients with CLBP. Optimal physical activity (PA) is recommended in the management of CLBP because it can reduce the risk of disability. However, the evidence of the association of PA intensity levels and

CLBP is inconsistent, and the knowledge about the association with CS is limited. This study aimed to investigate PA patterns in patients with CLBP and low or high CS using an unsupervised machine learning approach. METHODS: Forty-two patients were included (23 CLBP-, a CS Inventory score lower than 40; 19 CLBP+, 40-100). Patients wore a 3D accelerometer for about one week. For each patient, 4 days of data were used for analyses. Accelerometer data were corrected for gravity and the vector magnitude was calculated. For each group, a Hidden semi Markov Model (HSMM) was made to measure the temporal organization and transition of hidden states (PA intensity levels), based on accelerometer vector magnitude. To determine the number of hidden states (PA patterns), Bayesian Information Criterion (BIC) was used. Differences between CLBP- and CLBP+ in duration and occupation of hidden states were assessed with independent t-tests. The transition probability was assessed by Binomial-proportion test. The compositions of corresponding hidden states were assessed with Jensen-Shannon divergence (JSD). RESULTS: Indicated by BIC scores, 5 hidden states HSMMs were selected. The corresponding 5 hidden states of CLBP- and CLBP+ were similar, indicated by JSD. These states were defined as: rest (e.g., sleeping), sedentary (e.g., desk work), light activity (e.g., standing), light locomotion (e.g., slow walking), and moderate-vigorous activities (e.g., fast walking). Significant differences between 2 groups showed that CLBP+ exhibited higher duration and transition probability of active state (light activity, light locomotion, and moderate-vigorous states) and higher duration of inactive state (rest and sedentary states). CONCLUSIONS: The significant differences in temporal organization and transition of PA levels may suggest that CLBP- and CLBP+ had different PA patterns. CLBP- group trended to break tasks into smaller bouts and took frequent short rests. CLBP+ group exhibited a prolonged period of activity engagement (overactive) and then had a long period of rest. This PA pattern may suggest that CLBP+ had the distress-endures response pattern.

O.2.2: ***Training a deep convolutional neural network to evaluate postural instability in Parkinson's disease***

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BACKGROUND AND AIM: Parkinson´s disease (PD) is one of the most prevalent neurological disorders in today´s aging society. Postural instability is claimed to be among the symptoms most severely interfering with everyday life of those affected. Hence, an early detection of postural impairments is crucial to initiate countermeasures at early stages and facilitate therapy. To maintain balance, humans strongly rely on vision. When subjects perceive their body as moving, they trigger counter movements, resulting in body sway. In our study, we induced body sway by visually simulated self-motion in virtual reality (VR) and tracked participants´ center of pressure (COP) as well as several body segments to derive their center of mass (COM). Our aim was to use a deep convolutional neural network (CNN) to differentiate PD patients´ behavior at early stages of the disease from that of healthy age-matched controls during quiet stance as well as in response to unpredictable visual

perturbations. We hypothesized the network to perform better on the data obtained from the condition where balance was visually perturbed. METHODS:The visual environment consisted of a 3D-tunnel comprised of random black dots which stretched in the anterior-posterior direction within an infinite grey isotropic space. We implemented two visual conditions. In the static condition (SC), the tunnel remained motionless. In the unpredictable condition (UC), we induced unpredictable back-and-forth motion of the tunnel (random white noise displacements). Each participant performed 10 trials of the SC and 20 trials of the UC. Trials lasted for 30 s. We measured the trajectory of participants´ COP as well as of 25 individual body segment positions in 3D-space over time. Out of the body segment data, we calculated the trajectory of the COM. Visual stimuli were presented through a head-mounted display (HTC Vive). Subjects stood on a force plate (Nintendo Wii Balance Board) to track their COP. Body tracking was performed using a 3D-video system (Microsoft Kinect v2). We performed wavelet decomposition on the trajectories of the COP (x-y-coordinates) and COM (x-y-z-coordinates), respectively, and fed the resulting color-scaled frequency spectrograms as labelled images into a CNN based on the AlexNet image classification architecture. We used two output classes to differentiate between PD patients and age-matched controls (n=15, respectively). RESULTS: Our network reached test set accuracies of up to 82.5 % for the UC and up to 92.5 % for the SC, which made us reject our hypothesis. However, there were also training sessions after which the network performed better on data obtained from the UC. The results dependent strongly on the randomly selected samples for the training and test set. CONCLUSIONS: Given a larger data set and further improvements in architecture, our preliminary findings suggest our image classification network to be well suitable for distinction between early-onset PD patients and age-matched controls based on their posturographic data. This suggests our deep learning methodology to be a promising approach for an early detection of postural impairments as a symptom of progressing PD.
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O.2.3: ***Automatic Machine Learning-Based Vestibular Gait Detection: Examining the Effects of IMU Sensor Placement***

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BACKGROUND AND AIM: Screening for vestibular disorders helps identify at-risk patients and facilitates referral to specialized testing and intervention. Gait assessments such as the Functional Gait Assessment (FGA) are commonly used to assess for gait deficits as they are based on simple measures such as timing and observations of path deviations. However, these measures do not capture subtle changes or adaptations in movement and rely on visual examination by trained clinicians thus limiting their accessibility. Wearable inertial measurement units (IMU) can quantify movement without relying on outside observation. Recent work has investigated machine learning (ML) based approaches to create models for the detection of vestibular gait, but the effect of IMU placement on predictive performance remains unknown. The goal of this study was to examine the effects of IMU sensor placement on a classifier's ability to discriminate healthy from vestibulopathic gait.

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METHODS: Thirty study participants (15 with unilateral or bilateral vestibular diagnosis and 15 age-matched healthy controls) participated in a single-session walking study. Participants were equipped with a total of 13 wearable IMUs that were placed on the head, upper back, lower back, arms, wrists, thighs, shanks, and feet. Participants were instructed to walk 6 m with their eyes closed, among other walking tests not reported here. Kinematic features and spatiotemporal gait parameters were extracted from the IMU data. A random-forest (RF) classifier was trained on datasets from each IMU (13 IMUs = 13 models) to predict vestibular diagnosis and their performance was compared using the area under the receiver-operating characteristic curve (AUROC) scores. Specificity scores for the highest performing model(s) were reported for sensitivity thresholds of 0.75 and 0.90 and feature permutation importance analysis was performed to identify important features. RESULTS: Several models were able to predict vestibular diagnosis better than random (AUROC > 0.5). The highest classification performance (AUROC = 0.88, 95% CI = [0.84, 0.92]) was achieved when predicting study participants' diagnoses based on features extracted from the IMU placed on the left arm. Based on this model, specificities of 0.94 [0.89, 0.98] and 0.63 [0.47, 0.74] were achieved for sensitivity thresholds of 0.75 and 0.90, respectively. Participants with vestibular disorders showed a decrease in the root-mean-square (RMS) angular velocity and the range of pitch angular displacement of the left arm. CONCLUSIONS: Using one IMU on the left arm while study participants walked with their eyes closed, we were able to identify 75% to 90% of patients with vestibular diagnosis while screening out 63% to 94% of controls. This finding may have practical implications on the usability of IMU-based automatic screening tools for vestibular deficits, as an arm placement may be more convenient and less obtrusive than a head, trunk, or lower body placement.

O.2.4: *Probability of Instability: A New Statistic that Resolves the Margin of Stability Paradox*

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BACKGROUND & AIM: The mediolateral Margin of Stability (MoSML) (Hof et al., J. Biomech., 2005) has been widely-implemented to measure intrinsic mediolateral stability in walking. Most studies average MoSML across many steps. However, doing so yields paradoxical interpretations of stability status: e.g., gait pathologies (e.g., Watson et al., BMC Musc. Dis., 2021) and/or destabilizing environments (e.g., Wu et al., Gait & Pos., 2017) induce walkers to exhibit larger average MoSML. Given the fundamental ideas underlying MoSML, these larger values suggest greater mediolateral stability, despite clearly destabilizing intrinsic and/or extrinsic factors. To address mediolateral gait stability using MoSML, we must first resolve this paradox. METHODS: Using a Goal-Equivalent Manifold (GEM) framework, we visualized mediolateral center-of-mass (CoM) state fluctuations in the inverted pendulum phase plane. We define the lateral Probability of Instability (PoIL) by integrating the probability density function of a given time series of CoM state deviations over the range that achieves MoSML < 0. PoIL thereby directly measures a participant's likelihood of executing CoM dynamics that result in lateral instability on any given future step. 34 healthy adults (ages 18-75) performed treadmill walking with and without various types of mediolateral perturbations. We extracted time series of lateral CoM state (zn, żn), lateral support boundary (uz)n, and minimum mediolateral MoS (MoSML)n at each step n. We computed average MoSML, as well as the PoIL for each time series. We evaluated the effects of destabilizing perturbation conditions on each of average MoSML and PoIL. RESULTS: Consistent with the paradox, all participants exhibited significantly larger (supposedly "more stable") average MoSML during perturbed walking relative to unperturbed walking (p < 10-4). Conversely, all participants exhibited larger PoIL (p < 10-4) when perturbed. These larger PoIL indicated a greater likelihood of being laterally unstable for any future step. CONCLUSIONS: Consistent with the nature of the imposed destabilizing perturbations, PoIL revealed that participants were actually more likely to become laterally unstable when perturbed. This was despite their larger average MoSML, which suggested (counter-intuitively) improved stability. The Probability of Instability (PoI) accounts for step-to-step variance of CoM fluctuations to properly predict likelihood of intrinsic instability on any given future step. PoI thereby decisively resolves the existing paradox that arises from simply interpreting average MoSML to evaluate mediolateral stability status. FUNDING: NIH R01-AG049735.

O.2.5: ***Detection of the anterior cruciate ligament injury by implementing supervised algorithms on knee acceleration data***

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Background and aim: Anterior cruciate ligament (ACL) injury is a common knee problem, particularly in young, active and athletic individuals. Rapid and low-cost diagnosis of ACL injury is of great importance for preventing further complications. The clinical methods of ACL diagnosis are subjective and relay on the surgeon's experience. The arthrometry techniques, on the other hand, are hardware demanding and relatively expensive. The objective of this study was to investigate the feasibility of detecting the ACL injury, by analyzing the knee acceleration data, captured by inertial sensors, using machine learning techniques. Method: Twenty patients with ACL injury, confirmed later by arthroscopy, participated in this study. The knee joint acceleration data was captured from both the healthy and injured legs of patients, using inertial sensors, during three replications of anterior drawer test (60 trials in total). For each trial, the largest acceleration vector of the femur relative to the tibia was found and a number of features, including the root mean square, the standard deviation, and the maximum amount of acceleration were extracted from it. A variety of supervised learning algorithms, including support vector machine (SVM), k-nearest neighbors (KNN), Nearest Mean (NM), and logistic regression (LR) were used to classify the two groups of healthy and ACL injured knees using these features. The data of 84 trials (42 healthy and 42 ACL injured) was used as the training data, and that of the 36 trials (18 healthy and 18 ACL injured) as the test data. The performance of the algorithms in correct classification of the test data was assessed in terms of the accuracy, precision, retrieval, and specificity. Results: The results of the study (Table 1), indicated a reasonably good performance for the proposed method. The performance measures of the supervised learning algorithms in distinguishing the ACL injured knees from healthy ones, based on the acceleration data, were higher than 0.82 for SVM and KNN, and higher than 0.75 for LR and

NM. Conclusion: Based on our early results, the knee acceleration data captured using inertial sensors, might be sufficiently rich to enable detection of the ACL injury by using supervised learning algorithms. By using more experimental data, as well as more sophisticated features performance of the algorithms might be improved such that the proposed method could be practically used in clinics.

O.2.6: ***Estimating step length from a lower back-mounted IMU using machine learning: preliminary results***

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BACKGROUND AND AIM: Step length is an important diagnostic measure that can be used to assess a subject's gait and - as such - monitor the progression of diseases such as Parkinson's disease (PD) and the effectiveness of interventions. In the past, step length was typically evaluated in the lab using camera-based systems or instrumented gait mats. However, these assessments provide only a snapshot view of a person's walking and may be affected by transient influences like the time of the day, medication, and white coat syndrome. To address these issues, wearable sensors provide a way of measuring step length continuously and in a real-life environment. Accurate estimates have been obtained using shank and foot-worn sensors, but estimates of step length from an IMU placed on the lower back (e.g., based on an inverted pendulum model) are not yet ideal. Here we developed a machine learning model to estimate step length using a single lower back-mounted IMU in older adults. METHODS: Data were taken from a previously described study (A Mirelman et al., Lancet, 2016): 134 patients with PD (age 71.1±6.1 yrs, MDS-UPDRS score 63±21), 30 people with mild cognitive impairment (age 77.5±6.3 yrs) and 83 older adults (76.9±6.2 yrs). All subjects had a history of 2 or more falls. Subjects performed 3 one minute gait tests: 1) comfortable speed, 2) fast speed, and 3) while performing an additional cognitive task. The subjects were assessed 4 times during the study; a total of 83,569 steps were evaluated. During the testing, subjects wore an Opal sensor on the lower back, recording 3D acceleration and 3D gyroscope signals at 128Hz (APDM Inc). The subjects walked over a ProtoKinetics Zeno Walkway which served as the gold-standard to measure step length. The IMUs signals were used to extract gait features (e.g., mean, min, max, Fourier coefficients). Stepwise feature selection was applied to a small portion of the data. An XGB-based model (implementation of gradient boosted decision trees) estimated step length from the IMU extracted features. RESULTS: 5-fold cross-validation was performed to examine the model's robustness to different datasets. The average RMSE for estimating step length on an individual step was 6.27±0.38 cm (6.60±0.34 cm for PD patients, 5.61±0.56 cm for MCI patients, and 6.04±0.88 cm for OA patients). When applied to 10 consecutive steps, the RMSE was reduced to 4.62±0.50 cm (4.82±0.48 cm for PD patients, 4.20±0.81 cm for MCI patients, and 4.56±0.94 cm for OA patients). The Pearson correlation coefficient (r)

between the measured and the predicted step length was 0.83 (See Fig. 1). CONCLUSIONS: We aimed to estimate step length from a single lower-back mounted IMU in a relatively large number of older adults who had a range of neurological impairments and gait abilities (note the broad range in step length in Fig. 1). The results demonstrate that estimating step length in this approach is feasible, even in patients with poor gait. The average over 10-steps provides more accurate results, however, estimates among people with short step lengths and of single steps, are not yet ideal. Additional research is needed to further reduce the errors and the offsets.

O.3 – Neural I

O.3.1: ***A neuromuscular model of human locomotion combines stable walking with planned, goal-directed swing leg movements***

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BACKGROUND AND AIM: Human locomotion is amazingly flexible. We walk effortlessly in varied environments, choosing gaits and avoiding obstacles. To achieve that impressive flexibility, human walking requires sophisticated stabilization because the human body is mechanically unstable during locomotion and body configuration changes throughout the gait-cycle. Combining flexibility and stability is a challenge. Avoiding an obstacle, for instance, involves not only steering the foot over the obstacle, but also stabilizing the gait pattern that is disturbed by the avoidance maneuver. Various sensory systems must therefore estimate the state of the body in space and initiate adaptations of the movement plan to those disturbances. Changes of the movement plan must then be realized by adjustmenting the motor commands that are integrated with the biomechanics, muscle dynamics and the reflex pathways of the spinal cord. Here, we present a neural process model of human locomotion that is able to generate movement plans for steady state locomotion that are open to updating and integrated with muscle physiology, biomechanics and established spinal reflex pathways such as the stretch reflex. METHODS: We present a 3D-neuromuscular model of human locomotion that combines the flexibility to execute different movements with the swing leg, for instance, to avoid an obstacle, with the stability that is required for robust locomotion. The model organizes movement plans on the task level. During swing, vestibular feedback is used to determine a target joint angle coordination for foot placement on each step that generates stable walking. A movement plan is generated towards that target configuration as a minimal jerk trajectory. This movement plan is updated during the movement based on sensory information. The supraspinal controller uses an inverse internal model of the biomechanics, of muscle force generation and of spinal reflexes to generate descending commands that realize the task-level motor plan. On the spinal level, the descending commands during the stance phase are integrated with the stretch reflex and further spinal reflex circuits. The biomechanical model comprises 8 degrees of freedom, realistic moment arms and 22 Hill-type muscles. Muscles are innervated by α-motorneurons and are controlled shifting the threshold of the stretch reflex. RESULTS:

The presented combines stable locomotion at different speeds with flexible movements of the swing leg. This flexibility of the swing leg enables the model to step over- and around obstacles of different sizes and shapes. The model can walk on uneven terrain and resist to external pushes at different phases of the gait and change its walking direction. CONCLUSION: We show that it is possible to combine voluntary, goal directed movements of the swing leg with a reflex-based stance leg controller to generate walking patterns that are stable, yet flexible to execute a variety of planned movements with the swing leg.

O.3.2: ***Facilitating or disturbing? An explorative study to investigate the effect of auditory frequencies on cortical activity and postural sway***

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BACKGROUND It has been stated that "we hear with our ears, but we listen with our brain": auditory stimulation affects the auditory system, but also activates brain areas associated with higher cognitive processes, like the prefrontal cortex (PFC). Listening to a sound can also play a role in the postural regulation, providing an auditory landmark which helps in the stabilization process. However, the effects of specific frequency stimuli on upright posture maintenance are an almost unexplored field despite its potential in postural control. In addition, PFC activity patterns in response to continuous sound-stimuli remain unknown. Therefore, the study aims at minimizing this lack of information by investigating PFC and postural sway responses to different auditory frequency stimuli. METHODS Twenty healthy adults (24.4±2.7 y) performed a double-limb and a single-limb standing postural task (60s) under 4 auditory conditions: 500, 1000, 1500, and 2000Hz, binaurally delivered through noise-isolating headphones (Bose® SoundSport Free, 65dB) and in quiet condition, used as baseline. PFC activation and postural sway were quantified through a 100Hz functional near-infrared spectroscopy system (Brite 24, Artinis Medical Systems) and an inertial measurement unit at L5 level (Opal, APDM, 128Hz) by measuring changes in cortical oxygenated hemoglobin concentration (ΔO2Hb), and parameters in time and frequency-domains. Participants rated the perceived discomfort and pleasantness of each trial using a 0-100 visual analogue scale (VAS). Differences among sound-induced effects in PFC activation, postural sway parameters, and VAS were assessed through nonparametric repeated measure tests, while Spearman rho was computed for assessing correlations among parameters. RESULTS Statistically significant differences have been found in terms of ΔO2Hb among the four auditory conditions in both single-leg and double-leg stance (Figure). No differences have been observed in the sway postural parameters, while an inverse proportionality was found by VAS results, with 500Hz being the most pleasant (less discomfortable) and 2000Hz the less pleasant (most discomfortable) frequency in both tasks. In addition, reported pleasantness negatively correlated with ΔO2Hb at 2000Hz. CONCLUSION In the single-leg stance task, the increasing trend of ΔO2Hb from 500 to 2000Hz possibly indicates that more attention and executive functions are needed when more discomfortable auditory frequencies are delivered, according to the listening effort phenomenon. In the double-leg stance task, the highest PFC activation was observed at 1000Hz, known to elicit tone-evoked leg and neck muscle responses5. In this study, PFC activation could be at the highest at 1000Hz due to inhibitory and control processes occurring to avoid muscular movements. Present data support the importance of exploring the relation among tones, cortical activity and posture, also considering possible ecological applications.

O.3.3: *Lateralized beta modulation is related to arm swing in human gait*

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BACKGROUND AND AIM: Arm swing has been shown to be beneficial for maintaining and stabilizing human gait. Here we ask whether this is merely biomechanical or whether cortical contributions to arm swing activation also corroborate with those of gait. METHODS: We recorded 64-channel EEG in 12 young, healthy participants while walking on a treadmill at controlled speeds with and without arm swing. EEG signals were artifact corrected via band-pass filtering and independent component analysis: mode removal was based on (1) the corresponding spectral distribution that served to identify electromyographic activity and movement artifacts, and (2) the modes' topography to identify exaggerated muscle activity but also eye-movements. Signals were segmented into epochs of ±300 ms around step events (left and right heel-strike and toe-off) that we identified via the vertical components of the co-registered ground reaction forces. We estimated cortical sources via dynamical imaging of coherent sources beamformers in the beta frequency band (15-30 Hz). Per condition (with/without arm swing), step event (heel-strike/toe-off) and side (left/right) we determined their power, followed by a 2×2×2 ANOVA using SPM12b. RESULTS: The beamformer results revealed significant beta activation in sensorimotor and premotor areas. Both heel-strike/toe-off and left/right contrasts showed significant main effects while with/without arm swing did not. Interestingly, we found a significant condition × step event × side interaction clearly localized in left (pre-) motor areas. CONCLUSIONS: Beta band oscillations are known for their contributions to motor performance, especially in the upper extremities. During gait, the cyclic movement of the end-effectors is largely phase-locked, leading to more recent endeavors to combine both, upper and lower extremities, into muscle synergies or to construct whole-body muscle networks. Arguably, this strong coupling between muscles is a resemblance of a common neural input, in which beta oscillations seems to play a pivotal role. Whether beta activity itself forms that common input or whether it serves to entrain the motor network and channel its output at isolated moments in time remains unclear. Our results point at the latter given the clear lateralization to the left cortical hemisphere when comparing heel-strike and toe-off contrasts at either side of the body which disappears in the absence of arm swing. In earlier studies, this lateralization has been shown to increase with task complexity in the performance of upper extremities, especially when that complexity implies accurate motor sequencing and timing. Apparently, heel-strike and toe-off events come with differential timing demands for the arm swing to be beneficial. This may explain why the left-dominant activity is absent when arms are constrained.

O.3.4: ***Independent walking is accompanied by cortico-synergy coupling***

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When independent walking emerges, congenital muscle synergies are maintained and new ones appear [1]. Arguably, the two sets of synergies rely on different neural circuitries. Although utilization of brainstem and spinal structures appear pivotal for the congenital synergies, the supplementary synergies may capitalize on cortical networks. The emergence of the latter set coincides with the appearance of cortico-synergy coupling. Here, we present a longitudinal assessment of cortico-synergy coherence throughout early locomotor development. We hypothesized that the appearance of the supplementary synergies when babies do their first steps coincides with an increase in such coherence. We recorded babies at four timepoints. They visited our lab at around 5 months (16 babies; age (A): 5.7±0.9 (mean±SD in months); time since onset of walking, i.e. walking age (WA): -7.2±1.7), around 10 months (24 babies; A: 10.4±0.6 and WA: -2.8±1.8), first steps (19 babies; A: 13.7±2.0 and WA: 0.3±0.1) and 6 months after the first steps (24 babies; A: 19.6±1.9 and WA: 6.3±0.9). Depending on their age, babies performed either only treadmill walking or both over-ground and treadmill walking. We recorded 32-channel electro-encephalography (EEG) and trunk and leg muscles using 24-channel electromyography (EMG). Non-negative matrix factorization served to decompose multivariate EMG into four muscle synergies per group. To compare the synergy sets across timepoints we fixed the number to four for every group. Beta-band coherence (13-30 Hz) between EEG and virtual patterns (high-frequency estimates of the synergy patterns) was source localized using DICS-beamformers. We also computed time-resolved coherence as a function of the gait cycle between the spatially filtered EEG and virtual patterns. Beamformed and time-resolved coherences were subjected to voxel-wise general linear models to elucidate the factors Synergy (Congenital and Supplementary) and Timepoint (5 months, 10 months, First steps, and 6 months after the first steps). The main effect of Synergy was significant in both beamformed and time-resolved coherences. Coherence was clearly higher in the emerging synergies compared to the congenital synergies. The Synergy X Timepoint interaction revealed differential coherence development for the two synergy sets. Between the 10-months and first-steps groups, coherence increased considerably for the emerging synergies whereas the change for the congenital ones was negligible. The cortical source was localized around left sensorimotor areas. Time-resolved coherences showed this to be particularly pronounced during double support phases. The first independent steps in toddlers are accompanied by selective increases in beta-band coherence for the supplementary synergies. Such rises around the onset of walking can be seen as a sign of more powerful interactions between the cortex and these two synergies. It remains to be seen whether this is a sequence of causal events with independent walking preceded by cortical reorganizations enabling the emergence of the two supplementary synergies. [1] Dominici, N., et al. (2011). Science, 334(6058), 997-999.

O.3.5: ***Anatomically-constrained tractography reveals structural network connectivity differences between Parkinson's disease patients with and without Freezing of Gait***

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BACKGROUND AND AIM: Freezing of gait (FOG) is an episodic breakdown of locomotion that frequently occurs in people with Parkinson's disease (PD). FOG is thought to reflect a 'circuitopathy', whereby disruptions to any of several nodes in the network can result in episodic circuit failures. So far, structural imaging has used focused analyses to investigate connectivity between specific nodes, while the larger network underlying FOG is yet to be uncovered. Further, previously used diffusion-tensor metrics and tractography methods are methodologically limited in terms of resolving crossing fibres and anatomical abnormalities occurring with neurodegeneration. In this study, we used measures of fibre bundle capacity obtained from anatomically-constrained tractography of fibre orientation distributions to investigate the network connectivity differences between PD freezers (PD+FOG) and non-freezers (PD-FOG). METHODS: 19 PD+FOG and 15 PD-FOG underwent diffusion-weighted MRI scanning using a high-directional sequence with a single b-value (1300 s/mm2). Diffusion images were pre-processed using state-of-the-art methods and constrained spherical deconvolution was performed to obtain fibre orientation distributions within each voxel. Probabilistic tractography incorporating anatomical information to generate, truncate and terminate streamlines was performed to obtain the structural connectome containing 2 million streamlines needed to compute biologically accurate measures of fibre connectivity. An ANCOVA controlling for age, gender, height, disease duration and daily levodopa dose was performed along with network-based statistics to compare fibre connectivity across the connectome between PD+FOG and PD-FOG. RESULTS: Thresholding significant connections between PD+FOG and PD-FOG from small effects ($T_{32}=2.7$, $p<0.005$) to large effects ($T_{32}=4.5$, $p<0.0001$), revealed a diffuse network ($2.7 < T < 3.1$, $p = 0.83$-0.84) that localised to a smaller network with parietal and frontal components ($3.1 < T < 3.7$, $p = 0.047$-0.087) with the largest effects confined to a small frontal network ($T > 3.7$, $p = 0.030$-0.051) (Figure). Besides the connectivity within the parietal sensorimotor associative regions and between bilateral prefrontal control regions that were impaired, reduced connectivity with the midbrain was a common deficit in both components of the network. CONCLUSIONS: Using anatomically-constrained tractography, we showed that although PD+FOG have diffuse reductions in structural connectivity compared to PD-FOG, two networks are particularly affected involving within-network communication as well as connections with the midbrain locomotor output structures. The interaction between ineffective sensory integration into motor planning and the inability of cognitive control mechanisms to correct the deranged motor program, seem to be the most likely contributors to FOG. The dysfunctional connectome found warrants further association study with behavioural markers of FOG-events.

O.3.6: ***Resting State Brain Networks Differ Across Domains of Postural Control***

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Background and Aim: Parkinson's disease (PD) is a neurodegenerative disorder causing impairments across several postural domains that result in lack of automaticity of postural control, likely involving compensation via more cortical control. The objective of the study was to determine how connectivity between brain networks were related to three different domains of postural control (postural sway in stance, automatic postural responses (APRs) and anticipatory postural adjustments (APAs) in people with PD and healthy older adults (OA). We hypothesize that different domains of postural control will be associated with different brain network connectivities and that more cortical networks would be related to postural control in people with PD than in healthy OAs. Methods: The cohorts consisted of 65 people with PD (67.7±8.1 years old) tested in their OFF state and 42 OAs (69.7±8.2 years old). Six body-worn, inertial sensors measured postural sway area while standing on compliant foam, step length of APRs to a backward push-and-release perturbation, and magnitude of lateral APAs prior to voluntary step initiation. Resting state-fMRI data was reported for 360 cortical and 24 subcortical areas grouped into 11 cortical and 2 subcortical (Basal Ganglia and Cerebellum) functional brain networks. Associations between functional connectivity and balance metrics were characterized using partial least square regression predictive modeling, with an independent training (n=67) and test (n=40) dataset. Models in the training sample were optimized by leave-3-out cross-validation and 10K null-data simulations and performance of the best model was validated in the independent test dataset. Results: Functional connectivity of different brain networks predicted each domain of postural control in people with PD: Frontoparietal and Ventral Attention connectivity predicted APAs; Cerebellar-Subcortical and Visual connectivity and Auditory and Cerebellar-Subcortical connectivity predicted APRs; and Ventral Attention and Ventral Multimodal network connectivity predicted postural sway. In OA, only the CinguloOpercular and Somatomotor networks' functional connectivity predicted APAs. Conclusions: Consistent with the hypothesis of separate postural control domains, no overlap was found in network connectivity associated with APAs, APRs and postural sway parameters. People with PD have more cortical networks associated with posture control than OAs. People with PD show involvement of frontoparietal motor planning with attention networks for APAs, cerebellar-subcortical with discrete sensory networks for APRs and attention with multisensory cortical networks for control of postural sway in stance. Loss of automatic control of posture via basal ganglia subcortical networks with somatomotor networks in PD appears to result in more widespread involvement of higher-order cortical networks to compensate with separate network connectivities for each domain of postural control.

O.4 – Aging

O.4.1: ***Developing FDG-PET/MR imaging methodology to study gait in aging and neurodegenerative disease***

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BACKGROUND AND AIM: Studies suggest that hierarchically organised cerebral brain regions (supraspinal motor network) contribute to gait control. However, current understanding of discrete gait-brain networks is limited since monitoring of brain activity in real-time during walking is only possible with indirect methods that capture superficial cortical activity. The aim of this work was to develop a pulsed method of [18F]-2-fluoro-2-deoxyglucose (FDG) administration to differentiate gait-related brain activity from standing. FDG radiotracer is a glucose analogue and since glucose is the main metabolic substrate of the brain, glucose consumption is an ideal marker to study the neural correlates of gait. We then used Positron Emission Tomography (PET)-MR imaging methodology to map real-time neural activation changes during walking from standing. METHODS: We studied 15 healthy older adults (mean age: 65.7±3.9, 10 females). All participants received a bolus iv injection of FDG followed by 15-minute standing task and PET-MR brain imaging. Participants then received another FDG injection and completed a 15-minute walking task and another PET-MR scan. Gait characteristics were quantified using small, lightweight sensors according to a validated model of gait. To identify which regions of the brain were more active during walking relative to standing, the two FDG-PET images were coregistered, intensity normalised and then subtracted to generate a contrast image in standard space. Correlation between FDG metabolism and discrete gait characteristics was accomplished using a permutation approach. We additionally explored the cross-modality regional associations between FDG metabolism, grey matter volume (GMV) and white matter connectivity (WM-FA) using sparse canonical correlation analysis (sCCA). RESULTS: Walking relative to standing elicited increased FDG metabolism in the supraspinal motor network (sensorimotor cortex, locomotor regions, thalamus, and the striatum) in addition to vestibular, visual, and lateral prefrontal cortices (Fig 1). FDG in the midbrain locomotor region correlated with swing time variability ($r=0.72$, $p=0.05$). The multivariate sCCA analysis showed that elevated FDG in the cerebellar locomotor region was associated with decreased GMV in the frontal cortex. Also, increased FDG in the dorsal raphe, midbrain locomotor region and intralaminar subregion of the thalamus was associated with increased WM-FA in the sagittal stratum WM tract-a projection pathway connecting cortical regions with the thalamus, pontine nuclei and other brainstem structures. CONCLUSIONS: Here we have developed and successfully established the feasibility and safety of a functional protocol that robustly measures real-time neural substrates of gait and posture. This will allow us to detect brain network dysfunction in brain disease and test novel interventions to mitigate mobility decline and falls risk.
FUNDING: This work is funded by GE Healthcare.

O.4.2: *Descending cortical modulation of spinal sensorimotor circuits is reduced in neurotypical older adults during postural and volitional muscle activation*

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BACKGROUND AND AIM: Aging-related declines in sensorimotor connectivity can impair balance, resulting in increased fall risk. Significant knowledge gaps exist in our understanding of aging-related effects on cortical and spinal sensorimotor neural circuit connectivity. Here, we utilized paired cortical and peripheral nerve stimulation (PNS) to evaluate aging effects on descending modulation of spinal reflexes during tasks requiring voluntary and postural activation. When a subthreshold transcranial magnetic stimulation (TMS) conditioning pulse is delivered before or after PNS, the resulting modulation of Hoffman's (H-) reflexes probes the influence of an array of direct or faster (e.g., -1.5ms ISI) and indirect or slower descending volleys (e.g., +40ms ISI) on the spinal motoneuron pool. We hypothesized that: 1) task-dependent descending cortical modulation of spinal reflexes will be reduced in neurotypical older versus younger adults, and 2) descending cortical modulation of spinal reflexes will be associated with dynamic balance performance. METHODS: Eight neurotypical older (NOA, 5 female; age=57±9 years) and 11 younger (NYA, 6 female; age=27±3 years) adults have been evaluated. PNS was delivered to the posterior tibial nerve to generate a soleus H-reflex recruitment curve during seated active (SA) and quiet stance (QS) tasks. Subthreshold TMS to the soleus motor cortex (M1) hotspot was paired with PNS (intensity: 50% Hmax) at a range of inter-stimulus intervals (ISIs) (-10ms to +40ms). TMS-conditioned H-reflex amplitudes were used to calculate Conditioned H-reflex % (conditioned H-reflex / unconditioned H-reflex * 100%). The narrowing beam walking test (NBWT) assessed balance ability. RESULTS: Older adults showed a significant reduction in Conditioned H-reflex % at the +40ms ISI compared to younger adults during both SA (NYA=105±18%, NOA=75±22%; $p=0.003$) and QS (NYA=122±25%, NOA=68±23%; $p<0.001$) tasks. Younger adults showed a positive correlation between Conditioned H-reflex % and NBWT score at the -1.5ms ISI during QS, while older adults showed a negative correlation between Conditioned H-reflex % and NBWT score at the -1.5ms ISI during SA. CONCLUSIONS: Neurotypical aging may differentially alter slower-conducting, indirect intra-spinal networks and not the fast, direct corticomotoneuronal pathway. Interestingly, older but not young adults showed inhibition at the +40ms ISI, suggesting stronger inhibitory intra-spinal circuit activation in neurotypical aging. Finally, aging-related declines in the connectivity between cortical and spinal sensorimotor circuits may contribute to poorer balance performance. ACKNOWLEDGEMENTS AND FUNDING: P.I. Kesar is supported by NIH NICHD R01 1R01HD095975-01A1.

O.4.3: *Physical activity and health in nursing home residents*

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Background and aim: Physical activity, neuropsychiatric symptoms and sleep affects overall health and are affected by health condition in older adults. There is probably an untapped potential in a more systematic use and follow-up of daily activity levels for older adults living in nursing homes. However, there are few studies that have focused on physical activity in

older adults living in nursing homes, and studies have typically included a small sample with only the healthiest residents. Gaining more knowledge about physical activity levels as well as physical functioning in these residents regardless of diagnosis and functional ability, will provide valuable insight into everyday life in nursing homes. The aim of the current project is to investigate activity and sleep patterns in nursing home residents and to describe associations between activity patterns and important health markers such as neuropsychiatric symptoms, and cognitive- and physical function. Methods: A cross-sectional study including all residents in nursing homes in Trondheim Municipality, Norway, was performed. 7-days measurements with Axivity AX3 accelerometers (thigh and lower back) were used to estimate physical activity, sedentary time, and length of sleep. Sleep quality was measured on a sample of residents using Somnofy sleep monitor for 7-days. Physical function was measured with SPPB, while neuropsychiatric symptoms were measured with The Neuropsychiatric Inventory (NPI) and the Clinical Dementia Rating (CRD) was used to scale the staging of possible dementia. A previous developed machine learning model will be used to analyze activity data. Results: Twenty-eight nursing homes with a total of 1402 residents participated in the study. 1351 older adults with 24-hour care were enrolled in the study, and 800 of these agreed to undergo physical tests. In total, 770 older adults were scored on SPPB, 671 was fitted with one or two accelerometers, and 114 got a sleep monitor. The study was performed in September 2021 and data is not fully analyzed. Further results will be presented at the conference. Conclusion: This study will provide new knowledge regarding activity levels, physical behavior and sleep in older adults living in nursing homes. This study will contribute to put focus on the importance of physical activity for the frailest older adults and will give further ground to discuss how to implement activity as part of everyday care in nursing homes.

O.4.4: *Effect of Backward and Forward Walking on Random Number Generation - the Role of Aging*

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Background: The bidirectional influence of motor function and conceptual cognition throughout lifespan is still unclear. A back-to-front mental-number-line movement orientation may represent a connection between physical function and embodied cognition. Aim: To examine the presence of back-to-front mental-number-line during gait in young and old adults by a random number generation (RNG) task during backward and forward walking. In addition, to examine the associations between RNG acuity, spatial orientation, and gait variability. Methods: Twenty young (age 25.2 ± 2.2, 45% male) and 20 old (age 68.8 ± 5.3, 35% male) healthy adults generated random numbers during backward (BW) and forward walking (FW) in over-ground (GRD) walking without a focused directive, treadmill walking with an internal (IF) or external focus (EF); overall all 6 walking conditions. RNG was assessed via a moving series of 3 adjacent digits, each series classified as an ascending, descending, or non-sorted sequence. Stride time variability (STV) was collected via inertial measurement units, and spatial orientation was measured with a computerized test. A regression analysis investigated whether the sequence type (ascending, descending, or non-sorted) predicted age group affiliation. Multilevel Models (MLM) were used to compare the RNG sequences between groups. In addition, the correlations between RNG acuity, spatial orientation and gait variability were calculated. Results: The findings did not reveal the existence of a mental-number-line during walking on the back-to-front axis in either group. The linear regression identified the ascending sequence as a predictor for old group placement in five out of six test conditions ($p<0.05$). The MLM for ascending sequences as a dependent variable showed a significant difference between the groups ($p<0.05$). In the older adult group spatial orientation score negatively correlated with the percentage of ascending sequences in FW-GRD ($r=-048$, $p=0.03$) FW-EF ($r=-0.45$, $p=0.05$) and BW-EF ($r=-0.46$, $p=0.04$) conditions. A negative correlation in this group was also found between STV and SOT during FW IF condition ($r = -0.45$, $p=0.04$) and during FW EF condition ($r = -0.49$, $p=0.03$). In contrast, STV in the older adults group positively correlated with ascending sequences during backward EF ($r=0.58$, $p=0.01$) and forward EF walking ($r=0.48$, $p=0.04$). Conclusions: The results did not uncover an embodiment of numbers on the back-to-front axis during gait. Yet, the correlation between reduced "randomness" in the RNG task and increased gait variability in old adults may suggest similar executive control of gait and RNG. Conversely, the negative association between RNG acuity, gait variability, and spatial orientation may indicate that visuospatial ability may represent a different cognitive role in the control of gait.

O.4.5: ***Ageing affects dynamic balance differently across the stride***

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BACKGROUND AND AIM: The occurrence of balance and gait deficits increases with ageing and is associated with higher fall risk. While different aspects of gait balance have been studied in older persons, few studies covered all aspects of dynamic balance, i.e. the skilful coordination of the body's posture, momentum, and foot placement throughout the stride [1]. We examined age-related changes in dynamic balance throughout the stride in 138 adults covering 21-86 years of lifespan, combining more accurate models of the functional base-of-support (fBOS) and dynamic balance. METHODS: Ground reaction forces and full-body motion data were collected in able-bodied adults walking barefoot at comfortable speed (20±4 per decade) [3]. For dynamic balance we applied the foot-placement-estimator (FPE) model that uses both the body's linear and angular momentum to solve for the stepping location that will result in a balanced pose [4,5]. We report the dynamic margin of stability (dMoS): the distance in the walking direction between the stepping location and the nearest fBOS edge (Fig1a). The fBOS model fits the area in which people can move their center of pressure during flat feet standing to the foot placement throughout the stride [6]. Age-differences in dMoS were assessed across the stride using SPM analysis in Matlab and at certain gait events in SPSS using ANOVA and ANCOVA to account for speed variability, contrasting the older against the young (grouped 20-39 years) in post-hoc analysis. RESULTS: Age-effects on dynamic balance differed across the stride (Fig 1b). Initial contact was not affected by age ($p=0.46$; Fig 1c), although older adults more consistently seem to

place their stepping location 4-5cm inside the fBOS while some young had it even outside the fBOS (Fig 1c). In contrast, during peak single stance ($p<0.001$) and at toe-off ($p=0.008$) the oldest two decades had their stepping point closer to their fBOS and thus to being dynamically balanced (Fig 1c). These age-effects were related to a decreasing walking speed with age (Fig 1d): no age-effects remained when taking speed into account (IC: $p=0.978$; peak stance: $p=0.08$; toe-off: $p=0.884$). CONCLUSIONS: While older adults walk slower, they still regulate their foot placement well. They do become more cautious: carefully controlling their weight acceptance at initial contact and closer to being dynamically balanced during the more vulnerable single stance phase. These results contrast with previous findings of unchanged extrapolated COM margins in the walking direction during single stance [1] and generally assumed reductions in walking stability with ageing, although our analysis might reveal different balance behaviour when applied to frail or perturbed older adults. The question remains if older adults walk slower to stay more balanced or vice versa, but detailed analysis of dynamic balance such as these will bring us closer to identifying those at risk of falling across daily movements. FUNDING: Carl-Zeiss Stiftung, Germany
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O.4.6: *Timed Up and Go test with an obstacle: evaluating the ability of anticipatory locomotor adjustments in older adults based on the selection of route suitability*

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BACKGROUND & AIM: Timed Up and Go test (TUG) is a clinical tool widely used to evaluate balance and mobility. Given that planning a reasonable walking path outbound is critical to efficiently turning around a cone, leading to the quick completion of the task, performing the TUG test inherently involves anticipatory locomotor adjustments. To strengthen this nature of the TUG, we created a modified version of the TUG, called "Obs.-TUG," in which an additional pole obstacle was located beside the cone. With this task, participants are requested to decide which of two possible routes--passing through an aperture between the obstacles or taking a detour--is better for quickly completing the task. We investigated whether older adults would be able to choose a suitable route in response to the width of an aperture (i.e., the wider an aperture is, the quicker individuals can complete the task when choosing to pass through an aperture). METHODS: Thirty-eight older adults (75.0 ± 6.4 years) and twenty-five younger adults (25.2 ± 4.8 years) participated. Two poles 1 m tall were used to create an aperture (i.e., a cone was replaced with the pole). There were four aperture widths: 0.9, 1.05, 1.2, and 1.35 times the participant's shoulder width. Participants performed the Obs.-TUG test under two conditions: free choice and forced choice. For the free-choice condition, participants were requested to choose the route that they believed would enable them to most quickly complete the task. For the forced-choice condition, they were instructed which route they were to select. When completing the Obs.-TUG task under the forced-choice condition, participants' times when passing through an aperture and when taking a detour were compared to determine which route was most suitable for meeting the task goal for each aperture-width condition. Three-dimensional motion analyses were also conducted to describe the differences in locomotor patterns between older and younger participants. RESULTS AND CONCLUSION: Older participants chose taking a detour significantly more frequently than younger participants in the free-choice condition. Comparisons of the time taken to complete the Obs.-TUG task under the forced-choice condition showed that, for wider apertures (1.2, 1.35 times), the time to complete the task was significantly faster when passing through an aperture than when taking a detour. These results suggest that older adults preferred choosing to take a detour to passing through an aperture, even when it would not make completing the task faster. Three-dimensional motion analyses showed that (a) the magnitude of the decrease in movement speed before taking a turn is significantly lower in older participants and (b) the number of steps with which the shortened step length for taking a turn was recovered to the normal step length was greater in older participants. These findings suggest that older participants are likely to select the route with the lower demand for locomotor adaptability, rather than the more suitable route in terms of the task goal.

O.5 – Clinical I

O.5.1: *Gait analysis in hereditary spastic paraplegia type 4 reveals characteristic, progressively increasing abnormalities in prodromal and early manifest stages of the disease*

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BACKGROUND AND AIM: It is well-known from many neurodegenerative movement disorders, that subtle movement changes often occur years before clinical manifestation. The effectiveness of future interventions and their evaluation will, on the one hand, largely depend on detecting and quantifying these diseases as early as possible, and on the other hand on a more detailed understanding of dysfunctional motor control mechanisms within the prodromal stage. In this study we wanted to identify and quantitatively describe potential gait changes in mutation-carriers of hereditary spastic paraplegia type 4 (SPG4), before spastic gait has been manifested and clinical signs of spasticity have been evolved. METHODS: 71 subjects participated in quantitative gait assessment, including 30 prodromal mutation carriers of SPG4, 18 patients with manifest SPG4, and 23 healthy non-mutation carriers. Prodromal mutation carriers were categorized by not showing spastic gait characteristics in blinded video analyses by movement disorder specialists. Gait was assessed in a motion-capture laboratory by a marker-based infrared camera system (VICON). We analyzed discrete gait features like ranges of motion as well as continuous angle trajectories. Gait measures were correlated with a clinical rating scale (Spastic Paraplegia Rating Scale, SPRS) and a fluid biomarker of neurodegeneration (neurofilament light chain, NfL). RESULTS: In comparison to non-mutation carriers, we found significant gait changes in prodromal SPG4 mutation carriers during the swing phase in segmental angles of the lower leg ($p<0.05$) and foot ($p<0.01$), and in heel ground clearance ($p<0.01$). Furthermore, the range of motion of segmental angles was reduced significantly for the foot and lower leg. The identified gait changes in the prodromal stage showed a gradual expression compared to patients in the early manifest stage. Most interestingly, several gait changes already have been identified in SPG4 mutation carriers without any clinical signs of pyramidal affection (determined by the clinical rating scale SPRS). In this very early stage, more general gait features like step length or gait speed showed no changes. Furthermore, the identified gait features of the prodromal SPG4 group did correlate with the fluid biomarker (NfL). This observation gives evidence for a relationship of first subtle gait changes and processes of neurodegeneration in the CNS measured by the NFL biomarker in the early, prodromal stage of the disease. CONCLUSIONS: In this study, we quantified gait changes in prodromal and manifest SPG4 mutation carriers. Objectively measured gait features constitute promising motor biomarkers characterizing the subclinical development of spastic gait and might help to evaluate therapeutic interventions in SPG4 even in the prodromal stage of disease.

O.5.2: ***Stochastic resonance stimulation enables children with cerebral palsy to upweight proprioception for improving balance control during visually perturbed walking***

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BACKGROUND AND AIM: Children with cerebral palsy (CP) tend to rely on vision over other sensory modes to control their balance in standing and during single plane lower limb motion. While children with typical development (TD) can reweight sensory inputs from visual and proprioceptive sources, i.e., reduce the reliance on vision when subject to visual perturbations and on tactile input when subject to perturbations of the contact surface, it is not known, if children with CP will be able to upweight proprioceptive feedback and show reduced reliance on vision if their proprioception is augmented. A promising technique to upweight proprioception is the use of Stochastic Resonance (SR) stimulation, which uses random, sub-sensory, electrical noise to improve the sensitivity of sensory receptors to differentiate weak signals. The aim of this study is to investigate if SR stimulation can upweight proprioception and reduce reliance on vision during visually perturbed walking in children with CP and TD. METHODS: Twenty-two children (11 CP, 11 age-and sex-matched TD) between 8-24 years of age were recruited. SR stimulation was applied to the muscles and ligaments of ankle and hip joint via an electrical signal generated by custom software driving Biopac stimulators. An optimal SR intensity during walking was determined for each subject. Subjects walked on a self-paced treadmill in a virtual reality environment that induced a visual fall stimulus in the frontal plane once every 10-12 steps. Participants completed three trials of two minutes each using a random order of SR stimulation (SR) and no stimulation (noSR) control conditions. We performed two-way mixed ANOVAs with group (CP, TD) as between-subject and condition (noSR, SR) as within-subject factors. Our primary outcome measure was medial-lateral center of mass (COM) excursion. We hypothesized that COM M-L excursion in response to the visual perturbations would be smaller in trials with SR

stimulation vs. noSR trials. RESULTS: Our results showed a significant group by condition interaction (p=0.009). Post-hoc tests (Figure1) revealed that there was a significant improvement in the CP group with SR compared to noSR condition (p=0.002). No significant differences were found for the TD group between noSR and SR conditions (p=0.583). Also, there was a significant difference between CP and TD without SR stimulation i.e., between noSR CP vs noSR TD (p=0.004); and no significant difference with SR stimulation i.e., between SR CP and SR TD (p=0.922), implying that CP group responded with a COM excursion similar to that of TD group with SR. CONCLUSION: Our findings indicate that children with CP may be able to upweight proprioceptive input and reduce reliance on visual input through SR stimulation. Because higher visual dependence is associated with higher fall risk, we expect reduced reliance on vision to translate to enhanced balance and reduced fall risk during walking. ACKNOWLEDGEMENTS/FUNDING: This study has been funded through the Unidel Distinguished Scholars Fellowship.

O.5.3: ***Regional modulation of the ankle plantarflexors is attenuated following concussion***

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BACKGROUND AND AIM: Balance deficiencies are one of the most reported physical symptoms following a concussion. In a previous study, we observed that healthy participants responded to external perturbations during standing balance by regionally modulating the activity of their ankle plantarflexors. The findings suggested that the central nervous system activates motor units within different regions of the ankle plantarflexors in accordance with the force requirements of perturbations in different directions. The purpose of the present study was to examine whether concussion affects this regional modulation. METHODS: Fourteen participants (7 patients with a concussion (return to play stage 3, aged 23 ± 6.9 years) and 7 age- and sex-matched healthy controls) participated. Participants stood on their right leg and experienced five perturbations in each of the five perturbation directions. Perturbations were induced by applying external loads standardized to 1% of body mass into a cable-pulley system. High-density surface electromyography (HD-sEMG) was used to determine the amplitude and barycenter of the muscle activation. The barycenter, defined as the weighted mean of the maximal root mean square across the 7 columns and 7 rows, was used to evaluate the medio-lateral (X) and proximo-distal (Y) shifts of muscle activity within the three plantarflexor muscles. Measurements of joint kinematics and movement of the center of mass and center of pressure were taken. RESULTS: In the healthy controls, the HD-sEMG amplitude of the medial gastrocnemius (MG) and lateral gastrocnemius (LG) modulated with the perturbation directions (MG and LG $p < 0.01$, partial $\eta 2 > 0.500$; one-way repeated-measures ANOVAs), however, participants with a concussion did not modulate the amplitude of their plantarflexor muscles with perturbation direction ($p > 0.05$). The barycenters in the LG and the soleus was also modulated across the perturbation directions for healthy controls (LG: $p < 0.01$, partial $\eta 2 = 0.767$ for X coordinates; soleus: $p < 0.01$, partial $\eta 2 = 0.913$ for X&Y coordinates; one-way repeated-measures ANOVAs). No significant modulation of the barycenters of all three muscles was observed in participants with concussion ($p > 0.05$) with the magnitude of the barycenter shift being significantly lower in the concussion group compared to healthy controls ($p < 0.05$, Cohen's $d > 1.2$; one-way ANOVA). The relative contribution of MG activation compared to the total gastrocnemii activation was significantly lower in participants with concussion ($p < 0.05$, Cohen's $d = 0.85$; one-way ANOVA). Finally, in response to perturbations, the joint angle changes were smaller in the concussion group compared to healthy controls, suggesting a stiffer postural response. CONCLUSIONS: The findings suggest that the regional modulation of EMG activity is attenuated following concussion at return to play stage 3, and concussion patients may be at risk to meet the demands required for balance during perturbation tasks. ACKNOWLEDGEMENTS AND FUNDING: This study was supported by the Natural Sciences and Engineering Research Council.

O.5.4: *Gait in Sensory Challenging Conditions in Young Adults with Autism Spectrum Disorders*

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BACKGROUND AND AIM: Autism Spectrum Disorders (ASD), typically diagnosed based on challenges in social communication and interaction and restricted and/or repetitive behaviors, are also often accompanied with altered neuro-sensorimotor function in multiple domains including postural control [1]. Focusing on gait, a recent meta-analysis identified an association between ASD and gait patterns characterized by a wider step width, slower walking speed, longer gait cycle including stance and step duration, and increased gait variability [2]. Our understanding of the potential mechanisms contributing to these differences in gait kinematics between individuals with ASD and individuals who are neurotypical is limited. Given ASD-related challenges in multisensory integration processes relevant for balance [3, 4], the aim of this study was to determine if sensory challenging conditions further alter gait kinematics in young adults with ASD. METHODS:Twenty-one (N=21, 14 male) adults diagnosed with ASD and twenty-one (N=21) age- and gender-matched adults who are neurotypical participated in this study, ranging in age from 19 to 39 years old. A full factorial experimental design consisting of 12 walking conditions was used, including various combinations of information processing tasks, lighting and flooring conditions. Only findings related to the lighting (623 lux / 3 lux) and flooring (hard / carpeted) conditions are presented here. Participants were instrumented with motion capture markers (Vicon Motion Systems, Oxford, UK) and an accelerometer (Delsys Inc, Boston, MA). Full factorial mixed models were used in the analyses, with dependent measures consisting of average spatiotemporal gait patterns and gait variability measures. Statistical significance was set at 0.05. RESULTS:The analyses revealed a statistically significant impact of flooring/lighting on gait speed ($F(3,119)=5.5$, $p=0.0014$), average step length ($F(3,122)=17.5$, $p=0<0.0001$), average stance duration ($F(3,120)=36.6$, $p<0.0001$) and average step width ($F(3,120)=4.1$, $p=0.009$). Interestingly, an interaction effect of group x flooring/lighting on step length variability ($F(3,117)=3.6$, $p=0.015$) suggests that participants with ASD walked with greater step length variability on carpet compared to hard floor ($p<0.005$) in both lighting conditions, whereas flooring and lighting conditions did not significantly impact step

length variability for neurotypical participants (p>0.1). CONCLUSIONS: Altered somatosensory information during walking (carpet vs. hard floor) increased step length variability to a greater extent in young adults with ASD than in neurotypical participants. This suggests that there may be a difference in sensory integration for balance during locomotion in young adults with ASD. References: [1] APA, Diagnostic and statistical manual of mental disorders, 5th ed., 2013. [2] JAG Lum, Autism Res, 14: 733-47, 2021. [3] R Cham, Exp Brain Res, 239:1417-26, 2021. [4] NJ Minshew, Neurology, 63:2056-61, 2004. ACKNOWLEDGEMENTS AND FUNDING: NIH R21 HD079254.

O.5.5: ***Antagonistic muscle activity during reactive balance control is increased in children with spastic CP.***

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BACKGROUND AND AIM Balance impairments are common in children with spastic cerebral palsy (CP) [1] but we know little about how CP affects sensorimotor transformations, i.e. the relation between incoming sensory information and motor commands, underlying balance control. When standing balance is perturbed by support-surface translations, muscle activity in healthy individuals can be explained by delayed linear feedback of center of mass (COM) kinematics [2]. It was recently demonstrated that in Parkinson's disease, COM feedback was preserved in agonistic muscles, but increased in antagonistic muscles, likely contributing to balance impairments [3]. Here, we investigated whether a similar mechanism - unaltered feedback pathways but altered sensitivities - underlies altered reactive balance control in children with spastic CP. METHODS Our preliminary analysis includes data from 4 (out of 20) typically developing (TD) children and 6 (out of 20) children with CP. Standing balance was perturbed by backward support-surface translations that varied in magnitude (6 levels of 8 trials, Fig 1a). Perturbations were applied with unpredictable timing, where the magnitude was increased after eight trials if the participant did not take a step. Electromyography (EMG) of gastrocnemius medialis (GM) and tibialis anterior (TA) muscles was collected. COM kinematics were estimated from marker trajectories. Inspired by previous work [2,3], we reconstructed muscle activity by a weighted sum (positive part only) of anterior-posterior COM displacement, velocity, acceleration, and initial acceleration (i.e. truncated acceleration signal) occurring 100ms earlier. For the antagonistic TA muscle, we included both a weighted sum of COM kinematics and inverted COM kinematics to capture its roles as both an agonist (later part of the response, platform deceleration) and antagonist (first part of the response, platform acceleration). We computed feedback gains (or weights) by minimizing the error between recorded and reconstructed EMG signals. RESULTS EMG was fit to delayed COM kinematics in TD children and children with CP with a VAF ranging from 57.33% to 91.6%, and a mean of 76.1%. Feedback gains of both agonists and antagonists tended to be higher in children with CP than in TD children (Fig. 1b and c). CONCLUSIONS Our preliminary results suggest altered sensitivities of sensorimotor feedback transformation in children with CP as compared to TD children. Postural responses in both agonist muscle, which was stretched by the perturbation, and in the antagonist muscle were higher in children with CP. Similarly, passive joint rotations in clinical tests of spasticity also elicit increased and prolonged muscle activity in children with CP compared to TD children [4]. It is yet unclear whether a common mechanism underlies the altered response to passive stretches and stretches during standing, which we will explore in the current dataset. ACKNOWLEDGMENTS AND FUNDING Research Foundation - Flanders supported this work through fellowship 1192320N REFERENCES [1] Pavao et al. (2012), Research in developmental disabilities. - [2] Welch and Ting, (2008), Journal of neurophysiology. - [3] McKay et al., (2021), Plos one. - [4] Bar-On et al. (2013), Gait and posture.

O.5.6: *Perceiving virtual human emotional gait is task specific for individuals following moderate-to-severe TBI*

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BACKGROUND: The ability to read emotional expression is fundamental for successful community navigation and social interaction. While some studies using virtual reality (VR) include emotion through body movements, none have yet examined emotions while engaged in a locomotor task to avoid obstacles. An inability to recognize emotions is often seen following moderate to severe traumatic brain injury (m/sTBI) and can create additional challenges during a collision avoidance task and affect social participation. AIM: This study aims to examine changes in avoidance strategies following m/sTBI when interacting with a pedestrian expressing emotions. METHODS: To date, twenty healthy (30±3.61yrs) and five m/sTBI (44.4±18.34yrs) participants were immersed in a virtual environment in which they were instructed to enter a subway station and avoid any collisions with an approaching virtual pedestrian (VRP). The VRP expressed one of four possible emotions through whole-body movement only: neutral, angry, happy, or sad. Automatic sliding doors initially occluded the VRP, who approached from either directly in front of the participant or from ±40° to either side of straight ahead. The VRP crossed the participant's path at a theoretical point of collision. The task was completed as both a locomotor task and a standing perceptual task using a joystick to respond. Dependant variables included minimum clearance distance (m), interpersonal distance (IPD, m) at onset of trajectory deviation, and average walking velocity (m.s-1). RESULTS: Both groups perceived angry and sad emotions similarly during standing. When walking, clearance distance was overall greater for the TBI group (0.86±0.19m) compared to the healthy group (0.80±0.13m), but there were no observed effects of pedestrian emotion. There was a trend for an effect of emotion on the IPD for the healthy group (neutral: 3.71±1.01m; angry: 4.60±1.50m; happy: 3.70±1.02m; sad: 2.94±0.61m), while the TBI group showed an overall smaller IPD but no effect of emotion (neutral: 2.91±0.59m; angry: 3.60±1.35m; happy: 3.19±0.82m; sad: 2.56±0.55m). In addition, the healthy group had a smaller range of velocity (0.97±0.22 m.s-1) and overall had faster walking speeds (1.33±0.18 m.s-1) than the TBI group (respectively 0.46±0.26 m.s-1 and 1.06±0.15 m.s-1). However, no effect of emotion was observed on the minimum, average, or maximum velocity for either group. CONCLUSIONS: The fact that clearance distance was unaffected by pedestrian emotion suggests it is primarily a function of the task's physical demands and the

capabilities of the person. IPD was affected by emotion for the healthy group, and not the TBI group despite their ability to perceive emotions. This suggests that the physical demands of the task took precedent over emotion perception for this population known to also have residual locomotor deficits even after good recovery. ACKNOWLEDGEMENTS AND FUNDING: This research in collaboration with Association Québécoise des Traumatisés Crâniens was funded by the Quebec Rehabilitation Research Network (REPAR), Inclusive Society, and Mitacs (in collaboration with BeamMeUp, and Saccade Analytics).

O.6 – Neural II

O.6.1: ***A data-driven, dynamical approach to identify individual-specific signatures of healthy and impaired gait***

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BACKGROUND AND AIM: Gait is a complex motor behavior that involves dynamic interactions across multiple joints and complex inter-limb, and inter-joint coordination. Motor dysfunction adds another layer of complexity to dynamic control of gait as by the wide range of post-stroke gait impairments. Here we use machine learning to discover individual differences in gait dynamics, i.e. how kinematics and interdependencies of multiple joints evolve from one gait cycle phase to the next. We hypothesize that a dynamical model of gait will allow a robust, interpretable individual-specific understanding of gait impairment regardless of an individual's gait speed. We predicted that a data-driven, dynamical model of gait can parse individual-specific characteristics or 'gait signatures', and allow comparisons between individuals' gait despite differences in their walking speed. METHODS: Using 3-D motion capture, we collected continuous, bilateral, lower limb, sagittal plane joint angles (hip, knee, and ankle) from able-bodied (AB) (N=5) and post-stroke (N=7, > 6 months after stroke onset) participants who walked on a treadmill at six speeds. Kinematic data from all individuals served as inputs to a recurrent neural network model trained to predict a one-step time-shifted version of the kinematic input data. Internal activations for all individuals' gaits were extracted from the trained model, and reduced in dimension using principal components (PC) analysis. The weights on the PCs were phase averaged over the gait cycles at each speed. The resulting characterization was coined the 'gait signature,' a low-dimensional, representation of the parameters of a data-driven gait dynamics model that gives rise to an individual's unique kinematic patterns. Gait signatures were visualized as 3-dimensional (3-D) loops and compared using the 6-dimensional distances between gait signatures and the able-bodied gait signature centroid; these differences were visualized on a 2-dimensional (2-D) (dots) map using multidimensional scaling. RESULTS: Able-bodied individuals had similar but distinguishable, gait signature shapes (loops), but those of stroke survivors were much more variable. A 2-D gait map revealed that higher-functioning stroke survivors (preferred speed > 0.40 m/s) had similar gait dynamics to AB. Conversely, lower-functioning stroke survivors (preferred speed < 0.4 m/s) were most distant and less clustered, indicating more heterogeneity in gait dynamics. Further, gait signatures were speed-independent; gait signatures belonging to a single individual appear to all cluster together, rather than clustering with other individuals' gait signatures at similar gait speeds. Further, gait signatures can be decomposed into subcomponents of multi-joint coordination that identify how specific inter-limb or inter-joint coordination patterns are expressed in individuals. CONCLUSIONS: Gait signatures capture individual-specific gait differences irrespective of walking speed. Gait signatures use kinematic information (no kinetics) to identify differences in gait dynamics and are generative (future kinematics can be predicted) in nature. Gait signatures may enable more holistic and objective metrics for assessing gait dysfunction and personalizing rehabilitation.

O.6.2: *Vestibular-driven responses in the proximal upper limb during arm-supported balance control*

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BACKGROUND AND AIM: To produce appropriate balance adjustments to a vestibular perturbation, the central nervous system must integrate and process vestibular cues with other sensorimotor signals related to head-on-feet body orientation. When supporting posture with an upper limb, in addition to the feet, the direction of the vestibular-evoked balance response is a composite of the forces acting at the feet and upper limb. Further, the upper limbs are often used to support upright posture during many scenarios (e.g., using a cane, crutches, or railing). However, limited data are available on the vestibular control of balance during arm-supported postures. Thus, the purpose of this study was to characterize the vestibular-evoked balance response in the proximal upper limb in comparison to the lower limb during various head-on-feet postures. METHODS: Seventeen right-hand dominant participants, including seven females (22.4±2.8 years) and ten males (28.9±6.96 years), were exposed to binaural, bipolar stochastic (0-25 Hz; root mean square = 1 mA) electrical vestibular stimulation (EVS) while holding an earth-fixed handle with the right hand and vision occluded. All participants performed 100-s trials of three different head yaw postures: head facing over the left shoulder, anatomical, and head facing over the right shoulder. The relationship between the EVS signal and the rectified, electromyography (EMG) of the left (LMG) and right (RMG) medial gastrocnemius as well as the triceps brachii (TB) were estimated using the medium-latency peak amplitude of the cumulant density function. RESULTS: When rotating the head from a left (RMG: -0.035±0.019; LMG: -0.024±0.016) to a right (RMG: 0.018±0.019; LMG: 0.047±0.024) yaw posture, the EVS-EMG medium-latency peak amplitude for the gastrocnemii reversed polarity ($p<0.05$). The EVS-TB EMG medium-latency peak amplitude exhibited a similar finding when facing over the left (-0.052±0.036) compared to the right (0.012±0.031) shoulder ($p<0.05$). With the head in an anatomical posture, the EVS-LMG EMG medium-latency peak amplitude (0.036±0.021) was reversed compared with facing leftward ($p<0.05$), but there was no difference for the EVS-RMG (-0.031±0.014) and EVS-TB EMG (anatomical: -0.057±0.029) medium-latency peak amplitude ($p>0.05$). However, when comparing the anatomical head posture to facing rightward, there was no difference between the polarity of the EVS-LMG EMG medium-latency peak

amplitude ($p>0.05$), but the EVS-RMG and EVS-TB EMG medium-latency peak amplitudes were reversed ($p<0.05$). CONCLUSIONS: Our results indicate that vestibular-driven balance responses in the proximal upper limb are dependent upon head yaw posture during arm-supported whole-body balance control. Thus, the contribution of the upper limbs to the vestibular control of balance should be considered when performing tasks involving assistive devices for maintaining balance.

O.6.3: ***How Humans Adapt Stepping to Perform Lateral Maneuvers***

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BACKGROUND & AIM: Humans often perform maneuvers when traversing their environments to avoid obstacles or navigate complex terrain. Humans readily accomplish these tasks primarily by modulating their foot placement (Bruijn & van Dieën, 2018). We have previously developed a lateral stepping regulation framework that describes how humans regulate stepping movements from step-to-step during steady-state walking. This framework proposes goal functions that theoretically define the walking task and determines the possible task solutions as a Goal Equivalent Manifold (GEM). During steady-state walking, humans multi-objectively regulate primarily step width (w) and secondarily lateral body position (zB), and they enact this regulation via their left (zL) and right (zR) foot placements (Dingwell & Cusumano, 2019). Here, we re-examined the stepping requirements of lateral maneuvers in the context of this framework to make predictions as to how humans regulate their lateral stepping during non-steady-state lateral maneuvers. METHODS: 20 young healthy adults each performed 4 lateral lane-change maneuvers between two parallel paths centered 0.6m apart. Step-to-step time series of zL, zR, zB, and w were obtained from motion capture data. At each step of the lateral maneuver, foot placements were plotted in the [zL,zR] plane alongside the predicted zB and w GEMs from our theoretical framework. We fit variability ellipses to these stepping data and quantified their locations and geometric properties to determine the stepping goals and variance structure, respectively, at each step. We compared these empirical ellipse characteristics to those predicted by our stepping regulation model. RESULTS: Participants took approximately 3-4 non-steady-state steps to complete the lateral maneuver: a small preparatory step, a large transition step, and a small recovery step. The centers of the fitted ellipses corresponding to each of these intermediate steps were qualitatively consistent with our predicted stepping goals. Also consistent with our model predictions, the ellipses were more isotropic at the preparatory and transition step, indicating a trade-off in w for zB regulation from step to step. The areas of the stepping ellipses also increased at the preparatory, transition, and recovery steps. CONCLUSIONS: The lateral maneuver assessed here was relatively abrupt and thus among the more challenging of those humans are likely to experience during real-world walking. Therefore, the success of our stepping regulation framework to predict human stepping during this maneuver implies that this framework extends to a wide range of walking tasks beyond straight-ahead steady-state walking. In addition, in demonstrating the trade-off in w for zB regulation, our framework provides the first coherent, predictive, theoretical model of the

"stability-maneuverability trade-off" proposed in the literature (i.e., Acasio et al., 2017). FUNDING: NIH R01-AG049735 & R21-AG053470

O.6.4: ***Ankle exoskeleton torque improves reactive standing balance capacity if delivered before physiological response***

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BACKGROUND & AIM: Lower limb exoskeletons are typically designed to enhance walking performance, however their potential to improve user balance has not been well tested. Exoskeleton control approaches that intend to augment complex movements often rely on myoelectric input, as it is an indirect measure of user intention. However, in reactive standing balance control, muscle activity is not elicited until about 100ms after support-surface perturbation onset, with joint torques rising at about 150ms. Here we use two assistance timings to test whether ankle plantar flexion augmentation can improve reactive balance capacity in backward support-surface perturbations. The first timing provided plantarflexion torque immediately after perturbation detection. The second timing was delayed to emulate that of a myoelectric controller from plantarflexor muscles. We hypothesized that assistive plantarflexion torque produced both prior and simultaneously to the physiological reactive balance response would improve balance capacity compared to no assistance. We assessed balance capacity by measuring step thresholds, the perturbation level at which a person is unable to maintain standing balance 50% of the time. METHODS: Ten healthy adults (26 ± 2 yrs) wore ankle exoskeletons (Dephy ExoBoot, Dephy Inc.) and were instructed to maintain standing balance during backward support-surface perturbations. An accelerometer on the exoskeleton detected perturbation onset in ~20ms, after which the exoskeleton was commanded to either provide plantarflexion assistance (peak torque of 30 Nm with a 50ms rise time, followed by a decline to 0 Nm over 150ms) immediately (Fast), after an additional 100ms delay (Slow), or to provide no assistance (Off). At least 25 trials were completed for each condition for each participant, and all trial conditions were randomized. The perturbation magnitude - the travel distance of the platform - of each trial was set by an adaptive algorithm to iteratively estimate the participant's step threshold. Platform velocity and acceleration were scaled such that each perturbation lasted 500ms. To evaluate the effect of exoskeleton condition on step threshold, we used a linear mixed model with conditions as a fixed discrete effect and participant as a random effect. RESULTS: Step thresholds were on average 8.5% higher in the Fast condition (25 ± 2cm) compared to the Off condition (23 ± 2cm, $p < 0.001$). Interestingly, the Slow condition did not change step threshold compared to the Off condition (Slow, 23 ± 2cm, $p = 0.18$). CONCLUSION: If controlled fast enough, exoskeletons can improve user reactive balance capacity. Myoelectric feedback controllers may not improve reactive balance capacity compared to a mechanical feedback controller due to longer delay time. These data suggest that exoskeletons could aid balance in older adults with slower postural responses and plantarflexor torque generation. ACKNOWLEDGEMENTS & FUNDING: NIH R01 HD46922-10 (PI Ting)

O.6.5: *Visual-vestibular integration in Parkinson's disease gait*

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Background and Aim: Postural instability and gait disorders are debilitating symptoms of Parkinson's disease (PD) that respond poorly to current treatments. It has been suggested that these symptoms are caused in part by sensory integration deficits. PD has been shown to have decreased proprioception and an overreliance on vision but less is known about vestibular function. We aim to understand visual-vestibular integration in PD during steady-state gait. Methods: We tested 13 PD subjects, 13 age-matched older adults (OA), and 15 young adults (YA). We manipulated visual-vestibular information using virtual reality and galvanic vestibular stimulation. Subjects were asked to maintain straight-line walking while navigating in a virtual environment. The virtual environment shifted 20 degrees left or right as the subject progressed through the room, causing them to veer from midline to the side of the visual shift. Vestibular stimulation was applied at 2x individual thresholds, causing subjects to veer to the side of the anode. Veering from midline was measured using the absolute value of the resultant mediolateral endpoint of each trial. A general linear mixed model was used to assess the effects of Group (PD vs. OA vs. YA), Condition (visual vs. vestibular vs. visual-vestibular) and Direction (left shift, no shift, right shift). Results: There was a significant effect of Group ($p < 0.01$). PD subjects showed the most veering across all conditions. There was a significant effect of Condition ($p < 0.01$), where vision had the largest and vestibular had the smallest effect. There was effect of Direction ($p < 0.01$), with conflicting left vestibular and right visual shifts inducing the greatest response. Finally, there was a Group * Condition * Direction interaction. All groups differed in the left vestibular condition, where PD showed the most veering and young adults had the least. Conclusions: When both visual and vestibular information were available and conflicting, all groups relied mainly on vision. PD subjects did not over rely on vision more than older adults. In the vestibular condition, age and disease-dependent responses appeared. Overall, we demonstrated that PD subjects do not optimally reweigh vestibular information indicating a sensory integration deficit that may underlie gait symptoms. Acknowledgements and Funding: Graduate Student Scholarship, Parkinson Canada

O.6.6: *Contextual gait analysis: Developing an environment classification tool*

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BACKGROUND AND AIM: Contemporary gait analysis utilizes inertial wearables, with quantification beyond the lab important [1]. Yet, there is a need to understand impact of environmental (e.g., location and terrain type) on gait. Approaches to contextualise environment use cameras and a researcher manually sifting through hours of data, labelling videos by tagging location and terrain. Automated approaches use artificial intelligence (AI)

with a recent example using data from a waist mounted camera [2]. However, gathering sufficient videos to build robust ground truth datasets for good AI accuracies challenging due to e.g., habitual deployment of cameras. The aim here is to develop a web-based tool with ground truth data to enable automated classification, providing a research tool to analyse video automatically and efficiently. METHODS: Video sharing websites (e.g., YouTube) were mined for video data of different environments. A novel comprehensive first-person view dataset was created from scenes such as drone flythroughs of residential properties and GoPro-based city tours. Mined videos where segmented into frames and manually categorised (e.g., location: indoor, outdoor and terrain: wood, tiled, etc). This dataset was further segmented into tailored datasets for the individual classifiers involved (e.g., floor visible indoor, terrain type outdoor). Upon dataset creation a series of chained AI-based convolutional neural networks utilising the InceptionV3 architecture automatically classified location and terrain (3 terrains indoor, 7 terrains outdoor). For classifier validation, separate datasets were created and held back from the model during the training process for testing on unseen environments. RESULTS: Currently, the dataset is 146,624 video images spanning the overall model (environment: 79,251, floor visible: 28,347, terrain: 39,026). When trained, all classifiers achieved validation accuracies of >=90% (environment: 98%, floor visible indoor: 90%, floor visible outdoor: 96%, terrain indoor: 90%, terrain outdoor: 93%). CONCLUSIONS: Development of the AI-based tool is ongoing and will be openly available to automate contextual analysis. The tool is developed from a novel rich/diverse dataset that provides robust ground truth data to classify new videos, providing an effective method of classifying location and terrain. Ongoing work involves refining the AI process and providing more context by gathering representative data from primary sources accounting for variations in lighting conditions and image quality. ACKNOWLEDGEMENTS AND FUNDING: This research is co-funded by a grant from the National Institute of Health Research (NIHR) Applied Research Collaboration (ARC) North East and North Cumbria (NENC). This research is also co-funded by Northumbria University Engineering and Environment Faculty. REFERENCES [1] Del Din, et al, "Free-living gait characteristics in ageing and Parkinson's disease: impact of environment and ambulatory bout length," JNER, 2016. [2] Nouredanesh, et al, "Fall risk assessment in the wild: A critical examination of wearable sensor use in free-living conditions," G&P, 2021.

O.7 – Clinical II

O.7.1: ***Impaired neuromuscular control of reactive stepping in people with chronic stroke***

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Background and aim: In the chronic phase, people with stroke (PWS) often show impaired reactive balance control. In feet-in-place responses to perturbations, impairments in coordination were found to be direction specific, and related to poor stability. To prevent falling following larger perturbations, stepping responses are crucial. Reactive stepping capacity is even more impaired in PWS than feet-in-place balance recovery, but underlying mechanisms remain elusive. Here, we aimed to identify deficits in the neuromuscular control of stepping in people in the chronic phase after stroke using muscle synergy analysis. Methods: Fourteen PWS and 14 age-ranged healthy controls (HC) performed reactive steps in response to platform perturbations. Perturbations consisted of forward, 45°forward, lateral, 45°backward and backward translations of the support surface. Participants in the PWS group were instructed to step with their paretic leg and were compared to right leg steps of HC. We collected kinematic data and bilateral surface EMG from eight muscles: erector spinae, gluteus medius, biceps femoris, semitendinosis, soleus, rectus femoris, peroneus longus and tibialis anterior. EMG was rectified, time-warped from perturbation onset until foot strike and normalized to unit variance. Muscle synergies were extracted per leg using nonnegative matrix factorization We used Pearson's correlation coefficients (r) to determine presence (r>0.5) and structure of synergies in PWS compared to HC. We used sample-wise Mann-Whitney U Tests to compare activation coefficients between groups for each synergy and perturbation direction. Stepping performance was defined by the angle of the leg with the vertical at foot contact and compared between groups with a repeated-measures ANOVA. Results: The median number of synergies recruited in either group was 5 (range 3-5), with 85% and 84% variance accounted for (respectively, HC and PWS groups). The presence and structure of 4/5 synergies (W1, W3-5) were similar between groups(r>.80). The remaining synergy (W2, predominantly consisting of peroneus and gluteus) was less present (9/14) and structure-wise less consistent (r=0.73) in the PWS group. All synergies showed differences between groups in activation coefficients, in particular for lateral, 45°backward, and backward directions. Shortly after perturbation and prior to step initiation, PWS exhibited lower recruitment of W3 and W5 (mainly involving tibialis anterior and rectus femoris). Around step initiation, lower recruitment of W4 (semitendinosus and biceps femoris), was concurrent with excessive recruitment of W3. Followed by a lower recruitment of W1 (peroneus and soleus) and W2 during the paretic step. Stepping leg angles were smaller (i.e. worse) in PWS than HC. Conclusion: We identified stroke-related deficits in muscle coordination of paretic stepping that may underlie impaired balance control in backward and lateral directions. The pathological co-occurrence of W3 over-activation and W4 under-recruitment at step initiation may be related to impaired muscle selectivity. In addition, the defective structure and limited recruitment of W2 in PWS may suggest that cortical involvement and thus the effect of cortical lesions is most pronounced in this synergy.

O.7.2: ***What went wrong in the kinematics of the first reactive step in unsuccessful balance recovery resulted by unexpected balance loss in stroke survivors.***

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Background and Aims The proportion of falls leading to injury in people with stroke (PwS) is up to 69%. PwS who fall are twice as likely to sustain a hip fracture, mostly involving the affected side. A successful reactive balance response to a sudden loss of balance i.e., unexpected balance perturbation, is a critical factor that determines whether a fall occurs. Studies have documented characteristics of reactive stepping performances in PwS: initiating reactive step responses at lower levels of instability, taking multiple steps rather than a single step response and failure to recover equilibrium (i.e., fall). To our knowledge, prior studies did not investigate whether the kinematics of the initial balance recovery reaction (i.e., first reactive step) are different during unsuccessful recovery i.e., fall trials, compare to successful recovery trials during laboratory induced lateral falls in stroke survivors. Methods: The kinematics of 12 laboratory induced falls to a lateral destabilization of 12 stroke survivors were compared with 12 successful perturbation trials at the same perturbation magnitudes of the same participants. The participants were instructed to stand on a perturbation device that provided multi-directional surface translations and to "react naturally" to random time of onset and direction (right or left) surface translations that systematically increased from low to high magnitudes. Fall event was defined as: 1) the subject grasped the research assistant; 2) the participant caught by the research assistant before falling; 3) the safety harness stretched and the participant fell into the harness. During the falling trials, three-dimensional (3D) kinematic data were acquired. The following kinematic parameters (1) first recovery step initiation duration (ms); (2) first recovery step duration (ms); (3) first step length (cm); (4) CoM path displacement (cm), defined as the distance in cm of the CoM traveled from the initial point prior stepping to the end of first recovery step response. Results: The first recovery step initiation (i.e. foot lift-off the ground), and step length were similar between unsuccessful and successful recovery trials. However, CoM displacement during the first recovery step was significantly larger (see table 1). Swing phase duration and step duration of the first recovery step tended to be slower during the falling trials. Conclusion: Large CoM displacement during the first recovery step of fall events suggests that the participants were unable to control/decelerate the moving CoM over the base of support provided by the feet. This caused a longer reactive first swing phase and step duration and larger first step length, yet not significant, trying to prevent a fall unsuccessfully. This study suggests that training the lower limb muscle power capacity in situations that balance is lost in PwS should be an important purpose of rehabilitation.

O.7.3: ***Yaw, Pitch and Roll Plane Instability: Axis differences following acute Unilateral Vestibular Loss.***

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BACKGROUND: For a number of reasons, including ease of interpretation, clinical dynamic posturography concentrates on pitch and roll and not yaw plane measures. This emphasis may not, however, be representative of axis instability observed in clinical stance and gait tasks for heathy control (HC) subjects and patients with balance deficits, as well as differences between the 2 groups. To examine this question, we measured trunk sway in all 3 directions (pitch, roll and yaw) during stance and gait tasks for healthy controls (HC) and patients with acute unilateral vestibular neuritis (aUVN). METHODS: Results of 12 patients (mean age 61 years) recorded within 6 days of aUVN onset were compared within those of 8 age-matched healthy controls (HCs). All subjects performed a 2-legged stance task, standing eyes closed on foam (S2ecf), a semi-gait task - walking 8 tandem steps (tan), and 4 gait tasks - walking 3m with head rotating laterally, pitching, or eyes closed (w3hr, w3hp, w3ec), and walking over 4 barriers 24 cm high, spaced 1 m apart (barr). Task peak-to-peak yaw, pitch and roll angles and angular velocities were measured with a gyroscope-system (SwayStarTM) mounted at L1-3 and combined into 3, axis specific, balance control indexes (BCI) using angles (a) for tandem gait and barriers task and angular velocities (v) for all other tasks: ((2*s2ecf) + 1.5*(w3hr+w3hp+w3ec))v + (tan8+12*barr)a RESULTS: Yaw and pitch BCIs were significantly ($p \leq 0.004$) greater (88 and 30%, respectively) than roll BCIs for aUVN patients. For HCs only yaw but not pitch BCIs were greater ($p=0.002$) from those of roll (72%). Pitch and roll BCIs of HCs were approximately equal (12% difference). The order of BCI aUVL vs. HC differences was pitch, yaw, and roll: 55, 44 and 31%, respectively ($p \leq 0.002$). CONCLUSIONS: These results indicate greater yaw than pitch and roll trunk motion during clinical balance tasks is common to both aUVL patients and HCs. However aUVL leads to a larger increase in pitch than yaw plane instability and a lesser increase in roll plane instability This difference with respect to roll corresponds to the known greater yaw plane than roll plane asymmetry (40 vs 22%) following aUVN based on vestibular ocular reflex (VOR) responses. However the lower pitch plane asymmetry (3.5%) in VOR responses does not correspond with the pitch plane instability observed in balance control. Whether the directional specific recovery processes for balance control and VOR responses are similar remains to be investigated. The current results provide a strong rationale for clinical testing of directional specific balance responses, specifically concentrated on pitch and yaw.

O.7.4: ***Using parameters of error to quantify lower extremity motor performance after stroke***

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BACKGROUND AND AIMS: The lower-extremity motor coordination test (LEMOCOT) is a performance-based measure used to assess motor coordination deficits after stroke. In the test, performed while sitting, participants are instructed to move their lower extremity as fast and accurately as possible and alternately touch with their big toe a proximal and a distal target on the floor. The number of targets touched in 20 s constitutes the score. We aimed to explore whether performance parameters based on error analysis provide additional information regarding motor deficit that is not captured by the traditional LEMOCOT score in persons with stroke (PwS), and to assess the associations between these parameters and performance-based measures of lower-extremity impairments and mobility. METHODS: Twenty PwS (age: 62±11.8 years, time after stroke onset: 84±83 days; lower extremity Fugl-Meyer: 30.2±3.7) and 20 healthy controls (age: 42±15.8 years) performed the LEMOCOT on an electronic mat equipped with force sensors (Zebris FDM-T Treadmill, Zebris Medical GmbH, Germany). A dedicated algorithm and script were developed and used to analyze force data. We extracted the contact surface area, from which the endpoint location and the center of pressure (COP) location were computed. Also, the absolute and variable error were calculated. In addition, assessments of motor impairments and mobility (i.e., Fugl Meyer Assessment, Timed Up & Go test and 10 meter walk test) were conducted. RESULTS: PwS touched the targets with greater foot surface and demonstrated a greater distance between the endpoint location and the location of the COP. Greater absolute and variable errors of the endpoint were observed in the paretic leg than in the non-paretic leg and the legs of controls (Figure). Also, the COP variable error differentiated between the paretic, non-paretic, and control legs and this parameter was independent of the traditional score of in-target touch counts. Negative correlations with moderate effect size were found between the Fugl-Meyer assessment and the error parameters, while the Timed up & go and 10 meter walk tests demonstrated large negative associations with the traditional LEMOCOT score of in-target touches, but not with the parameters of error. CONCLUSIONS: PwS demonstrated lower performance in all outcome measures than did controls. Several parameters of error indicated differences between legs (paretic leg vs. non-paretic leg vs. controls) and were independent of in-target touch counts, suggesting they may reflect motor deficits that are not identified by the traditional LEMOCOT score. These parameters were also associated with the Fugl Meyer assessment which support their potential to capture even subtle changes of motor impairments of the paretic lower extremity over time or in response to training interventions.

O.7.5: ***Energetic cost of walking and gait parameters during the 6 minute walking test in persons with Multiple Sclerosis: preliminary data***

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BACKGROUND AND AIM: Persons with Multiple Sclerosis (pwMS) frequently experience gait impairments, often characterised by a decreased walking speed. In addition, increased levels of fatigue are reported which are related to the latter. A recent systematic review describing the relationship between walking speed and energetic cost of walking (Cw) reported that walking is energetically more costly for pwMS at any given speed compared to healthy subjects. Challenging gait paradigms, like the 6MWT, may be used to study the relationship between elevated Cw, fatigue and gait impairments. Therefore we aimed to assess whether the Cost of walking in pwMS changes over the course of a 6mwt and what changes in gait parameters and perceived fatigue are observed? METHODS: PwMS were included when aged between 18-65years, able to walk without walking aid and with an Expanded Disease Disability Scale (EDSS) <6. After measuring resting energy expenditure, all subjects performed a 6MWT on the instrumented treadmill of the Computer Assisted Rehabilitation ENvironment (CAREN) system (Motek, Amsterdam) while oxygen consumption and carbon dioxide production were measured continuously via indirect calorimetry (Omnical, Maastricht Instruments). Cost of walking was assessed over the last 4 minutes as steady state net Cw in Joules/kilogram bodyweight/meter minus resting energy expenditure (Net J·kg-1·m-1). During the walking trial, spatiotemporal parameters (i.e. walking speed, cadence, step length, step width) were collected and within subject difference per minute was assessed by repeated measures ANOVA and post-hoc pairwise comparisons between minutes. Perceived fatigue was rated by a 6-20 point Borg scale immediately before and after the 6MWT. RESULTS: Twenty-eight pwMS were included (mean age=45years; weight=76kg; height=169cm; EDSS=2.7). Total distance walked was 486 meters. The Cw differed between minute-3 and minute-6 with 0.65 J·kg-1·m-1 (F=6.640, p=.006) but increased throughout the test (Figure 1). Walking speed differed between minute-1 and minute-2 with 0.06m/s (F=6.615, p=.007) and cadence differed between minute-1 and minute-3 with 2 steps/minute (F=3.718, p=.047). Step- length and width remained steady over the course of the 6MWT. All subjects reported an increased perceived exertion with mean scores from 8 before and 12 after the 6MWT. CONCLUSIONS: The increased Cw could be related to the increased walking speed and cadence. This lag in Cw can be explained due to the delay in in the cardiopulmonary response which imposes that the Cw might not reflect the instantaneous energetic cost. The increased Cw and perceived fatigue could be explained by inefficient energy transfer between legs due to increased variability or altered muscle activation patterns. Additional biomechanical and muscle activation analyses for explaining the increased perceived fatigue and Cw could reveal gait impairments in pwMS.

O.7.6: ***Feasibility of gait and turning measures in daily life for fall prediction in people with MS***

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BACKGROUND AND AIM: Impaired balance is a common cause of falls in multiple sclerosis (MS). In people with MS (PwMS), most falls are known to occur inside the home during daily activity due to gait and turning dysfunction. Therefore, investigation of gait and turning impairments in the home environment is critical for early prediction and prevention of future falls. Body-worn inertial sensors may detect gait and turning dysfunction in PwMS earlier than conventional measures and hence have the potential for improving strategies for fall prevention. In this study, we aimed to investigate instrumented gait and turning measures during daily life in the home environment using a prospective study design to identify those at future risk of falls. METHODS: Passive monitoring of gait and turning during daily life was carried out in 26 PwMS using Mobility Life System (APDM Wearable Technology) (Shah VV et. al. 2021). Participants wore instrumented socks on each foot and one Opal inertial sensor over the lower lumbar area for at least 8 h/day for a week during daily life activities. The subjects removed the socks and the belt at night to recharge the batteries. Participants were followed for a year for any incidence of falls. PwMS were classified as fallers if they experienced >1 fall in the follow-up year. Independent t-test was used to compare the faller versus non-fallers group differences. In addition, the area under the receiver operating characteristic (ROC) curve (AUC) was computed for each gait and turning measure that discriminated fallers from non-fallers. Regression analysis was performed to identify the best prediction model for faller status. The strongest predictors (based on AUC) from the instrumented gait assessment were used to investigate the risk models. RESULTS: No significant differences were observed in the age, gender, EDSS, or disease duration between

faller and non-faller groups. The measures of gait and turning most discriminative in differentiating fallers from non-fallers in PwMS were found to be foot plantarflexion angle at toe-off, maximum foot plantarflexion, gait speed, and stride length (AUC>.80; p<0.05). Specifically, the fallers walked slower with smaller stride length, and with smaller pitch angle at initial contact, maximum pitch, and pitch at toe off-angle during walking when compared to non-fallers. When the outcome measures discriminative of fallers from non-fallers were entered in the prediction model, a stepwise regression yielded a significant model with R = .60 (p<0.05) consisting of one gait variable, foot plantarflexion at toe-off. CONCLUSIONS: Our cohort of MS subjects showed that smaller foot plantarflexion at toe-off, reflecting the strength of plantar-flexors to increase stride length and gait speed, predicted who experienced multiple falls in the next 12 months. ACKNOWLEDGEMENTS AND FUNDING: We thank our participants for generously donating their time to participate and Graham Harker for help with the data collection. This study was supported by the National Institutes of Health grants from National Institute on Aging (#R44AG055388 & #R43AG044863).

O.8 – Cognition

O.8.1: ***Express Visuomotor Responses in Hip Abductor Muscles: Evidence for an Intricate Relationship Between Fast Stepping and Postural Control***

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BACKGROUND AND AIM: Our ability to rapidly interact with our environment has been studied in reaching via the measurement of express visuomotor responses (EVRs). EVRs are directionally tuned muscle activity bursts that occur ≈100ms after visual stimulus appearance and aid in the rapid initiation of the goal-directed movement. In daily life, fast stepping responses are equally important and it can be assumed that express visuomotor responses also extend to the lower extremities. However, stepping is more complex than reaching due to increased postural demands which usually need to be compensated for via anticipatory postural adjustments (APAs). We here aimed to investigate stepping-related EVRs and their interaction with the APAs that precede step initiation. METHODS: We used an emerging target paradigm, during which healthy young subjects (N =16) were asked to rapidly step towards flashed visual targets presented randomly to the left or right. We recorded surface EMG of gluteus medius (GMed), a muscle that is involved in both APAs and stepping. We also recorded bilateral ground reaction forces. Two target location conditions were introduced. First, in a lateral stepping condition with reduced postural demands prior to step initiation, targets were presented in front of and lateral to the stepping leg. Second, in a medial stepping condition with increased postural demands, targets were presented in front of and medial to the stepping leg. Outcome measures were EVR presence, magnitude and latency, APA presence based on ground reaction forces, and stepping reaction times. RESULTS: In the lateral condition, EVRs were robustly and strongly present in GMed contralateral to the target (16/16 subjects, MM = .12, ML = 108ms). In medial stepping, EVRs were detected in fewer subjects (3/16) with lower magnitude (MM = .05, p < .001) and slightly longer latencies (ML = 111ms). Ground reaction forces revealed that APAs were present in the medial condition (ML = 167ms), following the EVRs by ≈55ms, whereas APAs were absent in the lateral condition. This coincided with significantly faster stepping RTs in the lateral (MRT = 323ms) compared to the medial condition (MRT = 442ms; $p < .001$). We found a strong negative correlation between EVR magnitude and subsequent stepping RT in lateral stepping ($r_s = -0.63$ $p < .001$). This correlation was absent in medial stepping. CONCLUSIONS: Here we provide evidence for an intricate relationship between express visuomotor responses and postural control. In the lateral condition, where APAs were absent due to low postural demands, EVRs aided in the execution of a fast step, as strong EVRs correlated with faster stepping RTs. In the medial condition, results were strikingly different: APAs were essential, as postural demands needed to be accounted for prior to making the step. EVRs were barely present in this condition, implying that higher-order areas suppressed the subcortical EVR network, as they would otherwise hinder APA execution.

O.8.2: ***Dual-tasking reveals the attentional cost of resolving sensory conflict induced by perturbed optic flow during treadmill walking***

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BACKGROUND AND AIM. The central nervous system must exert an active control on gait under mechanical or sensory constraints. For instance, mediolateral optic flow perturbations induce changes in spatio-temporal gait characteristics and their variability. However, the precise role of cognitive (or executive) control in the processing of optic flow has been rarely investigated. Therefore, this study aimed to determine whether coping with unreliable visual inputs during walking require cognitive resources. METHODS: Healthy young adults (n = 24) walked on a dual-belt instrumented treadmill in a virtual environment (Figure A) while being exposed to two optic flow conditions: normal (matched to the speed of the belts) and perturbed (continuous mediolateral pseudo-random oscillations). Each optic flow condition was performed under single-task (free walking) and dual-task (walking while performing the n-back task) conditions with increasing cognitive (working memory) load (1-back, 2-back, 3-back). Each condition lasted for three minutes. Foot placement kinematics (200 Hz) and surface electromyography (EMG) of soleus and gluteus medius (1000 Hz) were recorded. Means and standard deviations (SD) were computed from gait time series in lateral (width: W, lateral body position: zB, and change in lateral position: ΔzB) and anteroposterior (step velocity: SV) directions. For kinematic variables, statistical (anti-)persistence (step-to-step regulation) was quantified by means of detrended fluctuation analysis. For EMG variables, duration and variability of muscle activation (linear envelope) were calculated from the full width at half maximum (FWHM) and the variance ratio, respectively. The d prime (d') and reaction time (RT) served as dependent variables of n-back task performance. RESULTS: Cognitive performance decreased as cognitive load increased (decreased d' and increased RT), but remained preserved under dual-task walking for either optic flow condition. Under single-task walking, perturbed optic flow increased mean W, mean ΔzB, SD of kinematic variables, antipersistence in ΔzB ('heading'), and variance ratio of soleus and gluteus medius. Under dual-task walking, variability (SD, variance ratio) decreased, FWHM increased for soleus, regardless of the optic flow condition. Also, persistence in W and antipersistence in SV decreased as cognitive load increased. Lastly, interaction effects revealed that dual-tasking reduced the impact of optic flow perturbations on SD of kinematic variables. CONCLUSIONS: Perturbed optic flow led to a more variable gait, this despite the adoption of a more cautious gait pattern to counteract the influence of unreliable visual cues. Interestingly, performing a secondary auditory task attenuated this effect at both the kinematic and muscular levels, suggesting that resolving conflicting visual cues is attentionally costly. FUNDING: This study was funded by the National Agency for Research and Technology (ANRT) and the NOVATEX MEDICAL company.

O.8.3: ***Contribution of lower back muscles with age during weight-shifting in single- and dual-task conditions***

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BACKGROUND AND AIM: Transferring bodyweight during stance is crucial for adequate postural control. This weight-shifting ability is impaired in older adults and may be mediated by an age-related increase in attentional demand to maintain postural control, as well as a higher relative muscle activation (%maximal voluntary contraction; %MVC). More specifically, mediolateral (ML) weight-shifting is a predictor of unstable gait and falls. Although the lower back muscles likely play an important role in postural control, the evidence on their involvement during ML weight-shifts is still limited. Therefore, this study aimed to investigate the effect of ageing and dual-tasking on muscle activity of the lumbar erector spinae muscles during ML weight-shifting. METHODS: Healthy adults (17 young and 17 older) performed weight-shifts in a novel virtual reality wasp game controlled by weight-shifts, captured in real-time with a VICON-system. In the game, participants were required to make ML weight-shifts towards 80% of their individual limits of stability to obliterate virtual wasps projected on a computer screen. Electromyography (EMG) was recorded bilaterally from m. iliocostalis lumborum and m. longissimus thoracis using a telemetric system. Electrodes were placed in accordance with SENIAM guidelines. Signals were normalized to the individual MVC, measured during back extension. Participants performed 5 trials with 40s of weight-shifting in both single (ST) and cognitive dual-task (DT, serial subtractions) conditions. Behavioral outcome measures included the number of wasps hit and weight-shifting speed. Muscle activation (%MVC) was calculated as mean and peak activation. Data analysis is still ongoing and we present preliminary results. RESULTS: Fewer wasp-hits and slower weight-shifting speed were found in older (wasps: 9.00±3.21; speed: 0.06±0.02) compared to young adults (wasps: 13.70±3.67; speed: 0.11±0.03) and in DT (wasps: 10.36±3.92; speed: 0.08±0.03) compared to ST (wasps: 12.34±4.20; speed: 0.09±0.04). No group*task interactions were observed. Higher mean and peak activations were found with age in all four muscles. Adding the DT resulted in lower mean and peak activation in the left muscles when shifting to the left

and vice versa. Older adults showed a higher mean activation in ST compared to DT in the right muscles when shifting to the right, whereas this was not seen in the young group (group*task, $p<0.01$). CONCLUSIONS: Weight-shifting is compromised with age and DT, even when scaling the task to individual stability limits. Older adults required higher relative activation of the erector spinae muscles to perform weight-shifts, suggesting that a higher muscle contribution is needed with age. Interestingly, the higher relative activations during ST vs DT, particularly in older adults, points towards an inhibition of muscular activity when distracted. However, this activation change did not hamper postural control during DT in older adults.

O.8.4: ***Validation of a multi-task protocol for simulating real-world walking speed in a lab setting***

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BACKGROUND AND AIM: Moving beyond standard gait assessment by including a range of complex mobility tasks offers the opportunity to gain a more comprehensive understanding of a patient's mobility. However, deciding which other observation of gait to include might not be straightforward, especially considering restrictions associated with being in a confined space like a lab. This study aims to validate a recently proposed multi-task protocol [1] in which the goal was to simulate variations if gait comparable to the real-world walking. The protocol consisted of a series of complex activities that: a) included at least one walking bout (defined as two consecutive strides [2]); b) induce a large variation in the observed walking speeds; and c) avoid redundancy in the tasks to minimise burden to the patient. The achievement of these goals was tested in five different cohorts: older healthy adults (OHA), Parkinson's disease (PD), Multiple Sclerosis (MS), Proximal Femoral Fracture (PFF), and Chronic Obstructive Pulmonary Disease (COPD). METHODS: Ninety participants (20 OHA, 18 PD, 19 MS, 16 PFF, and 17 COPD) were assessed as part of a multi-centre study (www.mobilise-d.eu). Experiments were carried out in five gait laboratories, highly differing for sizes and shapes. The multi-task protocol included three straight walking tasks (at comfortable, fast, and slow speeds) and five complex tasks including turns of different angles, sit-to-stand, step negotiation, changing surfaces, and a simulated daily activity task [1]. Walking speed was measured as the average of stride speed over a walking bout. This was measured by a stereophotogrammetric system and with one marker attached to each heel. RESULTS: At least one walking bout was detected in each task and a broad range of walking speeds were recorded for each task and cohort (Fig.1). The tasks that captured the various speeds, and in particular the slowest ones, varied among cohorts. Figure 1 - Frequency plots of the average walking speed per task captured during the lab-based protocol. CONCLUSION: The proposed protocol was successfully deployed in all cohorts and centres and allowed capture of a large range of walking speeds. The more complex tasks allowed for slower walking speeds to be captured in the cohorts that are considered to have lower levels of mobility (e.g., PFF). The inclusion of all tasks in this protocol allows for analysis of a large range in walking speed that would not likely be seen in standard gait observations. Further ongoing work is aiming to compare the range of walking speed of this lab-based protocol to real-world observations and share results with the research community once completed. ACKNOWLEDGEMENTS AND FUNDING: This work is part of the Mobilise-D project (IMI2 Joint Undertaking, grant agreement No 820820). REFERENCES: 1.Mazzà C. et al. (2021). BMJ open,11(12), e050785. 2.Kluge et al., (2021), PLoS ONE, 16(8)

O.8.5: *Age-related effect on cognitive-locomotor dual-task abilities in activities representative of daily life*

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BACKGROUND AND AIM: Age-related modifications in locomotor and cognitive functions can increase the risk of falling and therefore have a negative impact on community walking. Furthermore, the ability to perform another task while walking is essential for independent and safe walking in the community. The objectives to the present study were to (1) assess and compare locomotor and cognitive dual task (DT) abilities during activities representative of daily living in community-dwelling participants aged 55 years or older, and (2) examine age-related changes in DT abilities. METHODS: To assess DT abilities, healthy participants aged 55 years or older walked along a virtual shopping mall corridor and memorized a 5-item shopping list. Two levels of task complexity were used for the walking task (with or without virtual agents to avoid) and the cognitive task to recall a list of items (with or without a modification at mid-course). An omnidirectional platform and a virtual reality headset were used. Walking speed, fluidity, and minimal distance during avoidance were used to characterize locomotor performance. Cognitive performance was assessed by the number of correctly recalled items. Locomotor and cognitive DT costs (DTC) were calculated. After measuring the presence of DTC using one sample Wilcoxon signed-rank tests, a nonparametric two-way repeated measure ANOVA was performed to explore the impact of task complexity on DTCs. Pearson coefficients were used to examine the impact of age on DT abilities. RESULTS: Seventeen participants were recruited (median age: 64 years; 25th-75th percentiles: 61.00 - 70.00). Significant locomotor and cognitive DTCs were observed in all DT conditions (5.41% to 21.43%; p-values: <.001 to .010), except the simplest (without virtual agents to avoid and without item modification). These DTCs were mainly impacted by the complexity of the cognitive task. Significant age-related effects were observed on walking speed and fluidity of walking DTCs (Pearson's r : -.554 to +.774; p-values : <.001 to .021), whereas no relationship was observed between age and cognitive or minimal distance DTCs CONCLUSIONS: Healthy older adults showed locomotor and cognitive DTC during representative activities of daily living. Locomotor DTCs seemed to increase with age. In addition, DTCs quantified with our VR-based protocol which simulated activities representative of everyday life seems to provide a comprehensive assessment of locomotor and cognitive DT abilities. ACKNOWLEDGEMENTS AND FUNDING: The authors would like to thank Nicolas Robitaille for valuable assistance with VR protocol developping. The authors would also like to thank Caroline Rahn in the data collection and all the particpants for their contribution to this projet. This work was supported by the Team of researchers in Immersive Technlogy in Rehabilitation (ITR) of the Centre for interdisciplinary research in rehabilitation and social integration (Cirris). ADB received Ph.D. studentships from the Cirris, the Fonds de recherche et d'enseignement de la Faculté de médecine de l'Université Laval, and the Fonds de Recherche du Québec - Santé (FRQ-S).

O.8.6: ***Visual sensory reweighting in standing balance can be assessed using virtual reality***

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Sensory reweighting is a very important ability of human balance control. It refers to the context dependent change in sensory contributions, e.g. when a sensory reference becomes less reliable. Model based data analysis techniques and sophisticated experimental protocols to quantify sensory reweighting have existed for almost two decades [1]. However, these methods are rarely used in applied balance research and diagnostics, as they require expensive motorized setups to generate sensory conflicts. We recently showed that balance in virtual reality (VR) is comparable to balance when viewing a real-world scene, given the visual scene is fixed in space [2]. The current study aimed to investigate whether moving virtual scenes can be used as a substitute for motorized real-world setups to assess visual sensory reweighting. To this end, we recreated a moving screen experiment in VR and compared balance responses in our virtual setup to the previously published real-world data [1]. Seventeen young and healthy subjects wore a head-mounted VR display, viewing a half-cylindric screen that was placed inside a virtual room. Following four 2min-long warm-up trials, subjects were exposed to five 302.5-s long pseudo-random tilt sequences of the virtual screen. Each repetition had one of five amplitudes ranging from 0.5 to 8° peak-to-peak in random order. The experiment was repeated twice on different days. Body sway was measured using the built-in tracking of head-mounted display and a tracker (HTC Vive pro eye) attached to the hip. Whole body center of mass was calculated from head and hip movements using a two-segment model and anthropometric tables. Center of mass sway was then transformed to the frequency domain and statistically compared to the real-world data [1]. In addition we performed model simulations extracting visual sensory weights, and other parameters of each individual subjects balance control mechanism using a similar model as in [1]. The virtual moving screen evoked sway responses showing typical non-linear characteristics associated with reweighting. No significant difference was found for any amplitudes between virtual and the real-world data reported by Peterka [1]. Model-based analyses of the sway responses were possible for all subjects and confirmed that observed changes in body sway across stimulus amplitudes were associated with reweighting. In conclusion, we found that VR can be used to analyze the visual contribution to standing balance and visual sensory reweighting, and therefore, can provide an inexpensive alternative to motorized setups. Future work will aim to provide standardized VR tools and

analysis methods for a broad user community. [1] Peterka, R. J. (2002). Sensorimotor integration in human postural control. Journal of neurophysiology, 88(3), 1097-1118. [2] Assländer, L., & Streuber, S. (2020). Virtual reality as a tool for balance research: Eyes open body sway is reproduced in photo-realistic, but not in abstract virtual scenes. Plos one, 15(10).

O.9 – Training / Treatment

O.9.1: *Effects of directional subthalamic deep brain stimulation on gait and balance in Parkinson Disease patients*

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BACKGROUND AND AIM : Subthalamic deep brain stimulation (STN-DBS) is efficient to treat motor signs in PD patients. Its effects on freezing of gait (FOG) and falls are variable across individual patients, depending partly from the location of the stimulating contact. The possibility to use directional STN-DBS with specific shaping of the volume of tissue activated represents a new therapeutic option for these PD patients. METHODS : In this pilot study, we included 10 PD patients with FOG Off-dopa and tested the effects of directional STN-DBS versus single-ring STN-DBS on gait and balance disorders using gait recordings and validated clinical scales (motor disability-UPDRS III, axial motor score, gait and balance scale-GABS, freezing-of-gait questionnaire-FOGQ). Patients were first assessed before surgery (Off/On-dopa). After surgery, single-ring STN-DBS was applied. Six months after surgery, we tested 6 different STN-DBS conditions (Off-dopa) with a randomized cross-over double-blind design with: 1) single-ring, 2) directional STN-DBS with current shaping including the central part of the STN (gait 'hot-spot'), 3) dorsolateral part of the STN (sensorimotor area), 4) ventral part of the STN, or 5) outside of the STN and 5) Off STN-DBS. Patients were also reassessed one month later with chronic gait 'hot-spot' DBS (Off/On-dopa). We compared the effects of each STN-DBS conditions using a linear mixed model. RESULTS : Up to now, 8 patients were assessed 6 months after surgery. In these patients, all active STN-DBS conditions improved motor disability, axial and GABS scores relative to Off STN-DBS condition (mean improvement of 69.6%, 54.0%, 64.5%, respectively). The effects of single-ring, sensorimotor and directional STN-DBS conditions on global motor disability were not significantly different. The axial and GABS scores were significantly lower with the gait 'hot-spot' directional STN-DBS relative to the directional sensorimotor, ventral and outside conditions, with no significant difference with the single-ring condition. For gait recordings, we found that all STN-DBS conditions improved gait initiation parameters, stride length and velocity relative to Off STN-DBS. We also found better gait parameters with single-ring and directional gait 'hot-spot' STN-DBS relative to dorsolateral-sensorimotor directional STN-DBS, with lower gait initiation and double-stance phases durations, number of FOG episodes and gait asymmetry during straight-forward gait, and higher step length and turn amplitude. After one month with directional gait 'hot-spot' STN-DBS (n=7 patients), we

also found a lower FOGQ score relative to chronic single-ring STN-DBS. No major side-effects of directional STN-DBS occurred. CONCLUSIONS : These preliminary result suggest that directional central-gait 'hot-spot' STN-DBS is more efficient than dorsolateral-sensorimotor STN-DBS to improve gait and balance disorders in PD patients, with also a dramatic improvement in other parkinsonian symptoms. ACKNOWLEDGEMENTS AND FUNDING: This study was supported by Boston Scientific, Agence Nationale de la Recherche.

O.9.2: ***Augmented reality gait training does not improve gait adaptability in people with hereditary spastic paraplegia: results of a randomized controlled trial***

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BACKGROUND AND AIM: Hereditary spastic paraplegia (HSP) is a neurodegenerative disorder characterized by progressive lower-limb spasticity, muscle weakness and reduced proprioception. People with HSP have difficulties adapting their gait to meet environmental demands. Beneficial effects of gait adaptability on gait and balance performance have been reported in several neurological populations, however, it is unknown whether people with HSP also benefit from this type of training. To fill this gap, we conducted the Move-HSP trial, a randomized controlled trial to assess the efficacy of a five-week gait adaptability training using augmented reality in people with pure HSP.[1] METHOD: Thirty-six people with pure HSP (i.e. with lower-body involvement only; 27 females, 48±11 years, 11±4 points on spastic paraplegia rating scale) were stratified by disease duration (0-15 yrs, >15 yrs) and randomised 1:1 to either an intervention group (n=18) receiving five weeks of gait adaptability training or a control group (n=18) receiving five weeks of usual care. Training was performed on the C-Mill, a treadmill equipped with augmented reality. Visual projections were used to train obstacle negotiation, precision stepping, and coping with speeding up and slowing down. Training sessions were given twice a week (60 min/session). In the control group, participants continued their usual care. The primary outcome was the obstacle subtask of the Emory Functional Ambulation Profile (EFAP). Secondary outcomes consisted of Mini Balance Evaluation System Test (MiniBEST), Activities-specific Balance Confidence scale (ABC), Ten-Meter Walk Test, Walking Adaptability Ladder Test (WALT), and spatiotemporal gait parameters (stride length, stride time, step width, walking velocity and cadence) assessed through 3D-motion analysis (VICON Plug-in Gait). To evaluate training effects, we used an analysis of variance (ANCOVA) with the pre-intervention EFAP-scores as covariate and group as between-subject factor. RESULTS: Augmented reality gait training did not improve performance on the EFAP-obstacle subtask (difference training vs. control = -0.33 seconds, 95%CI [-1.3;0.6], p=0.47, see figure 1), nor did it result in beneficial effects on the MiniBEST (difference training vs. control = 1.03 points, 95%CI [-0.5;2.5], p=0.17), ABC (difference training vs. control = 3.40 points, 95%CI [-2.7;9.5], p=0.27), or any other secondary outcomes, with the exception of the WALT - one foot per target (difference training vs. control = 2.14 seconds, 95%CI [-4.1;-0.1], p=0.04), in comparison to usual care. CONCLUSIONS: Whereas both groups generally showed improved EFAP-obstacle subtask

scores post intervention, five weeks of augmented reality gait training did not prove to be beneficial over five weeks of usual care to improve gait adaptability or balance capacity in people with pure HSP. Future studies should confirm our findings and look for the effectiveness of other treatment approaches to improve gait adaptability in this population. ACKNOWLEDGEMENTS: The Move-HSP trial was funded by the Jacques and Gloria Gossweiler Foundation. A grant from Ipsen Pharmaceuticals covered the costs of the physiotherapists delivering the training. REFERENCES: [1] van de Venis et al. (2021). Trials

O.9.3: ***The effect of split-belt treadmill training on anticipatory postural adjustments and first step characteristics in people with Parkinson's Disease***

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BACKGROUND AND AIM: Gait initiation (GI) consisting of the anticipatory postural adjustment (APA) and the first step execution, is known to be compromised in people with Parkinson's Disease (PD), even more severely in PD with Freezing of Gait (FOG). To date there is limited research on whether components of GI can be improved via exercise. Treadmill training has previously shown to increase step length while walking, and may also improve scaling of GI. On the other hand, split-belt treadmill training, where belts under each leg can run at different speeds, is a complex gait training which may enhance postural control as stance time continuously needs to be adjusted to the changing motor pattern. The aim of this study is to investigate the differential effects and retention of split-belt training (SBT) and tied-belt training (TBT) on APAs and first step characteristics in people with PD. METHODS: Fifty-two people with PD (20 with FOG) were randomized into a 4-week (3x/week) SBT or TBT intervention. Assessments were carried out a week before (Pre), a week after (Post) and 4 weeks after (follow-up (FU)) the training. GI was recorded using wearable sensors on the feet and the lower back under single task (ST) and dual task (DT) conditions. APAs and first step outcomes were computed using a customized Matlab script. Statistical analysis including linear mixed models (whole cohort + FOG subgroup) and Cohen's d was used to investigate time by training group interactions on the following outcomes: medio-lateral APA size, anterior-posterior APA size, APA latency, APA duration, first step range of motion (ROM) and first step time. RESULTS: A significant time by training group interaction was found for ST first step time. Post-hoc tests were insignificant, however there was a tendency in SBT for improved ST first step time from Pre to FU ($p=0.097$, $d=0.355$). The other outcomes did not show any significant interactions. Irrespective of the training group, participants had reduced their ST APA latency ($p=0.048$) and increased their ST first step ROM ($p=0.003$) at Post. APAs and first step characteristics during DT conditions did not show significant results. The sub analysis of PD with FOG revealed a significant time by training group interaction for DT first step ROM, which only increased significantly in the TBT group from Pre to Post ($p=0.034$). CONCLUSIONS: SBT and TBT were both effective to make participants generate a quicker release of the step after introducing the APA and take larger first steps, however training effects were not retained at 4-weeks follow-up. PD with

FOG improved similarly to those without FOG, however they benefited more from TBT for DT first step execution. Overall, these results are promising as we showed that both treadmill training protocols could improve aspects of GI in people with PD. Future studies should investigate the tendency that SBT leads to quicker first steps and the clinical relevance of training effects. ACKNOWLEDGEMENTS AND FUNDING: This project was funded by Jacques and Gloria Gossweiler Foundation (Switzerland).

O.9.4: *Effect of hearing loss and biological sex on dual-task performance before and after exercise or cognitive training in older adults with mild cognitive impairment*

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BACKGROUND: As we age, there is an increased interaction between cognitive, motor, and sensory functioning. Indeed, hearing loss is predictive of cognitive decline, mild cognitive impairment (MCI), and an increased risk of falling. Notably, hearing loss is more prevalent in males compared to females, possibly due to the protective effects of estrogen prior to menopause. One risk factor for MCI is slow dual-task walking speed (i.e., walking while simultaneously completing a cognitive task). Although cognitive and physical training has been shown to improve dual-task walking speed and cognitive performance in older adults, it is currently unclear whether hearing ability or sex characteristics affect cognitive or physical training efficacy on dual-task walking and working memory performance in individuals with MCI. METHODS: Using data from the Canadian Consortium on Neurodegeneration in Aging (i.e., COMPASS-ND and SYNERGIC datasets; n = 70) we investigated the effect of hearing loss (normal hearing vs. mild to moderate hearing loss) and sex characteristics (i.e., male vs. female; age of menopause) on changes in dual-task working memory performance (i.e., serial seven subtractions, semantic fluency) and walking speed (cm/sec) in older adults with MCI following 20 weeks of either: i) combined exercise and cognitive training, ii) exercise training alone, or iii) a control group. RESULTS: We found that single- and dual-task walking speed increased significantly following combined exercise and cognitive training only. Greater improvements in dual-task gait speed were found for participants with hearing loss compared to those with normal hearing. Regarding working memory performance, we found significant improvements in single-task semantic fluency in the exercise only group. We also found that biological sex influenced training outcomes, with serial 7 dual-task cost scores improving more in females compared to males in the exercise only group. Additionally, serial sevens single-task performance was found to improve more in females who reached menopause at an earlier age compared to a later age following combined exercise and cognitive training. CONCLUSIONS: The study findings help clarify the relationship between hearing ability, cognition, and mobility in older adults with MCI. These results also inform training recommendations for patients with MCI based on hearing ability and sex. Specifically, our findings suggest that older adults with MCI who have poor hearing are more likely to benefit from combined exercise and cognitive training, whereas older adults with normal hearing may benefit from either combined training or exercise alone. This finding reinforces the importance of early hearing screening to better understand which mode of

training may be most beneficial for older adults with MCI. Additionally, females who reach menopause at an earlier age may benefit more from exercise and cognitive training, possibly due to the protective effects of estrogen on hearing and cognitive health, leading to poorer performance at baseline when estrogen is depleted following menopause. ACKNOWLEDGEMENTS: This research was funded by CCNA's Interdisciplinary Trainee Research Innovation Challenge and Women, Sex, Gender, and Dementia awards.

O.9.5: ***Targeted tDCS mitigates dual-task costs to gait and balance in older adults***

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BACKGROUND AND AIM: Among older adults, the ability to stand or walk while performing cognitive tasks (i.e., dual-tasking) requires coordinated activation of several brain networks. In this multi-center, double-blinded, randomized, and sham-controlled study, we examined the effects of modulating the excitability of the left dorsolateral prefrontal cortex (L-DLPFC) and the primary sensorimotor cortex (SM1) on dual-task performance 'costs' to standing and walking. METHODS: Fifty-seven older adults without overt illness or disease completed four separate study visits during which they received 20-minutes of transcranial direct current stimulation (tDCS) optimized to facilitate the excitability of the L-DLPFC and SM1 simultaneously, each region separately, or neither region (sham). tDCS and sham stimulation were delivered with the participant sitting and resting. The montage (electrode placement and current parameters) for each stimulation condition was developed using an advanced computational optimization technique based upon a realistic template head mode (Figure 1). To ensure safety, the maximum current intensity of one electrode of tDCS was 1.5 mA. The sham stimulation was developed using the "acti-sham" approach, which sent the current at minimum intensity of 0.25 mA to the cortical regions that did not interfere with the targeting regions (i.e., L-DLFPC or SM1). Before and immediately after stimulation, participants completed a dual-task paradigm in which they were asked to stand and walk with and without concurrent performance of a serial-subtraction task. RESULTS: Two-way repeated-measures ANOVA models adjusted for age, sex, and site indicated significant interactions between stimulation condition and time for dual-task postural sway speed ($F=3.4$, $p=0.01$, Cohen's $d=0.68$), dual-task postural sway area ($F=3.5$, $p=0.02$, Cohen's $d=0.8$), and the dual-task costs to both sway speed ($F=6.1$, $p=0.0001$, Cohen's $d=0.84$ Figure 3A) and area ($F=4.6$, $p=0.006$, Cohen's $d=0.7$, Figure 3B); Similar significant effects of L-DLPFC tDCS and L-DLFPC+SM1 tDCS on the dual-task cost to gait speed ($F=3.8$, $p=0.01$, Cohen's $d=0.81$) were observed. Tukey's post-hoc analysis revealed that such dual-task costs to standing postural sway and gait speed ($p<0.03$) was lower following DLPFC-only and L-DLPFC+SM1 tDCS, as compared to all other pre- and post-stimulation means. Blinding efficacy was excellent ($p>0.31$) and participant subjective belief in the type of stimulation they received (real or sham) did not contribute to the observed functional benefits of tDCS on dual task costs to gait and standing balance. CONCLUSIONS: These results demonstrate that in older adults, dual-task decrements may be amenable to change and implicate L-DPFC excitability as a modifiable component of the control system that enables dual-task standing and walking. tDCS may be used to improve resilience and the ability of older results to walk and stand under challenging conditions, potentially enhancing everyday functioning. ACKNOWLEDGEMENTS AND FUNDING: This work was supported by grants from the U.S.-Israel Binational Science Foundation (2015271) and the Boston Claude D. Pepper Older Americans Independence Center (P30-AG013679).

O.9.6: ***Unexpected-perturbation training during stationary bicycling improves reactive and proactive balance among older Adults: A Blinded Randomized Controlled Trial***

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BACKGROUND AND AIM: Perturbation training approach reduce fall rates by improving reactive balance responses. Currently, perturbation training programs are designed only for older adults who are able to stand and walk independently on a perturbation device during the treatment sessions. However, high-risk people such as frail older adults may not have this ability and they cannot participate. Thus, we aim to investigate whether an alternative balance program that provides perturbations during hands-free bicycling in a sitting position can be transferred to improve balance function, in standing and waking, among pre-frail older adults. METHODS: Older adults were randomized to 2 training groups: Perturbation Training during hands-free Stationary Bicycling Riding (PerTSBR, n=29), included a progressive 22-intensity-levels training program with 50 unexpected lateral perturbations at each session. Training of Stationary Bicycle Riding without perturbations (TSBR, Control, n=27). Both groups received 20 sessions in 12 weeks by the PerStBiRo system (attached Figure) in combination with concurrent cognitive tasks and pedalling resistance. We assessed reactive balance during standing. Four directional unexpected surface translations (right/left/forward/backward) were applied at 10 different magnitudes. The single- and multiple-step thresholds, defined as the minimum perturbation magnitude that consistently elicited a single-step response and sequence of recovery steps, respectively, was determined. Voluntary step execution times (proactive balance), postural sway, Berg Balance Scale (BBS) and 6 minute-walk test (6MWT) were also assessed. Trial registration: clinicaltrials.gov, NCT03636672. RESULTS: Regarding reactive balance, Compared to TSBR (completed n=23), Participating in PerTSBR (completed n=24) increased the single and multiple-step threshold in mediolateral [ML] direction (p=0.001, effect size [ES]=0.80 and p=0.001, ES=0.76, respectively) and the multiple-step threshold in anteroposterior [AP] direction [p=0.022, ES=0.40]. In voluntary step execution, PerTSBR training led to faster initiation phase (p=0.007, ES = -0.92) and foot contact time (p=0.030, ES = -0.56) compared to TSBR training, with no differences in preparation and swing phases. The PerTSBR group also significantly decreased the ML sway range compared with the TSBR group (p=0.024, ES = -0.46). The AP sway, sway velocity and sway area did not change as a result of training for both groups. Both training groups significantly increased the means of BBS score and the

6MWT distance. CONCLUSIONS: Participating in perturbation-based bicycling training improved reactive and proactive balance parameters, particularly in the ML direction, as they were particularly trained. This indicate that older people were able to learn specific balance responses during perturbation exercise in sitting position and to generalize these balance skills to performance-based measures of balance in standing and walking, that may suggest fall risks were reduced. ACKNOWLEDGEMENTS AND FUNDING: This study was supported by the Helmsley Charitable Trust through the Agricultural, Biological, and Cognitive Robotics Initiative of Ben-Gurion University of the Negev.

Poster Session 1

A - Activity monitoring

P1-A-1: ***Advancing free-living gait bout segmentation using smart garments***

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Background and Aim: Examining natural gait behaviour under free-living conditions presents a technical challenge to reliably detect and classify gait bouts. Current solutions for gait bout detection using hip-worn accelerometer employ machine learning (ML) models, such as GaitPy [1]. A limitation of GaitPy is failure to detect smaller bouts (<10 steps) which make up a significant portion of steps in free-living behavior. The present study aims to advance gait segmentation methods to detect gait bouts of >5 steps using a waist 3D accelerometer embedded in a smart undergarment device (SKIIN, Myant Inc., Canada). Methods: Gait data was collected in 20 young, healthy participants with the SKIIN system. Participants performed: 4 m walk (x10), timed-up-and-go (TUG) (x3), and free walking (2 minutes). SKIIN devices collected 3D accelerometry located over the left anterior superior iliac spine at 100Hz. Pressure-sensitive insoles (SCIENCE Insole3, Moticon Rego AG, Germany), were used as criterion-standard method to label initial and final foot contacts. A gait bout was operationally defined as 5 consecutive reciprocal footfalls within 1 sec of each other. For detection, accelerometer features were extracted from 2 sec windows with 1 sec overlap. Features extracted were: mean and standard deviation for each accelerometer direction, and root-mean-square (RMS), integral, standard deviation, max derivative, kurtosis and skewness for the overall accelerometer signal. A random forest model was trained and tested using a leave-one-subject-out (LOSO) approach, training the model on all data except for one participant. The held out participant is used as the test set, and the process is repeated for each participant acting as a test set. Results:<\b> With the LOSO evaluation, model performance yielded mean±SD F1-score and accuracy of 0.76±0.16 and 0.82±0.09, respectively. In comparison, the benchmark GaitPy algorithm yielded F1-score and accuracy results were 0.60±0.24 and 0.70±0.15 on the same test data. A representative sample of model outputs and labeled bouts is shown in Fig. 1, illustrating improved performance in detecting small gait bouts. Conclusions: <\b> Based on the results, the random forest model outperforms GaitPy in detecting smaller bouts often seen in free-living gait. These results provide a promising outlook for the detection and analysis of free-living gait bouts using the SKIIN system, with implications on fall risk assessment. Acknowledgements: <\b> This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Board (REB #42689). This study was conducted in partnership with Myant Inc., which provided equipment and partial funding. References: <\b> [1] M. Czech and S. Patel, "Gaitpy: An open-source python package for gait analysis using an accelerometer on the lower back." J Open Source Software, Vol. 4, p.1778, 2019.

P1-A-2: ***Associations between caregiver psychosocial status and changes in physical activity over 18 months in people with Parkinson's disease***

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BACKGROUND AND AIMS: Parkinson's disease is a progressive neurodegenerative disorder, leading to dependence and disability as the disease progresses. Participation in habitual physical activity (HPA), such as walking, can support people with Parkinson's disease (PwP) to maintain their independence and function for longer. HPA refers to any movement by the skeletal muscles which leads to energy expenditure. PwP participate in lower volumes, lower variability, and have different patterns (e.g. shorter walking bouts) of HPA compared to normal ageing controls. It is important to identify modifiable predictors of HPA in PwP, with associations already established between poorer cognitive and motor function and less HPA participation. However, as carers are considered key facilitators of HPA in other neurodegenerative conditions, carers' psychosocial wellbeing may also influence HPA in PwP. This pilot study aimed to (1) examine HPA over time in PwP, with and without caregiver support; (2) identify caregiver characteristics associated with HPA, and (3) determine predictors of change in HPA in PwP. METHODS: As part of the larger ICICLE-Gait study, 64 PwP were recruited to participate in physical activity assessment; 40 participants had carers who also consented to take part. Participants wore a tri-axial accelerometer on their lower backs continuously for seven days at two time points (18 months apart), measuring volume, pattern and variability of HPA. Linear mixed effects analysis identified relationships between demographic, clinical and psychosocial data and HPA from baseline to 18 months. Benjamini-Hochberg multiple comparisons correction with a 5% false discovery rate were applied for all analyses. RESULTS: There was no main effect for time for the overall Parkinson's disease group, nor for PwP with carers only, for any HPA characteristic. Key results in PwP with carers only indicated that carer anxiety and depression were associated with increased HPA volume ($p<.01$), while poorer carer self-care was associated with reduced volume of HPA over 18 months ($p<.01$). Greater carer strain was associated with taking longer walking bouts after 18 months ($p<.01$). Greater carer depression was associated with lower variability of HPA cross-sectionally ($p=.009$). CONCLUSIONS: This pilot study provides novel evidence of the influence of carer psychosocial factors on HPA participation in PwP. In Parkinson's, carers have dynamic roles which evolve and become increasingly time-consuming over the disease course, providing emotional and physical support to PwP. This may restrict carers from pursuing their own self-care, leading to greater strain and worse anxiety and depression. Results suggest that interventions aiming to support independence in PwP should also aim to improve carer's self-care and mental health, in order to benefit the dyadic unit as a whole.

P1-A-3: ***Quantifying Digital Mobility Outcomes: A Comprehensive and Objective Methodology for Algorithms Comparison and Ranking across Datasets***

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Background & Aim: Digital mobility outcomes (DMO) can be obtained through algorithms processing wearable sensors (WS) signals. Multiple algorithms have been proposed, although there is not yet a widely accepted method to select the best. To determine algorithm validity, DMOs are compared to equivalent outcomes derived from a reference system. Differences in patient population, measurement protocol, system and environment, however, collectively influence algorithm performance, and algorithm selection must account for this heterogeneity. We propose a comprehensive methodology to compare and rank algorithms to quantify DMOs in datasets including Parkinson's disease (PD) and healthy controls (HC), aiming to select the top performers. Methods: Available WS-based datasets within the Mobilise-D consortium were used. Algorithms were implemented to quantify specific DMO: gait sequence detection (n=13 algorithms), step detection (SD) (n=20), cadence (n=18), stride length (n=19) and foot laterality (e.g. Left/Right step detection) (n=3). A method to rank algorithms was developed1 and applied to the datasets. Here we focus on SD algorithms to demonstrate proof of concept, applied to two datasets, recorded in HC and PD, named ICICLE2 (65 HC, 74 PD) and UNIGE (10 HC, 10 PD),3 respectively. The ranking method accounted for different: gait speed, accuracy of reference system and number of participants from each dataset, and algorithm performance based on specific statistical analyses.1 Each performance metric was assigned a weight (w) and treated as "cost" ("c", when lower values indicate better performance) or as "benefit" ("b", the higher, the better1) determined as follows: average (w=0.223, c) and standard deviation (w=0.223, c) of SD relative error, inter-class correlation coefficient of SD (w=0.359, b), sensitivity (w=0.099, b) and positive predictive value (w=0.096, b) of initial contact event identification. The mentioned metrics and weights were combined to provide a single normalised overall performance index ranging between 0 (worse performance) and 1 (best) for each algorithm. This index was then used to rank the algorithms. Results: The 3 top-ranked SD algorithms presented an overall performance index between 0.88 and 0.89 for HC, and between 0.61 and 0.62 for PD. The top-ranked algorithm had an average relative error of 0.39% for HC and 0.90% for PD, a standard deviation relative error of 0.60% (HC) and 1.64% (PD), an ICC of 1.00 (HC) and 0.92 (PD), a positive predictive value of 0.88 (HC) and 0.89 (PD) and a sensitivity of 1.00 (HC) and 0.98 (PD). Conclusions: This study provides a methodological framework that should be considered by key stakeholders and researchers to standardise algorithm comparison and selection, accommodating heterogeneity and diverse range of outcomes. Acknowledgments. We thank Dr Hugo Hiden for his support with the data management and analytics platform. References: 1. Bonci T. et al. Sensors. 2020;20(22):6509. 2. Yarnall A. et al. Neurology. 2014;82:308-16. 3. Trojanello et al. JNER 2014;11(1):1-12.

P1-A-4: ***Associations between activity digital measure with sleep and fatigue PROs assessed in the real-world: an IDEA-FAST feasibility study***

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BACKGROUND AND AIMS: Sleep disturbances and fatigue are commonly reported symptoms in individuals with neurological and immune disorders. Current assessment of sleep and fatigue rely on patient reported outcomes (PROs), which are subjective, prone to recall biases and do not capture variability over time. Wearable technologies now provide objective and reliable estimates that are sensitive to change. Here, we evaluate the performance of four activity monitoring devices to assess the feasibility of capturing digital measures of fatigue and sleep in a feasibility study of the IDEA-FAST from six different disease groups (Parkinson's disease (PD), Huntington's disease (HD), Rheumatoid arthritis (RA), Systemic Lupus Erythematosus (SLE), Primary Sjogren's Syndrome (PSS), Inflammatory Bowel Disease (IBD)) and healthy controls (HC). METHODS: Upto 120 participants in 6 individual disease groups (PD=18, HD=6, RA=17, SLE=16, PSS=17, IBD=12,) and healthy controls (HC=34) wore four wearable devices (i.e. AX6, MoveMonitor, VitalPatch, and Sensor Dot from Byteflies) continuously for a maximum of ten days at home. Participants completed sleep, fatigue and pain related PROs upto 4 times a day, using a mobile phone application. Performance of different activity monitors was assessed by evaluating the coverage, data quality of device features, and its association with PROs in all participants and in individual disease cohorts. AX6 attached on wrist and Sensor Dot on ankle gave signal vector magnitude (SVM), while the McRoberts attached on lower back, and VitalPatch on chest provided the number of steps. For quality assessment of various activity devices, coverage of each device was calculated as the ratio of valid measurement days to the expected number of days. The relative agreement between the PROs and activity device specific features were calculated with the repeated measure correlation. RESULTS: Most of the participants wore the device over 10 days. Therefore, the coverage for AX6 was 100%. MoveMonitor and VitalPatch had reasonably good coverage (80%). For MoveMonitor, the daily coverage was relatively low for IBD and SLE cohorts compared to the cohort-specific coverage levels of VitalPatch and AX6. The Sensor Dot had the poorest coverage overall. From current analysis, MoveMonitor features produced the highest correlations with PROs (perceived sleepiness, r=-0.33), but AX6 outperformed the other devices in terms of data coverage (100%). Simple features provided by the device manufacturer had a weak correlation with the PROs. CONCLUSION: Activity devices attached on the lower back seems to provide the highest data quality and correlation, whereas the wrist provided the highest data coverage. In future studies, other clinically relevant features of mobility (e.g. gait speed) and specific aspects of mobility (e.g. gait/turning) should be explored to assess their association with sleep and fatigue. ACKNOWLEDGEMENT: The project leading to this application has received funding from the Innovative Medicines Initiative 2 Joint Undertaking under Grant Agreement No. 853981. This Joint Undertaking receives support from the European Union's Horizon 2020 research and innovation programme and EFPIA.

B - Adaptation, learning, plasticity and compensation

P1-B-5: *Mutual avoidance behaviours of two young adults passing through a door-way aperture*

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BACKGROUND AND AIM: Individuals are constantly adapting their movements to avoid various obstacles in the environment. Vision is the primary sensory system used to adapt locomotion to environmental constraints, such as passing through an aperture or avoiding a collision with an oncoming pedestrian. However, it is currently unknown how individuals use vision to control behaviours when required to pass through a confined space and avoid a collision with an approaching person simultaneously. As such, the objective of the present study was to determine whether young adults can effectively use visual information to inform passing order through an aperture during a head-on mutual avoidance task. METHODS: Young adult males (n = 10, 178 ± 4 cm, 21.5 years) and females (n = 10, 163 ± 7 cm, 21.2 years) participated in the study. Starting at one of two starting locations on opposite sides of a 10 m pathway, the participant and a female research assistant were instructed to approach one another, and mutually decide who would pass first through an aperture located halfway (5 m) along the path. Kinematic trunk data was collected from both the participant and research assistant using the Optotrak motion analysis system at a sampling frequency of 100 Hz. RESULTS: On 90.9% of the trials, participants were able to effectively use visual information to inform proper passing order through the aperture. In other words, the individual who was expected to arrive second (P2) deviated from their pathway to allow the other individual (P1) to pass through the doorway first. There was no significant difference in the proportions of proper passing order between males (94.1%) and females (87.1%). However, results revealed that personal space (i.e., the distance between the participant and the research assistant at the time of avoidance) during the proper passing trials was significantly greater ($p= .01$) for males (4.5 m) than females (3.4 m). CONCLUSIONS: Findings from the current study suggest that when approaching a confined space while mutually avoiding another person, individuals will accurately perceive the difference in arrival time to predict and maintain proper passing order. Regardless of sex, P2 contributed more to the mutual avoidance by deviating from their straight path trajectory. At the time when an avoidance behaviour was initiated, personal space was found to be greater for males than females. However, since males were significantly taller than females, personal space is most likely a product of one's height. Therefore, when individuals approach a doorway from opposite directions, they will use vision to maintain proper passing order while considering not only their own personal space (~2m) but that of the approaching person (~2m) as well.

P1-B-6: ***Rapid adaptation to the sensory conflict between visual and rotatory vestibular stimuli during upright stance***

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BACKGROUND AND AIM: Rapid adaptation to the changing environment is critical in humans to maintain an upright bipedal stance. Previous studies showed that the greatest postural sway reduction across trials occurred between the very first balance perturbation and the second, identical one. This phenomenon was referred to as the "first trial effect", which reveals that the rapid adaptation to the mechanical perturbation is obvious. Besides the mechanical perturbation, sensory conflict is suggested to induce postural instability and motion sickness. Does the rapid adaptation also occur during the sensory conflict? Thus, the study aimed to assess (a) whether the rapid adaptation occurs during the sensory conflict between continuous visual and vestibular stimulation to maintain upright bipedal stance and (b) how the transfer of rapid adaptation of postural control is affected by changing environment. METHODS:22 young adults (mean age = 23.69 years, SD = 2.28years) participated in the study. Participants stood on a rotatory platform (clockwise rotating at 40 degree/s) and wore a virtual reality headset. The virtual scene moved in two ways: in the "congruent" condition (moved in the opposite direction of platform rotation, i.e., natural visual stimulation) and in the "incongruent" condition (moved in the same direction of platform rotation, i.e., conflicted visual stimulation) (Figure 1). Without any preceding trials, participants first completed the congruent task consisting of 4 identical trials and then completed the following incongruent task consisting of 4 identical trials. Center of pressure was recorded in each trial to evaluate the rapid adaptation during upright stance. RESULTS:(1) "First trial effect" was obvious in the congruent condition in the adaptation phases (∼30% greater than subsequent trials, $p<0.05$) (Figure 2a). (2) After rapidly adapting to the congruent condition (i.e., compared to the 4th trial of the congruent condition), sway distance was greater in both adaptation and recovery phases when participants completed the following first trial of the incongruent condition ($p<0.05$). (3) "First trial effect" reappeared in the incongruent condition in both late-adaptation (~30% greater than subsequent trials, $p<0.05$) and early-recovery phases (~60% greater than subsequent trials, $p<0.01$). However, the first trial effect was absent in the early-adaptation phase (Figure 2b). CONCLUSIONS: It seems difficult that rapid adaptation of postural control to sensory congruency can be transferred directly to the sensory conflict between visual and rotatory vestibular stimuli. Thus, the first trial effect reappears in the following sensory incongruent condition during upright stance. However, rapid adaptation to the sensory conflict does occur, though the efficiency decreases.

P1-B-7: ***Precision stepping during a visuomotor gait task***

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BACKGROUND AND AIM: Gait in a natural environment involves proactive visually guided modifications of the gait pattern. These modifications include adjustment of gait speed and ensuring precise foot placement when walking in uneven terrain. We aimed to investigate behavioral strategies when executing these common, yet complex, gait modifications. Therefore, we developed a methodology for investigating the effect of target on precision foot placement during gait. METHODS: Twelve neurologically intact adults (34 ±5.5 years, 6 females, 6 males) were enrolled in the study. Participants were asked to hit moving visual targets as precise as possible while walking on a treadmill. Targets and foot position were projected on a wall in front of the participant. We recorded kinematics, EMG activity from the lower extremities and gaze using eye tracking glasses in order to investigate behavioral strategy and error in foot placement in relation to target appearance, location, and speed. RESULTS: Preliminary results showed that precision error increased with speed. Targets located medially showed higher error than targets located laterally. Targets abbreviated compared to stride length showed the highest error, whereas neutral targets showed a minimum degree of error. Error also increased the further away- and the later a target was visually presented. Participants increased their step length and acceleration of forward swing when targets were presented. Furthermore, co-contraction was present during end of stance phase when opposite leg was attempting to aim for a target and also present in the leg aiming for the target. Gaze data indicates different strategies according to the complexity of the appearing targets. CONCLUSIONS: Neurologically intact adults use gait modifications such as elongation of base of support and co-contraction to increase precise foot placement when aiming for a target. Higher gait speed, shorter visual time span and targets requiring shortening or narrowing of steps in relation to target placement demonstrated higher precision error. The methodology will contribute to describing behavioral factors during a visuo-motor gait task, ultimately leading to development of a learning task mapping age-related visuomotor learning in individuals with and without brain lesion.

P1-B-8: ***The Effectiveness of Reactive Step Training in People with Parkinson's Disease and Postural Disturbances***

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BACKGROUND AND AIM: Falls are poorly controlled in people with Parkinson's disease (PwPD). Reactive stepping after a loss of balance has been related to falls and is altered in PwPD. However, there is limited data regarding whether reactive step training improves steps in PwPD, and whether these improvements can be retained for extended periods. This is particularly true for PwPD and postural disturbances, a group with elevated fall risk. Therefore, this study aimed to determine whether 1) reactive stepping improved following two weeks of reactive step training in PwPD and postural disturbances and 2) improvements are retained eight-weeks post-practice. METHODS: 24 PwPD at risk for falls (70.5 ± 6.4 yrs) were recruited to an 18-week multiple baseline study. Participants attended 2 baseline assessments (B1 and B2) before training, a 2-week, 6-session step training protocol, and 2 post-training assessments (P1 and P2) to assess the acute (P1) and retained (P2- 8 weeks post-training) effects of training. Each assessment consisted of 3 forward and 3 backward reactive step trials at constant participant-specific perturbation intensity. Training consisted of 32 (8 each in forward, backward, left, rightward directions) stepping trials per day with increasing perturbation intensity throughout training. Steps were elicited via support-surface translations using an instrumented split-belt treadmill. 3D motion capture and force plate data were captured. The primary outcome was the anterior-posterior margin of stability (MOS) during backward stepping. Backward steps were prioritized due to the particular difficulty of backward loss of balance in PwPD. Secondary outcomes included step latency and length, and all outcomes during forward stepping. Repeated measures ANOVAs were assessed training (B2 - P1; n = 24) and retention (B2 - P2; n = 20) effects. RESULTS: Participants improved backward step length ($p = 0.043$) and MOS ($p < 0.001$; Figure 1) after training compared to pre-training (P1-B2), and these improvements were retained at the follow-up (MOS: $p < 0.001$; step length: $p = 0.028$). Step latency was significantly reduced between the two pre-assessments ($p = 0.002$), but no acute training ($p = 0.180$) or retention effects ($p = 0.384$) were observed. The only significant effect observed for forward stepping was step latency, which was significantly reduced through training ($p = 0.003$) and retained at the follow-up ($p = 0.011$). CONCLUSIONS: A two-week step training program resulted in improved in reactive stepping in PwPD and postural disturbances, and improvements were retained for 2 months. These findings suggest that reactive step training may be an effective approach to improve reactive balance in PwPD with compromised balance difficulties. Given the importance of reactive stepping for fall prevention and the higher risk for falls in this PD subtype, this work can potentially impact rehabilitative care, and reduce fall risk for people with PD and postural disturbances. ACKNOWLEDGEMENTS AND FUNDING: This work was supported by the Michael J Fox Foundation.

P1-B-9: ***A Preliminary Analysis of the Spatial and Temporal Contributions to Step Length Asymmetry during Split-Belt Adaptation in Healthy Older Adults***

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BACKGROUND AND AIM: The adaptability of human gait is critical to meet the demands of our ever-changing environments. The inability to adapt gait may increase fall risk, which is even more critical for populations such as older adults, who are already at an elevated fall risk. To adapt gait, healthy young adults change both spatial and temporal parameters. However, little is known about the temporal and spatial adaptation strategies during gait adaptation in healthy older adults. Therefore, this study compares spatial and temporal contributions to step length asymmetry (SLA) during early and late adaptation in healthy younger and older adults. METHODS: Nine healthy young adults (7 females, 2 males, 21 ± 2 years) and nine healthy older adults (7 females, 2 males, 65 ± 7 years) walked on a split-belt treadmill with their non-dominant leg moving twice as fast as their dominant leg for ten minutes. Early adaptation consisted of the first ten strides of the adaptation period, while late adaptation consisted of the final ten strides. Spatial contributions to SLA refer to contributions of step position to SLA, while temporal contributions to SLA refer to the product of step timing asymmetry and foot velocity asymmetry. Spatial and temporal

contributions to SLA between young and older adults during early and late adaptation were investigated using a MANCOVA, covarying for the speed of the fast belt. RESULTS: There was a significant multivariate difference between groups in spatial and temporal contributions to SLA during early adaptation, $F(2, 17) = 6.78$, $p = .009$, Wilk's $\Lambda = 0.508$, $\eta p^2 = .49$. There was a significant group difference in spatial contributions to SLA during early adaptation ($F (1, 17) = 6.66$, $p = .02$, $\eta p^2 = .31$) but no difference in temporal contributions ($F (1, 17) = 2.15$, $p < .16$, $\eta p^2 = .13$). Specifically, older adults exhibited smaller spatial contributions to SLA during early adaptation compared to younger adults ($p = .02$). There was also a significant difference between groups in spatial and temporal contributions to SLA during late adaptation, $F(2, 17) = 7.65$, $p = .006$, Wilk's $\Lambda = 0.478$, $\eta p^2 = .52$. Significant group differences were found for both spatial contributions $F(1, 17) = 14.08$, $p = .002$, $\eta p^2 = .48$) and temporal contributions $F(1, 17) = 9.58$, $p = .007$, $\eta p^2 = .39$). Specifically, older adults exhibited smaller spatial contributions to SLA ($p = .002$) and temporal contributions to SLA ($p=.007$) compared to younger adults during late adaptation. CONCLUSION: Older and younger adults display altered strategies when adapting a novel gait pattern. Further elucidation of strategies that older adults use to adapt a novel gait pattern can enhance our understanding of gait abnormalities in older adults and permit patient-centered rehabilitation approaches.

P1-B-10: ***Offline learning of a locomotor sequence with reinforcement feedback***

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BACKGROUND AND AIM: Complex movement sequences are acquired with repeated practice and become stabilized over time. Healthy young adults are able to learn a repeating stepping sequence during treadmill walking, but the consolidation of locomotor sequence learning and the effects of reinforcement feedback is unclear. The objective of this study was to examine the effects of reinforcement feedback on (1) online learning (i.e., improvement in performance during practice) and (2) offline learning (i.e., improvement in performance over time without additional practice) of locomotor sequence learning. METHODS: Twenty-eight healthy young adults (20 ± 2.9 yrs) were presented with (R)andom and (S)equence stepping targets while walking on a treadmill (Fig. A). The S blocks consisted of a repeating step length sequence (e.g., long-short-medium-short-long-medium), and R blocks consisted of random step length sequence. The score for each block was based on the number of steps that was within 4 cm from the center of the target. All participants completed two sessions 6 ± 2 hrs apart. In the first session, participants were randomly assigned to control (CON; n= 9; scores not visible), reward (REW; n = 10; visible scores that increased by 1 for each accurate step), and punishment (PUN; n = 9; visible scores that decreased by 1 for each inaccurate step) groups. In the second session, all participants performed the same blocks without seeing their scores. Locomotor sequence-specific learning (LSL) was quantified as the S test block score minus the average of two adjacent R test block scores (Fig. B). Online learning was assessed as the change in LSL across three timepoints during the first session. Offline learning was assessed by the change in LSL between end of session 1 and beginning of session 2. RESULTS: Participants showed online locomotor sequence learning during the

first session, but there was no group effect nor a group x block interaction effect (LSL scores: $p < 0.002$; Group: $p = 0.730$; Interaction: $p = 0.816$). There was significant forgetting of the sequence (i.e., negative offline learning), but group effect and group x test score interaction effect was not significant (LSL scores: $p = 0.047$; Groups: $p = 0.596$; Interaction: $p = 0.453$). CONCLUSIONS: Reinforcement feedback did not affect online locomotor sequence learning, nor offline learning. Unlike upper extremity sequence learning which show offline improvements between sessions, healthy young adults forget the newly learned stepping sequences between the sessions. There may be interference with locomotor sequence learning, as participants were free to walk (but they were asked to not perform any vigorous exercises). Further understanding of differences between upper and lower extremity learning may lead to effective gait interventions to enhance offline learning. FUNDING: NSF Grant #2001222

C – Aging

P1-C-11: ***Body movement strategies to initiate the crossing of a street in front of traditional and self-driving cars in young and older adults***

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BACKGROUND AND AIM:The safety of elderlies is a key societal issue, especially when considering that 48% of pedestrian fatalities involve people aged 65 or more (Sécurité Routière 2017-France). Aging affects street crossing behavior, with a decrease of walking speed or more risky decisions because elderly people have difficulties to estimate the approaching speed of vehicles, especially in complex situations. In young adults, recent work focused on body movement performed to initiate the crossing, showing a top down sequence of advancement along the antero-posterior axis: the head initiates the crossing movement, followed by the shoulders, elbows, wrists, hips, knees and ankles. Identifying such motion invariants can be particularly useful in the context of self-driving vehicles which aim at predicting the intent of crossing. In this study, we aim at investigating body movement strategies performed before crossing in older adults in complex mixed traffic. METHODS: 30 young adults (YA, 21-39yo) and 30 older adults (OA, 68-81yo) were asked to cross (or not) a virtual two-way street by walking in a simulator. Participants performed a total of 120 trials where we manipulated: the type of vehicles (Conventional and/or Self driving car, the latest always stopping to let the pedestrian cross the street), their speed (30 or 50km/h), their position on the lane (far/near lane), as well as the temporal gap available to cross the street (1,2,3,4 or 5s). After computing temporal body segment motion and orientations, we analyzed the delays in initiating the crossing movement for the head, shoulders and hips with respect to the feet. We also performed hierarchical clustering to identify specific groups of behavior. RESULTS: Preliminary results show a top-down sequence of forward body motion, starting from the head to the feet, whatever the traffic condition and the group. In OA, the

head initiates the motion sooner than YA wrt their feet. Moreover, while the horizontal angle profile of the head, shoulders and hips does not allow to identify invariants due to the large variety of behaviors before crossing, the trunk tilt angle profile appears to be a relevant marker for predicting the intent to cross the street. CONCLUSIONS: While aging was shown to affect street crossing decisions, our results highlight consistent behavior between YA and OA regarding trunk tilt profile when initiating the crossing. In line with previous work on YA, we also show a top down sequence of advancement of body segments. Future work is needed to use our results to predict the intent of crossing on a new database. Beside the choice to cross the street, future work is also needed to understand body segment motion and walking speed profile while crossing.

P1-C-12: ***Impact of ageing, fall history and exercise on postural reflexes following unpredictable perturbations: A systematic review and meta-analyses***

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Background and aims: Age-related degeneration in bodily systems including vision, hearing and muscle contribute to the elevated risk of falls in older adults. However it is unknown whether postural reflexes in the form of muscle activation onset latency are affected in ageing, and if exercise is able to elicit beneficial adaptations. Therefore, this review examined the impact of ageing, fall history and exercise on postural reflexes and adaptation to unpredictable perturbations. Methods: MEDLINE, EMBASE, Scopus, SportDiscus and Web of Science were systematically searched for cross-sectional and intervention studies that assessed activation muscle onset latency following unpredictable postural perturbations in adults (CRD42020170861). Results: Thirty-seven articles (n=1257) were included in this review. Older adults had slower postural reflexes compared to young adults (mean difference: 14ms, 95% CI: 10, 18, P<0.001). Regular exercisers had faster postural reflexes compared to sedentary/untrained participants (mean difference: 11ms, 95%CI: -19, -4, P=0.002). Exercise interventions delivered in randomised control trials (RCTs) led to faster postural reflexes (mean difference: -4ms, 95%CI: -9, 0, P=0.04). Uncontrolled clinical trials of exercise (mainly short-term) did not show changes in postural reflexes in pre-post tests (mean difference: -2ms, 95%CI: -5, 1, P=0.36). Conclusions: This review demonstrated that postural reflexes are significantly delayed in older compared to young adults, potentially contributing to delayed balance recovery. Further, adults who regularly exercised for a minimum of one year were able to activate their muscles for postural correction faster compared to their less active counterparts. No significant changes in postural reflexes were evident in uncontrolled clinical trials of short duration, but longer-term RCTs indicated postural reflexes are responsive to training.

P1-C-13: ***Effects of speed on gait complexity***

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BACKGROUND AND AIM: Healthy gait is characterised by smooth, regular and repeating patterns of movement. Studies using biomechanical measures (i.e., kinematics and kinetic) confirm this perception with gait patterns being relatively constant across gait cycles. However, more careful examination of the gait patterns emphasizes complex fluctuations over time. The application of nonlinear dynamics analysis (NLD) provides evidence that this complexity is associated with flexible adaptations to everyday stresses and perturbations placed on the human body during gait. Furthermore, a link is being established between reduced in gait complexity and unhealthy states in gait. Multi scale entropy (MSE) is a NLD tool proposed by Costa et al. (2003) as a measure of gait complexity. Generally, healthy states of walking demonstrate higher complexity, with ageing and disease states being characterised by reduced complexity. Reduced walking speed is a sign of ageing or unhealthy gait. However, to the best of our knowledge, there is no study evaluating the effects of walking speed on gait complexity for continuous variables. The objective of this study was to apply MSE on different kinematics variables in different walking speeds to investigate the effects of walking speed on gait complexity. METHODS: Fifteen healthy female participants (age: 26.8 ± 4.3 yrs, BMI: 22.9 ± 3.7 kg/m2) walked on an instrumented treadmill (M-Gait, Motek Medical BV, Netherlands) at preferred speed (PW) and ± 20% PW. Ethical approval was granted (Uni. of Exeter 210324-A-02). Whole-body marker trajectories were recorded at 220Hz (Miqus M3, Qualisys AB, Sweden). Centre of mass (CoM) and joint angles of Ankle, Knee and Hip in sagittal plane were estimated. One-way repeated measures ANOVAs were used to investigate the effect of speed on gait complexity. Box plots were used to visualize comparison of MSE values in ankle, knee and hip angular displacement, and CoM position, three walking speed, and their estimated central tendency. RESULTS: MSE increased with increasing walking speed for all variables (see Figure 1). Significant effect of speed could be seen only for Ankle complexity ($F(2, 42) = 4.93$, $p = 0.01$) but not for CoM position ($F(2, 42) = 2.43$, $p = 0.1$) or Knee ($F(2, 42) = 2.88$, $p = 0.07$) and Hip ($F(2, 42) = 1.21$, $p = 0.31$) joint angle. CONCLUSIONS: From the results, it was found that complexity increased with increasing walking speed for all variables. Complexity of ankle joint angle significantly increased with increasing walking speed. However, complexity did not significantly change for CoM position for Knee and Hip joints with increasing speed. Findings at the ankle joint are in line with Dingwell et al. (2000), who found that dynamic stability is lower in the gait of older people with slower compared to faster walking speed. Complexity of the ankle joint angle appears to be more sensitive to changes in speed than CoM position for Knee and Hip angles. Hence, it is important to carefully consider and report the exact variables and the NLD performed as this may affect the results and interpretation of changes in NLD with gait speed or other factors such as ageing.

P1-C-14: ***Exploring the influence of clinical outcomes on decline in real world gait speed in older adults and people with Parkinson's disease***

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BACKGROUND: Gait speed is reflective of overall health. Gait speed declines over time in older adults (OA), and to a greater extent in people with Parkinson's disease (PwP)[1]. Slower gait speeds are associated with adverse outcomes such as falls and mortality[2,3]. Previous studies investigating gait speed decline have evaluated explanatory factors such as body composition in isolation[4] or utilised multivariate models to predict laboratory-derived gait speed[5]. Quantifying gait speed in the real world (RWS) provides an ecologically valid outcome measure reflecting functional mobility and is more sensitive to pathology than laboratory-derived gait speed[6]. Establishing which factors influence RWS decline is important for directing prognostic and therapeutic advances. AIM: To investigate which combination of clinical outcomes account for the greatest variance in RWS decline in OA and PwP. METHODS: RWS and clinical outcomes were measured every 18-months over 4.5 years[6]. 60 OA and 69 PwP completed at least two assessments. RWS was measured over 7 consecutive days using a triaxial accelerometer (Axivity Ax3 100Hz). Clinical outcomes included; global cognition (Mini Mental State Examination, Montreal Cognitive Assessment), depression (Geriatric Depression Scale), balance confidence (Activities Balance Confidence (ABC) scale) and PD-specific outcomes (Movement Disorders Society Unified Parkinson's disease Rating Scale Part II; MDS-UPDRSII and Part III; MDS-UPDRSIII, Hohen & Yahr disease stage, levodopa daily dose). Basic descriptors were also included (age, sex, height, mass, BMI, education). Linear mixed effects models evaluated which combination of outcomes accounted for the greatest variance in RWS decline. RESULTS: In OA, RWS significantly declined by 0.045 m/s ($p=0.002$) over 4.5 years and the combination of age, mass and self-reported balance confidence (ABC scale) accounted for the greatest variance ($R^2=82.6\%$) in RWS decline. In PwP, RWS significantly declined by 0.054 m/s ($p<0.001$) over 4.5 years and the combination of age, BMI and self-reported functional mobility (MDS-UPDRSII) accounted for the greatest variance ($R^2=85.1\%$) in RWS decline. CONCLUSIONS: RWS significantly declined over time in both OA and PwP with a greater rate of decline in PwP. Mitigating RWS decline requires a multifactorial approach - simultaneously managing and treating clinical outcomes is likely to offer the greatest impact. Patient-reported outcomes, such as functional mobility and balance confidence (ABC scale, MDS-UPDRSII), provide unique insights and are important factors explaining RWS decline in ageing and Parkinson's disease. References: [1] Wilson 2020 Frontiers Aging Neurosci [2] Del Din 2017 J Gerontol Med Sci [3] White 2013 J Gerontol [4] Beavers 2013 American J Clin Nut [5] Nemanich 2013 Parkinsons Disease [6] Shah 2020 J Neuroeng Rehab [7] Del Din 2016 Frontiers J Neuroeng

P1-C-15: ***Effects of age on the visuo-locomotor control used to circumvent a virtual pedestrian with different limb movements***

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Background: It is known that young adults (YA) circumvent a cylinder differently than another pedestrian. In addition, local movements of the pedestrian (i.e. of the arms and legs) appear to influence minimum clearance but not path planning if the pedestrian's approach is predictable. However, the role of local movements on circumvention planning remains unknown when pedestrian trajectory is initially unpredictable. In addition, older adults (OA) tend to initiate trajectory deviation earlier, and reduce minimal clearance for pedestrian avoidance compared to young adults (YA), but the effects of age in relation to using local vs. global (whole body) movements for trajectory planning and clearance are not known. The aim of this study was to understand how local limb movements of a pedestrian with an initially unpredictable trajectory affect circumvention control in YA and healthy OA. Methods: Fourteen YA and 14 OA (> 70 years) were immersed in a virtual shopping mall and instructed to circumvent a virtual agent (VA) approaching from straight ahead with either normal locomotor movements, upper limbs fixed, lower limbs fixed, or both upper and lower limbs fixed. In addition, in order to keep the walking trajectory initially unpredictable, catch trials were interspersed where the VA deviated 25 degrees to the right or left after walking 1 m. Onset distance for trajectory deviation, minimum clearance, body segment yaw angles and gaze behaviour were analyzed. Nonparametric Analysis of Longitudinal Data were used to compare variables across the age groups and conditions. Results: Lack of upper or lower limb movements resulted in deviations initiated farther from the VA for both age groups ($p<0.001$), but the changes were related more specifically to lack of lower limb movement for the YA group. Minimal clearance was unchanged across conditions and similar for both age groups. In general, OA walked slower ($p<0.001$), began deviation farther from the VA ($p<0.001$), produced smaller head ($p=0.02$) and trunk yaw ($p=0.005$), and visually focused on the VA for a greater percentage of time ($p=0.041$). Concerning gaze towards the different body parts of the virtual agent, both groups looked more at the trunk compared to other segments ($p<0.02$ for both), but OA focused more on the lower limbs when they were fixed ($p<0.04$). Conclusions: Lack of limb movements of another pedestrian resulted in more conservative circumvention control, as reflected by the increased distance for initial deviation onset. The OA needed more time to process visual information which resulted in an even earlier deviation onset. Such age-related changes in pedestrian circumvention in a healthy older group could lead to a greater risk of falls in OA populations with reduced balance and mobility, limiting their community ambulation.

P1-C-16: ***The electromechanical delay and its association with maximal force and rate of force development before and after fatigue in young and elderly men***

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BACKGROUND & AIM: Aging is associated with a progressive loss of muscle mass and muscle force, and an alteration of motor units discharge properties. These changes could be based on some neurogenic alterations. The loss of muscle strength, the decrease in the rate of force development (RFD) and the changes in electromechanical delay (EMD) might explain the decrease in functional capacities and mobility accompanying human aging. Moreover, these changes and their effects may be exacerbated by fatigue. Thus, the aim of the present study is to assess the electromechanical delay and its relationship with maximal force (Fmax) and rate of force development before and after fatigue. METHODS: Twenty-five young healthy men (Y: Age=24.6±3.0y; Ht=1.77±0.05m; Wt=81.4±20.1kg), and 22 old healthy men (O: Age=75.6±9.2y; Ht=1.70±0.05m; Wt=77.5±10.7kg) preformed 3-2s maximal voluntary isometric contraction (MVC) of the right knee extensors followed by a fatigue test (FT). The FT consisted of a series of 2s MVC alternated with 1s rest until Fmax reached 50% of the initial value. Muscle twitches were produced using 3 to 5-1ms electrical pulses before and after the FT. EMD was determined for muscle twitches [EMD(Tw)], MVC [EMD(MVC)] and the end of FT [EMD(eFT)]. The Fmax and RFD were determined for MVC, and the end of fatigue (eFT). Statistical significance was set at $p<0.05$. RESULTS: Young individuals were nearly twice as strong as the elderly participants (Y: 533.8±154.1N vs O: 306.2±73.8N). Their RFD, normalized as % of Fmax, were similar in both groups (Y: 335.9±128.7%Fmax/s vs O: 317.63±94.5%Fmax/s). The EMD(MVC) was shorter in the young participants (Y: 34.7±13.1ms vs O: 51.7±17.7ms). There were similar negative associations between EMD(MVC) and Fmax before fatigue (Y: r=-0.36 & O: r=-0.48). The EMD(MVC)-RFD associations were similar for both groups (Y: r=-0.44 & O: r=-0.37). The EMD(eFT) increased by similar amounts for both groups (Y: 17.1±16.9ms vs O: 18.1±21.3ms). Its associations with RFD (Y: r=-0.50 & O: r=-0.36) remained the same in both groups at eFT. Although the correlation was similar for EMD(eFT)-Force for young (r=-0.50), there was no association for elderly participants (r=-0.06). Finally, the EMD(Tw) was similar in both groups before (Y: 13,5±2.0ms vs O: 13.9±2.1 ms) and after fatigue (Y: 15.1±2.8ms vs O: 14,8±1,7ms). CONCLUSIONS: The EMD(MVC) was longer in old men than in young individuals and similarly negatively correlated with Fmax and RFD. Fatigue increased the EMD equally in both groups and the correlations with Fmax remained unchanged. Likewise, after fatigue, the association between EMD(eFT) and RFD remained the same for young men but it was uncorrelated for the elderly individuals. The muscle twitch EMD was similar in both groups and was unchanged by fatigue. FUNDING: CIHR, RQRV, FRQS (MAL, GG), CFI (MAL), GRAPA.

P1-C-17: ***Dual task walking and healthy ageing: Effect narrow and wide walking paths***

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BACKGROUND AND AIM: Walking is a popular form of physical activity for many urban-dwelling older adults, however common features in the built environment such as narrow sidewalks can discourage walking, and are likely to be taxing for older adults' gait and cognitive resources. Therefore, dual task walking on challenging city streets may lead to gait instability and a higher fall risk for older adults. This study aimed to assess how older adults' gait is affected when walking on a narrow path and simultaneously performing a cognitive task. METHOD: The study was carried out in lab conditions which aimed to imitate common urban environments. Nineteen young and eighteen older adults walked ten metres on a narrow path (40cm width) and a wide path (80cm width), and performed a cognitive task, specifically the auditory n-back task which was individually adjusted to 80% baseline accuracy. All participants performed the walking and cognitive tasks separately (single task) and concurrently (dual task). RESULTS: In both groups narrow path walking was associated with fast gait and narrow step width, whereas dual task walking was associated with slow gait and short stride length. For older adults, dual task walking on a narrow path led to increased dual task costs for both the cognitive task and gait characteristics including speed, step width, and stride length. CONCLUSIONS: These results suggest that dual task walking may adversely affect gait on narrow pathways. Such conditions could lead to gait instability and higher fall risk for older adults, particularly when walking along narrow sidewalks which are commonly found in the built environment.

P1-C-18: ***Age-Related Changes in Gait Domains: Results from the LonGenity Study***

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Background: Poorer performance in specific gait domains such as slower pace and increased rhythm and variability are associated with falls, frailty, cognitive decline, and dementia. Little is known, however, about the longitudinal changes in gait domains with advancing age. The aim of this study was to examine age-related changes in gait domains overall, and specifically in those with cognitive and mobility impairments. Methods: A sample of community dwelling older adults of Ashkenazi Jewish descent (n=927; M Age=75.0±6.5 years; 55.9% female) were followed for up to 12 years (M follow-up=4.0±3.2 years). Those with a diagnosis of dementia, severe visual or hearing impairment, and siblings already enrolled in the study were excluded. Gait was assessed using a computerized GAITRite walkway while participants completed one walking trial at their usual pace. Gait velocity and absolute values of right side 1) step length, 2) step time, 3) cadence, and 4) base of support (BOS) were directly obtained from the GAITRite software. Variability in step length, step time, and BOS were calculated as the standard deviation of each measure across all steps. Linear mixed effect models examined age-related changes in gait domains overall, and in those with motoric cognitive risk (MCR; slow gait and cognitive complaint) and or mobility disability (inability to climb stairs). Results: A principal component analysis revealed three gait domains: pace (velocity, step length), rhythm (step time, cadence) and variability (step length variability, step time variability). Pace declined with advancing age in a non-linear (accelerating) fashion (at 68.4 years β= -0.092, 95%CI -0.107, -0.077, at 89.7 years -0.234, 95%CI -0.252, -0.215). Rhythm (β= 0.087, 95%CI 0.022, 0.153) and variability (β= 0.111, 95%CI 0.024, 0.197) showed linear increases with age. Pace showed a faster decline in those with MCR (β= -0.034, 95%CI -0.046, -0.021) and mobility disability (-β= 0.046 96%CI -0.061, -0.032) compared to those without MCR and mobility disability. Discussion: This study suggests that age-related changes in gait domains are not uniform, and that individuals with MCR and mobility disability are particularly vulnerable to accelerated decline in pace.

P1-C-19: ***Longitudinal associations between falls and risk of gait decline: The Central Control of Mobility and Aging Study***

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Background: Poor gait is an important risk factor for falls. It is less clear, however whether falls predict future gait decline. The aim of this study was to examine whether falls are associated with longitudinal changes in different gait domains and the onset of clinical gait abnormalities. Methods: Community-dwelling older adults (n=428, mean age 77.8±6.4 years) that were free of dementia and able to ambulate independently in the community were examined. The exposure variable was the number of falls (categorized as none, single, multiple) during the first year of follow-up. Gait was assessed during usual pace walking with a computerized walkway. The outcome measures of pace, rhythm and variability (1.7±1.5 years after the first year follow-up) were derived from individual gait measures, using principal component analysis. Clinical gait abnormalities (neurological, non-neurological, mixed) were visually assessed by clinicians. Linear mixed effects models were used to examine the associations between falls and longitudinal changes in gait domains. Multinomial logistic regression was used to examine the association between falls and the onset of clinical gait abnormalities. All models were adjusted for sex and education, age, body mass index, global health and gait speed at the first year follow-up, and for time between the last fall and subsequent gait assessment. Results: The pace domain (composed of velocity and stride length) declined at a faster rate (b -0.12, 95% CI -0.20, -0.03 p=0.01) in 32 participants with multiple falls during the first year of follow-up compared to the 299 participants without falls - corresponding to a 0.6% faster decline per year. The rhythm domain (stride time, stance time, swing time, double support time) increased at a faster rate (b 0.32, 95%CI 0.38, 1.27 p=0.001) - corresponding to a 3.3% faster increase. The variability domain (stride time, stance time, swing time, double support time) also increased at a faster rate (b 0.82 95%CI 0.38, 1.27 p<0.001) - corresponding to a 6.8% faster increase. There was no increased risk developing clinical gait abnormalities. Those with single falls showed no differences in the rate of decline or in the risk of developing clinical gait abnormalities, compared to people with no falls. Conclusions: Multiple falls predict future gait decline in multiple domains in older adults. Interventions to prevent gait decline following multiple falls should be investigated.

P1-C-20: ***A shift in electromyographic power spectrum of leg muscles to higher frequencies during walking in older females: indication of altered motor unit recruitment?***

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BACKGROUND: Sarcopenia, an age related disease, affects quality, quantity, strength, function, and structure of human muscles [1]. One of the primary factors leading to age-

related muscle weakness is the loss of motor units and denervation of the related muscles caused by increased inflammation and oxidative stress in peripheral nervous system [2]. Electromyography (EMG) signals may provide information about recruited motor units [3]. Time-frequency analysis of electromyography by wavelet analysis has been used to understand the recruitment of motor units and related dynamics of type I and type II muscle fibres in laboratory settings [4]. This time-frequency analysis may be able to identify related motor dysfunction in sarcopenia. AIM: To evaluate the effect of age on frequency band distribution of the intensity of the EMG signal from lower limb muscles. METHODS: Data were collected from twelve healthy female participants; 6 young (21-30 years, median 23) and 6 older (60 -75 years; median 66). Muscle activity was recorded from 3 leg muscles (soleus (SO), tibialis anterior (TA), medial gastrocnemius (MG)) using a wireless EMG system (PLUX S.A., Portugal, 1000Hz). Participants walked for 5-minutes on a motorised treadmill at their comfortable walking speed. Contact switches on the plantar foot recorded heel contact and toe-off events. Power spectral density was estimated using a nonlinearly scaled wavelet transform with a bank of 11 wavelets (7 - 395 Hz). The first 2 wavelets (w1, w2) were removed due to movement artefact. The sum of intensities in low (w3-w5), medium (w6-w8) and high (w9-w11) bands were calculated, and the ratio of total intensity (w3-w11) was determined. Linear mixed effect models were applied with participant group and muscle as main factors and treadmill speed as a covariate. RESULTS: Significant differences in intensity ratio in low and high wavelet bands were found in TA, SO and MG between young and old females. Older females had more energy in higher frequency bands compared to younger females in the one-joint muscles TA and SO. More energy was contained in lower frequency bands in the two-joint muscle MG in older compared to younger females. CONCLUSION: These results may indicate a combination of altered morphology, and different motor unit recruitment during walking in older adults. Further investigation is needed to determine if these changes relate to altered motor function often present in older adults. ACKNOWLEDGEMENTS AND FUNDING: We acknowledge funding from European Commission Marie-Sklodowska-Curie Innovative Training Networks 860173, UKRI Industrial Strategy Challenge Fund and Newcastle Wellcome Trust Translational Partnership (NWTTP) for the project. REFERENCES: [1] Cruz-Jentoft, A.J., et al., Age and Ageing, 2019. 48(1): p. 16-31.[2] McKinnon, N.B., et al., Exp Geront, 2015. 70: p. 111-118. [3] Wakeling, J.M., et al.,. J R Soc Interface, 2006. 3(9): p. 533-544. [4] Qi, L., et al., J Electromyogr Kinesiol, 2011. 21(1): p. 128-135.

P1-C-21: ***Association between body shape metrics and spinal alignment among healthy women***

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BACKGROUND AND AIM: It has been reported that spinal alignment is associated with fall risk and locomotive syndrome. Although the relationship between body shape and spinal alignment has been investigated, the body shape metrics remain limited. Therefore, it is not well understood as to which body shape metrics are associated with spinal alignment. The body shape can be changed by non-invasive methods such as exercise therapy and changes in spinal alignment that would ultimately enhance physical functions. This study aimed to determine the body shape metrics that affect the spinal alignment. METHODS: The participants were 51 healthy women between the age of 21-68 years (mean 46.8 ± 13.2). We used Spinal Mouse (Index Ltd., Japan) to evaluate the spinal alignment in upright standing position by measuring the thoracic kyphosis angle (TKA), lumbar lordosis angle (LLA), sacral slope angle (SSA), and the spinal inclination angle (SIA). We measured the following body shape metrics: over-bust chest circumference (OBCC), under-bust chest circumference (UBCC), waist circumference (WC), buttock transverse diameter (BTD), and anteroposterior diameter between the greater trochanter and buttock top (GT-BT). The OBCC, UBCC, and WC were measured using a tape measure, BTD was measured using a caliper, and GT-BT was calculated using a 3D body scanner (SIZE STREAM Ltd., USA). We calculated the ratio of the measured body shape metrics, and the following parameters were also included in the analyses as appearance indicators representing body shape: OBCC/WC, UBCC/WC, BTD/GT-BT, WC/BTD, and WC/GT-BT. Simple regression analysis was used to investigate the association between the body shape metrics and spinal alignment, as well as the relationship between the age and spinal alignment. This was followed by a stepwise multiple regression analysis to evaluate which body shape metrics are related to the spinal alignment with and without adjustment by age. All statistical analyses were performed using SPSS Software version 22 (IBM Japan Ltd., Japan). Statical significance was set at $p<0.05$. RESULTS: Simple regression analysis showed that only TKA was associated with age($\beta=0.325$, $p=0.020$). Regarding the relationship between body shape metrics and spinal alignment, OBCC ($\beta=0.418$, $p=0.002$), UBCC ($\beta=0.483$, $p<0.001$), WC ($\beta=0.447$, $p=0.001$), GT-BT ($\beta=0.352$, $p=0.011$), and WC/BTD ($\beta=0.363$, $p=0.009$) were all related to TKA. No significant correlations were found in the body shape metrics and other spinal alignment parameters (LLA, SSA, and SIA). The multiple regression analysis showed that UBCC was significantly associated with TKA, even after adjusted by age ($\beta=0.442$, $p=0.001$, Table 1). CONCLUSIONS: We showed that a larger under-bust chest circumference was significantly associated with an increase in thoracic kyphosis angle despite the influence of age. Our results suggest that decreasing the under-bust chest circumference by weight control and exercise therapy may reduce thoracic kyphosis angle.

P1-C-22: ***Effect of a customized safety harness on dance-based exergaming movement kinematics among people with chronic stroke***

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Background: Previous dance-based exergaming (DBExG) trials have exhibited improvement in motor and cardiovascular fitness in people with chronic stroke (PwCS). These trials comprised of contact guard assistance via gait belt to the participants during training. However, to achieve the present need of an unsupervised home-based rehabilitation approach, it would help to develop methods, such as safety harness that can facilitate independent self-training. Different methods could alter the biomechanical or kinematic demands of movement control and could result in distinct movement adaptations and safety.

Objective: Thus, the purpose of the current study was to investigate chronic stroke survivor's movement kinematics of dance movements to different conditions (no assistance-NA, safety harness assistance -SHA, contact guard assistance with gait belt-CGA) using DBExG among PwCS. Methods: Community-dwelling PwCS participated in the study. Seven inertial sensors (IS) were used to capture dance movements of ten participants. Participants danced to three songs of slow (120 beats per minute, bpm), medium (130 bpm), and fast pace (138 bpm). Three-10 seconds trial were recorded for each dance and the mean values of variables were used for analysis. For analysis, a customized MATLAB code generated segment angle excursions (difference between the maximum and minimum angle peaks) of the right and left thighs (Rt and Lt thighs), right and left shanks (Rt and Lt shanks), and the right and left feet (Rt and Lt feet) joints in the sagittal plane were used. Results: For the slow pace dance, there was a significant increase in hip and ankle joint excursions between NA condition and CGA condition ($p < 0.05$). For the hip and knee joint excursions ($p < 0.05$), there was a significant increase between NA condition and SHA condition. Similarly, there was a significant increase for the hip joint excursion ($p < 0.05$) for the SHA condition and CGA condition. For the medium pace dance, there was a significant increase in ankle joint excursions between NA condition and CGA condition ($p < 0.05$). Further the ankle joint excursions increased in CGA condition in comparison to SHA ($p < 0.05$). With respect to the fast pace dance, participants showed a significant increase in hip joint excursions between NA condition and CGA condition ($p < 0.05$), along with increase seen in CGA with gait belt condition in comparison to SHA condition ($p < 0.05$). Further there was a significant increase in the ankle joint excursions in the SHA condition in comparison to the NA condition ($p < 0.05$). Conclusion: The results shows that SHA, and CGA condition exhibited similar levels of joint angle excursions, however hip (slow, and fast pace), and ankle (medium pace) joint angle excursions were significantly higher in CGA group in comparison to SHA group. The present study represents the first of its kind to attempt to determine quantitatively the joint angle excursions that are influenced by different conditions among PwCS. Future studies, should be conducted to develop, customize and prescribe feasibility of safety harness augmented DBExG rehabilitation.

P1-C-23: ***The impact of advanced age on prosthetic rehabilitation gait outcomes following a lower limb amputation***

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BACKGROUND AND AIM: More than 75% of all lower limb amputations (LLAs) occur in people over the age of 65 years primarily due to complications of diabetes and peripheral vascular disease. The rate of LLAs performed in people aged 80 and over (oldest old) is expected to increase as they are the fastest-growing age group in which these conditions are common. The goal of prosthetic rehabilitation is to restore walking ability, which is the most important factor contributing to quality of life in people with an LLA. However, rehabilitation for the oldest old can be complicated by the presence of multiple comorbidities acquired with age. Unfortunately, studies investigating the effect of age on gait outcomes that included the oldest old are limited. The aim of this study was to evaluate the impact of

age on functional gait outcomes at discharge from an inpatient prosthetic rehabilitation program. METHODS: This was a retrospective cohort study using chart audit of consecutive admissions (January 2012 to December 2019) to the inpatient amputee program at Parkwood Institute in London, Ontario. Study criteria were: transtibial level LLA and above, ≥18 years old. Participants were stratified into 7 categories based on age decades: 18-29, 30-39, 40-49, 50-59, 60-69, 70-79 and 80+. The L-Test of Functional Mobility and 6-Minute Walk Test (6MWT) assessed functional mobility and endurance, respectively. The Activities-specific Balance Confidence (ABC) scale evaluated balance confidence. Three separate one-way analysis of variance (ANOVA) models with post-hoc Tukey testing for pairwise comparisons evaluated outcome data across age groups at discharge. RESULTS: A total of 601 participants (62.3±14.1 years, 434 males) were included in the analysis. The oldest old category consisted of 63 participants (84.9±3.7 years, 41 males). The average length of stay for all participants in the program from admission to discharge was 29.2±27.0 days. The ANOVAs were statistically significant for the L-Test, 6MWT and ABC scale ($p<0.001$). Post-hoc testing for the L-Test and 6MWT demonstrated that the oldest old had significantly reduced performance compared to the 4 age groups under 60 years old [(18-29, 30-39, 40-49 and 50-59), $p<0.05$], but there were no significant differences between the oldest old and the 60-69 [(L-Test, $p=0.113$), (6MWT, $p=0.094$)] and 70-79 [(L-Test, $p=0.866$), (6MWT, $p=0.907$)] age groups. For the ABC scale, the oldest old reported significantly lower balance confidence compared to all 6 age groups ($p<0.05$). There were no significant differences for balance confidence observed between the other age groups (18-29, 30-39, 40-49, 50-59, 60-69 and 70-79). CONCLUSIONS: The results of this study demonstrate that gait performance decreases with increasing age up to 60 years old in people with LLAs. The differences in gait across the different age groups can inform clinicians on prognostic expectations during prosthetic rehabilitation programs. Importantly, the oldest old show similar potential for improved walking ability as the most common group of people with an LLA (≥60 years old). Therefore, advanced age alone should not disqualify individuals from entering prosthetic rehabilitation.

P1-C-24: ***Standing, Transition and Walking Ability in Older Adults: The Case for Independently Evaluating Different Domains of Mobility Function***

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BACKGROUND AND AIMS: Independent mobility is a complex behavior that relies on the ability to walk, maintain stability and transition between postures. However, guidelines for assessment that detail what elements of mobility to evaluate and how they should be measured remain unclear. METHODS: Performance on tests of standing, sit-to-stand, and walking were evaluated in a cohort of 135 complex, co-morbid, older adults (mean age 87 ± 5.5 years). Correlational analysis was conducted to examine the degree of association for measures within and between mobility domains on a subset of participants (n=83) able to complete all tasks unaided. Participants were also grouped by presence of risk markers for frailty (gait speed, grip strength) to determine if level of overall impairment impacted

performance scores and if among those with risk markers, the degree of association was greater. RESULTS: Within-domain relationships for sit-to-stand and walking were modest (rho=0.01-0.60). Associations either did not exist or relationships were weak for measures reflecting different domains (rho=-0.35-0.25, p>.05). As expected, gait speed differed between those with and without frailty risk markers (p<0.001), however, balance and sit-to-stand measures did not (p≥0.05). CONCLUSIONS: This study highlights the need to independently evaluate different mobility domains within an individual as a standard assessment approach. Modest within-domain relationships emphasize the need to account for multiple, unique control challenges within more complex domains. These findings have important implications for standardized mobility assessment and targeted rehabilitation strategies for older adults. ACKNOWLEDGMENTS AND FUNDING: NSERC Canada.

D – Biomechanics

P1-D-25: *Locomotion behavior of chronic non-specific low back pain patients while walking through apertures*

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BACKGROUND AND AIM: Chronic Low Back Pain has been identified as one of the leading global causes of disability, and in most cases is characterized by symptoms without clear patho-anatomical causes, called chronic Non-Specific Low Back Pain (cNSLBP) [1]. The majority of clinical trials assess cNSLBP using scales or questionnaires reporting an influence of cognitive, emotional and behavioral factors [2]. Previous studies have evaluated the motor consequences of cNSLBP using biomechanical analysis, showing alterations in the kinematics and dynamics of locomotion [3,4]. However, few studies have evaluated cNSLBP participants in ecological situations, such as walking with obstacles or avoidance, allowing a simultaneous evaluation of cognitive, perceptual and motor components in a situation closer to the one encountered in daily life. In this context, using a horizontal aperture crossing paradigm [5], this study aimed to 1) understand the effect of cNSLBP in action strategies and (2) identify factors that may influence these decisions. METHODS: Healthy adults (N=15) and cNSLBP adults (N=15) performed a walking protocol composed of 3 random blocks of 19 trials with aperture ranging from 0.9 to 1.8 x shoulder width. The dimensions of the obstacle causing an individual to change their actions (shoulders rotation, velocity, trunk stability) is referred to as the Critical Point (CP). RESULTS: In these preliminary results considering shoulder width, welch's t-test showed that the average CP in the healthy group was significantly larger (1.20, SD = 0.052) than the one of cNSLBP group (1.15, SD = 0.029) (t(20.08) = 3.07, p<0.01, d = 1.16). CONCLUSIONS: This analysis on shoulder data is a first attempt to investigate the influence of cNSLBP on motor behavior and decisions in an ecological paradigm. Results show a slightly more risky behavior of patients with smaller CP. Future work is required to study walking speed profile and to relate behavioral data with variables that can influence pain perception (intensity, duration, kinesiophobia, fear avoidance beliefs, catastrophism and psychological inflexibility). [1] Maher et al. (2017) The Lancet. [2] Chiarotto et al. (2015) European Spine Journal. [3] Koch et al. (2019) Frontiers in psychology. [4] Moissenet et al. (2021) Scientific reports. [5] Higuchi et al. (2006) Experimental Brain Research. ACKNOWLEDGEMENTS AND FUNDING: Rennes 2 University, Rennes, France.

P1-D-26: ***Gait stability prediction from stride-to-stride motor variability of upper limb joint angles in healthy young adults***

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BACKGROUND AND AIM: Arm swing amplitude is linked to gait stability. In young adults, active accentuation of arm swing increases trunk local dynamic stability [1] but decreases centre-of-mass smoothness [2]. Coinciding with these changes were adjustments in the stride-to-stride (motor) variability of lower limb joint angles [3]. However, these patterns have been unexplored in the upper limb. We determined if motor variability of upper limb joint angles during arm swing predicts gait stability for young adults. METHODS: Healthy young adults (N = 14; 7 females) were instrumented for gait analysis with an 11-camera optoelectronic system (Vantage, Vicon). Participants walked three 7-minute trials on a treadmill at 100%, 70%, and 130% of preferred speed. Inverse kinematics were computed for 200 consecutive constant-speed right strides in OpenSim using a full-body model [4]. Gait stability was quantified by the local divergence exponent (λmax) of trunk velocity and by anterior-posterior, medio-lateral, and vertical harmonic ratios (HRs) of centre-of-mass linear acceleration. Arm swing motor variability measures were the stride-to-stride mean standard deviation (meanSD), λmax, and sample entropy (SaEn) of left elbow and tridimensional shoulder and wrist angles. Step-wise multiple linear regressions were conducted on speed-pooled values to determine if arm swing motor variability predicted trunk λmax and centre-of-mass HRs (significance: $p < 0.050$). RESULTS: Arm swing motor variability significantly predicted trunk λmax (adjusted $R2 = 0.64$, $p < 0.001$), anterior-posterior HR (adjusted $R2 = 0.38$, $p < 0.001$), medio-lateral HR (adjusted $R2 = 0.19$, $p = 0.002$), and vertical HR (adjusted $R2 = 0.31$, $p < 0.001$). Unstandardized β coefficients (Table 1) revealed that higher trunk λmax was independently predicted by higher elbow flexion λmax, higher wrist flexion meanSD, and higher wrist flexion SaEn. Lower anterior-posterior HR was independently predicted by higher elbow flexion SaEn and lower shoulder abduction SaEn. Lower medio-lateral HR was independently predicted by higher elbow flexion SaEn. Finally, lower vertical HR was independently predicted by higher elbow flexion SaEn, higher wrist flexion meanSD, and lower wrist pronation λmax. CONCLUSIONS: Upper limb motor variability predicted gait stability in young adults. Lower regularity of shoulder abduction, higher magnitude of elbow flexion variability, and lower local dynamic stability of wrist pronation predicted smoother centre-of-mass accelerations, suggesting that higher upper limb variability does not always harm gait smoothness. Predictors were primarily the variability of elbow flexion and wrist angles, suggesting that adjustments in patterns of the distal upper limb enhance gait stability.
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P1-D-27: *Do Humans Regulate Mediolateral Margin of Stability from Step-to-Step?*

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BACKGROUND & AIM: Maintaining frontal-plane stability is a major objective of human walking. Generally, humans prevent or overcome mediolateral instability by adjusting center-of-mass (CoM) dynamics and foot placement (Bruijn and van Dieën, 2018). Several simulated and empirical walking studies have proposed that humans adjust these dynamics to achieve a constant minimum mediolateral Margin-of-Stability (MoSML). However, we still lack a coherent theoretical framework to develop and test hypotheses regarding how humans regulate fluctuations to achieve gait stability. Here, we unify the inverted-pendulum model with analyses based on the goal-equivalent manifold (GEM) concept (Cusumano and Cesari, 2006). We use this framework to evaluate whether humans regulate their step-to-step movements to achieve a constant MoSML. METHODS: We identify a linear candidate stability GEM in the inverted pendulum model phase plane. All CoM dynamics along this line achieve a constant MoSML. We tested the hypothesis that humans coordinate CoM dynamics to exploit redundancy along this GEM. We extracted time series of CoM state (z, $\dot{z}$), lateral support boundary (uz), and minimum mediolateral MoS (MoSML) at each step from walking trials of 17 older (ages 60+) and 17 young (ages 18-31) adults. We converted [z-uz, $\dot{z}/\omega 0$] coordinates into perpendicular, 'goal-relevant' (δ(P)) and tangent, 'goal-equivalent' (δ(T)) deviations from the candidate stability GEM. We quantified variability (σ) and statistical persistence (DFA α) of each. If humans seek a constant MoSML at each step, we expected that they would demonstrate reduced variability of CoM dynamics perpendicular to the GEM ($\sigma(\delta(P)) \ll \sigma(\delta(T))$) and readily correct deviations perpendicular to but not along the GEM ($\alpha(\delta(P)) \approx 0.5 \ll \alpha(\delta(T))$). RESULTS: Participants did exhibit δ(P) deviations from the constant-MoSML GEM that were far less-variable than δ(T) deviations along the GEM. However, while participants readily corrected δ(P) deviations off of the GEM (i.e., $\alpha(\delta(P)) \approx 0.5$), they also readily corrected δ(T) deviations along the GEM (i.e., $\alpha(\delta(P)) \approx \alpha(\delta(T)) \ll 1$). Furthermore, the extent to which participants regulated step width (w), and lateral body position (zB), strongly predicted the extent to which they regulated step-to-step CoM deviations. CONCLUSIONS: Since participants readily corrected δ(T) deviations tangent to the candidate stability GEM, they did NOT exploit equifinality along the GEM in ways consistent with a constant-MoSML stabilizing strategy. Still, the CoM dynamics were found to be tightly regulated from step-to-step for all participants. We show here that the regulation of w (and to a lesser-extent zB) predicted this regulation of CoM state. Since walking humans cannot directly actuate their CoM itself, this suggests that regulation of mediolateral CoM state occurs as a biomechanical consequence of foot placement regulation. FUNDING:NIH R01-AG049735

P1-D-28: ***Age-related differences in sit-to-stand motor strategy: a musculoskeletal computer simulation analysis***

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BACKGROUND AND AIM: Sit-to-stand (STS) task is one of the most commonly performed functional activities, and its impairment is associated with the risk of falls. The STS motor strategy can be classified by the horizontal momentum (velocity) of whole-body center of mass (COM) and its location to the base of support (BOS). The elderly choose a conservative strategy to ensure the body's stability, in which the COM is positioned inside the BOS prior to seat-off. In contrast, the young tend to initiate STS while their COM is located posterior to the BOS and utilize a larger horizontal momentum to bring the COM inside the BOS at seat-off. However, it is unclear whether such differences in the strategy would result from: (i) the age-related differences in muscular functions, or (ii) prioritizing a different objective for COM control, i.e., COM position or velocity. This study investigated the differences in COM control during STS task by musculoskeletal simulation between the models with and without deficits in muscular functions, when the different objective functions for COM control were used. METHODS: STS task was simulated using two different musculoskeletal models representing the young (Young) and elderly (Elderly) through numerical optimization. Muscle parameter values for Young and Elderly models and duration time for simulation were derived from previous studies. Numerical optimization was executed to find the muscle activation patterns that yield the upright posture from the sitting position under the following three different objective functions: (a) base function (BASE), and BASE with an additional function, (b) minimizing a COM position with respect to the mid-point of the BOS (POS), or (c) maximizing a COM velocity at seat-off (VEL). BASE function was set to minimize the difference between the simulated and targeted upright posture at the end of the simulation. Horizontal COM position and its velocity at seat-off were used to evaluate the STS strategy. RESULTS: In the BASE condition, the COM was located posterior to the BOS with a larger horizontal velocity at seat-off in Young, while it was inside the BOS with a smaller horizontal velocity in Elderly (Figure). Although Young successfully performed STS in both POS and VEL conditions, Elderly could not complete the task within the duration of simulation in the VEL condition. CONCLUSIONS: Elderly model with reduced muscle parameters positioned the COM inside the BOS before lifting up the upper body, while Young model utilized a larger horizontal velocity to bring the posteriorly-located COM inside the BOS. These results coincide with previously reported STS strategies chosen by the young and elderly. When the COM velocity was added to the objective function, Elderly model failed the task, while Young model successfully performed the task with a large COM velocity. These findings suggest that age-related degeneration of muscular function would be a limiting factor to execute the STS task with a large horizontal momentum. ACKNOWLEDGEMENTS AND FUNDING: This work was supported by JSPS KAKENHI Grant Number JP21J01097.

P1-D-29: ***Stable passive dynamics during obstacle crossing may indicate a safety-energy efficiency trade-off in older adults.***

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BACKGROUND & AIM Walking in the community requires fulfilling multiple goals simultaneously such as avoiding hazards while maintaining stable forward locomotion [1]. Stable gait in anteroposterior (AP) direction is achieved by appropriate foot placement [2]. In an uncluttered and unperturbed environment, stable gait is associated with consistent foot placements. In a cluttered environment, individuals adjust foot placements to achieve stable gait while navigating hazards. During unobstructed walking, young and older adults rely on passive rotation of the body about the stance ankle to maintain forward progression [4]; however, this reliance on the passive dynamics may change during obstructed gait and in response to increasing age [5]. Further, individuals may proactively modulate passive stability to facilitate transition between unobstructed and obstructed gait. Therefore, our aim is to determine if passive stability is modulated as a function of task, age, and during transition between unobstructed and obstructed gait. METHODS Twenty young (22±4 years) and nine (71±3 years) healthy older adults walked on a 6 m walkway and stepped over an obstacle when present. Each participant completed fifteen trials with and without obstacle. We recorded lower-body kinematics with a motion capture system. We quantified passive dynamic stability in AP direction at each heel contact using margin of stability (MOSap; Fig.1A). Positive (negative) MOSap indicate passively stable (unstable) state [3]. RESULTS A significant three-way interaction (age × task × step) was observed for MOSap ($F_{12,243}$ = 47.10; $p < 0.01$, Fig. 1B). Post-hoc analyses revealed that MOSap was not different in the following steps in both age groups: all steps when an obstacle was not present and three steps during the approach to the obstacle (steps-4,-3,-2). MOSap significantly increased in the step before the obstacle (step-1), and increased further during the obstacle crossing step; the obstacle crossing step was the only step where MOSap was larger for older versus young adults. CONCLUSION Negative MOSap for all but one step indicates exploitation of the passive forward motion of the COM to maintain forward progression. However, this behavior is altered by task, age and during transition. Healthy young and older adults rely less on passive dynamics for forward progression while crossing an obstacle compared to unobstructed walking. Furthermore, the positive MOSap for the obstacle-crossing step indicates a preference for safety over energy efficiency. Although stable passive dynamics will facilitate recovery from a potential perturbation (e.g., a trip), the higher stability also means that more energy (greater push-off force) will be required to regain speed after obstacle crossing. Older adults prioritize safety more than young adults. Finally, young and older adults proactively alter MOSap one step before the crossing step, presumably to facilitate obstacle crossing. REFERENCES [1] Chen et al. (1991). J. Gerontol. 46, M196-M203. [2] Winter, D.A (1995). Gait Posture 3, 193-214. [3] Hof, A.L (2008). Hum. Mov. Sci. 27, 112-125. [4] Reimann et al., (2020). Front. Sports Act. Living 2, 94. [5] Hak et al. (2019). J. Biomech. 84, 147-152.

P1-D-30: ***Wearables for Running Gait Analysis: A Systematic Review***

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BACKGROUND AND AIM: Running gait assessment has traditionally been performed using subjective observation or expensive laboratory-based objective technologies, such as 3D motion capture (Vicon) or force plates. However, recent developments in wearable technology allow for continuous monitoring and analysis of running mechanics in any environment. Objective measurement of running gait is an important clinical tool for injury assessment and provides measures that can be used to enhance performance. Therefore, the aim of this systematic review was to identify how wearable technology is being used for running gait analysis in adults. METHODS: A systematic search of literature was conducted in the following scientific databases: PubMed, Scopus, WebofScience, and SportDiscus. Articles published from January 1994 to February 12th, 2021, were reviewed. Information was extracted from each included article regarding the type of study, participants, protocol, wearable device(s), main outcomes/measures, analysis, and key findings. RESULTS: A total of 102 articles were reviewed: 44 investigated the validity of wearable technology, 15 examined the reliability and 59 focused on applied use. Most studies used inertial measurement units (IMU) (n=43) (i.e., a combination of accelerometers, gyroscopes, and magnetometers) or solely accelerometers (n=34), with one using gyroscopes and 27 using pressure sensors. Wearable locations were distributed among the shank, shoe, and the waist/lower back/pelvis. The mean number of participants was 23 (±21), with an average age of 28.1 (±7.3) years, with only two studies examining solely female participants. Most studies took place indoors, using a treadmill; performed retrospective group-based analyses, with the main aims seeking to identify running gait outcomes or investigate the effects of injury, fatigue, intrinsic factors (e.g., age, sex, morphology) or footwear on running gait outcomes. CONCLUSIONS: Generally, wearables were found to be valid and reliable tools for assessing running gait compared to reference standards. Despite the advancements in wearable-specific outcomes for running gait analysis, there is a need for prospective, subject, and sub-group specific investigations that analyse running gait over prolonged periods, among larger numbers of participants, and in natural running environments. The development of multi-modal wearables to give a more comprehensive analysis of running gait would further aid analysis outside of the laboratory. Furthermore, consensus regarding terminology, testing validity and reliability of devices and suitability of performance outcomes needs to be established. Recommendations for future studies examining wearables for running gait assessment are provided and discussed.

P1-D-31: ***Speed-accuracy trade-off in stepping does not depend on age or motor noise***

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BACKGROUND A common cause for falls in older adults is incorrect body weight shifting (Robinovitch et al., 2013). Step initiation requires a series of well described weight shifts (Tisserand et al., 2016). Increased variability in weight shifting is associated with decreased

foot placement accuracy (Bancroft & Day, 2016). Foot placement accuracy has also been found to decrease with speed in walking (Roerdink et al., 2021). The speed-accuracy trade-off is well studied in reaching (Harris & Wolpert, 1998) where signal-dependent motor noise has been identified as a possible origin of the reduced accuracy with increased speed. Motor noise has been found to be higher in older than in young adults (Singh et al., 2013). We therefore investigated whether the speed-accuracy trade-off in a stepping task is stronger in older than in young adults and whether differences in motor noise could explain differences in the speed-accuracy trade-off. AIM Examine - as part of a larger preregistered study - the effect of age on the speed-accuracy trade-off during step initiation and its relationship with motor noise. METHODS We analyzed data from a subsample of 10 (out of 25) young (mean=23.0, SD=2.7 years) and healthy older (mean=73.7, SD=6.5 years) adults. Subjects were instructed to step into targets projected on the ground at comfortable speed and as fast as possible. Foot placement error (ϵfoot) was calculated as the distance between the end position of the foot and target, and averaged over both feet (Figure A). Step duration was determined as the time between target appearance and trailing leg foot-ground contact. We used a linear-model to investigate the relation between changes in step duration and changes in foot placement error (Figure B). To assess motor noise, participants performed a 30Nm knee torque matching task (with visual feedback). We investigated the relationship between the speed-accuracy trade-off (ratio of change in error to change in step duration) and torque fluctuations. RESULTS Foot placement errors increased more in subjects who reduced step duration more (slope=-0.021 m/s; $p < 0.001$, $R2 = 0.51$), and this relationship was similar for young and older adults. We found no difference in slope between young and older adults by adding group-step duration change interaction ($p = 0.57$). Torque fluctuations did not differ between young and older adults, $p = 0.24$. Moreover, we did not find a relationship between speed-accuracy trade-off and torque fluctuation in young ($p > 0.05$) and older adults ($p > 0.05$). CONCLUSIONS Foot placement accuracy similarly decreased with speed in young and older adults, which might be explained by motor noise not being different in both groups. These preliminary results are part of a larger study including assessment of sensory noise and stability during stepping. Understanding the origins of age-related differences in stepping, a task requiring well-defined body weight shifts, will contribute to insight into why body weight shifts might lead to falls in older adults. ACKNOWLEDGEMENTS Friedl De Groote was funded by FWO (FWO research project G088420).

P1-D-32: ***The control of mediolateral gait stability***

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BACKGROUND AND AIM: Stability during walking can be maintained by shifts of the Center of Pressure through modulation of foot placement and ankle moments (CoP-mechanism)[1]. An additional mechanism to stabilize gait, is the counter-rotation mechanism i.e. changing the angular momentum of segments around the Center of Mass (CoM) to change the direction of the ground reaction force[1]. To study if and how humans use the counter-rotation mechanism to control the CoM during walking and how this interacts with the CoP-

mechanism, we assessed the contribution of both mechanisms during normal walking and during walking with constrained ankle moments and foot placement in mediolateral (ML) direction. METHODS: Thirteen healthy adults (6 males, aged 23.8±3.7 years) walked on a treadmill at 2.5km/h during three conditions; 1) 10 minutes steady-state walking. 2) 15 minutes walking on LesSchuh, i.e. constraining the ML CoP shifts underneath the stance foot through a 1cm ridge attached to the sole. 3) 5 minutes walking on LesSchuh at 50% of normal step width, constraining both foot placement and ankle mechanisms (LesSchuh50%). Full-body kinematic and force plate data were obtained to calculate the contributions of the CoP and the counter-rotation mechanisms to control the CoM[1].The average time normalized curve of the total CoM acceleration and of the contributions of the CoP and counter-rotation mechanisms during a stride were compared between conditions using SPM repeated measures ANOVA. Also, the magnitude of within-stride control for each of the three variables were determined by calculating the average standard deviation of the time series within single stance per trial. One-way repeated measures ANOVAs were used to determine the effect of Condition on the magnitude of within-stride control. RESULTS: The magnitude of within-stride control by the ankle mechanism was decreased and by the counter-rotation mechanism was increased during LesSchuh50% compared to steady-state walking and LesSchuh (Figure 1B). The mean contribution of the counter-rotation mechanism over strides did not increase during LesSchuh50% compared to steady-state walking (Figure 1A). CONCLUSIONS: A decreased magnitude of within-stride control by the CoP-mechanism was compensated for by an increased magnitude of within-stride control by the counter-rotation mechanism during LesSchuh50% compared to steady-state walking. This suggests that the counter-rotation mechanism is used to stabilize gait when needed. However, the mean contribution of the counter-rotation mechanism over strides did not increase during LesSchuh50% compared to steady-state walking. The CoP-mechanism was the main contributor to the total CoM acceleration. The use of the counter-rotation mechanism may be limited because angular accelerations ultimately need to be reversed and because of interference with other task constraints, such as head stabilization and preventing interference with the gait pattern. REFERENCES: 1. Hof. 2007

P1-D-160: ***Inter- and Intra-Rater Reliability of Oxford Foot Model Marker Placement***

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Background and Aims: While many 3D models use rigid body feet, some employ multi-segmental foot models (MFMs), dividing the foot into at least three segments (De Mits et al., 2012; Dixon et al., 2012, MacWilliams et al., 2003). Baker and Robb (2006) describe the Oxford foot model (OFM) (Carson et al., 2001) as the consensus MFMs. Deschamps, et al. (2011) reported MFM repeatability varied widely and that the use of MFM was unsupported, recommending reliability and validity studies be conducted. The study examined the reliability of OFM 10-marker placement by two individuals, one week apart. Methods: Marker data from static trials of 9 subjects were used to establish reliability. Subjects were tested twice, one week apart. Each week, OFM markers were applied twice, once by KN, a kinesiologist with 25+ years of experience, and by PD, a podiatrist with 25+ years' clinical experience. The order was determined by a toss of a coin. The markers were applied in a separate room. Subjects stood for 2-3 seconds while a static trial was recorded by a 12-camera motion capture system. The markers were removed, and the protocol was repeated with the other investigator. To eliminate the bias introduced by where subjects stood during the trial relative to the origin of the laboratory global coordinate system (GCS), the OFM markers' X (medial-lateral) and Y (anterior-posterior) locations were translated into the pelvis local coordinate system (LCS). The Z (vertical) marker was unchanged. Results: Intraclass correlation coefficients (ICC) were calculated for OFM marker data. A total of 30 possible statistical comparisons (10 markers x 3 planar locations) for both inter-rater reliability (KN vs PD) and intra-rater reliability (Visit 1 vs Visit 2) ICCs were calculated. For KN, 24 ICCs were statistically significant ($P<0.05$) with effect sizes ranging from moderate to nearly perfect. PD had 18 statistically significant ICCs with effect sizes ranging from small to nearly perfect. The ICC data for Visit 1 had 23 ICCs that were statistically significant as compared to Visit 2, which had 26 ICCs that were statistically significant. In the former case, the effect sizes ranged from trivial to nearly perfect, while in the latter case, there were no trivial effect sizes. Conclusions: KN and PD had different interests in foot biomechanics. KN had mostly employed simple, rigid body segment foot models while PD primarily focused on the foot and had more clinical interests. Regardless, there was very good to excellent agreement within investigators, between investigators, and between days. Based on our data, persons applying MFM markers are reliable provided they have sufficient understanding of the foot model marker locations and the anatomical landmarks of the foot. Baker, R., & Robb, J. (2006). Gait & Posture, 23, 399-400. Carson, M. C. C. et al. (2001). Journal of Biomechanics, 34, 1299-1307. De Mits et al. (2012). Journal of Orthopaedic Research, 30, 655-661. Deschamps, K et al. (2011). Gait & Posture, 33, 338-349 Dixon, P. C et al. (2012). Journal of Biomechanics, 45, 1011-1016. Hopkins, W. G. (2016). A New View of Statistics. Available from: http://sportsci.org/resource/stats/effectmag. MacWilliams et al. (2003). Gait & Posture, 17, 214-224.

E - Brain imaging/activation during posture and gait

P1-E-33: ***Greater cortical sensorimotor beta activity evoked during reactive balance recovery may indicate reduced automaticity of balance correcting muscle activity***

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BACKGROUND AND AIM: We currently lack a mechanistic understanding of how/when cortical resources become engaged during balance control, which limits our ability to improve fall risk assessments and rehabilitation interventions. In response to a destabilizing event, initial (~100ms post perturbation) balance correcting muscle activity consists of an automatic, brainstem-mediated portion and a longer latency (>150ms) portion that may also be cortically-mediated. We previously showed that this muscle activity is driven by sensory information encoding balance error and can be fit to a pseudolinear combination of delayed center of mass kinematics by our sensorimotor response model (SRM). Recently, we showed that sensorimotor cortical beta activity (β; 13-30Hz oscillatory brain activity at the central midline electrode [Cz]) shared a similar time course to balance correcting muscle activity and increased with balance difficulty and in individuals with lower balance ability. We hypothesize that β reflects cortical engagement in balance control and drives later portions of balance correcting muscle activity. We predict that 1) perturbation-evoked β is driven by similar sensory information as muscle activity and can be reconstructed by the SRM, and 2) during periods of greater evoked β, balance correcting muscle activity is less automatic. METHODS: 18 individuals (Age: 26±5, 10F) underwent a series of support-surface perturbations of unpredictable timing and magnitude. Body kinematics, β, and medial gastrocnemius (MG) muscle activity were recorded throughout balance recovery (-0.5-2s relative to perturbation onset). To determine if β and MG activity are driven by similar sensory inputs, we assessed the SRM goodness of fit (R2) of β and MG activity. β and MG R2 were then tested for correlation with peak evoked β across perturbation magnitudes and subjects to determine if more cortical engagement is associated with reduced automaticity of balance correcting muscle activity. RESULTS: SRM goodness of fit ranged for both β and MG activity (β: 0.00-0.84; MG: 0.06-0.94). Larger magnitudes of evoked β were correlated with higher reconstruction accuracies of perturbation evoked β ($R2=0.59$ $p<0.001$). Conversely, MG goodness of fit was negatively correlated with perturbation evoked β ($R2=0.17$ $p=0.002$). CONCLUSIONS: The positive correlation between SRM β reconstruction accuracy and peak evoked β suggest that β is driven by similar sensory information as balance correcting muscle activity when cortical engagement is high. The negative correlation between MG reconstruction accuracy and evoked β suggests that the SRM better reconstructs muscle activity in conditions with less cortical engagement. As such, β may index when brainstem-mediated balance reactions are insufficient for balance recovery and cortical resources begin to be recruited, thereby reflecting reduced automaticity of balance correcting muscle activity.

P1-E-34: ***Mental simulation of reactive stepping engages the sensorimotor beta rhythm***

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BACKGROUND AND AIM: Falls during daily-life activities are often related to inadequate stepping responses. Perturbation-based balance training can help improve reactive stepping and reduce falls among individuals with diminished balance capacity. Complementing exercise therapy with mental simulation of balance training could potentially enhance therapy outcome, because purposeful mental simulation is beneficial for motor learning and skill transfer. Mental simulation of simple movements (e.g., imagination of finger tapping) recruits sensorimotor cortices similarly to actual movement execution. However, whether mental simulation of balance training (complex movements) engages the cortical areas involved in reactive balance control is unknown. The aim was to identify cortical patterns that indicate the engagement of sensorimotor cortices in mental simulation of reactive stepping responses, particularly in individuals without prior experience with balance training. METHODS: Eighteen healthy individuals (20-32 y; 5 female) participated in this study. High-density EEG was recorded while participants attentively observed a third person reacting to strong balance perturbations (i.e., translation of a movable platform; duration: 1.1 s; perturbation profile: 0-300 ms acceleration at 3 m/s^2, 300-800 ms constant velocity, 800-1100 ms deceleration at 3 m/s^2) that elicited backward stepping reactions. None of the participants had prior experience with these balance perturbations. Participants were explicitly instructed to imagine themselves performing reactive steps in the same manner without actually performing any movement. In this way, mental simulation is assisted by action observation and motor imagery. During a control condition, participants observed movements of the platform alone, and were instructed to refrain from motor imagery. Each participant performed 60 trials per condition (Mental simulation and Control). Spatial filters were created to obtain EEG components that corresponded with previously reported balance-related cortical responses. Group-level time-frequency analyses of the EEG were used to determine modulations of intrinsic cortical rhythms, revealing time-dependent variations of cortical activation. Differences in cortical activation between conditions were evaluated with multiple paired t-tests. Statistical significance was controlled via non-parametric permutations (α=0.01, 1000 permutations). RESULTS: In both conditions, the analyses revealed a transient enhancement of the θ (4-7 Hz) rhythm shortly after onset of platform movement (Fig. 1), and a suppression of sensorimotor μ (8-12 Hz) and β (13-35 Hz) rhythms after observing a third person's stepping response (which occurred approximately 300-600 ms after perturbation onset). Analysis of sensorimotor rhythms indicated significantly stronger suppression of the β rhythm for mental simulation. CONCLUSIONS: Mental simulation of reactive stepping engages the sensorimotor cortices, in particular the sensorimotor β rhythm. This is similar to mental simulation of simple movements such as finger tapping. Furthermore, the temporal spectral patterns of cortical activity resembled those found during actual reactive stepping in response to balance perturbations.

P1-E-35: ***Performance and brain activity in older adults while playing leaning and stepping exergames***

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Background and aim: Exergames are videogames that are controlled using body movements and are found to be equally effective as - or more effective than - traditional exercise rehabilitation programs (1). In addition, exergames inherently have a cognitive component, at least in in young adults (2). A combined exercise program of physical training and cognition could be beneficial for fall prevention in older adults. In the current study, we investigated brain activity while playing exergames in older adults. We expected the exergaming condition to be more cognitive demanding than the baseline situation, indicated by a higher frontal activity for the exergaming situation (3). Furthermore, within the exergaming conditions, the hard condition is expected to be more cognitive demanding than the easy condition, which we expect will lead to further increased cortical processing as reflected by increasing frontal theta (4). Methods: 28 independently living older adults (13 female, 74.75 ± 4.13 years) played two exergames at two difficulty levels (Puzzle & The Fox, Silverfit, Netherlands) by shifting weight in a standing position and by taking steps to the side, respectively. Additionally, they performed the same movements without the games as a baseline measurement. During the entire protocol, brain activity was recorded using a 64-channel active EEG system (Liveamp, Brain Products, GER). Furthermore, accelerometer data at the lower back (AX3, UK) and scores from the games were collected. The EEG data was processed using EEGLAB v14 (5) and consisted of filtering, sampling, re-referencing and automated artefact rejection using ASR and ICA. Independent Components containing brain activity will be clustered. For data analysis, mean spectral power will be calculated for theta activity (4-7 Hz) in a frontal cluster. From the acceleration data, vector magnitude will be calculated using Matlab. Results: Preliminary analyses indicate that the participants needed more time for the hard level of the puzzle game (PH: 115.45 ± 21.91 sec; PE: 70.90 ± 10.06 sec)and had a lower rate of caught items in the hard level of the fox game (FH: 97.43 ± 3.45 %, FE: 99.63 ± 1.16 %) compared to the easy levels. Acceleration data and EEG data are currently being analyzed and will be presented at the conference. Conclusion: With a more specific knowledge about the relationship of movement, cognitive demands and different levels in the game, recommendations for the practical application and development of games can be given. References 1. Skjæret et al., 2016, Int J Med Inform [Internet].;85(1):1-16. 2. Anders et al., 2018, Front Behav Neurosci.;12. 3. Sauseng et al., 2004, Neurosci Lett.;354(2):123-6. 4. Gevins et al. 1997, Cereb Cortex.;7(4):374-85. 5. Delorme et al., 2004, J Neurosci Methods;134(1):9-21.

P1-E-36: ***Distinct features of the cortical N1 response to balance perturbation are associated with balance and cognitive impairments in Parkinson's disease***

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BACKGROUND AND AIM: Balance and cognitive impairments are associated in aging populations through unknown mechanisms. A better understanding of the underlying mechanisms could enable more targeted treatment. A balance disturbance evokes a cortical N1 response in the supplementary motor area that we recently showed is associated with balance and cognitive abilities in younger and older adult populations, respectively. However, the cortical N1 has not been investigated in impaired populations, such as people with Parkinson's disease (PD). We hypothesized that the N1 reflects a single process at the intersection of balance and cognitive function that would be simultaneously associated with balance and cognitive impairments in people with PD. METHODS: We measured the cortical N1 response to support-surface translational balance perturbations in 16 people with PD (OFF-medication, age 69±7) and a control group of 19 older adults (OA; age 71±6). We performed a battery of assessments of cognition, balance, and parkinsonian motor symptom severity. We tested for group differences in the N1 peak amplitude, latency, and width (full-width half maximum). In the OA group, we tested associations between the N1s and individual measures in our assessment battery. In the PD group, to address a large number of correlations between N1s and covarying measures in our assessment battery, we performed principal components (PC) analysis on the assessment battery scores, and tested for associations between the N1s and the magnitudes of first two PCs across PD participants. RESULTS: PD and OA groups did not differ in N1 peak amplitude (29±16 µV, p=0.66), latency (176±19 ms, p=0.062), or width (78±35 ms, p=0.17). In the OA group, larger N1 amplitudes were associated with lower cognitive set shifting ability (Trail Making Test B-A, p=0.006, R2=0.37) and lower balance confidence (Activities Specific Balance Confidence Scale, p=0.026, R2=0.26), with no other associations between N1s and our assessment battery. In the PD group, PC1 represented measures of balance ability and parkinsonian motor symptom severity (44% of variance), while PC2 represented cognitive measures (19% of variance). Lower balance ability and greater parkinsonian motor symptom severity in PC1 were associated with shorter N1 latencies (p=0.040, R2=0.22) and narrower N1 widths (p=0.0019, R2=0.52), while lower cognitive function in PC2 was associated with larger N1 amplitudes (p=0.028, R2=0.34). CONCLUSIONS: These data suggest balance and cognitive impairments are dissociable and related to distinct features of the cortical N1 response, suggesting there is more than one underlying process, in contrast to our hypothesis of a single process. If the N1 response reflects an intersection between balance and cognitive processes, a deeper understanding of the underlying mechanisms could facilitate the development of more targeted rehabilitation for individuals with comorbid balance and cognitive impairments.

P1-E-37: ***Determining the contributions of specific descending neural pathways in postural control***

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BACKGROUND: Balance maintenance and postural control is achieved through coordinated activity in neural pathways descending from the cortex and brainstem to the spinal cord. However, the contributions of each pathway are not completely understood. It has been suggested that motor evoked potentials (MEP), propagated by descending motor pathways, can be divided into early and late sections of activity, reflective of the areas responsible for each. Transcranial magnetic stimulation (TMS) has potential to access subcortical pathways, and could potentially identify the specific activity from various descending pathways, when paired with conditions that preference the role of one pathway over another. Refinement of a technique that could give insight into the specifics of each tract's output could enlighten diagnoses of their integrity assist understanding and direct research to develop targeted therapies for clinical disorders. METHODS: We present two studies aimed at assessing contributions of cortical and brainstem pathways to TMS responses during balance control: The initial experiment assessed the amplitude of a MEP in the gastrocnemius muscle, induced by TMS, with electromyography (EMG). Participants of varying ages were stimulated while seated, standing on both legs, and then standing on the left and right legs in turn. A second experiment was designed to investigate the impacts of environmental stability on the modulation of MEP responses. Similar techniques were utilised but instead of free standing, participants stood on a pendulum-like balance board and were required to maintain a neutral position. Centre of pressure (COP) and muscle activity were recorded for comparison with MEP components. All conditions had muscle activity controlled for and matched to eliminate the effect of increased recruitment. RESULTS: Experiment one saw a significant proportional decrease in the earlier portion of the MEP in the gastrocnemius muscle, resulting in a proportionally larger later portion when participants were in a position of higher postural demand. The later component was larger in the right leg during right single leg stance, and larger in the left leg during left leg stance. In experiment two, early portions of the MEP increased in the tibialis anterior, and late portions of the MEPs increased in the gastrocnemius muscle with instability, independent of tonic muscle activity. The latency and onset of the MEP was significantly affected by age. CONCLUSIONS We conclude that early and late MEPs components are independently modulated in response to postural stabilisation requirements. These changes in components are indicative of different neural origins for the early and late MEP, which we suggest is the Corticospinal Tract (early MEP) and the Reticulospinal Tract (late MEP) due to their characteristics and roles in posture and balance. It was also concluded that age effects underlying neural control but balance measures like COP and muscle activity are not related to MEP changes. These findings represent initial steps in improving our understanding of the neural correlates of balance control in humans with non-invasive stimulation

P1-E-38: ***Increased motor cortex interhemispheric connectivity was correlated with bilateral coordination in PD: Preliminary results***

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Background and Aim: During cortical control of motor tasks, there are age-typical reductions in the asymmetrical interhemispheric cortical activities, as a result of increased left and right cortical activation (HAROLD model[1]). Hemispheric asymmetrical reductions may reflect in higher interhemispheric coherence. In Parkinson's disease (PD), such reductions are expected to be more pronounced attempting to compensate for the underlying neurological impairments. Neurological PD deficits lead to gait disturbances, such as a 58% higher Phase Coordination Index (PCI; quantifying consistency and variability of the phase relationship between steps timing; higher PCI = reduced coordination)[2]. An unanswered question is whether an increased interhemispheric coherence correlates with lower phase coordination. Therefore, we verified the correlation between the cortical-cortical coherence of the left and right M1(Broadman's area 4) channels and PCI. Methods: PD patients (n=7) walked back and forth within a 12m long corridor. Inertial measurement units (OPAL®; APDM, USA) and electroencephalogram signals (32 channels EEG) were used to acquire left-right step durations and cortical activations, respectively. Based on left-right step durations, we computed the PCI[2]. After pre-processing, interhemispheric connectivity was estimated by computing the frequency-domain coupling (coherence) between C3 and C4 electrodes during the swing and stance phases of 60 steps. We determined the auto- and cross-spectrum of the C3 and C4 pairs using Welch's periodogram method. Coherence was calculated based on the squared modulus of the cross-spectrum power normalized by the product of the C3 and C4 auto-spectra powers. We calculated the amount of coherence by cumulative sum for the characteristic frequency ranges of the alpha (5-15hz), beta (15-35hz) and gamma (35-55hz) bands for the stance and swing phases. Spearman's correlations between PCI and the interhemispheric coherence were calculated for each band during the swing and stance phases. Results: We observed a very strong negative correlation indicating that higher interhemispheric connectivity (coherence) at the gamma-band during the swing phase was associated with lower PCI (i.e., better coordination $r=-0.86$; $p=0.014$). Although not significant ($p>0.05$), we observed moderate correlations showing that increased beta-band coherence for stance and swing and gamma-band coherence for stance were associated with lower PCI (r-range= -0.50 to -0.57) (Fig 1). Conclusion: Our results indicated that higher coherences are associated with better gait coordination in PD. We speculate that the interhemispheric connectivity between the left and right motor cortex may be needed as a compensatory mechanism[3] to PD-related neural deficits for the participants to maintain relatively consistent left-right steps timing. Acknowledgments and Funding: This research was supported by the Estate of Naomi K. Shapiro (n.721926). [1]Berlingeri, M. et al. Exp Brain Res. 2013; [2] Plotnik, M. et al. Exp Brain Res. 2007; [3] Silberstein, P. et al., Brain 2005

P1-E-39: ***Distinct cortico-muscular interaction with step and stance leg during reactive stepping revealed through spectral Granger causality***

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BACKGROUND AND AIM: Balance recovery following a perturbation often relies on successful stepping responses. Cortical involvement in reactive stepping is evident, as cortical lesions lead to impaired stepping responses and thus affect balance capacity. Yet, knowledge on cortico-muscular interaction during balance performance remains limited. We conducted an exploratory analysis investigating cortical interaction with leg muscles through spectral Granger causality during a reactive stepping task. We hypothesized that cortical coupling would differ for step and stance leg because of their functional role during the step response. In particular, we expected that stronger cortico-muscular interaction would be most evident for the agonist muscles involved in generating the stepping movement, and that an increase in cortico-muscular interaction would precede upregulation in EMG activity in these muscles. METHODS: We analyzed high-density EEG, multi-site surface EMG and motion tracking of 18 able-bodied participants while they stood on a platform that delivered whole-body balance perturbations at different intensities, in the anterior and posterior directions. The participants were instructed to maintain their feet in place, unless stepping was unavoidable. Time-dependent spectral Granger causality analysis was used to identify the frequencies that reveal cortico-muscular interaction. RESULTS: We observed distinct Granger gain dynamics over Theta (3-8Hz), Beta (15-25Hz) and Gamma (40-80Hz) frequency bands for step and stance leg muscles (Figure 1). During forward stepping (see Fig.1a), we found significantly stronger Granger gain over all frequency bands with the stance leg soleus and step leg tibialis anterior muscle. Upper leg muscles predominantly showed stronger Granger gain in the gamma frequency for hamstring step leg muscles. The rectus femoris showed significantly stronger Granger gain in the stance leg over beta and gamma frequency rhythms. During backward stepping (see Fig. 1b) step leg hamstring muscles and stance leg rectus femoris showed an increase in Granger gain over multiple frequency bands. Interestingly, between-leg differences in granger gains lagged divergence of EMG activity by ~170ms in all muscles, with the onset of Granger gain changes roughly coinciding with EMG peak activity in the respective muscles. CONCLUSIONS: Our work demonstrates cortical involvement in the later phases of reactive balance responses and provides insightful information on its temporal and spectral aspects. Overall, the findings suggest that the higher levels of cortico-muscular interaction that we observed may be involved with downregulating the activity of stepping-related muscles, rather than with their initial recruitment. This work is relevant for future studies in clinical populations, e.g. in people with stroke who have impaired reactive stepping capacity, where analysis of cortico-muscular coupling may shed light on the underlying pathophysiological mechanisms.

P1-E-40: ***Cortical midfrontal theta dynamics index monitoring of postural stability***

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BACKGROUND AND AIM: Sudden changes in postural stability have been linked to neuroelectrical markers such as the N1 potential and theta rhythm dynamics. Previous studies showed a relation between the cortical N1 and theta response with perturbation intensity and the ensuing recovery response (stepping or feet-in-place) (1). It was hypothesized that midfrontal theta dynamics index the engagement of an action monitoring system that estimates the impact of a perturbation according to an internal model of stability. Here, we aimed to provide evidence for this hypothesis by manipulating the initial leaning posture. If midfrontal theta indeed subserves an action monitoring role of postural stability, different initial leaning postures, leading to distinct conditions of postural threat, should modulate midfrontal theta dynamics. METHODS: We recorded EEG and 3D motion data of 20 young able-bodied participants while they stood on a platform that delivered forward and backward balance perturbations. Platform accelerations were randomized and ranged from 0.25m/s2 to 1.9m/s2 with a higher resolution at lower accelerations in both forward and backward sway direction. This distribution was chosen, because we expected theta modulations to be more pronounced during the feet-in-place responses at lower platform accelerations (1). Prior to perturbation, the participants assumed one of three leaning postures (neutral at 90°, at 5° forward or 5° backward leaning angle) and they were instructed to try their hardest to keep their feet in place in response to the perturbation. We calculated margins of stability; and we used targeted spatial filtering of EEG data in combination with mixed effects modeling to test our hypothesis. RESULTS: As intended, different postural threats (i.e. leaning conditions) had a significant effect on the margin of stability over the whole range of perturbations (figure 1 left panel). Similarly, we found that different postural threats changed the relation between platform acceleration and midfrontal theta power, but only in the forward direction ($\beta = 1.26$ CI: [0.78 1.75], $p = 2.91e-7$) (figure 1 right panel). In particular, for feet-in-place responses we found a significantly steeper slope of theta power dynamics with increasing perturbation intensity for forward as compared to backward leaning conditions. Overall, theta power was higher in stepping than in feet-in-place trials, but we did not find additional effects of initial leaning posture on stepping-trial theta dynamics. CONCLUSIONS: This novel finding corroborates the role of the midfrontal theta dynamics in balance monitoring and suggests that in stepping trials a certain threshold is met where steps are initiated. To seek further evidence for the hypothesis of midfrontal theta involvement in stability monitoring, it may be of interest to study responses to balance perturbations in patients with known deficits in internal modeling (e.g. cerebellar pathology).

P1-E-41: ***Be inspired by the biomimetism to recruit an efficient sensorimotor cortical network for postural control***

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BACKGROUND AND AIM: A challenge in motor control research is to understand the transformation of sensory inputs into postural reaction when equilibrium is jeopardized by the displacement of the support surface. The relative movement between the feet and the surface evokes a mechanical friction (i.e., shear forces) that stimulates the plantar skin receptors (i.e., mechanoreceptors) which are one of the main contributors to the postural reaction. In a previous study, we found that subjects showed increased activities in the somatosensory and sensorimotor cortices when they stood on a moving surface complying with the characteristics of the mechanoreceptors and the skin dermatoglyphs (i.e., biomimetic) compared to when they stood on control surfaces (i.e., grooved or smooth). When standing on moving control surfaces, subjects showed greater activities over regions involved in attentional processes. Here, we hypothesized that standing on a biomimetic surface allows the use of a sensorimotor network (as opposed to a cognitive one), thereby decreasing the attentional demand for planning the postural reaction. Submitting subjects to a cognitive dual task (DT), we expected less cognitive-motor interference when they stood on a biomimetic surface. METHODS: We measured the postural reactions (i.e., motor task, AMTI platform) of 21 subjects submitted to small lateral accelerations of the supporting surface (peak ~0.07m.s-2). We also measured the errors shown by subjects when reporting the number of times that 7 was present in a series of 10 three-digit numbers they heard just before translation onset (i.e., cognitive task). The subjects stood with the eyes closed on either a biomimetic or grooved surface and performed either the DT or the single motor task. RESULTS: To determine the performance in the cognitive task, we computed the percentage of errors. A paired t-test did not show significant difference [$t(20)= -0.20$; $p = 0.85$] between the biomimetic and the grooved surfaces (24 ± 11.5%). The postural reaction was greater [$F(1,18)= 4.78$; $p=0.04$] and had shorter latency [$F(1,18)= 21.183$; $p < 0.05$] when performing a DT. Interestingly, the ANOVAs revealed that when standing on the biomimetic surface, the postural reaction had greater amplitude [$F(1,18)= 5.92$, $p=0.03$] and smaller latency [$F(1,18)= 6.95$; $p = 0.02$]. Such attributes are thought to attest the efficiency of the dynamical postural reactions (1). CONCLUSIONS: Interestingly, our results showed that standing on the biomimetic surface while being involved in a DT task leads to a powerful, short latency

postural reaction. These results are consistent with the hypothesis that the biomimetic surface facilitates the postural reaction by enabling the use of a sensorimotor network when balance demand is challenged by loading the higher-level cognitive system. (1) Ikai et al (2003). AJPM&R 82 : 496-469

P1-E-42: ***Prefrontal Cortex Activation During Single and Dual Task Posture & Gait***

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BACKGROUND AND AIM: The prefrontal cortex (PFC) facilitates cognitive function and goal directed action. In neurologically impaired populations, increased left PFC activity relates to complex gait (e.g. dual task [DT]) performance, suggesting PFC activity mediates DT gait. Neurologic populations often display cortical and motor impairments during posture and gait compared to healthy controls, but the role of the PFC during increasingly complex motor task (e.g. single task [ST] to DT posture and gait) remains poorly understood. We sought to determine whether motor task dependent changes exist in the left PFC activity in healthy individuals during ST and DT posture and gait. METHODS: Nine healthy males (mean age 21.0[2.1]yrs) completed a ST and a DT 2-minute standing posture and overground gait task (four conditions). Functional near-infrared spectroscopy quantified changes in oxyhemoglobin (O2Hb; μM/L) concentration for the left PFC during posture and gait conditions. Three wearable sensors (waist and both feet) quantified postural jerk (m2/s5) and root mean square (RMS) sway (m/s2), gait speed (m/s) and double support % of gait cycle. Serial 7s was the cognitive task for DT, quantified by accuracy (%). Group differences were tested with independent samples t-tests, with an a priori $\alpha = 0.05$. Means, standard deviations and Cohen's effect sizes are reported. RESULTS: Greater change in PFC activity occurred during ST gait (-0.82±0.6 μM/L) compared to ST posture (0.01±0.57 μM/L) (p=0.03; ES=0.85). Moderate effects were observed between DT posture (1.05±0.67 μM/L) and gait (0.39±0.65 μM/L; p=0.10, ES=0.63). PFC activity increased from ST to DT during both posture (p=0.01, ES=-1.29) and gait (p=0.01, ES=-1.24). Cognitive tasks significantly increased jerk (ST: 9.06±1.85; DT:27.38±20.47; p=0.03, ES=-0.93), and had small effects on RMS sway (ST: 0.14±0.03; DT: 0.18±0.08; p=0.10, ES=-0.67) during posture, while significantly reducing speed (ST: 1.04±0.11; DT: 0.86±0.16; p<0.01, ES=1.88) and increasing double support % (ST: 22.56±1.74; DT: 25.21±2.36; p=0.06, ES=-1.37) during gait. No statistically significant differences in correct response % were observed during posture (90.45±10.67) and gait (92.98±9.16; p=0.14, ES=-0.59). CONCLUSIONS: In healthy young adults, less left PFC activity was observed from posture to gait tasks, though DT motor tasks appears to require more PFC activity that ST. While PFC activity did not change during ST posture, the additional cognitive task increased PFC activity and decreased motor performance during DT posture and gait, with the greatest overall increase in PFC activity during DT posture. Cognitive resource allocation in response to a cognitive task may differ between these two motor tasks, as indicated by the greater overall change in PFC activity between ST and DT gait compared to posture. These findings expand on the current neurophysiological literature, highlighting PFC activity pattern dependency on motor task demands.

F - Cognitive impairments

P1-F-43: ***Pilot testing of a novel comprehensive assessment system of posture and saccades, using head-mounted display virtual reality technology, for MCI screening***

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BACKGROUND AND AIM: Older adults prone to mild cognitive impairment (MCI) can express dysfunction in postural sway and saccadic eye movements compared with healthy older adults (HA). MCI population also have impairment in short-term visuospatial memory (VM) and spatial orientation (SO). While each single assessment of these motor skills has the potential for dementia screening, a comprehensive evaluation could improve the screening accuracy. We have developed a novel comprehensive assessment system to measure posture and saccades, using a head-mounted display virtual reality (VR) technology. We aimed at evaluating the system feasibility for MCI. We hypothesised that differences are observable in postural and saccade behaviours between HA and MCI groups. METHODS: 23 older adults were recruited. All were screened using the Montreal Cognitive Assessment (MoCA) to assess the cognitive status. We classified them into two groups: 20 HA (70.4±4.8 years old) and 3 MCI people (74.7±3.3 years old), considering age, sex, and education years into MoCA score. Using our new assessment system consisting of a stabilometer (GP-5000 by ANIMA) and VR headset with eye-trackers (VIVE Pro Eye by HTC), we measured changes of centre of pressure (COP) and saccadic eye movements simultaneously. Six test conditions were measured with 2 types of saccadic eye movements (pro- and anti-saccades) and 3 different cognitive tasks (none, VM, SO) in randomised order. Participants were wearing the VR headset while standing on the stabilometer. RESULTS: HA group achieved MoCA score of 26.8±1.6, while MCI group reached 20.0±2.2 points. The attrition rate was zero. We performed logistic regression analysis to evaluate whether the proposed comprehensive assessment could classify MCI. We used two postural sway parameters: COP displacement in anterior-posterior and medio-lateral directions and two saccade parameters: mean latency and error rate as independent variables and MoCA score as dependent variable. We found medio-lateral postural sway was significantly associated with MoCA score in two conditions: VM with pro-saccade task ($R2=0.315$, odds ratio=1.713) and SO with anti-saccade task ($R2=0.426$, odds ratio=6.68). These results imply that the comprehensive assessment could be useful to improve the classification of MCI compared to a single assessment. CONCLUSIONS: Our evaluations showed that the MCI population had more postural sway than the HA group in the conditions with more cognitive tasks of VM and SO, whereas no significant differences were observed in saccade behaviours. Presence of more postural sway in these conditions could be caused by more demanding attentional resources and could be an early sign of MCI. The results of this study warrant further research by comparing the two groups with an increasing sample size. ACKNOWLEDGEMENTS: We would like to acknowledge the support from ANIMA Corporation, Japan, who kindly lent us the stabilometer for body balance analysis.

P1-F-44: *Associations between selected brain regions and gait and balance in memory clinic patients*

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Background: Research has shown that brain regions involved in higher-level cognitive functions are also required to coordinate mobility, and people with cognitive impairment (CI) and dementia exhibit reduced gait speed and balance impairments. Still, the role of various brain regions in gait and balance in people with CI and dementia is a matter of debate. We aimed to test for associations between selected brain regions and gait and balance in memory clinic patients. Methods: Participants attending a memory clinic, with a T1-weighted structural brain MRI taken within +/- 6 months from the clinical assessment were included in this study (n=54). All participants underwent a comprehensive cognitive assessment, and 10 (18.5%) were categorised as having subjective cognitive impairment, 15 (27.8%) had mild cognitive impairment, and 29 (53.7%) had (all cause) dementia. Prefrontal cortical thickness (PFCt), hippocampal volume (HCv), T1-weighted white matter hypointensities (WMHypo) and cerebellar volume were quantified from MRI using FreeSurfer. Gait was assessed as 4-m habitual gait speed (m/s) and balance was assessed with mini-BESTest. We conducted correlation analyses and subsequent multiple regression analyses to control for age, sex, and global cognition (Mini Mental State Examination, MMSE). Results: Average age of the participants was 67.9 (sd 8.6) years, 25 (46.3%) were women, and average MMSE was 26.0 (sd 4.7). Balance was significantly correlated with HCv (r=0.33), PFCt (r=0.30), WMHypo (r=-0.33) (all p<0.05) but not with cerebellar volume (r=-0.16, p=0.3). The correlations between gait speed and HCv (r=-0.21), PFCt (r=-0.15), WMHypo (r=0.27), and cerebellar volume (r=-0.12) were not statistically significant (all p>0.05). Balance and gait speed were not significantly associated with the selected brain structures in the multiple regression analyses. Conclusion: In this heterogenous sample of memory clinic patients, we observed stronger correlations between balance and the selected brain regions, than for gait speed. However, age and global cognition appears to be important confounding factors for these associations. Future studies examining the role of brain regions in gait and balance in people with CI and dementia should include a larger number of participants, investigate balance more closely and explore gait parameters beyond gait speed, such as gait variability.

P1-F-45: *The role of spatial navigation for physical activity and life-space mobility in memory clinic patients*

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Background and aim: Getting lost and loss of navigational abilities are common in persons with dementia. Still, there is a lack of knowledge about the role of spatial navigation for daily physical activity and life-space mobility. Thus, the aim of this study was to explore the associations between spatial navigation, daily physical activity and life-space mobility in patients attending a memory clinic. Methods: We included 88 patients from the Memory Clinic at Oslo University Hospital; 11 (12.5%) had subjective cognitive impairment (SCI), 19 (21.6%) had mild cognitive impairment (MCI), and 58 (65.9%) had dementia. Mini Mental State Examination was used for global cognitive functioning, scale 0-30 points, with higher score representing better cognition. Spatial navigation was assessed using the Floor Maze test (FMT), where the patients are asked to walk through a two-dimensional 9m2 labyrinth, and outcome is time to complete the walk (including planning time). Patients not completing the test (n=15) were assigned the time of the slowest finisher (285 sec). We used body-worn sensors (activPALs) continuously for 4 days to measure daily physical activity, with mean upright time (standing and walking) as primary, and walking and standing time as secondary outcomes, as mean per 24 hours. Life-space Assessment (LSA) was used for life-space mobility, scores 0-120 where higher score indicates a larger life-space with a higher level of independency. We performed multiple regression analyses to examine the association between spatial navigation and 1) daily physical activity and 2) life-space mobility. Age, sex, comorbidity, gait speed and cognitive status (SCI/MCI/dementia) were included as covariates. Results: The participants (mean age 68.3, ±7.3 yrs., 49 (55.7%) men) median (Q1, Q3) MMSE score was 27.0 (21.8, 29.0). Mean (SD) upright time was 362 (116) minutes per day, and mean score on the LSA was 76.6 (16.2). In the adjusted models, longer time on the FMT were associated with more upright time (B (95%CI) = 0.4 (0.04, 0.7), p=0.029), more standing time (B (95%CI) = 0.4 (0.08, 0.7), p=0.013), and with a lower score on the LSA (B (95%CI) = -0.1 (-0.1, -0.02), p=0.003). We did not find any associations between the FMT and walking time (B (95%CI) = 0.03 (-0.1, 0.2), p=0.67). Conclusion: Contrary to our hypothesis, impaired spatial navigation was associated with being more physically active, and this association was driven by standing time and not walking time. In line with our expectations, worse performance on the spatial navigation test was associated with a smaller life space. Future studies should explore different outcomes of daily physical activity and movement patterns in persons with cognitive impairment, especially in relation to facilitators and barriers to being physically active and participating in activities outside their homes.

G - Cognitive, attentional, and emotional influences

P1-G-46: ***Did I Sway? Yes, No, Maybe so?***

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Background and Aim Visual motion directly influences postural sway even when visual motion stimuli fall below perceptual thresholds. Visual motion may also cause a perceived illusion of self-motion. It is unclear whether perceived change in body sway or perceived illusory motion drives changes in body sway induced by visual motion. Developing methods

to quantify perception of postural sway will address an unmet need for populations with imbalance or perceptual symptoms such as dizziness. We aim to quantify perception of postural sway in healthy adults. Methods Healthy adults (n = 20, age 37.5 ±21.2, 10 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 (yes/no) whether they visually perceived the room to move (visual motion perception) or if they perceived their body to sway (sway motion perception). 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-test compared PSEs between conditions (visual motion versus sway motion). Separate mixed models compared head sway area before, during, and after the visual perturbation to determine if head sway area differed for perceived ("yes") versus non-perceived ("no") responses. Results The PSE for detecting visual motion (0.42 degrees) was significantly lower than the PSE for detecting sway motion (2.02 degrees) [$t(1,18) = 4.4714$, $p = 0.00029$]. Sway area was significantly larger during ($z = 11.53$, $p < 0.001$) and after ($z = 5.09$, $p < 0.001$) the visual perturbation onset only for "yes" responses and only during the sway increased condition. Conclusions Visual perturbations resulted in distinct, task specific PSE for detecting increased visual motion versus sway motion; with the PSE for perceived sway motion requiring larger visual perturbations. Greater sway for "yes" responses during the "did sway increase?" condition indicates subjects were responding to increased sway rather than identifying illusory self-motion perception. This technique holds promise for quantifying perceptual elements of imbalance and dizziness in clinical populations addressing an existing gap in clinical assessment.

P1-G-47: ***Dissociating automatic from conscious adaptations during conditions of postural threat***

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BACKGROUND AND AIM: The 'two-system' view of fear builds on traditional conceptualisations of emotion; proposing that the mechanisms responsible for behavioural and physiological responses to threat may be distinct from those underpinning the (conscious) emotional experience itself. We empirically tested this notion within a novel, applied context of social and economic importance: fear of falling in older adults. METHODS: Older adults (n=44) performed a narrow-stance quiet standing during conditions of low and high threat (raised platform). Participants were stratified based on whether they reported any fear in response to this postural threat. Postural control outcomes were measured via a forceplate. RESULTS: Irrespective of whether participants reported any increase in fear of falling, we observed behaviours indicative of postural 'stiffening' during the threat condition. Self-reports indicated that participants cognitively monitored these changes in balance, and fear of falling was experienced in those who interpreted these behaviours to imply that harm was likely to occur. Fearful participants exhibited additional changes in balance (increased movement complexity and altered utilisation of sensory feedback) - behaviours likely influenced to some degree by attempts to consciously control balance. CONCLUSIONS: Taken together, these findings provide novel insight into the systems that regulate behavioural and emotional responses to postural threats. The findings suggest that the behaviours driven by the conscious emotional response differ from those associated with 'automatic' threat responses. The novel conceptual framework developed from these findings helps identify specific mechanisms that might be targeted through clinical intervention.

P1-G-48: ***Effects of height-induced postural threat on whole-body and upper-limb postural control***

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BACKGROUND AND AIM: Height-induced postural threat influences anxiety, fear of falling, and control of standing balance [1]. Although the effect of anxiety and fear on upper-limb (UL) motor control is less established, results suggest that the effects may depend on the task and source of threat [2]. Therefore, the study aimed to compare changes in an UL postural control task and a whole-body standing balance (SB) task performed under the same postural threat conditions. We hypothesized that SB sway amplitude will decrease, while UL amplitude will increase with threat. In contrast, the frequency of SB and UL displacements will both increase with threat reflecting more global and systemic changes. METHODS: 13 participants (mean age=23.7; 7 female) stood with eyes open on a force plate at the edge of an elevating platform with feet hip-width apart. A custom device held the dominant arm in a 90° elbow-flexed position, while the pronated wrist controlled a wooden tray resting on the back of the hand. A potentiometer measured angular displacements of the wrist. Participants performed nine 90-second trials (3 practice, 6 experimental). The pseudo-randomized experimental trials included the following 3 tasks, performed while standing at low (76 cm) and high (270 cm) surface heights: Standing Balance (SB): Standing quietly with hands relaxed Upper-limb Balance (UL-B): Balancing a tin can on the handheld tray Upper-limb Postural Control (UL-PC): Maintaining the hand in a static position using auditory feedback with a 1° threshold (not currently analyzed) Cognitive-emotional changes were measured using electrodermal activity (EDA) and questionnaires on balance confidence, fear of falling, anxiety, and attentional focus. Mean power frequency (MPF) and standard deviation (SD) were calculated from centre of pressure (COP) for all tasks, and from the potentiometer for UL tasks. Two-way (threat x task) within-subject ANOVAs were used for all cognitive-emotional and COP measures and paired t-tests examined threat effects on wrist measures. RESULTS: Significant threat effects were observed for all cognitive-emotional measures ($p<0.05$). COP amplitude decreased with threat (-9% during SB; -10% during UL-B), whereas wrist amplitude increased 20% with threat in the UL-B task. There was a significant main effect of threat on COP frequency ($p<0.05$) which significantly increased independent of task (48% during SB; 52% during UL-B). Contrary to our hypothesis, wrist movement frequency significantly decreased with threat (-34%; $p<0.05$). CONCLUSIONS: Despite comparable cognitive-emotional changes with threat, there were distinct differences in amplitude and frequency changes with threat for SB and UL postural

control tasks. These findings suggest that postural threat has unique effects on SB and UL postural control that likely rely on different underlying mechanisms. 1.Davis et al. Gait & Posture, 2009: 29(2), 275-279 2.Arora et al. Surgery, 2010: 147(3), 318-33

P1-G-49: ***How instructions improve balance: The impact of attention on sensory integration for postural control.***

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BACKGROUND AND AIMS: Where one places their attention during balance tasks can lead to different performance outcomes. However, what underlying mechanisms are affected by the focus of attention remains unclear. Postural control requires accurate integration of multiple senses to maintain body orientation and equilibrium. By studying how directing attention can influence sensory processing, we can better understand how to improve balance and prevent falls. The present study investigates how different focus of attention affects visual integration for posture. METHODS: Forty-one healthy adults (mean age = 26 +/- 6) underwent an experimental paradigm where they stood on a rocker board while wearing a virtual reality head-mounted display (HMD) and a 32-channel electroencephalography (EEG) cap. The HMD displayed a virtual world of standing on a boat that tilted from side to side in the mediolateral (ML) direction at a frequency of 0.2Hz and amplitudes of 2 ± 0.2 degrees. All participants were first instructed to look straight ahead and keep their bodies as still as possible (pre-test). Participants were then randomly instructed (post-test) to either 1) keep the rocker board flat as possible to help stabilize their body (external group; n=14), 2) keep both feet leveled to each other to help stabilize their body (internal group; n=14), or 3) continue to keep their body still without any additional instructions (control group; n =13). The dependent variables were root-mean-square (RMS) of ML head displacement, visual gain response of ML head displacement relative to the 0.2Hz visual stimulus, percent change of EEG alpha power (9-13Hz) at occipital channels. RESULTS: ANCOVA using pre-test as covariates revealed a significant ($p<0.01$) interaction among the three groups at post-test for RMS and visual gain. Post-hoc (Bonferroni corrected) comparisons on visual gain revealed a significant difference between the external and control groups. Post-hoc comparisons for RMS revealed a significant difference between external group vs. control group and external group vs. internal group. ANOVA for occipital alpha power change showed significant interaction ($p<0.01$) among the three groups, with post-hoc comparisons revealing a significant difference between the internal vs. control groups and the external vs. control groups. Pearson correlations on all participants showed a significant positive correlation between visual gain and RMS changes ($r = 0.86$, $p < 0.01$), and a significant negative correlation between RMS and occipital alpha power changes ($r = -0.36$, $p <0.05$). CONCLUSIONS: Current findings agree with previous research suggesting that instructions that encourage external focus are more effective than internal or no focus for balance performance. The current study reveals that the improved balance performance achieved through external focus may be associated with improved sensory integration, mainly in visual processing for postural control. ACKNOWLEDGEMENTS AND FUNDING:

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P1-G-50: ***Investigating perceived balance confidence using the Activities-specific Balance Confidence scale among people with a lower extremity amputation***

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BACKGROUND AND AIM: The Activities-specific Balance Confidence scale (ABC) is the most commonly used scale to evaluate balance confidence in people with lower extremity amputations (PLEA). The content validity of items within this scale may not fully address the challenges for PLEA as the scale was developed for community-dwelling older adults. It is important to understand the unique challenges experienced by PLEA that result in diminished balance confidence. The aim of this research is to determine which items on the ABC align with the functional abilities of PLEA and explore additional activities that PLEA are unable to perform. METHODS: Cross-sectional, web-based survey. Individuals were recruited from the Outpatient Amputee Clinic at Parkwood Institute in London, Ontario. The inclusion criteria were 18 years of age or older, currently using a prosthesis for ambulation and completed a prosthetic rehabilitation program. Balance confidence was assessed using the 16-item ABC. Participants were asked if they were physically unable to complete any of the items on the ABC and to provide activities that were challenging to perform using open-ended questions. The total ABC score was the average of all items, with scores ranging from 0% (no confidence) to 100% (complete confidence). The frequency of ABC items that individuals indicated they were unable to perform was calculated. Open-ended responses were systematically coded and categorized. RESULTS: Forty-eight adults (61.8±11.6 years, 33 males) participated. Total ABC scores ranged from 32% to 100%. Sixty-seven percent of participants indicated they were unable to perform at least one activity on the ABC, including "Stand on a chair and reach for something" (n=26), "Step onto or off an escalator while holding onto parcels such that you cannot hold onto the railing" (n=20) and "Walk outside on icy sidewalks" (n=17). Forty-five participants described additional activities they find challenging to perform, including sports (running at 21% and biking at 17%), climbing ladders (38%), long walks (21%), and walking without mobility aids (17%). CONCLUSIONS: This study has demonstrated that multiple items on the ABC do not align with the functional capabilities of the majority of PLEA. To effectively address and monitor balance confidence during rehabilitation, a complete understanding of the limitations of standardized scales used among PLEA is required.

P1-G-51: ***Turning on the Brain; Associations between Turning Performance and Cognitive Function***

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BACKGROUND: Older adults often experience gradual declines in walking and cognitive function. A robust body of literature indicates that walking is a complex motor task. Input from higher order cognitive centers is required for safe, effective, and independent walking. While associations between walking and cognition have been reported extensively for older adults, they are primarily based on tests of walking in a straight line. As such, it remains unclear whether more ecologically valid walking tasks, such as turning, demonstrate similar associations with cognitive function. Therefore, the purpose of this study is to identify associations between 180° and 360° turning performance and multidomain cognitive function in typical older adults. METHODS: For this ongoing study, nine older adult participants (78.7 ± 5.1 years) were asked to conduct a series of 180° and 360° turns at their self-selected normal and fastest safe pace. Quantification of turning was assessed using wireless inertial sensors placed on each foot, each shank, around the waist, on the sternum, and on the forehead. Turn related performance measures included turn duration (sec), turn angle (deg), and peak turn velocity (deg/sec). Participants completed the Cambridge Brain Sciences cognitive assessment battery on a computer, which included tests of executive function (i.e., response inhibition, attention, visuospatial working memory, and visuospatial processing). RESULTS: The preliminary results indicate significant differences between normal and fast pace turn duration and peak turn velocity, but not for turn angle. Our results demonstrate significant associations between various 180° and 360° turn measures and cognitive function, particularly for the domain of attention. For the normal pace 180° turns, we observed a significant association between turn duration and attention ($r=-0.75$, $p=0.02$). For the fast pace 180° turns our results reveal associations between turn duration and attention ($r=-0.70$, $p=0.04$), and peak turn velocity and attention ($r=0.84$, $p<0.01$) and visuospatial processing ($r=0.73$, $p=0.027$). For the normal pace 360° turns we report significant associations between turn duration and attention ($r=-0.84$, $p<0.01$) and peak turn velocity and attention ($r=0.72$, $p=0.03$). For the fast pace 360° turns we report significant associations between turn duration and attention ($r=-0.71$, $p=0.03$) and peak turn velocity and attention ($r=0.75$, $p=0.02$). CONCLUSIONS: The preliminary results of this on-going study indicate that older adults demonstrate the ability to shorten turn duration and augment peak turn velocity when instructed. Further our results reveal associations between turning performance and attention, and visuospatial processing. Older adults with lower cognitive function exhibit poorer turning performance. These preliminary results suggest that enhancing attention in older adults may improve dynamic movements, thereby reducing fall risk.

P1-G-52: ***Arousal and valence effects on center of pressure trajectory during quiet standing***

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BACKGROUND AND AIM: Many previous studies revealed that emotional state could influence postural control by using affective pictures or movies. Emotional state can be represented as two dimensions of valence (pleasant and unpleasant) and arousal (high and low). Although the previous postural control studies investigated effects of valence on center of pressure (COP) of a force plate, effects of arousal and their combined effects on postural control have not been investigated. Therefore, the purpose of this study was to investigate the effects of both valence and arousal on postural control during a quiet standing task. METHODS: Seven healthy male individuals (18-36 yr) were recruited in the study. The participants were asked to stand on a force plate with their feet shoulder-width and arms relaxed along trunk and look at a monitor. The monitor was placed at 1 m in front of subjects and its height was adjusted to their eye line. The experiment consisted of 8 blocks and each block started with 60 s baseline phase followed by 72 s intervention phase. A fixation cross was displayed in baseline phase. In the intervention phase of each block, the monitor displayed following types of pictures: (1) pleasant-valence and high-arousal; (2) pleasant-valence and neutral-arousal; (3) neutral-valence and high-arousal; (4) neutral-valence and neutral-arousal; (5) neutral-valence and low-arousal; (6) unpleasant-valence and high-arousal; (7) unpleasant-valence and neutral-arousal; and (8) fixation cross (control). Control condition contained 1 picture while other conditions contained 12 pictures and each picture was presented for 6 s. Ground reaction forces were collected throughout each block, and COP was calculated for the latter 30 s of the baseline phase and for the intervention phase. Then we calculated standard deviation of COP in both anterior-posterior (AP) and medial-lateral (ML) directions for postural stability and mean position of COP in AP direction for action tendencies (approach and avoidance). RESULTS: The standard deviation of ML direction of the pleasant-valence and high-arousal condition was higher than that of the baseline, and of AP direction of the unpleasant-valence and high-arousal condition was lower than that of the baseline. In contrast to the standard deviation, no significant difference of the mean position in AP direction was observed compared with baseline in any blocks. CONCLUSION: Our results demonstrated that pleasant and unpleasant valence states changed postural stability. However, the changes in postural stability were observed only in case of high arousal state. In particular, reduced body sway in unpleasant-valence and high-arousal condition may be interpreted as freezing behavior. Conversely, emotional state had no effect on the postural expressions of action tendencies.

P1-G-53: ***Older people with depressive symptoms walk less, have poorer balance and quality of everyday walking, and fall more***

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Background and Aim: Depressive symptoms are common amongst older people, especially in those at higher risk for falls. Previous studies show that depressive symptoms lead to reduced amounts of physical activity, which likely results in deconditioning, affecting balance and gait, and increasing fall risk. We used wearable sensors to confirm that older people with depressive symptoms are indeed less active and provide novel insight into how depressive symptoms affect physiological fall risk, quality of daily life gait, and fall rates. Methods: 503 community-living older people (age 77.4 years, SD 5.5; 67% female) underwent assessments of depressive symptoms (Patient Health Questionnaire-9; PHQ-9), physiological fall risk (Physiological Profile Assessment) and habitual planned exercise (Incidental-Planned Exercise Questionnaire). They wore an accelerometer (McRoberts MoveMonitor) on their

lower back for one week, from which we derived the amount and quality of everyday walking. Fall incidence was followed up for 1-year. We used linear and negative binomial regressions to elucidate the relationship between depressive symptoms and falls and to determine whether physical inactivity and balance and gait impairments underpin this relationship. Results: 104 (21%) people displayed mild-to-severe depressive symptoms (PHQ-9 ≥ 5). People with depressive symptoms did 1.6 hrs [95% confidence interval (CI): 0.7-2.4] less planned exercise per week, walked 1.4 hrs [95% CI: 0.7-2.0] less per week, and had a 36% [95% CI:13-59] higher physiological fall risk. They also had a poorer quality of gait, as reflected by a 0.06 m/s [95% CI:0.03-0.10] slower walking speed and 32% [95% CI:10-55] lower gait quality composite score. They experienced 1.6 [95% CI:1.1-2.3] times more falls during follow-up. While quality of gait and physiological fall risk were significantly associated with fall rates, they only explained 8% of the relationship between depressive symptoms and falls. Conclusions: Depressive symptoms were associated with lower physical activity levels, poorer balance and gait quality. Balance and gait impairments explain a small part of the increased risk for falls in older people with depressive symptoms. These results highlight the importance of considering depressive symptoms as an independent risk factor of falls in older people.

P1-G-161: ***Using virtual reality to determine age-differences in gait performance in anxiety-inducing settings***

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BACKGROUND AND AIM: Older adults experiencing a fear of falling exhibit conservative gait behaviors that may exacerbate fall-risk (e.g., slowing gait speed, taking wider steps). We evaluated the influence of age and experimentally induced anxiety on walking when instructed to move at self-selected (SS) and fast speeds. METHODS: We used virtual reality (VR) (HTC Vive) to compare gait performance of younger (YA; n=8, age=24.7±5.3 yrs, 3 women) and older adults (OA; n=14, age=63.6±5.7 yrs, 9 women) as they walked along a wooden path (55cm x 350cm) with matching texture and dimensions at simulated low (ground level) and high elevation (15m above ground) immersive VR settings (Unity Technologies). Tracking accessories on the ankle provided visual feedback of the feet and recorded positional data to calculate gait speed, step length, and step width. Participants traversed to the end of the walkway and returned to the starting point both at a 'comfortable pace' and 'at their fastest speed, without running'. Turning steps were removed from the analysis. We used factorial Linear Mixed-Effect Regression to determine statistically significant effects in an Age (Younger, Older) x Speed (SS, Fast) x Height (Low, High) model, with random-effects to account for the within-participant factors of Speed and Height. RESULTS: Gait Speed was significantly faster compared to SS speed ($F=40.91$ $p<0.001$) and OA walked slower than YA ($F=6.31$ $p=0.012$). However, speed was not affected by height ($F=2.89$, $p=0.090$) and no interaction effects were detected (all p's>0.17). A three-way interaction was present for step length ($F=5.34$, $p=0.021$) and step width ($F=8.25$, $p=0.004$).

Step length differences were driven by a Task x Height interaction; participants took longer steps to walk fast (F=30.17, p<0.001) and shorter steps at high elevation (F=33.90, p<0.001), but limited taking longer steps for fast speeds at high heights (F=7.82, p=0.005). Age-differences were detected in step width, OA took wider steps than YA (F=5.14, p=0.024), but the effect did not exist at high height (F=0.84, p=0.360), perhaps due to a fixed path width preventing wider steps at high heights for OA, while YA widened their steps at high heights. A tendency to take wider steps at high heights was supported by a Task x Elevation interaction showing participants took more narrow steps on the SS compared to fast speed (F=4.54, p=0.033) but not at high heights (F=0.35, p=0.554). To walk fast at high height, participants increased their step width (F=7.07, p=0.008). CONCLUSIONS: Although we detected age-differences in step-width at low elevation, these were not present in anxiety-inducing settings. In future, researchers should determine if OA steps widen at VR high height using a wider walkway. When instructed to walk fast in anxiety-inducing VR settings, OA and YA did not change speed. Instead, participants adjusted gait so that steps were wider and shorter, potentially to enhance stability in case of a perturbation at high heights.

H - Coordination of posture and gait

P1-H-54: ***Effects of galvanic vestibular stimulation on gait symmetry in healthy individuals***

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Background: Although asymmetrical gait is a significant issue in rehabilitation, it is unclear how this deficiency develops or how to best treat it. Numerous studies have demonstrated that asymmetrical gait can be reduced by utilizing asymmetrical somatosensory signals. Galvanic vestibular stimulation (GVS) can induce side-dependent variations in muscle activity during locomotion, however the effect of GVS on spatio-temporal parameters remains unknown. Objective: Determine the influence of asymmetrical GVS on the cycle duration during walking in healthy subjects. Methods: 7 healthy right-handed subjects participated. Electromyography (EMG) recordings of bilateral soleus were performed, and an accelerometer was put on the vertex. First, using the amplitude of the responses evoked on the accelerometer by the GVS, we constructed a recruitment curve (bipolar GVS;1-4.5 mA, 200 ms, cathode behind the right ear) and determined the motor threshold (T). Then, participants were stimulated at the onset of the stance phase while walking on a treadmill. GVS was applied at an intensity of 1T and 1.5T, with a minimal interstimuli interval of 5 seconds. Vestibular responses triggered by GVS in SOL were averaged (n=30 stimuli) and analyzed. The mean cycle length of the stimulated gait cycle (STIM cycle), the following gait cycle (NEXT cycle) and control cycle (CTRL cycle) were measured. Results: GVS stimulation during walking (mean=3.75 km/h) produced a medium-latency facilitatory response (MLR) in the soleus during the STIM cycle and significantly decreases cycle length during the NEXT cycle. When using an intensity of 1T, the duration of the NEXT cycle was shorter than that of the stimulated cycle (p= 0.0008) and of the control cycle (p= 0.0009). At an intensity of 1.5T, the cycle length of the NEXT cycle was also shorter than the stimulated cycle (p= 0.043), but not shorter than the control cycle. Conclusion: This pilot investigation demonstrates that brief, low-intensity GVS delivered at the stance onset may reduce the duration of the subsequent gait cycle (NEXT cycle). If confirmed, a similar strategy could be used to help individuals with neurological disorders reduce their gait asymmetries.

P1-H-55: ***The use of stepping strategy during visual manipulations in healthy participants.***

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BACKGROUND AND AIM: Foot placement is considered the predominant strategy for mediolateral (ML) balance control during gait and appears to be closely linked to center of mass (COM) dynamics. The relation between COM velocity (vCOM) and foot placement appeared to be very strong when mechanical perturbations are given directly to the COM in healthy subjects. Such perturbations, however, introduce external forces on the body which limits translation to regular walking. In contrast, visual manipulations may result in COM shifts without introducing external forces on the body. Therefore, the aim of this study was to introduce subject-initiated ML COM shifts through visual manipulations and subsequently characterize the vCOM dependent stepping strategy during walking. METHODS: Sixteen young, healthy participants performed six 2-minute walk tests under the following four conditions: 1) no manipulation (NM) , continuous manipulations at 2) low (CML) and 3) high (CMH) intensity and 4) periodical manipulations at high intensity (PM). Manipulations consisted of ML rotations of the VR environment in the Gait Real-time Interactive Lab (GRAIL). ML COM shifts were quantified by the average vCOM per step during manipulations. Stepping strategy was defined as the correlation (R2) between the vCOM at heel strike and the ML COP location at contralateral toe off with respect to the ML COM position, over all steps. Data were analyzed in ML direction and repeated measures ANOVA with post hoc Bonferroni was used to test differences between conditions. RESULTS: All participants showed COM shifts in the direction of manipulation. vCOM values were significantly different between all conditions; NM: -0.033±0.048 CML: 0.15±0.07, CMH: 0.22±0.09 and PM: 0.32±0.09 m/s (all p<0.001). Mean COP to COM distance was significantly depended on the manipulation direction (all p<0.001). Stepping strategy showed moderate correlations for NM (R2=0.46±0.09), CML (R2=0.43±0.09), CMH (R2=0.41±0.6), and PM (R20.44±0.09), which did not differ between conditions (F(3)=1.34, p=0.27). CONCLUSION: All visual manipulations successfully led to participant-initiated ML COM shifts in the direction of manipulation. Severity of shift increased with higher manipulation intensity and increased even further if the manipulation was given periodically. Interestingly, the stepping strategy remained similar to unperturbed gait while the average vCOM increased, suggesting that the stepping strategy is used to actively shift the base of support in the direction of and proportional to ML vCOM dynamics.

P1-H-56: ***Common muscle co-activation patterns in isolated knee extension flexion movements and treadmill walking in people post-stroke***

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BACKGROUND AND AIM: Ambulant people post-stroke often experience difficulties with gait due to reduced motor control, muscle function, and sensory impairments. Impaired muscle coordination after stroke has been characterized by a reduced number of motor modules or muscle synergies in gait [1]. Muscle synergies might reflect both task constraints and neural constraints in muscle coordination. To find common co-activation patterns that may describe neural constraints in muscle coordination, we assess the relationship between muscle co-activation patterns during selective lower extremity movements and treadmill walking in people post-stroke. Based on commonly observed synergies and join torque coupling patterns after stroke [1,2], we hypothesize that the amount of co-activation between the 1) knee extensor and knee flexor muscles and 2) knee extensor and ankle plantarflexor muscles, during treadmill walking relates to the amount of co-activation during an isolated knee extension-flexion movement [3]. METHODS: A preliminary sample of eight people with chronic stroke walked on an instrumented treadmill for three minutes, the last minute was used for analysis. Participants performed a unilateral knee extension-flexion-extension task with the paretic leg three times, while sitting in a chair with both legs hanging freely. Electromyography was measured from the following ankle plantarflexors: m. soleus (SOL), m. gastrocnemius lateralis (GL), m. gastrocnemius medialis (GM); knee flexors: m. biceps femoris (BF), m. semitendinosus (ST); knee extensors: m. rectus femoris (RF), m. vastus lateralis (VL). Correlation coefficients were calculated for the muscle pairs from the two hypotheses, for each participant, as a measure of co-activation between muscles. On group level, Pearson's correlation coefficients were calculated between knee extension-flexion and treadmill walking co-activation coefficients, with an alpha of 0.05. We did not correct for multiple comparisons because we consider this an exploratory analysis on a preliminary dataset. RESULTS: Scatter plots of the results are shown in Figure 1. The preliminary analysis showed significant correlations between knee extension-flexion and treadmill walking muscle co-activation coefficients for the knee extensor and knee flexor muscles; RF-ST (r=0.79; Fig 1B) and knee extensor and ankle plantarflexor muscles; VL-GM (r=0.84; Fig 1J). CONCLUSIONS: Muscle co-activation patterns during isolated joint motions are reflected during gait. This indicates that instrumented measures of selective motor control that do not only score selectivity but also assess muscle activity using electromyography, can be used to assess neural constraints. The ability to distinguish compensations and underlying impairments might help and inspire the future design of assistive devices and the identification of treatment targets in therapy. REFERENCES: [1] Clark et al. (2010) J. Neurophysiol. [2] Sánchez et al. (2017) Neurorehabil. Neural Repair. [3] Fowler et al. (2009). Dev. Med. Child Neurol.

P1-H-57: ***Effects of training on kinematic synergy structures during a balance task***

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BACKGROUND AND AIM: The problem of degrees of freedom (DoFs) indicates that there are several ways for employing the joints of the human body to perform a motor skill. Bernstein proposed that the redundancy of these DoFs is solved by the central nervous system, based on the learning stages of the movement skill. Previous studies on Bernstein's hypothesis have often investigated the coordination of joint movements by calculating the joint angle variances. In this study, Bernstein's hypothesis is examined using the synergy analysis technique. The kinematic synergies during a balance task, before and after training, are extracted from the kinematics data to answer two main questions: What motor synergies are involved in maintaining balance? How do the structures and activation patterns of these motor synergies change as a result of exercise? METHOD: Marker location data was recorded at 120 Hz using a ten-camera motion analysis system for eight healthy male individuals while trying to maintain their balance on a tilt board. The data was acquired in two sessions, before and after six hours of training. Eight kinematic DoFs were considered including: ankle dorsal/plantar flexion, ankle inversion/eversion, knee flexion, hip flexion/extension, abduction/adduction, and internal/external rotation, and pelvis obliquity and rotation. The structures and activation profiles of the kinematic synergies were extracted using the non-negative matrix factorization (NNMF) method. The kinematic synergy structures were then classified using the k-means clustering technique, to identify the structures with similar weights for DoFs and determine the characteristic synergy structures. RESULT: There were five kinematic synergy structures involved in the tilt board balance task, each representing a specific balance strategy, namely, the hip, the ankle posterior, the ankle anterior, the pelvic, and the knee (Fig 1). The six hours exercise did not change the number of the kinematic synergies but altered the associated DoF weights, as well as the consistency, separation, and distinctness of the synergy structures. In particular, following exercise, the second (ankle posterior) synergy experienced a significant decrease in the weight of the pelvic tilt and an increase in that of the knee flexion. Also, the exercise reduced the ankle dorsiflexion and increased the hip flexion of the fifth (knee) synergy, significantly. Finally, analysis of the activation patterns revealed decreased and increased recruitments of the second (ankle posterior) and third (ankle anterior) synergies, following exercise. CONCLUSION: The synergy analysis technique can help to unveil the kinematic strategies involved in human motors skills and their change following training. We found five kinematic synergies for the tilt board balance task, each associated with a specific balance strategy. A short training process did not change the number of kinematic synergies but altered their structures and activation profiles significantly.

P1-H-58: ***A longitudinal analysis of changes in cautious gait behaviour in community-dwelling adults with concussion; Findings from The Toronto Concussion Study***

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BACKGROUND AND AIM: Walking is not an automatic task as it involves a cognitive load needed for navigation and obstacle avoidance. An example of this is the adoption of a cautious gait strategy during instances of divided attention, which is a normal response in healthy adults that is used to maintain gait stability. This strategy is characterized by slower gait velocity and an increase in time spent in double support (time with both feet on the ground during the gait cycle). Acutely after concussion, individuals experience cognitive deficits that could increase cognitive burden, thereby altering gait patterns. Ongoing work in this lab has indicated that individuals with concussion assessed within one week of injury display more cautious gait behaviour than a healthy control group during tasks of increasing cognitive load. It remains unknown as to whether this cautious gait behaviour changes over time in individuals with non-sport related concussion. Thus, the purpose of this study is to assess changes in cautious gait behaviour by examining recovery of gait measures longitudinally over a 12-week window in community-dwelling adults with concussion. METHODS: This is a retrospective analysis of data that were collected at the Hull-Ellis Concussion and Research Clinic at the Toronto Rehabilitation Institute where individuals with concussion were referred from 6 partnering emergency departments in Toronto. Data were collected from February 2016 to September 2019. Patients were assessed within 7 days of injury to mark Week 1, and were subsequently reassessed at Week 2, 4, 8 and 12. Individuals with concussion who completed evaluations at Weeks 1 and 12 were included in this study (n = 113). Healthy control data were also collected (n = 15). Gait measures (velocity, cadence, step length, double support time) were analyzed at two time points (Week 1 and 12) across three conditions of progressively increasing cognitive load: self-paced (no explicit cognitive load), counting (counting upwards by 1), and dual-task (backwards 7's). RESULTS: This preliminary analysis showed a reduction in double support time and an increase in velocity, cadence, and step length in the concussion group at Week 12 compared to Week 1. In each condition, means for double support time, velocity and cadence in the concussion group fell outside of the 95% CI of the healthy group at Week 1, but were within the healthy 95% CI at Week 12. The reduction of cautious gait behaviour, particularly during the motor-cognitive tasks where division of attention is required, may be an indicator that potential cognitive deficits that occur after concussion recover by Week 12 post-injury. CONCLUSIONS: This study demonstrates that the increased cautious gait behaviour observed within one week of injury in community-dwelling adults with concussion returns to healthy levels by Week 12 post-injury. The decrease in cautious gait behaviour from Weeks 1 to 12 during the motor-cognitive tasks may be an indicator of cognitive and overall concussion recovery in community-dwelling adults with concussion.
ACKNOWLEDGMENTS: I'd like to thank my supervisor Dr. George Mochizuki and the team at the Hull-Ellis Concussion and Research Clinic for all their feedback and support with this project.

P1-H-59: ***Repetitive Head Impact Exposure Does Not Affect Dual Task Cost in Early to Middle-Aged Adults***

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BACKGROUND AND AIM: Research on the long-term effects of repetitive head impacts (RHI) has been homogenous, utilizing self-report and subjective outcome measures. Further, samples have lacked generalizability and comparison, having included primarily middle-aged males, with a history of playing high school or professional American football, despite evidence that females suffer worse outcomes to repetitive neurotrauma. Single task (ST) and dual task gait (DT) are established measures of neurobehavioral function and known to be negatively impacted by neurotrauma, providing an objective marker for neurophysiological health. Further, dual task cost (DTC), the change in performance in DT relative to ST provides insight on subtle gait and/or cognitive deficits. Thus, a need exists to investigate the mid-life effects of RHI exposure using objective measures and multiple comparison groups and both sexes. Thus, the purpose of this study was to determine the effect of prolonged RHI exposure on measures of ST and DT gait among early-middle aged adults with varying levels of physical activity and RHI exposure. METHODS: 113 adults (34.9 + 11.8 years, 53.0% female) representing four distinct groups participated in this study: those with no history of RHI who are not physically active (NON) or those who are physically active (NCA); and those who are physically active with a history of RHI through high-risk sports (HRS) or prolonged RHI exposure through rugby (RUG). Gait data was collected using inertial measurement unit measured level-overground ST and DT gait. DTC was calculated for all gait variables (double support, gait speed, stride length). Groups were compared using a one-way ANCOVA on DTC outcomes with known covariates included in the model (concussion history, height, age, contact/collision sport career duration--a measurement of lifetime RHI exposure, and learning disability history). RESULTS: ST Gait Speeds and DTC Gait Speed by group are as follows: NON: 1.07 + 0.16 m/s (DTC: -17.04 + 11.51%); NCA: 1.13 + 0.15 m/s (DTC: -15.96 + 12.58%); HRS: 1.12 + 0.15 m/s (DTC: -11.69 +8.67%); RUG: 1.03 + 0.13 m/s (DTC: -12.64 + 10.13%). There were no significant group differences for DTC double support (p=0.961), gait speed (p=0.911), or DTC stride length (p=0.875). CONCLUSIONS: When accounting for lifetime RHI exposure, physically active individuals with a history of RHI or prolonged RHI exposure through contact/collision sport participation (i.e., HRS and RUG) do not have worse gait performance as assessed by DTC in early- to mid-adulthood than physically active individuals with no history of RHI exposure (NCA). These findings highlight the potential neuroprotective benefits of physical activity against the detrimental effects of RHI throughout ageing. ACKNOWLEDGEMENTS AND FUNDING: This study was supported by the University of Delaware Unidel Fellowship and KAAP Doctoral Research Fund.

P1-H-60: ***Characteristics of uneven surface walking in post-stroke patients: Kinematics and neuromuscular control***

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BACKGROUND AND AIM: Post-stroke patients (SP) have walking deficits including decreased walking speed, lower limb joint angles and increased trunk instability during walking. In recent years, these have been attributed to the decreasing complexity of neuromuscular control in muscle synergy, which represents the coordinated control patterns of multiple muscles during walking. Additionally, SPs have problems such as difficulty walking in the "outdoor community". Therefore, it is necessary to understand the characteristics of walking deficits in outdoor environment, including on uneven surfaces. We expect that the challenging outdoor surfaces, including uneven surfaces, will enhance the walking deficits of SPs. This study examines the differences in kinematic parameters and muscle synergy during even and uneven surface walking between SPs and age-matched healthy people (HP) to identify the unique characteristics of uneven surface walking in SPs. METHODS: Twelve SPs (age: 67.9±17.1, after onset: 66 [53-87] days) who could walk independently and twelve HP (age: 67.0 ± 8.6) participated in this study. Participants walked on a 6 m even surface and a 6m uneven surface covered with artificial grass on top of randomly placed blocks of Ethylene-Vinyl Acetate foam material. An accelerometer was attached to the L3 level, and eight wireless electromyography (EMG) were attached to the paretic leg of the SPs and the right leg of HP, and two video cameras were used for filming. Using these devices, we quantified the following four characteristics: from an accelerometer, video camera, and EMG; 1) walking speed, 2) trunk instability, 3) peak joint angle during the swing and stance phase, and 4) Variance Accounted For 1 (VAF1), showing the complexity of neuromuscular control. RESULTS: Walking speed decreased in SPs compared to HP and decreased in the uneven surface compared to the even surface. Trunk instability was approximately 162% greater during uneven surface walking in SPs than in HP ($p < 0.001$). For the peak joint angle, peak hip flexion and knee flexion in the swing phase were decreased in SPs compared to HP and increased on the uneven surface compared to the even surface. In the stance phase, there was no significant difference in peak knee extension, while there was an interaction ($F(1,22) = 12.2$, $p = 0.002$, $\eta p2 = 0.358$) for peak hip extension (PHE). The results show that compared to HP, SPs had a 50.4% reduction in PHE during uneven surface walking compared to HP ($p = 0.005$). The correlation between PHE and VAF1 in uneven surface walking was not significant in HP ($r = 0.245$, $p = 0.442$) but was significant in SPs ($r = 0.706$, $p = 0.010$). These findings indicate that the unique characteristics of uneven surface walking in SPs are an increase in trunk instability, and a decrease in PHE due to simpler neuromuscular control. Therefore, these mechanisms make outdoor walking for SPs difficult. CONCLUSIONS: During uneven surface walking, compared with HP, SPs had increased trunk instability and decreased PHE. Furthermore, we found that PHE and VAF1 were associated in uneven surface walking in SPs.

P1-H-61: ***Common strategy to maintain balance during upright and hand-walking: minimising torque around the center of mass***

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BACKGROUND AND AIM: With practice, humans may learn to walk on their hands. Even after extended practice, balance during hand-stance and hand-walking remains more precarious than in the upright posture. In upright walking, the ground reaction force (GRF) is approximately aligned with the body center of mass (CoM). This may be a useful strategy for maintaining balance during walking, since it keeps the net torque around the CoM small, both in the sagittal and the lateral planes. This study assesses whether this strategy is also used during hand-walking. METHODS: Sixteen gymnasts performed upright walking and hand-walking. Eight force plates (Kistler) were used to record the GRF and the center of pressure (CoP). The positions of 38 markers placed on the body were recorded (Qualysis) and used to estimate the position of the CoM. The angle of the GRF relative to the vertical was compared to the angle of line connecting the CoM to the CoP, in both the sagittal and lateral planes. RESULTS: The comparison of the trajectories of the CoM (Fig. 1, A-D blue) and CoP (Fig. 1, A-D green) in the sagittal (Fig. 1, A, B) and lateral (Fig. 1, C, D) planes suggest similar strategies for balance control during upright (Fig. 1, left column) and hand-walking (Fig. 1, right column). In both cases, the GRF is approximately aligned with the CoM. The angle of the line connecting the CoM to the CoP (Fig. 1, E-H black) explains 95% of the variance of the angle of the GRF relative to the vertical (Fig. 1, E-H red) in the lateral plane for both upright walking (Fig. 1G) and hand-walking (Fig. 1H). In the sagittal plane, it explains 86% and 88% of the variance for upright (Fig. 1E) and hand-walking (Fig. 1F) respectively. CONCLUSIONS: Despite the differences in the musculo-skeletal structures involved in maintaining balance in upgright versus hand-walking, gymnasts use a common balance strategy in both cases. They maintain the GRF approximately aligned with the CoM. This suggests that minimising the net torque around the CoM may be a crucial requirement to maintain balance during dynamic movement. Future work will address how this strategy emerges in gymnasts learning to walk on their hands.

P1-H-62: ***Ankle proprioception is important for perceiving small slip-like disturbances***

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BACKGROUND AND AIM: We recently found young adults can perceive small slip-like locomotor disturbances [1]. Which sensory modalities contribute to this perception (e.g., visual, vestibular, proprioceptive, and/or somatosensory) remains unknown. Understanding the ability to perceive locomotor disturbances and changes due to aging and disease may provide targets for rehabilitation aimed at improving locomotor balance. As a first step, we examined the extent to which kinematic analogues of sensory feedback could explain the ability of young adults to perceive small slip-like locomotor disturbances. METHODS: Methods: 11 young adults (7M, 22±2.3yrs) walked on a split-belt instrumented treadmill at self-selected walking speed while experiencing disturbances every 8-12 strides. Disturbances were executed through short decreases in treadmill belt velocity triggered at heel-strike that varied in magnitude (Fig. 1A). Disturbances were randomized and repeated 5 times on the dominant leg with nondominant leg disturbances interspersed. After each disturbance, subjects were asked if they perceived the disturbance. The perception threshold was determined by fitting a psychometric curve to the proportion of perceived perturbations. Perturbation-induced deviations were analyzed as sensory analogies for head angle (visual), head angular velocity (vestibular), sagittal hip, knee, and ankle angles (proprioceptive), and anterior-posterior center-of-pressure (COP, somatosensation) in response to the two perturbation levels nearest each subject's perception threshold. For each variable, the deviation between the perturbed gait cycle and the five cycles preceding the perturbation was calculated as (x_i-y_i)/SD_i, where i is gait cycle % from 20-60% (i.e.,

mid-to-late stance), x is the perturbed gait cycle, and y and SD are the average and standard deviation of the pre-perturbation gait cycles. Because head angle and angular velocity varied substantially during pre-perturbation steps, our analysis focused on joint angle and COP deviations. RESULTS: Results: Young adults perceived locomotor disturbances of only 0.08±0.03 m/s. Ten perturbations were analyzed per subject, with a median of 5 perceived perturbations (range:3-7). A rank-sum test identified perturbation-induced ankle deviation was the only variable that differed between perceived and non-perceived perturbations (p=0.001, Fig. 1B). Separate logistical mixed effects models identified ankle angle deviation as the only variable whose 95% confidence interval on the odds ratio (OR) did not cross one, with an estimated OR of 1.96 (Fig. 1C). CONCLUSIONS: Sensing changes in ankle motion may play an important role in perceiving subtle slip-like locomotor disturbances. Reduced mechanoreceptor sensitivity that can occur with aging or disease may decrease the ability to consciously perceive locomotor disturbances, contributing to an increased risk of falls. ACKNOWLEDGEMENTS AND FUNDING: NIH 5U54GM104942 and T32GM133369
References: [1] Liss et al., 2021. Gait Posture

P1-H-63: ***Vestibular input modulates stepping balance reactions early in the pre-step phase through to post-recovery***

Brye McMorran[1], John Zettel[1], Leah Bent[1]

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BACKGROUND AND AIM: Compensatory stepping reactions to recover from balance perturbations are affected by head turns, which may be related to decrements in vestibular feedback due to the vestibular apparatus oriented in a less familiar position. To determine this as a possible mechanism for head-turn effects (Dalton 2017 JNeurophys), it first must be established whether vestibular input plays a role in compensatory stepping. Galvanic vestibular stimulation (GVS) applied during non-stepping balance reactions only affects a re-establishment of equilibrium after recovery but not the sway reaction itself (Inglis 1995 JNeurophys), suggesting vestibular input may not affect compensatory steps. The current study assessed whether more complex step responses utilize vestibular input by combining GVS stimulation with step-inducing balance perturbations. METHODS: Standing balance was perturbed via large unpredictable support surface translations, with GVS that induced perception of left- (LGVS) or rightward (RGVS) postural motion as well as no-GVS. Forward steps taken with the dominant (right) leg were compared between unconstrained stepping (noOB) and clearing an obstacle (OB) to assess whether increased step response complexity affects the use of vestibular feedback. Responses were quantified by anticipatory postural adjustments (APAs), whole-body center of mass (COM) motion, and stability margins (SM: COM motion relative to base of support (BOS) boundaries). RESULTS: GVS affected all phases of the step response with noOB and OB. The APA prior to the step was largest in the RGVS condition (p=0.02), acting to drive the COM (displacement, velocity: p's <0.009) leftwards at foot-off (FO) to create a larger rightward SM (p=0.02). Conversely, LGVS did not mirror the RGVS pattern, with no rightward COM shift nor change in SM, likely limited by the reduced BOS to the right in stepping with that leg. The COM motion at foot-contact (FC) was similar: greater leftward COM motion in RGVS (p's<0.006) with no difference between LGVS and no-GVS. LGVS, however, did evoke a leftward step placement ($p<0.0001$) against the sensed fall. The result was SMs to the right being largest with RGVS and smallest with LGVS compared to no-GVS ($p<0.0001$). In post-recovery, COM motion was largest to the left and smallest to the right for RGVS and vice-versa for LGVS (p's<0.006), such that the SM against the GVS-sensed postural motion was equivalent to no-GVS, but at a trade-off with a smaller SM in the opposite direction (p's<0.005). CONCLUSIONS: These results establish that vestibular input influences compensatory stepping reactions in the early pre-step phase through to post-recovery, and that GVS-induced adjustments are made according to stability features of the step (step placement and SM at FC). These results identify reduced vestibular fidelity as a possible mechanism for the head-orientation effect on compensatory stepping reactions.

P1-H-64: ***The effect of head and eye position on balance reactions***

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BACKGROUND AND AIM: Head and eye orientation influences stability in quiet stance and gait, and may similarly affect balance reactions, particularly in older adults (OA) who are reluctant to shift head and gaze orientation from neutral position with an impending perturbation. This study aimed to distinguish whether eccentric head and eye position affect compensatory stepping reactions and whether any effects are exacerbated in OAs. Eccentric head and eye positions are expected to decrease sensory feedback fidelity impairing sensory-determination of perturbation induced body-motion and bias the stepping response in the direction of the deviated head and eye position. This will compromise balance reactions via delay of the response and alter step parameters (e.g. step direction and magnitude) to increase COM motion and decrease stability, with OAs more susceptible to such effects. METHODS: Balance in young adults (YA) (12) and OAs (12) was perturbed via unpredictable horizontal support surface translations. Trials began in quiet stance, with head and eye position in one of nine conditions (Fig. 1). Whole body kinematic data was used to determine response timing, step parameters, center of mass (CoM) motion, and stability in the anteroposterior (AP) and mediolateral (ML) axes during forward, backward, and lateral body perturbations. RESULTS: Greater COM motion occurred in the direction of body perturbation when the head or eyes were aligned with the perturbation direction, with more steps taken to regain stability in forward and lateral perturbations when the head was positioned eccentrically. In AP perturbations, ML COM motion was increased in the direction of head-orientation, with reduced lateral stability when head and/or eyes were directed towards the step-side leg; surprisingly, the opposite occurred in backward perturbations. Backward responses also differed in that the response onset was faster with the head oriented eccentrically. In lateral perturbations, AP stability was reduced with eccentric gaze. YA responses were altered in terms of reaction time, COM motion, and lateral step displacement when eye position did not match perturbation direction, however the same effect was not observed in OAs. CONCLUSIONS: Head and eye position altered compensatory stepping reactions in terms of reaction time, step parameters, COM motion, and stability, causing a biased response in the direction of the head and/or eyes. Age

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differences revealed that when eye position deviated from body perturbation direction, OAs did not show an adaptation in control strategy to altered eye position that occurred in YAs. Follow-up studies are investigating whether these head and eye orientation effects are due to decreased sensory fidelity from less familiar sensor orientation and/or altered motor pathway excitability affecting the compensatory stepping response.

P1-H-65: ***Different methods of foot elevation do not change the elevation position of the foot***

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BACKGROUND AND AIM: Obstacle crossing requires visuomotor transformation. To securely cross over an obstacle, visual information about the obstacle's height must be transformed into motor commands to raise the foot. It has been known that the foot trajectories and the clearance of the leading leg and trailing leg and the risk of tripping are higher in the trailing leg than in the leading leg (Heijinen et al., 2012). We hypothesized that the difference in the behavior could be attributed to the visuomotor transformation between the leading and the trailing limbs because of the difference in the alignment (i.e., one raises the leading leg in front of the body and the trailing leg at the back of the body). To test the hypothesis, we showed an obstacle to participants and asked them to raise their foot at the same height of the obstacle, either in front of or at the back of the body. METHODS: In this study, six healthy adults (2 males and 4 females, age: 21.0 ± 1.0 years, height: 165.2 ± 6.1 cm) participated. The participants looked at an obstacle placed at a distance of 3 m and raised their feet so that their toes reached the same height as the obstacle. The participants were instructed to fixate on the obstacle and not watch their feet during the task. Two different ways of elevation were used: front and back. The participants flexed the hip and knee joints like the leading leg during obstacle crossing for the front raise condition. For the back raise condition, the thigh segments remained up straight, and the knee joint was flexed like the trailing leg. Two obstacle heights were tested: 5 cm and 15 cm, and the tasks were performed by both left and right feet. Twelve trials were performed for each of the eight conditions. The maximum toe elevation was calculated as the height of the marker attached to the edge of the foot's thumb. The difference between the maximum toe elevation and the obstacle height was compared between conditions. RESULTS: All the participants raised their feet higher than the obstacle height. As there were no apparent differences between the left and right feet, we report the averaged values over both feet. There was no difference in the foot elevation between the front and back raise conditions (obstacle height 5 cm: front 86.6±28.8 mm, back 85.7±46.9 mm; obstacle height 15 cm: front 106.4±50.7 mm, back 104.4±54.8 mm). The memory of the obstacle height might be shared and used to control the vertical position of the feet no matter whether in the front and back raise conditions, which is in line with the previous findings that the motor memory of the leading and trailing legs is shared in a motor learning task in a virtual reality environment (Hagio et al., 2020). It means that the difference in the risk of tripping cannot be explained by the difference in the visuomotor transformation between the leading and trailing limbs. CONCLUSIONS: No difference was observed in the visuomotor transformation regarding the vertical foot position

between the front and back raise conditions. ACKNOWLEDGMENTS AND FUNDING This work was supported by Tateisi Science and Technology Foundation and JST SPRING, Grant Number JPMJSP2132.

P1-H-66: ***Characterizing neuromechanical properties of abductor hallucis and their potential relationship with standing postural control***

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BACKGROUND & AIM: The abductor hallucis (AH), is a small, intrinsic foot muscle that abducts and flexes the great toe, and its activation is modulated by changes in postural demand - potentially highlighting its role in postural control. Further, for other muscle groups, neuromechanical measures such as strength, voluntary activation and contractile twitch properties are linked to standing balance performance. However, these neuromechanical measures and their relationship with standing balance remain unknown for AH. As such, we aimed to quantify AH strength, voluntary activation (VA), and contractile twitch properties and to correlate these measures with centre of pressure (COP) sway measures. METHODS: Nine participants (6 M; age: 28±7 years) had their right foot strapped into a custom isometric myograph. To measure strength, participants performed maximal voluntary isometric great toe abductions. During each maximal contraction, we measured voluntary activation with the interpolated twitch technique. Contractile twitch properties were sampled from electrically evoked contractions. Measures included peak force, contraction time (CT), half-relaxation time (HRT), rate of force development (RFD) and relaxation rate (RR). We correlated strength, VA, and contractile properties to anterior-posterior (AP) and mediolateral (ML) COP velocity (VEL) and standard deviation (SD) during two-60 second, single-legged (right leg) stance trials. RESULTS: During maximal voluntary great toe abduction, average strength and VA were 33.9±21.3 N, and 79.5±32.2% (6 participants achieved >90%, 3 achieved <65%), respectively. Twitch peak force was 5.8±3.3 N while CT and HRT were 169.8±32.3 ms and 124.1±29.2 ms, respectively. RFD was 62.9±40.7 N*s-1 and RR was 38.7±24.3 N*s-1. AH strength exhibited moderate negative correlations with AP and ML COP VEL (AP: r = -0.46; ML: r = -0.68). Moderate and strong correlations were observed between COP VEL and both RFD (AP: r = -0.84; ML: r = -0.61) and HRT (AP: r = 0.70; ML: r = 0.53). CONCLUSIONS: Our results may suggest that most participants were able to achieve high great toe abduction VA, however a subset of participants may require training to achieve high VA values. AH contractile twitch properties appear to be similar to those of other slow muscles such as soleus which may indicate the AH is designed for slower, ongoing motor tasks such as postural control. Our correlations suggest that great toe abduction strength and contractile speeds may be important factors that influence postural balance control during single-legged stance , at least in a healthy young population. Overall, our data may provide further insights into AH function and its possible role in postural control .

P1-H-67: ***A treadmill interaction: Ankle moment constraints differentially affect the degree of foot placement control with an additional stepping constraint***

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BACKGROUND AND AIM: Coordinated foot placement with respect the kinematic state of the center of mass (CoM) is a dominant mechanism to maintain stability during steady-state walking 1,2. We have recently found that errors in foot placement are partially compensated for by ankle moment control 3. Therefore, when constraining ankle moment control, we expected a higher degree of foot placement control. Recently, we have found the opposite; on a split-belt treadmill constraining ankle moments resulted in a decrease in the degree of foot placement control 4. However, this result may in part be attributed to the treadmill's properties. The ankle moment constraint, a shoe with a flexible narrow ridge under the length of the sole, required participants to avoid stepping into the gap in between the split belts. Here, we repeated the experiment to see whether this additional stepping constraint influenced our outcomes. METHODS: Participants walked both on a split-belt and a normal (single-belt) treadmill. On each treadmill, one trial was performed with normal shoes, and one trial with the ankle moment constraints. Each trial consisted of five minutes of walking at normal speed with a metronome-controlled step frequency. We analyzed the degree of foot placement control as the percentage of variance in mediolateral foot placement that could be explained by the swing phase CoM kinematic state 2,4,5. RESULTS: On the split-belt, similar to our previous findings, the degree of foot placement control decreased when walking with constrained ankle moments. However, this did not occur on the single-belt treadmill, for which towards the end of the step cycle, we even found a trend towards an increased degree of foot placement control. Moreover, overall the degree of foot placement control was higher on the single-belt as compared to the split-belt treadmill. CONCLUSIONS: We showed that the gap between the split-belts influenced the effect of walking with ankle moment constraints. Based on the findings on the normal treadmill, it seems that participants tend to enhance foot placement control, to compensate for restricted ankle moment control. However, the additional stepping constraint imposed by the split-belt caused an opposite effect. We interpret this as a trade-off between two, seemingly conflicting, foot placement related tasks on the split-belt. The first being to maintain the relationship between CoM kinematic state and foot placement, and the second to avoid stepping in, or onto the gap. Here, we showed this has implications for investigating the degree on foot placement control on a split-belt treadmill. REFERENCES: 1 Bruijn, S. M. & van Dieën, J. H. Journal of The Royal Society Interface 15, 20170816 (2018). 2 Wang, Y. & Srinivasan, M. Biology letters 10 (2014). 3 van Leeuwen, A., van Dieën, J., Daffertshofer, A. & Bruijn, S. Scientific reports 11, 1-14 (2021). 4 van Leeuwen, A. M., van Dieen, J. H., Daffertshofer, A. & Bruijn, S. M. Plos one 15, e0242215 (2020). 5 Mahaki, M., Bruijn, S. M. & Van Dieën, J. H. PeerJ 7, e7939 (2019).

P1-H-68: ***Human-Human Hand Interactions Aid Balance During Walking by Haptic Communication***

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BACKGROUND AND AIM: Principles from human-human physical interaction may be necessary to design more intuitive and seamless robotic devices to aid human movement. Previous studies have shown that light touch can aid balance and that haptic communication, quantified by interaction forces, can improve performance of physical tasks. However, the effects of touch between two humans on walking balance has not been previously characterized. This study examines physical interaction between two persons when one person aids another in performing a balance-challenging beam-walking task. METHODS: 12 pairs of healthy young adults held a force sensor with one hand while one person walked on a narrow balance beam (2 cm wide x 3.7m long) and the other walked overground by their side (Figure 1A). We measured beam-walker kinematics via motion capture and interaction kinetics through the force sensor (Figure 1B). We compare balance performance during partnered vs. solo beam-walking to examine the effects of haptic interaction, and we compare hand interaction mechanics during partnered beam-walking vs. overground walking to examine how the interaction aided balance. To gain insight into feasible controller designs to emulate human-human physical interactions for aiding walking balance, we model the relationship between interaction kinetics and beam-walker kinematics as a mass-spring-damper system. RESULTS: While holding the hand of a partner, participants were able to walk further on the beam without falling, reduce lateral sway, and decrease angular momentum in the frontal plane. We measured small hand force magnitudes (mean of 2.2 N laterally and 3.4 N vertically) that created opposing torque components on the beam-walker's body about the beam axis (Figure 1B). To quantify haptic communication, we calculated the interaction torque ("Ty_Int" in Figure 1B), the overlapping opposing torque that does not contribute to motion of the beam-walker's body. We found higher interaction torque magnitudes during partnered beam-walking vs. partnered overground walking (Figure 1C), and a correlation between interaction torque magnitude and reductions in lateral sway (Figure 1D). Our model relating each torque component to motion of the beam-walker's body showed opposite types (active vs. passive) of mechanical elements (damping and stiffness) for the two torque components. CONCLUSIONS: This study demonstrates that hand interactions aid balance by creating opposing torques on the beam-walker's body and is the first study to quantify human-human physical interactions in a balance-challenging beam-walking task that is relevant to physical assistance and rehabilitation. The small force magnitudes and significance of interaction torque for improving balance suggest that hand interactions primarily serve haptic communication. The human-human balance-aiding principle of opposing dynamics can be implemented in human-robot interaction controllers through our mass-spring-damper model parameters and provides a conceptual framework for designing future walking aids and rehabilitation devices.

P1-H-69: ***The stepping strategy during walking in people with incomplete spinal cord injury***

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BACKGROUND AND AIM: Impaired balance during walking is a common problem in people with incomplete spinal cord injury (iSCI). To improve their walking capacity, it is essential to understand how walking balance is affected in this population. In healthy subjects, the dominant mechanism to maintain postural stability during walking is the stepping strategy, which involves adjustments to the location and timing of foot placement. The literature suggests that mediolateral foot placement adjustments are based on the mediolateral center of mass (COM) kinematics. iSCI impairs motor control and sensory perception below the spinal lesion and may therefore impact the stepping strategy. This study aimed to characterize the use of the mediolateral stepping strategy during walking in people with iSCI compared to healthy controls. METHODS: People with iSCI ($n = 28$) and healthy controls ($n = 20$) performed a two-minute walking test on an instrumented treadmill at a self-selected walking speed. Kinematic data and ground reaction forces were recorded and analyzed. To study the use of the stepping strategy, the relation between 1) mediolateral COM velocity at heel strike and 2) mediolateral foot placement was quantified by linear regression [1]. Foot placement was defined as the center of pressure relative to the COM at contralateral toe-off. The explained variance R^2 of this relation was used to quantify the use of the stepping strategy and was called foot placement adherence. To test if the severity of the iSCI was related to the use of the stepping strategy, the correlation between foot placement adherence and the self-selected walking speed, as an indicator of gait capacity, was determined. RESULTS: An independent t-test showed that foot placement adherence was significantly lower in people with iSCI ($R^2 = 0.30 \pm 0.17$) compared to healthy controls ($R^2 = 0.48 \pm 0.09$); $t(46) = -4.21$, $p < 0.01$ (see Figure 1A). Furthermore, foot placement adherence in people with iSCI was related to their self-selected walking speed ($r = 0.73$, $p < 0.01$), whereas foot placement adherence in healthy controls did not show such a correlation ($r = -0.29$, $p = 0.21$) (see Figure 1B). CONCLUSIONS: Our findings suggest that people with iSCI have a reduced use of the mediolateral stepping strategy during walking compared to healthy controls. Besides, the use of the stepping strategy in people with iSCI was related to the self-selected walking speed which could indicate that the severity of the iSCI is related to the use of the stepping strategy. However, the effect of walking speed on the use of the stepping strategy should be further analyzed to understand if a reduced foot placement adherence in people with iSCI is a result of an impaired capacity to use the stepping strategy and/or a result of a lower preferred walking speed. [1] Vlutters, M., van Asseldonk, E.H.F. and van der Kooij, H. (2016). Center of mass velocity-based predictions in balance recovery following pelvis perturbations during human walking. Journal of Experimental Biology 219, 1514-1523.

J - Development of posture and gait

P1-J-70: ***Young adult and adolescent balance control strategies during a dual-task stone-stepping paradigm***

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BACKGROUND AND AIMS: Stone-stepping is a type of adaptive locomotion that demands greater attention and visuomotor integration, as it requires precise foot placement. The amount of attention required during locomotion is typically assessed with a secondary task, by analyzing the dual-task cost. Young adults have lower dual-task cost than children, suggesting children are most affected by the performance of a secondary task while walking. The purpose of the current study was to explore the balance control and dual-task cost differences between adolescents and young adults during a stone-stepping paradigm. We hypothesized that adolescents would experience greater balance control deficits and dual-task cost while performing the secondary task compared to the young adults, especially while on the uneven terrain. METHODS: Young adults (n= 20, ages 18-25) and adolescents (n= 18, ages 12-17) performed a dual-task stone-stepping paradigm across two different terrains (flat and uneven), with or without an auditory Stroop test. The flat terrain had foot targets placed on the ground whereas the uneven terrain had rock climbing holds attached to plywood. Both terrains had identical predetermined paths with 12 steps for the right and left foot start. The auditory Stroop test consistent of the words "high" and "low" said in a high or low pitch, in which the participant reported the pitch of the word. Each participant completed four conditions: (1) even terrain, no auditory Stroop; (2) even terrain, with auditory Stroop; (3) uneven terrain, no auditory Stroop; (4) uneven terrain, with auditory Stroop. Participants' full body kinematics were recorded using an Optotrak Certus camera system collected at 100Hz to calculate walking speed, as well as trunk pitch and roll. RESULTS: The findings revealed that adolescents significantly ($p < .05$) decreased their walking speed from single- (68.2 1.6 cm/s) to dual- (66.8 1.5 cm/s) tasking, compared to young adults who maintained consistent walking speed during single- (71.4 1.5 cm/s) and dual-task (71.8 1.4 cm/s). Adolescents also had a significantly ($p < .05$) higher trunk pitch variability while on uneven terrain (2.7 0.1) compared to even terrain (1.94 0.10), whereas young adults had little change from even (1.8 0.1) to uneven (M=2.3 0.1) terrain. However, trunk roll variability was unaffected by condition or task between the participants. CONCLUSIONS: Adolescents experienced a higher dual-task cost compared to young adults and needed to decrease their walking speed while dual-tasking. Additionally, adolescents' increased trunk pitch variability on the uneven terrain indicates their inability to consistently maintain their postural control in the plane of progression while adapting to the demands of the terrain. Therefore, adolescents appear to lack adult-like (hip) motor coordination when walking on uneven terrains as well as an underdeveloped executive function during locomotion.

P1-J-71: ***Emergence of running and walking experience, a longitudinal case series***

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BACKGROUND AND AIM: Children start to run after they master walking. In a previous study on treadmill running, we found no direct agreement between chronological age and the maturity of the running pattern in children aged 59 to 106 months (Bach, Daffertshofer, & Dominici, 2021). This, however, does not exclude that the emergence and development of the running pattern depends on walking experience. We investigated whether walking experience indicates the development of running and whether specific features of running are already present in or develop slowly during the first period after the emergence of walking. We also ask: does the ability to run with a flight phase indicate mature running? We present preliminary results of a case study with two participants recorded multiple times between two weeks after the first independent steps until 32 months of walking experience while walking and running overground and on a treadmill. METHODS: We recorded leg and trunk 3D kinematics and EMG in two typically developing children with a mean (±std) of 144 (± 79) strides per session. Both participants underwent six consecutive recording sessions within a period of three years to assess the development of running after the onset of independent walking. We recorded walking during the first session (at the age of 11.9 and 10.6 months) and fast walking/running for the subsequent sessions. More than 100 kinematic and spatiotemporal parameters were determined for each session, stride, and leg. The data of four young adults served to define mature running. The sets were reduced via principal component analysis to eliminate covariation. Subsequently a cluster analysis was employed which allowed for using the average pairwise correlation distance to the adult running cluster as a measure for maturity. RESULTS: Walking experience could be confirmed as an indicator for running development, despite the absence of a direct linear relationship between the maturity of running and the walking age. Our preliminary analysis revealed substantial difference in the ability to run with a flight phase between the two participants. Yet, the cluster analysis did not separate participants, suggesting that running with a flight phase is not the only feature to consider, even in very young children. CONCLUSIONS: Monitoring two participants over a period of almost three years with extensive measurements such as bilateral leg and trunk 3D kinematics, spatiotemporal parameters, and bilateral leg and trunk muscle activity provided new insights into the development of running at very early stage after reaching independent walking. ACKNOWLEDGEMENT AND FUNDING: This project has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement no 715945 Learn2Walk) and from the Dutch Organisation for Scientific Research (NWO) VIDI grant (016.156.346 FirSTeps). REFERENCES: Bach, M. M., Daffertshofer, A., & Dominici, N. (2021). The development of mature gait patterns in children during walking and running. Eur J Appl Physiol, 121(4), 1073-1085. doi:10.1007/s00421-020-04592-2

P1-J-72: ***Relations between infants' spatiotemporal gait variability and fall rate***

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BACKGROUND AND AIM: The human gait cycle is highly patterned, and consistency is a hallmark of skilled, mature gait. Nonetheless, all humans display gait variability--small stride-to-stride variations in walking parameters. Prior work showed that gait variability predicts falls

in older adults, suggesting that sub-optimal levels of consistency are associated with walking instability. But does gait variability predict falls in infancy, when gait control is still developing, steps are variable, and falls are rampant? And if so, which measure of gait variability best predicts infants' fall rate? METHODS: We investigated the relations between spatiotemporal measures of gait variability and real-time falls in a preliminary dataset of 65 15-month-old walking infants (additional data from 50+ infants will be added to the final dataset). Walking experience ranged from 0.2 to 5.5 months (M = 3.0 months). We measured infants' step length, speed, and step width with a pressure-sensitive gait mat and calculated the coefficient of variation (CV; standard deviation divided by the mean) for each measure to characterize gait variability. We recorded infants' locomotor activity during 10-25 minutes of free play in a laboratory playroom, video-coded infants' falls, and calculated infants' fall rate (number of falls divided by the total minutes in motion, multiplied by 60). RESULTS: Step length CV ranged from 6% to 23% (M = 11%), speed CV ranged from 3% to 28% (M = 12%), and step width CV ranged from 10% to 48% (M = 23%). Infants' fall rate ranged from 0 to 117 (M = 21) falls per hour in motion; 16 infants never fell. We conducted a linear regression model with fall rate as the outcome variable (natural log transformed to account for positive skew), and walking experience, step length CV, speed CV, and step width CV as predictor variables. The model accounted for 19% of the variance in fall rate; R2adj = .19, F(4,44) = 3.78, p= 0.01. Step length CV significantly predicted fall rate; b = .10, t(44) = 2.72, p =.01. That is, for every one-percent increase in step length CV, fall rate increased by 10%. Neither walking experience (p = .09), speed CV (p = .65), nor step width CV (p = .57) significantly predicted fall rate after adjusting for the other predictor variables. CONCLUSIONS: These preliminary results suggest that step length variability is a significant predictor of falls in infants. Thus, gait variability not only predicts falls in older adults with deteriorating gait control, but also in infants with developing gait control. Future analyses will assess step-to-step variability to better characterize gait variability.

P1-J-73: ***Characteristics of obstacle avoidance strategy in children aged 2-5 years: A pilot study.***

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BACKGROUND AND AIMS: Obstacle crossing, one of the adaptive walking, requires complex information processing that integrates sensorimotor system and cognitive functions. Previous studies suggest that level walking can be achieved at the age of 5 or 6 in terms of normalized step length and step speed (Lythgo et al., 2011), and obstacle crossing behavior in children aged 7 years was different from that in adults (Berard and Vallis, 2006; Corporaal et al., 2016). In this pilot study, we will report the characteristics of obstacle crossing behavior in children aged 2-5 years. METHODS: Ten healthy preschool children participated in this study: 2 years (n = 2), 3 years (n = 2), 4 years (n = 2), 5 years (n = 4). An informed consent was obtained from the parent of each child prior to the start of the experiment. The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethical committee of Oita University Faculty of Welfare and Health Science (approval number: F200016). The children crossed an obstacle with a height normalized to 10% of their leg length and repeated at least 2 trials (5 trials at most). The gait motion was captured by three video cameras (1980 × 1080, 120 fps). We used OpenPose (Cao, 2017), a marker-less motion capture algorithm, to estimate the 2D coordinates of the body and we transformed them into 3D coordinates using the direct linear transformation method. From the kinematic data, we calculated the step length and the horizontal distance between the obstacle and the foot, the step width, and the step speed, which were normalized to the leg length, pelvis width, and the square root of gravity times leg length, respectively. In addition, the vertical toe clearance was calculated. RESULTS: All the participants successfully stepped over the obstacle. The vertical toe clearance of the lead and trail limbs were 94 ± 26 mm, and 92 ± 33 mm, respectively. The first common feature was a long step of the lead limb during crossing the obstacle, which might be interpreted as a cautious strategy to avoid the collision to the obstacle. The other was a larger step width of the trail limb, regarded as a strategy to increase the medio-lateral dynamic stability. Two children aged 2 years showed a small step length, slow approaching speed, and placed their lead foot closer to the obstacle prior to obstacle crossing, which might indicate that they required more steps for adjusting foot placements compared to the older children. CONCLUSIONS: Children aged 2-5 years were able to clearance the obstacle by increasing the step length of the lead limb, and the step width of the trail limb. The slow and cautious behavior observed in the 2-year-old children might suggest that the complex information processing for obstacle crossing is developing around the age of 2. ACKNOWLEDGEMENTS AND FUNDING: This work was supported by JSPS/MEXT KAKENHI Grant-in-Aid, Grant Number: 17H04750, 19K19901, 21H05334.

L - Devices to improve posture and gait

P1-L-75: ***Preliminary Kinematic Evaluation of Custom versus Generic Human-Robot Coupling Interfaces on Lower-Limb Rehabilitation Exoskeletons***

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BACKGROUND AND AIM: In the development of lower limb rehabilitation devices (e.g. prostheses, orthoses), consideration of the interface surface between the user and device is important. In particular, certified clinicians (e.g. orthotists, prosthetists) design interfaces to maintain an effective "quality of fit" to minimise risk of skin injury, allow for long term use, and ensure effective rehabilitation [1]. For Lower-Limb rehabilitation exoskeletons (LLREs) there has been little focus in literature on interface design, the risks they pose to the user, and their influence on the effectiveness of the device in short and/or long term use [2]. The present study aims to evaluate a generic strapping interface against custom surfaces in LLREs in a controlled testbench environment. METHODS: The H3 Exoskeleton (Technaid,Spain), a 6 DOF bilateral LLRE, was suspended by the hips on a mounting-frame to isolate sagittal plane motion. The H3 is controlled by an app for standard straight walking cycles. Modelled from the first author's leg, a 2 DOF mannequin leg was generated to provide a passive testbench without the variability of human input and skin integrity across tests. Two sets of interface surfaces were evaluated: the "generic" surface with a curvature intended to fit across a wide array of individuals, and a set of custom straps developed with the advice of a certified orthotist to closely match the mannequin. Mounting locations and securing methods remained consistent between the interfaces. The exoskeleton and both surfaces are shown in Figure 1(a). VICON motion capture was used to capture kinematic knee-joint data of the H3 and Mannequin legs over ten steps. Kinematic "Quality of Fit" was measured as root mean squared error (RMSE) between the exoskeleton and mannequin knee angles, indicating relative movement between user and device. Initial offsets due to join misalignment were removed. RESULTS: Relative knee angle difference between the generic and custom interfaces for ten steps are shown in Figure 1(b). RMSE of the generic strapping ranged from 1.41 to 2.03 degrees across 10 steps, with higher values observed in the later steps. RMSE of the custom strapping ranged between 0.41 to 0.47 degrees. CONCLUSIONS: Preliminary kinematic results show higher variability within the generic strapping, increasing with each step. The increasing movement over the generic trial is likely attributable to inelastic deformation with successive steps. These initial findings indicate conforming and better pressure distributing surfaces offer more stability to the system compared to that of generic interfaces. Follow-up studies will assess the influence of surface placement relative to centre of mass, number of straps, steps taken, and securing methods. [1] S. Turner and A. H. McGregor, Archives of Rehabilitation Research and Clinical Translation, 2020. [2] A. S. Gorgey, World Journal of Orthopedics, vol. 9, no. 9, pp. 112-119, 2018.

P1-L-76: ***Does the amount of vibrotactile feedback matter to improve balance control?***

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BACKGROUND AND AIMS: The brain uses visual, somatosensory, and vestibular cues to estimate body amplitude and direction. Accurate estimation of body sway is crucial to maintain standing balance. Individuals with altered sensory information show balance control impairment. For these individuals, vibrotactile feedback (VF) improves their balance. It is unclear, however, if VF must be provided each time balance is compromised. The goal of this study was to compare balance control of participants provided with VF every time their balance was compromised to other provided with VF only one-third of the time that balance was compromised. VF was related to body sway angle and direction. The secondary goals were: 1) to determine if following VF, balance control changes lasted, and 2) to examine if erroneous (sham) VF altered balance control. We hypothesized that VF would improve balance more when it was provided each time that balance was compromised. We expected to observe altered balance control in the sham condition, suggesting the processing of VF. METHODS: 24 healthy young adults were randomly assigned to two groups (n=12/group; 12 females): groups 100% and 33% VF. Participants wore a custom belt with four vibrating motors placed on the anterior, posterior, left, and right sides of the trunk at T12 vertebrae. VF provided tactile information according to body sway angular amplitude and direction. Body sway angle and angular velocity were measured by an inertial measurement unit located at the L4 vertebrae. We compared balance control while participants stood on a hard surface with their eyes open or closed, and standing on a foam surface with their eyes closed. To assess whether balance control changes lasted in absence of VF, participants stood on the foam surface with eyes closed without any VF. Participants underwent a last condition in which VF was unrelated to body sway direction (sham). We calculated the root mean square (RMS) of body sway (i.e., angle and angular velocity) and ground reaction forces. RESULTS: In both groups, VF decreased the RMS value of the body sway angle but increased angular velocity and ground forces. Immediately following VF, the reduction in body sway angle variability was maintained and body sway velocity and ground forces variability decreased in both groups. Variability in body sway angle, angle velocity, and ground reaction forces increased in the sham condition. This result confirmed that participants processed VF to control their balance. CONCLUSION: VF effectively improved balance control regardless of the amount provided (33% vs 100%). We argue that providing VF one-third of the time, compared to 100% of the time, during compromised balance control could enhance balance control while avoiding excessive cognitive load. Further studies should extend this protocol in clinical populations experiencing somatosensory loss (e.g., peripheral neuropathy) to prevent the risks of falling.

P1-L-77: ***Holocue: a wearable holographic cueing application for alleviating freezing of gait in Parkinson's disease***

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BACKGROUND AND AIM: External visual cueing is a well-known means to target freezing of gait (FOG) in Parkinson's disease patients. Holocue (Figure 1) is a wearable visual cueing application that allows the HoloLens 1 mixed-reality headset to present on-demand patient-tailored action-relevant 2D and 3D holographic visual cues in free-living environments. The aim of this study was twofold: 1) to explore unfamiliarity and habituation effects associated with wearing the HoloLens on FOG and 2) to evaluate the potential immediate effect of Holocue on alleviating FOG in the home environment. METHODS: Three sessions in the home environment of 24 Parkinson's disease patients with dopaminergic ON-state FOG were conducted to examine 1) the effect of wearing the unfamiliar HoloLens on FOG by comparing walking with and without the HoloLens, 2) habituation effects to wearing the HoloLens by comparing FOG while walking with HoloLens over sessions and 3) the potential immediate effect of Holocue on FOG by comparing walking with HoloLens with and without Holocue. RESULTS: Holocue had overall no immediate effect on FOG, although objective and subjective benefits were observed for some individuals, most notably those with long and/or many FOG episodes. Wearing the HoloLens (without Holocue) did significantly increase the number and duration of FOG episodes, but this unfamiliarity effect disappeared with habituation over sessions. CONCLUSIONS: Holocue, with its patient-tailored action-relevant holographic cues, had no systematic immediate effect on ON-state FOG in the home environment in Parkinson disease patients. Nevertheless, Holocue holds promise for alleviating FOG because of (1) objective and subjective benefits for some participants (i.e., those with long and/or many FOG episodes), (2) current and anticipated future design choices being validated by end-users, and (3) identified internal (i.e., better patient-tailoring,

modality of cues) and external (i.e., better mixed-reality headsets to improve comfort and action relevance) opportunities for improvement. Finally, our study testifies to the importance of controlling for unfamiliarity and habituation effects (as these demonstrably affected the number and duration of FOG episodes) to prevent drawing false-positive or false-negative conclusions regarding the effect of new wearable cueing technology. Figure 1. Holocue, a holographic visual cueing application developed for Microsoft's HoloLens 1 (A), for presenting cues in a home environment (B) from a library of different types of action-relevant holographic cues such as 2D stepping targets (C), 2D zebra stripes (D), 3D beams (E) and 3D hurdles (F). ACKNOWLEDGEMENTS AND FUNDING: This research was funded by The Michael J. Fox Foundation for Parkinson's Research, Grant ID 16595.

P1-L-78: *Vibrating socks as a novel cueing device for patients with Parkinson´s disease.*

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BACKGROUND AND AIM: Freezing of gait (FOG) is a disabling symptom in Parkinson´s disease (PD). As pharmacological approaches do not resolve FOG completely¸ complementary non-pharmacological approaches¸ such as external cueing, are needed. However¸it remains difficult to translate such cueing strategies into an efficient ambulatory device that is effective¸ but at the same time socially acceptable (i.e. "invisible" to outsiders). We developed vibrating socks a cueing device for tactile cueing. In this lab study¸ we evaluated the effectiveness of these socks. METHODS: Thirty-one people with PD and regularly occurring FOG were included. In two separate sessions (on and off dopaminergic medication) participants performed three different gait tasks: 1) a trajectory including turning and narrow passages 2) 360° turns and 3) walking 10 meters. The gait tasks were carried out under four cueing conditions in a balanced order; 1) no cueing 2) open loop tactile cueing 3) closed loop tactile cueing and 4) auditory cueing. Open loop tactile cueing provided a vibration stimulus alternating between both feet at a set frequency. The frequency was optimized for the individual patient and identical for tactile and auditory cueing. The closed loop tactile cueing provided a vibration stimulus at the standing leg. All gait tasks were videotaped and analysed offline by experienced raters. Participants were identified as responder when the percent time spent frozen was reduced with at least 10% by a cueing modality compared to no cueing. RESULTS: At the group level, no effect for both tactile and auditory cueing was found ($p = 0.124$ for the Off-state and $p = 0.202$ for the On-state by a Friedman test) on the primary outcome measure percent time frozen during various gait tasks. The amount of freezing episodes was also not effected by any form of cueing ($p = 0.872$ for the Off-state and $p = 0.777$ for the On-state). We identified 14 unique responders to one or multiple forms of cueing in the Off-state and 16 in the On-state. The greatest response was to both auditory and open loop tactile cueing. In the Off-state we found 7 responders to open loop tactile cueing and 11 to auditory cueing¸ of whom 5 overlapped. In the On-state we found 12 responders to open loop tactile cueing and 13 to auditory cueing¸

of whom 10 overlapped. The largest improvement in percent time spent frozen by open loop tactile cueing in the Off-state was 36%¸ 19% in the On-state. The largest improvement by auditory cueing yields 34% in the Off-state, 46% in the On-state. The figure depicts the individual improvement of percent time FOG of these responders. CONCLUSIONS: Both tactile and auditory cueing did not significant alleviate FOG on group level. However¸ we were able to identity responders for both auditory and tactile cueing¸ which could be further explored in order to create a personalized rehabilitation programme. Tactile cueing has a great benefit as it´s invisible to outsiders. ACKNOWLEDGEMENTS AND FUNDING: This project was funded by a research grant of the Michael J. Fox Foundation (Grant-ID MJFF-008397).

P1-L-79: ***Assessing the effect of relevant and irrelevant visual information during visual feedback tasks in quiet standing***

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BACKGROUND AND AIM: Several studies have found that real time visual feedback (vFB) of the center of pressure (COP) displacement can be used to improve postural control. As vFBs can be used in many situations like in rehabilitation, a better understanding of how it can affect postural control might help strengthen its use in today's world. To investigate how visual reliance can be tuned during quiet standing tasks using vFB, the objective of this study was to assess the effect of erroneous vFB and accurate vFB on postural sway. Based on a similar study specific to trunk sway during sitting (Goodworth et al., 2020), we hypothesized that an accurate vFB should decrease postural sway during quiet standing while an erroneous vFB should increase postural sway due to the presence of sensory noises that can't be tuned off. METHODS: Nine healthy young adults (26.11 ± 2.71 years old) took part in this pilot study. Participants stood on a force platform (100 Hz) during 60s trials where they had to stay as still as possible. For the first four trials (baseline), participants had to look at a static target in front of them. Thereafter, accurate and erroneous vFB conditions were performed randomly four times each. In the accurate condition, a real-time display of their COP was available. In the erroneous condition, a meaningless COP displacement, which was the COP displacement of one of the control conditions, was displayed. Participants were only told that what they see on the screen could or could not be useful for the task. Postural sway was assessed using linear (sample entropy) and nonlinear (area of the 90% confidence interval, standard deviation and path length) measures of the COP. One-way repeated measures ANOVA were performed for each variable. RESULTS: Accurate vFB reduced sway area, COP variability in the medial lateral direction (ML) and increased sample entropy value in ML. Both vFB conditions also increased path length in ML, although there were no other significant changes for the erroneous vFB condition compared to baseline. After questioning participants at the end of the experiment, only two mentioned being aware of the two types of vFB. Despite that, significant differences were observed between the conditions which suggest different effects of the two types of vFB. CONCLUSIONS: The results suggest that even without understanding what was displayed in front of them, participants seemed to exhibit a better postural control only during the accurate vFB. The central nervous system

might thus be able to use unaware relevant visual information to improve postural control. Yet, the increase in sway path during the erroneous vFB may suggest the presence of sensory noise or a difficulty to tune off the unaware irrelevant visual information during that condition. A question arises however as for what role instructions to the participants play in this experiment. ACKNOWLEDGEMENTS AND FUNDING: Primary author has the NSERC Postgraduate Scholarship.

P1-L-80: ***The relationship between foot posture and plantar intrinsic foot muscle activity during gait***

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BACKGROUND AND AIM: Recent literature has begun exploring how the function of plantar intrinsic foot muscles (PIFMs) change across different foot postures [1]. Previous neurophysiology research has linked cutaneous mechanoreceptors in plantar foot sole skin to motorneuron pools in the lower extremities [2]. The foot orthotic industry has yet to capitalize on the plausibility of using different foot orthoses designs to facilitate cutaneous mechanoreceptor activation as a method of modulating PIFMs activation. Thus, the purpose of this study was to explore: 1) how foot posture modifies PIFMs electromyography (EMG) when walking in a non-textured and textured foot orthoses, and 2) the relationship between foot posture and PIFMs EMG. METHODS: Forty healthy young adults (age: 27 ± 5.2 years, height: 175.5 ± 10.4cm, weight: 80.2 ± 18.7 kg) completed twenty-five level walking trials in two different foot orthoses (10 x non-textured (FO), 10 x textured (FOT) foot orthoses, 5 x barefoot trials). Participant's foot posture was classified with the Foot Posture Index (FPI) [3] which differentiated postural variance along a spectrum of highly pronated to highly supinated feet. Fine-wire EMG (2000Hz, Noraxon, USA) recorded muscle activation in 4 PIFMs (abductor hallucis, transverse head of adductor hallucis, flexor digitorum brevis and abductor digiti minimi). The stance to terminal swing phases of gait were extrapolated from force places (AMTI, USA) embedded flush with the walking surface. RESULTS: When walking barefoot, there was a significantly low positive relationship between FPI score and adductor hallucis EMG, $r=0.34$, $p<.0001$ (Figure 1a). Pronated feet generated higher magnitudes of adductor hallucis EMG compared to supinated feet when barefoot. In FOTs, there was a significantly low positive relationship between FPI score and abductor hallucis EMG, $r=0.29$, $p<.0001$ (Figure 1b). When walking in textured foot orthoses, pronated feet generated higher magnitudes of abductor hallucis EMG compared to supinated feet. CONCLUSIONS: The results of this study suggest that the AddH, a muscle spanning the distal transverse arch of the foot, has greater functional demands when the medial longitudinal arch of the foot is lower to the walking surface. Furthermore, the addition of tactile stimulation in foot orthoses design, generates greater AbdH aEMG in pronated feet compared to normal and supinated foot postures. In the interest of exploring this connection between cutaneous sensory feedback and foot orthoses design, future experimental protocols should be designed to add tactile feedback under the foot sole, specifically when heightened sensory information may be required, and subsequently measuring PIFM modulation across differing foot postures. ACKNOWLEDGEMENTS AND FUNDING: Sole, Pedorthic Research Foundation of Canada, Natural Science and Engineering Research Council (NSERC), and Canadian Foundation for Innovation (CFI). REFERENCES: [1] Angin S et al. (2018). Gait and Posture, 61: 238-242. [2] Fallon JB et al. (2005). J. Neurophysiol, 94: 3795-3804. [3] Redmond AC et al. (2006). Arch Phys Med Rehaib, 88: 88-93.

O - Exercise and physical activity

P1-O-81: ***Interventions for Improving Balance in People with Multiple Sclerosis: A systematic review***

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Background and aim: Selection of appropriate exercise type and training parameters can significantly improve balance (BAL) in individuals with multiple sclerosis (MS) and, in turn, the ability to perform their activities of daily living and reduce the risk of falling. The aim of this systematic review (SR) was to evaluate the parameters (mode, dose, volume and duration) of different exercise programs. Materials and Methods: Electronic databases were searched (PubMed, Cinhal, Cochrane, and Embase) from August 2009-2019 to identify randomized controlled trials (RCTs) using keywords: "Multiple Sclerosis", "Rehabilitation", "Exercise therapy", "Balance training", "Balance", and "Postural Control". Studies were reviewed using participants, interventions, comparisons, and outcomes (PICO) criteria: P=MS, I=Rehabilitation Interventions, C=RCTs, O=measures of BAL. Study inclusion criteria: RCTs, MS, published in English, and BAL as a primary outcome measure. Two reviewers independently extracted data using the Cochrane Risk of Bias tool. Rehabilitation interventions/training programs were categorized into one of the following exercise modes: Strength and Endurance (SE), Gait, Balance, and Functional training (GBF), Aerobic training (AT), Virtual reality and game console training (VR). Treatment volume (minutes per week) and duration (number of weeks) were used to calculate the treatment dose (minutes per program). The suggested ideal exercise dose is 50 hours for a 26 week intervention program. This SR included studies that were 12 weeks or less; therefore, an adjusted ideal dose of 25 hours for 12 weeks was used as a threshold. Pearson's correlation coefficient was used to investigate the relationship between effect size, dose, volume, and duration of the studies using the 25 hour threshold. An independent T-test was used to compare effect size of the studies that were above and below the threshold. Results: The initial search yielded 1114 publications: 25 were included in this SR. The most frequently reported exercise mode was SE (38.89%), followed by GBF (33.3%), VR (16.67%), and AT (11.1%). The mean volume across studies was 134.06 ± 73.32; SE 123.46 ± 57.2, GBF 145.67 ± 71.2, AT 166.67 ± 96.09, VR 117.5 ± 105.82. The mean program duration across studies was 8.03 ± 2.71; SE 9.54 ± 2.47 , GBF 7.67 ± 2.02 , AT 4.67 ± 3.06 , VR 7.17 ± 2.71. The mean program dose across studies was 1063.65 ± 734.61; SE 1213.85 ± 790.92, GBF 1138.67 ± 681.34, AT 593.33 ± 50.33, VR 823.33 ± 874.02. Analysis of the relationship between effect size, dose, duration and volume showed no significant correlation. There was a small, nonsignificant difference (P=0.07) in effect size between studies above and below the 25-hour threshold.

Conclusions: Results of this SR support use of GBF and SE training to improve BAL in individuals with MS. The limited number of studies and heterogeneity in exercise parameters used limit conclusions and highlight the need for further research.

P1-O-82: ***Gaming-based tele-exercise program to improve physical function and balance control in older adults: A preliminary study***

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BACKGROUND: Aging is characterized by a decline in physical, cognitive, and cardiovascular function resulting in progression to frailty. Recent exercise-based interventions studies have shown promising results for improving physical function in pre frail/frail older adults. However, the compliance to physical activity interventions remains significantly lower in frailer older adults. Further, it is important to enhance physical function to slow the progression of frailty; other important domains of frailty such as balance, cardiovascular, and compliance to intervention remain under targeted. Thus, it is imperative to evaluate a feasible, compliant, and scalable intervention that can be provided to older adults at an earlier stage (prefrail) to reduce the harmful effects of a sedentary lifestyle and progression frailty. Purpose: The purpose of this study was to determine the compliance, feasibility, and effect of a custom-designed gaming-based tele-exercise program delivered in home-setting for improving physical function, balance and cardiovascular endurance. METHODS: Community-dwelling older adults (n=20, >65 years) participated in the study and received a tele-exercise program where in they performed an exergaming protocol consisting of four modules of 15 minutes each with 3-5 minutes of rest break between modules: Dancing, aerobics, cognitive-motor gaming and mind-body exercises (yoga and tai-chi) in groups of 5. The health coach launched the video-conferencing meeting and protocol for each session and provided tele-supervision and guidance for participants to follow the cognitive-motor stepping games or exercises demonstrated by a virtual avatar. They performed a total of 20 sessions for one hour thirty minutes for 4 weeks (3 sessions/week). Change in lower limb strength, endurance (30-second chair stand test), static balance (one-legged stand test, Romberg test), and dynamic balance (4-step square test), aerobic endurance (2-minute step in place test), motivation (Intrinsic Motivation Inventory (IMI)) and balance confidence (Activities balance confidence scale) were assessed. Participants were provided with wearable sensors and education to self monitor heart-rate during exercise and report back to health coach after each module. RESULTS: All participants were able to tolerate the program and compliance was >90%. Post-training, there were significant improvements in 30-second chair stand test; ($p<0.01$) one-legged stand test, ($p<0.05$), Romberg test, ($p<0.05$), and 4-step square test, ($p<0.05$). Participants significantly increase in the number of steps in the 2-minute step-in-place test ($p < 0.05$) with improved scores on IMI and ABC as well ($p<0.05$). CONCLUSIONS: These findings suggest that gaming-based tele-exercise programs could be safely implemented in community-based settings to improve compliance to participation in physical activity while enhancing physical function and reducing fall-risk in community-dwelling older adults. FUNDING: Dept. of Physical Therapy and Midwest Roybal pilot grant

P1-O-83: ***Differences In Resting-State Functional Connectivity Between Sedentary Older Adults and Master Athletes***

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BACKGROUND AND AIM: Aging is characterized by a decline in physical and cognitive functions, which often results in a decreased quality of life. Physical activity has been proposed as a mean to slow down and even counteract the aging process, thus allowing to maintain that quality of life, as well as preserve cognitive and physical functions. This theory has been strengthened by the study of Master's Athletes (MA). MAs are generally people in their seventies or eighties who outperform the competition level of their age group, making them a model of healthy and physically active older adults (OA). MAs usually have better cognitive functions than sedentary OA, a phenomenon that could potentially be explained mechanistically by exploring direct differences in aging-related changes in the brain. The purpose of this study was to use a functional Magnetic Resonance Imaging (fMRI) technique, resting-state Functional Connectivity (rs-FC), to identify if the improved cognitive functions in MAs were linked to changes in functional connectivity in the brain at rest. METHODS: Fifteen MAs and twelve age-matched OA participants of at least 75 years old (mean MA: 80 [SD = 5] years, OA: 81 [SD = 5] years) underwent a resting state fMRI scan. A seed-based analysis was used to identify regions across the entire brain whose activation was correlated with activation of the seed (anterior cingulate cortex, supplementary motor area (SMA), pre-SMA, premotor cortex, primary motor cortex, and primary sensory cortex). A significant correlation between a seed region and a cluster of voxels indicates that those areas are functionally connected. Group differences were determined using a mixed effect model using a cluster threshold and significance threshold of $Z>2.3$ and $p<0.05$, respectively. RESULTS: The analysis revealed higher connectivity between regions of the cognitive and motor networks for the OA group, whereas the MA group had stronger connectivity between different regions of the same network, in both the cognitive and motor networks. The differences between the groups also appeared as individual differences, as the connectivity of the regions was directly correlated to aerobic physical fitness, quantified using VO2 max levels. In other words, our results seem to support a near linear relationship between aerobic physical fitness and preservation of brain connectivity. CONCLUSION: These results are in line with the literature, which suggests that aging reduces the segregation between functional networks, suggesting a stronger cognitive involvement during performance of motor tasks in sedentary OA. Aging also causes regions within the same network to be less strongly connected, as seen in the sedentary OA group when compared to the MA group. MAs thus seem to maintain a better brain health than OA, most likely because of their physically active lifestyle.

P1-O-84: ***Effect of aging on turning strategy while walking***

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BACKGROUND AND AIM: About one third of our daily movements are associated with turning [1]. Established geriatric fall risk assessments generally limit their focus to straight-line walking, while turning tasks are more challenging and dynamic movements, and therefore lead to more serious injuries when falling [2]. Unfortunately, there is conflicting evidence if older adults differ in their turning strategy from younger adults [3,4], while biomechanical analysis of dynamic balance has hardly been performed in this group [5]. Therefore, this study describes the stepping strategy in older (OA) vs middle-aged (MA) and younger (YA) adults. METHODS: Eight older (70-92 years), ten middle-aged (40-65 years) and eleven young (18-35 years) adults walked with 45° and 90° turns towards their non-dominant side in random order, with 3 repetitions each (see Fig 1A). Full-body motion capture data and videos were recorded, as well as the Short Physical Performance Battery (SPPB) and Timed Up and Go (TUG). For the initial analysis in this abstract, turning strategy (step vs spin turn) and number of steps to complete the turn were derived from the videos (Fig 1B, C). We compared these outcomes between OA, MA and YA using a strategy-sum-score (lower score means tend to step turns) of turning preference for an analysis of variances (ANOVA), with Bonferroni correction for post-hoc tests. RESULTS The OA showed signs of reduced functional mobility in terms of TUG (OA 11.0±1.6s vs MA 9.1±2.2s; YA 8.4±0.8s) and SPPB score (9.6±2.6 vs MA: 11.9±0.3; YA: 12±0). To perform a 45° turn, OA tend to rely on step turns over spin turns with an average strategy-sum-score of 1.2 while MA and YA have a higher score of 1.5, 1.9, respectively ($F=0.75$, $p=.48$). (Fig 1D). To perform a 90° turn, OA used step turns less often compared to 45° turning (score: 90: 1.6 vs 45: 1.25), but more often than MA and YA 1.8 vs. 2.2, respectively. OA conducted 11% more steps in a 45° turn compared to MA and 14% more compared to YA ($F=2.9$; $p=0.07$). During 90° turns, OA conducted 5% more steps than in 45° turns, but 9% more steps compared to MA and 20% compared to YA respectively. CONCLUSION These initial results indicate that older adults are more cautious during turning, as they tend to step into and take more strides during a turn while younger participants spin over their standing foot. Interestingly, OA relied a bit more on spin turns to make a larger turn, which poses the question which factors other than remaining balanced are affecting the turning strategy. Step turns presumably result in a more balanced strategy through a greater base of support and less rotational velocity (Taylor et al., 2005), which we are currently validating. This work will also explore dynamic balance, angular velocity, and lower/upper body orientation as potential biomarkers for future falls our extended dataset of 15 Y, 15 MA and 15 OA, to provide the basis for inclusion of turning balance in geriatric fall assessments.

P1-O-85: ***Cardiorespiratory fitness effects on cerebral oxygenation during cognitive and exercise tasks: A systematic review of functional near-infrared spectroscopy studies***

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BACKGROUND AND AIM: Previous studies have proposed the cardiorespiratory hypothesis to explain the effects of exercise on cognition such that higher fit individuals demonstrate improved cerebral oxygenation and performance during cognitive and exercise tasks compared to lower fit individuals. The aim of this review was to consolidate findings from functional near-infrared spectroscopy (fNIRS) studies examining the interaction between cardiorespiratory fitness, as determined by direct and estimated measures of VO2max, and cerebral oxygenation during cognitive and exercise tasks. METHODS: Medline, Embase, SPORTDiscus, and Web of Science were systematically searched from database inception until July 2021. Studies using fNIRS to measure cerebral oxygenation in healthy younger, middle-aged, and older adults and those using direct or estimated measures of VO2max to quantify cardiorespiratory fitness were included. Studies were excluded if they examined patient populations or people with neurological disorders. Hemodynamic response outcomes were assessed using oxyhemoglobin (HbO2) and deoxyhemoglobin (HHb). RESULTS: Fourteen studies were retained following abstract and full-text screenings. Seven studies examined the effects of cardiorespiratory fitness on cerebral oxygenation during exercise tasks and the remaining seven evaluated cerebral oxygenation during cognitive tasks. One study used a questionnaire to estimate cardiorespiratory fitness whereas the rest used cycle ergometer or treadmill tests. Studies measuring cerebral oxygenation in the prefrontal cortex during cognitive tasks demonstrated increased HbO2 in higher compared to lower fit groups. There were no significant interactions in HHb except for one study revealing greater HHb in the higher fit group only. Exercise tasks targeted young and middle-aged adults and primarily featured cycling tests, with one study measuring a static handgrip test. At submaximal intensities, prefrontal cortex HbO2 was greater in higher fit individuals compared to lower fit individuals. Greater HHb was also observed in long- versus short-term trained males but not in females. During the static handgrip task, motor cortex activation extended beyond maximal intensity in the non-athlete group. CONCLUSION: Consistent with the cardiorespiratory hypothesis, increased cerebral oxygenation was observed in young, middle-aged, and older adults with higher compared to lower cardiorespiratory fitness. Factors such as exercise intensity, age, and sex can contribute to cerebral oxygenation variability. In addition, fNIRS processing methods should be reported in greater detail to increase reproducibility. Randomized controlled trials are needed to support these effects and future research should incorporate fNIRS to assess the effects of training interventions to improve fitness and cerebral oxygenation longitudinally. ACKNOWLEDGEMENTS AND FUNDING: Open access publication of this systematic review will be supported by the University of Ottawa Scholarly Communication funds.

P - Falls and fall prevention

P1-P-86: ***Control of Balance in Individuals with Parkinson's Disease***

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Background: Falls are the leading cause of injury for older adults resulting in expensive medical costs and increased mortality rates, and the majority of falls occur during walking. Therefore, control of upright stability during walking is crucial, especially for high fall-risk populations such as the elderly or those with movement disorders, e.g. Parkinson's disease (PD). Young healthy individuals use multiple mechanisms to maintain upright stability during walking: (1) the lateral ankle roll, altering the ankle inversion/eversion angle during single stance; (2) foot placement, the location of the foot after swing phase; and (3) push off modulation, a modulation of the trailing leg ankle plantarflexion angle during double stance. Recruitment of these mechanisms depends upon accurate estimation of body dynamics from the visual, vestibular and proprioceptive systems. Older adults and individuals with PD are known to have deficits in sensory processing. Older adults rely more on visual information to control upright balance and individuals with PD have proprioceptive deficits. These sensory deficits may contribute to fall-risk by altering how balance mechanisms are used during walking. Therefore, this exploratory study aims to understand how older adults and individuals with PD use the balance mechanisms to regain stability after a visual disturbance. Methods: Twelve adults diagnosed with Parkinson's disease and four age matched controls walked on an instrumented treadmill for ten two-minute trials in a 3D virtual reality environment. At randomized heel strikes, the visual field was rotated with constant acceleration for 600 ms, resulting in a perceived fall to the side. We measured kinematics and muscle activation to determine changes in the ankle roll, foot placement and push-off mechanisms for balance control. Results: Following a visual perturbation, both groups responded to the perceived fall by shifting their center of mass (CoM) in the opposite direction of the fall. The PD group had a larger CoM displacement than the control group. The PD group also showed a diminished ankle roll response in the first post-stimulus step, relative to the control group. Both groups showed a foot placement response. Conclusions: Based on our preliminary analysis, the PD group showed greater CoM displacement following a visually perceived fall. The PD group also showed greater use of proximal balance mechanisms (step placement) rather than distal mechanisms (ankle roll) compared to the older adult group. Previous work has shown that the lack of ankle roll in response to a balance disturbance necessitates a larger step response, suggesting that reliance on a single balance mechanism may place individuals with PD at higher fall risk.

P1-P-87: ***Identifying priorities for balance interventions through a participatory co-design approach with end-users***

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BACKGROUND AND AIM: Falling is a health care crisis, especially for individuals with impaired balance control due to neurological conditions. As a result, developing effective interventions for balance is a research priority. The purpose of this study was to identify and understand the priorities for balance interventions from the perspectives of end-users, including individuals with spinal cord injury (SCI) or stroke, physical therapists (PTs), and hospital administrators, to assist with the design of a standing balance intervention that combines functional electrical stimulation (FES) with visual feedback training. METHODS: Two individuals with SCI, one individual with stroke, two PTs and one hospital administrator were recruited by convenience sampling from three hospitals in Ontario, Canada. Participants attended three focus group meetings, each lasting 50-53 minutes. A researcher followed a semi-structured interview guide to lead the meetings, which queried participants' experiences with balance deficits and interventions, and FES. Meetings were audio-recorded and transcribed verbatim. An iterative and reflexive inductive thematic analysis was applied to the transcripts by three researchers. RESULTS: Four themes were identified: 1) The complexity and importance of balance for daily life and rehabilitation. As described by a participant, "without balance you cannot do anything." Participants acknowledged the variety of factors influencing balance control. Participants described how balance deficits interfered with participation in some therapeutic activities and stressed the importance of continuing to work on one's balance after discharge from hospital-based rehabilitation. 2) Considerations for balance interventions. Participants explained that balance interventions should be tailored to a patient's unique needs and goals, relevant to their life, and be fun and engaging. They also discussed the need to balance safety and risk in balance interventions. 3) Prior experiences with FES to inform future therapeutic use. Participants with stroke or SCI described initial apprehension with FES, but experienced numerous benefits (e.g., "awakened some muscles", greater confidence in their movements, increased quality of life) that motivated them to continue with FES therapy. The PTs and the hospital administrator highlighted the scientific evidence as motivation to use FES. Challenges with FES were mentioned, including wires, cost, and time of set up. 4) Potential role of FES in balance interventions. Participants felt that FES would complement balance interventions; however, they had not experienced this combination of therapies in their rehabilitation or clinical practice. CONCLUSIONS: End-users shared their experiences and perceptions of balance deficits, balance interventions and FES. The priorities and challenges identified will inform the design and implementation of an intervention combining FES and visual feedback training for standing balance. ACKNOWLEDGMENTS AND FUNDING: This research was funded by the Canadian Institutes of Health Research and the Natural Sciences and Engineering Research Council of Canada.

P1-P-88: ***Barriers to and facilitators of adherence to prescribed home exercise in older Singaporean adults at risk of falling***

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Background: Adherence to prescribed exercise poses significant challenges for older adults despite proven benefits of exercise. The aim of this study was to explore the perceived barriers to and facilitators of adherence to prescribed home exercise in older adults aged 65 years and above who are at risk of falling in Singapore. Methods: Three focus groups with 17 older adults (mean age 77±SD 5 years) recruited from public hospital outpatient settings in Singapore were conducted. An inductive approach of thematic analysis with six phases was

used to discover patterns and develop themes. Results: Our study revealed that 'the level of motivation' of individual older adults constantly influenced their exercise behaviour (adherence). Furthermore, the level of motivation appeared to be a fluid concept and changed due to interactions with internal/individual factors (e.g., health beliefs, preferences) and external factors (e.g., family/live-in domestic helper/healthcare professional support to exercise). Therefore, adherence to prescribed exercise call for tailored exercise programmes that consider individual and external factors to keep motivational levels high. Conclusion: Older adults are more likely to adhere to home-based exercises when clinicians address individual factors while providing external supports. Addressing perspectives of older adults is vital in enhancing their adherence to prescribed home exercise. The challenge is how to integrate the perspective of patients as well as offer strategies to address them in the clinical setting. Singapore is a developed country with a culturally unique perspective, having a multi-ethnic urban Asian population. This lens further adds to our understanding of cultural influence on exercise adherence. Future research is needed to determine the impact of factors identified on home-based exercise adherence and falls prevention.

P1-P-89: ***The cardiorespiratory challenge of reactive balance training in people with stroke: cross-sectional findings from an ongoing randomized controlled trial.***

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Background: Reactive balance training improves balance and fall risk in people with stroke. Reactive balance training involves whole body movements that may also challenge the cardiorespiratory system. Aim: To determine if cardiorespiratory demands of reactive balance training are similar to those of aerobic and strength training among people with stroke. Methods: Six participants (aged 60.2±12.3 years (mean±standard deviation), 1 female) with stroke were recruited as part of an ongoing randomized controlled trial. All participants completed a maximal graded exercise test before training. Participants were randomly allocated to receive 36 sessions (60 minutes per session, 3 times per week, 12 weeks) of reactive balance training, which consisted of at least 60 perturbations, or aerobic and strength training, at an intensity of heart rate (HR) that occurred at the anaerobic threshold during the graded exercise test. HR was recorded during all sessions. Oxygen consumption (VO2) and carbon dioxide production (VCO2) were measured breath-by-breath using a portable spiroergometer for a single session at week 5. Average HR, expressed as a percentage of age-predicted maximum (%ApHR) and time spent in aerobic HR zones (60-80% HR reserve) during training sessions were compared using non-parametric tests. Results: To date, two participants attended 20 reactive balance training sessions and four participants attended 72 aerobic and strength training sessions. Four participants were prescribed beta blockers (n=4) and thus the intervention was conducted at the same time of day as the baseline cardiopulmonary assessment. Average HR was significantly higher during reactive balance training (51.4 ±5.4%ApHR) compared to aerobic and strength training sessions (47.1±6.9%ApHR; X2=6.63; p=0.010). However, there was no statistically

significant difference between reactive balance training (8.9±8.2 minutes) and aerobic and strength training (5.1±6.6 minutes) in time spent in aerobic HR zones (X2=2.66; p=0.10) during training sessions. On average, during a single reactive balance training session, the participant consumed 66.4% of VO2peak achieving 0.9 respiratory exchange ratio and during an aerobic and strength training session, the participants (n=2) consumed 83.1% of their VO2peak achieving 1.0 respiratory exchange ratio. Conclusion: Participants with stroke who attended reactive balance training had significantly higher average HR and similar time in target HR zones as participants who attended aerobic and strength training. However, the participant who completed reactive balance training consumed lower amounts of oxygen compared to aerobic and strength training sessions. Therefore, the increase in HR during reactive balance training may be related to anxiety rather than increased cardiorespiratory challenge of exercise; expired gas analysis of more participants and sessions will be needed to confirm these preliminary results.

P1-P-90: ***Dual task strategies relate to falls history in multiple sclerosis***

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Background and Aim: Multiple sclerosis (MS) may lead to motor and cognitive changes that result in increased falls, particularly when performing two tasks at the same time (i.e., dual tasking). Although dual tasking typically results in decrements in cognitive and/or motor performance, some persons with MS (pwMS) may also show improvements in either or both tasks. These dual task strategies may differently affect falls. The aims of this study were (1) to characterize dual task strategies; and (2) calculate associations between dual task strategies and falls history in MS. Methods: 105 pwMS (age: 47.84 ± 9.94; 74 (70.5%) women; Expanded Disability Status Scale 3.7 ± 1.3) were recruited. The motor single task was a 1-minute overground walk at a self-selected speed. The cognitive single task used word list generating with a selected letter. Both tasks performed simultaneously constituted the featured dual task. Dual task cost (DTC) was calculated for both motor and cognitive components. Based on the DTCs, dual task strategies were grouped into: 1) both motor and cognitive tasks deteriorated with DT (M-C-), 2) motor task worsened, cognitive task improved with DT (M-C+), 3) motor task improved, cognitive task worsened with DT (M+C-), and 4) both motor and cognitive task performance improved with DT (M+C+). The average number of falls in the six months prior to consent was the main outcome and was compared between groups using multinomial regression analysis. Clinical, demographic, gait, and cognitive variables were compared between the four groups using ANOVA, Kruskal-Wallis, or Chi-square tests, as appropriate. Results: Dual task strategies were dispersed in all four groups: M-C- = 46 (43.81%), M-C+ = 35 (33.33%), M+C- = 10 (9.52%), M+C+ = 14 (13.33%). Figure 1 shows that persons with M+C- reported most falls (5.00 ± 9.08), followed by M-C- (1.61 ± 3.85), M-C+ (1.56 ± 3.19), and M+C+ (0.86 ± 1.56). Post-hoc analyses showed that persons with M+C- reported more falls compared to those with M+C+ (p = 0.025). No differences in

demographic or clinical variables were found between the four groups. However, persons with M-C+ generated more words during DT walking compared to M-C- ($p<0.05$). Persons with M+C+ took longer steps compared to M-C+ ($p<0.05$) and M-C- ($p<0.05$). Conclusions: Dual task strategies vary widely among pwMS. About 10% of pwMS who prioritize the motor task at the expense of the cognitive task report most falls. Individuals who adopt this strategy may not have the cognitive resources to walk faster under DT conditions, thus increasing the likelihood of falls. Fall prevention and rehabilitation strategies should particularly target these individuals. Funding: NIH T32 Training Grant (Award Number T32HD057850) and Parent RCT VR4MS funded by the NMSS (RG-1507-05433)

P1-P-91: ***Falls among people with bilateral vestibulopathy: a narrative review of causes, incidence, injuries and methodology***

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BACKGROUND AND AIM: People with bilateral vestibulopathy (BVP) experience severe balance and mobility issues1,2. Fear and anxiety lead to reduced activity which can further affect balance and fall risk3. Understanding and intervening on falls in this population is essential. The aims of this narrative review are to provide an overview of current knowledge and applied methodology on fall incidence, causes and injuries in BVP. METHODS: For this review, articles were deemed eligible to include if they reported falls incidence data (using any method) among people with BVP (>18 years of age). Studies were gathered by means of manually screening reference lists from previous projects2,4,5 and a broad search was completed in PubMed and Web of Science. All available data on patient characteristics, BVP aetiology, and falls incidence, causes and injuries (data and methodology) were extracted. RESULTS: Ten articles reporting falls incidence in people with BVP were deemed eligible, including two prospective and eight retrospective studies, with a total of 317 participants of which 43% experienced a fall over the assessed period. When reported, the most common perceived causes of falls were loss of balance, darkness and uneven ground. Information on sustained injuries was limited, with bruises and scrapes being the most common, and only four fractures being reported. As most studies included falls as a secondary outcome measure, falls data obtained using best practice guidelines was lacking: only five studies reported their definition of a fall, of which two studies explicitly reported the way subjects were asked about fall status; only two studies performed a prospective daily fall assessment using monthly fall diaries (recommended practice) while the remaining studies retrospectively collected fall-related data through questionnaires or interviews; and while most studies reported the number of (non-)fallers, the number of total falls in individual studies was lacking. CONCLUSIONS: Our findings indicate that falls in people with BVP are common but remain an understudied consequence of the disease. Larger prospective studies, following best practice guidelines for fall data collection, with the aim of obtaining and reporting falls data are required to improved current fall risk assessment and interventions in BVP. 1. Schniepp et al. (2017) J Neurol 264(2), 277-283 2. Herssens et al. (2020) Phys Ther 100(9), 1582-1594 3. Guinand et al. (2012) Ann Otol Rhinol Laryngol

121(7), 471-477 4. Herssens (2020), doi: 10.13140/RG.2.2.33546.08647 5. McCrum (2019), doi: 10.26481/dis.20191219cm

P1-P-92: ***Balance recovery stepping responses during walking were not affected by concurrent cognitive task among older adults***

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BACKGROUND AND AIM: Most of older adults' falls are related to inefficient balance recovery after an unexpected loss of balance, i.e., postural perturbation. Effective balance recovery responses are crucial to prevent falls. Selection and engagement of balance recovery responses depend on the integration of many sensorimotor processes, which tend to deteriorate with age. In addition, cognitive abilities also decline with age, especially pre-frontal functions. Studies examining interactions between cognitive and postural functions indicate that though pre-frontal cognitive resources are deteriorating, older adults tend to increase reliance on these resources for motor control tasks. Due to the considerable consequences of lateral falls and the high incidence of falls when waking, this study aimed to examine the effect of concurrent cognitive task on older adults' balance recovery stepping abilities from unannounced lateral perturbations while walking. We also aimed to explore whether cognitive performance accuracy is affected by perturbed walking as well as between task trade-offs. METHODS: Twenty healthy older adults (>70 years old) performed the following test conditions: (1) cognitive task while sitting; (2) perturbed walking; and (3) perturbed walking with a concurrent cognitive task. The cognitive task was serial subtractions by seven. Single-step and multiple-step thresholds, highest perturbation achieved, 3D kinematic analysis of the first recovery step, (i.e., the spatiotemporal characteristics), and cognitive task performance accuracy were compared between single-task (ST) and dual-task (DT) conditions. Between task trade-offs were examined by dual-task effect (DTE). RESULTS: Single-step and multiple-step thresholds, number of recovery step trials, and kinematic recovery step parameters were all similar in ST and DT conditions. As for the highest perturbation achieved, participants achieved significantly higher perturbation magnitudes in the DT trials ($p=0.036$). Cognitive performance was not significantly affected by DT conditions. However, different possible trade-offs between cognitive and recovery step performances were identified using DTE (Fig 1). CONCLUSIONS: Balance recovery responses to unexpected balance loss during walking were unaffected by concurrent cognitive load in older adults in this study. However, when we compared perturbed walking to unperturbed walking, cognitive performance appeared to be slightly affected by the postural challenge. Thus, in situations where the postural threat is substantial, such as unexpected balance loss during walking, it is likely that the posture first strategy was the mechanism that occurred while concurrently performing continuous cognitive task.

P1-P-93: ***Impact of Medication and Setting on Gait and Turning Digital Markers Related to Falls in People with Parkinson's Disease***

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Background and Aim: Although much is known about the multifactorial nature of falls in Parkinson's disease (PD), it remains unclear which gait and turning measures best separate fallers from non-fallers. In addition, it is unknown whether medication status and laboratory versus home settings play a role in selecting the most discriminative objective measures of fall risk. In this study, we investigated which gait and turning digital measures best discriminated fallers from non-fallers with PD in 2 levodopa states (On or Off) and 2 settings (laboratory or daily-life). Methods: We recruited 34 subjects who were diagnosed with PD (17 fallers and 17 non-fallers). Participants were classified as fallers (at least one fall) or non-fallers based on self-reported history of falls in the six months prior to the study visit. Subjects wore three inertial sensors (Opals, APDM Wearable Technologies) attached to both feet and the lumbar region. In the laboratory, subjects performed a 3-minute walking task at their natural pace, in both the Off and On levodopa states. Subjects wore the same sensors during daily life activities for a week at an average of 8 hours per day. We derived 26 clinical measures, and 40 gait and 10 turn metrics averaged over the 3-minute walk and across all strides from a week of passive monitoring. Wilcoxon test was used to investigate faller from non-fallers group differences. Spearman correlation was used to investigate the association between the top clinical and objective measures discriminating fallers from non-fallers. Results: All clinical measures were similar in fallers and non-fallers except the patient-reported outcomes, UPDRS Part II total score ($p=0.008$), and Life Space total score ($p=0.015$), that were worse in the fallers. Digital measures, from the 3-minute walk test, that best separated the groups were average turn velocity ($p=0.014$), average number of steps to complete a turn ($p=0.026$), and variability of gait speed ($p=0.028$) collected in the Off levodopa state. None of the objective measures of gait and turning were significantly different between fallers and non-fallers while walking in the On levodopa state. Two measures of variability, specifically, variability of transverse range of trunk motion ($p=0.023$) and variability of turn rate ($p=0.044$), were statistically significant between fallers and non-fallers during daily life, with fallers showing more variability. Both patients reported outcomes, UPDRS Part II total score ($r=0.38$; $p=0.02$) and Life Space total score ($r=-0.35$; $p=0.04$) were significantly correlated with the average number of steps to complete a turn. Conclusions: Objective measures of turning, specifically slower turning during a 3-minute walk when Off levodopa and increasing variability of turn rate during daily life, were most sensitive to discriminate PD fallers from non-fallers, and the number of steps to turn 180 degrees was related to the patient-reported quality of life.

P1-P-94: ***Measurement of 3D gaze during falls in humans***

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BACKGROUND AND AIM: Falls tend to elicit protective responses for safe landing, which are tailored to features of the environment (Schonnop et al 2013). Vision is essential to movement planning in complex environments (Marigold and Patla 2007), and visual impairment is a risk factor for fall-related injuries (de Boer et al 2004). However, the role of vision in the generation of protective responses during falls is unknown. Here, we developed, evaluated and applied an approach for using eye tracking to measure 3D gaze during falls. We conducted laboratory-based falls to measure the accuracy of the technique for identifying gaze intersections with specific areas of interest (AOI) in the environment (Aim 1). We then applied our approach to compare gaze behaviour during falls in simple versus complex environments (Aim 2). METHODS: Participants experienced perturbation-induced falls onto a padded platform. For each fall, we measured 2D gaze positions from eye tracking (Pupil Labs) and body segment positions with 3D motion capture (Qualisys). We synchronized these data (Matthis et al 2018), and identified intersections of the 3D gaze vector with AOI using a Ray-Box Intersection rendering technique (Mena-Chalco 2019). In Aim 1, three participants fixated on reflective markers (of 1 cm diameter) positioned in the centre or edge of a foam chair AOI in front. Two falls were acquired in each condition. Data analysis focused on percent of time the gaze vector intersected the chair. In Aim 2, two different participants experienced a single unexpected sideways fall on an empty platform (simple environment) or with padded chairs in front and to their side (complex environment). We compared gaze behaviour in the two environments and determined how closely gaze approached the location where the hand(s) impacted the chair or ground. RESULTS: Aim 1: For falls where participants focused on the centre chair marker, the gaze vector intersected the chair 99% of the time before, 74% during and 84% after the fall. For the edge marker, these percentages declined to 0%, 40%, and 0%. Addition of a virtual cylinder surrounding the gaze vector (to account for spatial error) increased detected intersections with the edge of the chair to 17%, 65% and 45% for a 50mm cylinder and 55%, 86% and 66% for a 100mm cylinder. Intersections with the centre marker increased to 84%. Aim 2: In the complex environment fall, gaze shifted towards the chair, and approached within 24cm of the right hand and 10cm of the left hand impact locations, 100ms and 60ms before contact, respectively. In contrast, falling in the simple environment did not elicit gaze shifts towards the hand contact location. Instead, gaze shifted to the edge of the perturbation platform. CONCLUSIONS: Our results demonstrate the feasibility of using eye tracking and motion capture to record gaze during laboratory falls. We also show how our approach allows comparison of gaze behaviour between simple and complex environments. ACKNOWLEDGEMENTS AND FUNDING: This work was supported by an operating grant from the AGE-WELL National Centre for Excellence (AWCRP-2020-04). NS was supported by a Simon Fraser University Graduate Dean's Entrance Scholarship.

Q - Habilitation & rehabilitation

P1-Q-95: ***Clinical Validation of Inertial Measurement Units to Track Recovery: A Case Study Following Partial Knee Meniscectomy***

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BACKGROUND AND AIM: Physiotherapists typically see patients once a week in clinic to provide assessment, treatment and exercise prescription, with the bulk of recovery taking place outside these visits. While validated clinical tools, such as goniometers, force plates, and motion capture, can provide quantitative recovery metrics they are limited to clinics. Mobile inertial measurement units (IMUs) that can reconstruct 3D human motion have been proposed to monitor exercise performance. This case study provides clinical validation of IMU's to monitor rehabilitation following arthroscopic partial meniscectomy (APM) surgery remotely. METHODS: The case study tracks the recovery of a female varsity volleyball player following APM surgery while performing rehabilitation exercises, from day 1 post-surgery to return to play (day 15 post-surgery). Kinematic data was acquired from Vicon motion capture using a modified Helen-Hayes marker layout. Seven (7) wireless IMU sensors were placed on each lower limb segment. IMU and motion capture joint angles were calculated using Kalman filter sensor fusion with a 35 degree of freedom full body kinematic model as described in [1]. Kinematic data were segmented by repetitions on each day and for each exercise using characteristic motion qualities. Spatiotemporal recovery metrics, selected based on literature, clinical professional input, and incidental findings, were extracted for each repetition/exercise. RESULTS: Knee range of motion during lying heel slide exercise is an important indicator of recovery. Motion capture- and IMU-based mean peak knee flexion angle for day 2, 3, and 6 during heel slide is shown in Fig. 1. Criterion-standard motion capture knee flexion increased from 91.61º ± 4.17º to 127.42º ± 2.35º from day 2 to 6. In comparison, IMU data reported knee flexion increasing from 76.03º ± 0.94º to 111.63º ± 2.82º over the same period. Although magnitude error was 17% and 12% for both days, respectively, both motion capture and IMU detected increases of 35º. Conclusions: Preliminary results indicate IMU data shows the same recovery trend for the lying heel slide exercise, supporting the use of IMUs to inform clinicians of recovery progress remotely. The remaining exercises in the first phase of recovery (e.g., leg raise, walking) will be analyzed to further examine the validity of IMU data to track recovery with sufficient accuracy compared to motion capture over the range of exercises performed. REFERENCES: [1] V. Joukov, J. F. S. Lin, K. Westermann, and D. Kulić, "Real-Time Unlabeled Marker Pose Estimation via Constrained Extended Kalman Filter," Springer Proc. Adv. Robot., vol. 11, pp. 762-771, Nov. 2018, doi: 10.1007/978-3-030-33950-0_65.

P1-Q-96: ***Course of gait recovery in early subacute stroke survivors over first 6 months***

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Backround and aim: Regaining gait independence is one of the most common goals of stroke survivors. Timing of rehabilitation and training intensity are currently important issues for maximizing potential of gait recovery poststroke. The aim of this study was to compare the course of gait recovery during first six months in first-ever ischemic stroke (IS) patient. Methods: Consecutive middle cerebral artery IS patients, who were enrolled in the prospective GAITFAIST trial (NCT04824482), were recruited at the Comprehensive Stroke Center and then transferred into the Rehabilitation department of our hospital. Patients were examined during four visits - at the beginning (V1; (<10 days after stroke onset) and et the end (V2) of two weeks intensive inpatient rehabilitation including gait training, then three months (V3) and six months (V4) after stroke onset. In all patients, clinical assessments as the Functional Ambulation Category (FAC), the 10 meters-walking test (10MWT), the Fugl-Meyer Assessments for the lower limbs (FMA-LL), the Timed Up and Go test (TUG) and the spatiotemporal gait characteristic as gait speed, stride length, cadence and stance phase duration for paretic and non-paretic limb using treadmill with inbuild sensors (Zebris) were performed. Results: Five (age 72 ±7 yrs) of all currently enrolled patients completed all study visits. The greatest change in most of assessments was observed between V1 and V2 (averaged improvement of more than 20 % was found for FAC, 10MWT, TUG, FMA-LL for motor and sensory domain, gait speed on treadmill, stride length and double stance support). Instead of other parameters the FAC, the 10 MWT and the treadmill gait speed improved in average of more than 10 % even when comparing V2 and V3, or V3 and V4. All patients become fully independent walkers after 6 months (FAC=5). Conclusions: The greatest gait improvement occurred within the first weeks after stroke onset after the intensive rehabilitation including gait training. However, the gait improvement was observed up to 6 months after stroke in some of the gait parameters. Further larger analysis including more patients is needed. Acknowledgement: The study supported by Ministry of Health, Czech Republic (FNOl, 0098892).

P1-Q-97: ***Impact of stroboscopic disruption of vision on gait in Parkinson's***

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BACKGROUND AND AIM: People with Parkinson's disease (PD) often have impaired proprioception and deficits in automaticity of movement which leads to over-reliance on their visuo-cognitive (combined visual and cognitive) system for safe and effective walking. Gait impairment is therefore intrinsically related to visuo-cognitive dysfunction, which supports the importance of multimodal (visual, cognitive, motor) interventions when addressing walking difficulties in PD. Stroboscopic disruption of vision (delivered via "strobe glasses" that have lenses that flicker between clear and opaque) may be a useful rehabilitation tool, as it could reduce reliance on visuo-cognitive input and processing during walking. However, while stroboscopic glasses have been used in healthy young and other neurological populations, they have yet to be used in PD. This pilot study aimed to investigate the immediate effects of stroboscopic glasses on gait characteristics in PD. METHODS: Eight people with PD (Age 61.1±4.2 years; Hoehn & Yahr stage 1.8±0.9; Disease duration 5.3±6.3 years; UPDRS III 28.9±17.0 points; MoCA 28.6±1.7 points; ON medication) walked over-ground for two minutes with, and without, stroboscopic glasses. Mobile stroboscopic glasses (Senaptec Ltd, Oregon, USA) delivered intermittent visual occlusion during walking (~6Hz flicker) and eight synchronised inertial sensors measured gait (APDM wearables, Oregon, USA). Gait characteristics of speed, stride length, foot strike angle, double support time and gait cycle duration, as well as turn duration, steps in turn and turn velocity were measured. Differences in gait with stroboscopic glasses were analysed using Wilcoxon signed-rank tests. RESULTS: There were no significant alterations in gait or turning with stroboscopic visual occlusion in PD. Specifically, gait speed (Z=-.140, p=0.888), stride length (Z=-.423, p=.673), foot strike angle (Z=-.700, p=.484), double support time (Z=-.700, p=.484) and gait cycle duration (Z=-.594, p=.553) did not change when walking with stroboscopic disruption of vision in PD. Similarly, turn duration (Z=-1.120, p=.263), steps in turn (Z=-.280, p=.779) and turn velocity (Z=-1.680, p=0.093) did not change when walking with strobe glasses compared to without in PD. CONCLUSIONS: Our preliminary findings suggest that immediate use of strobe glasses during walking in PD does not significantly change gait or turning outcomes. While our PD cohort was mild (H&Y I-II), it is encouraging that mobility was not impaired with stroboscopic visual occlusion as this may indicate that it is safe to deploy this tool within rehabilitation protocols. Further research is needed in larger cohorts of people with PD to determine the effect of stroboscopic glasses gait over longer periods of time and safety during more challenging motor tasks, as well as the effect of reduced strobe frequencies (<6Hz; i.e., longer time with occluded vision). ACKNOWLEDGEMENTS AND FUNDING: This study is based at the Physiotherapy Innovation Laboratory and has been funded by a Northumbria University Collaborative PhD studentship supported by Senaptec Inc. Dr Stuart is supported by a Parkinson's Foundation Post-Doctoral Fellowship for Basic Scientists (PF-FBS-1989-18-21) and a Clinical Research Award (PF-CRA-2073).

P1-Q-98: ***The effect of exercise interventions on gait outcomes in individuals with a lower limb amputation: A systematic review and meta-analysis***

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BACKGROUND: Walking ability is a significant contributor to the quality of life in people with a lower limb amputation (PLLA). Yet, ongoing gait problems are common even after successful completion of prosthetic rehabilitation programs. The literature on exercise protocols to improve gait in PLLA have not been synthesized to inform clinical practice. AIM: 1) Perform a systematic review and meta-analysis of the literature evaluating the effects of exercise interventions on gait outcomes in PLLA, and 2) make recommendations on the elements that should be included in an exercise program for optimizing gait performance in PLLA. METHODS: Electronic databases MEDLINE, EMBASE, CINAHL, SPORTDiscus, Scopus and the Cochrane Library were searched (inception to November 17, 2021). Inclusion criteria: randomized controlled trials assessing gait outcomes following exercise intervention; subjects were ≥18 years of age, had a unilateral or bilateral amputation at the transtibial or transfemoral level and used a prosthesis for walking. Methodological quality was assessed via the Physiotherapy Evidence Database (PEDro) scale and the Cochrane Risk of Bias Scale (RoB2). A meta-analysis was performed on primary gait outcomes across all studies using a random effects model with inverse variance to generate summary measures of effect in the form of standardized mean difference. RESULTS: Fourteen studies were included. Reporting quality was excellent in one study, good in ten, and fair in three.

Three studies had a low risk of bias, seven studies had some concern of bias, and four studies had a high risk of bias. Four studies examined subjects in the sub-acute stage of recovery (post-amputation discharge from acute hospital to 6 months post-amputation), while ten studies examined those in the chronic stage (>6 months post-amputation). Thirteen studies consisted of a multi-component exercise intervention (combination of gait, balance, and strength training), while one consisted solely of strength training. Interventions ranged from 15 to 60-minute sessions, 1 to 7 times per week, for 2 to 16 weeks. Primary gait outcomes were gait velocity, weight-bearing, ground reaction force, the Two-Minute Walk Test, the Six-Minute Walk Test, the Timed Up and Go test, the Amputee Mobility Predictor, and the Locomotor Capabilities Index. Overall, a moderate sized improvement was seen in primary gait outcomes (SMD = 0.55, 95% CI (0.33, 0.77), I2 = 23.0%) in favour of the exercise intervention groups. CONCLUSIONS: The results of this study demonstrate that multi-component exercise programs consisting minimally of gait, balance, and strength training are effective at improving gait outcomes in PLLA across stages of recovery. However, the optimal duration and frequency of exercise is unclear due to the variation observed between interventions, highlighting an area for future work. FUNDING: Ontario Graduate Scholarship, Western's Bone and Joint Institute transdisciplinary training award.

R – Modeling

P1-R-99: ***Opening the loop of balance control: is positive torque feedback revealed in artificially restricted quiet standing?***

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Background and aim: Closed-loop models of human postural control best reproduce low frequency sway responses to surface tilts when positive torque feedback is included with a PD controller [1]. Positive torque feedback predicts that body lean away from a neutral upright position corresponds with increasing torque as the system attempts to restore the upright position. However, a torque feedback mechanism for standing balance remains theoretical and has yet to be verified experimentally. Our aim was to use a unique balance apparatus to test the hypothesis that positive torque feedback contributes to upright stance. The apparatus incorporates a closed-loop system that permits normal sway until movement of the centre of mass (COM) is discretely restricted by a brake [2]. Assuming the COM is locked in space, a small difference between an internal torque reference and actual torque would lead to increasing torque over time. Methods: Subjects (n=9) stood quietly on a force plate embedded in a platform controlled by a linear motor. They were fixed to a board that permitted rotation only about the ankle joints. The board was attached to a closed-loop pulley system that could be locked in place. Subjects completed a series of standing trials, each starting with unrestricted standing for 90s followed by restricted COM conditions when the centre of pressure (COP) was within the unrestricted standing mean ± 0.5*SD. When the COM was restricted, subjects either remained in this position (0mm) or were imperceptibly shifted into slight forward leans by 3mm and 6mm backward ramp-and-hold platform translations. Each position was held for 90s. A linear trendline was fit to individual restricted anteroposterior COP responses (0-30s after each translation). COP trendline slopes were averaged across subjects and compared across all leaning trials with a 1-way RM-ANOVA. The relation between COP trendline slopes and degree of lean was examined with bivariate correlations across all subjects and conditions. Experimental results were compared with simulated data from a closed-loop model modified from [1]. Results: Significant effects of lean were observed for COP trendline slopes (p=.008), with greater slopes following the 6mm translation, followed by 3mm and 0mm. Linear trendline slopes were correlated with degree of lean (r=.411; p=.037), suggesting greater forward leans were associated with greater increases in COP over time. Comparable results were obtained from simulated data, although some differences were observed in the slopes of restricted COP responses. Conclusions: This study provides experimental evidence for positive torque feedback as a self-calibration mechanism contributing to upright stance and supports claims that it may be an important component to incorporate into postural control models [1]. Future work is required to optimize closed-loop models to reproduce experimental data with greater accuracy. [1] Peterka 2003 IEEE EMBS [2] Carpenter et al 2010 Neurosci

P1-R-100: ***A neuromuscular model of human locomotion that flexibly adapts its gait parameters***

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BACKGROUND AND AIM: Human walking is remarkably flexible. We effortlessly walk with different combinations of step length, cadence and speed and are able to easily adapt different gait patterns. Achieving that flexibility requires sophisticated mechanisms of stabilization as the human body is mechanically unstable during locomotion and the body's configuration changes throughout the gait-cycle. Changing the gait pattern, therefore, is a challenge. Increasing the walking cadence, for instance, does not only involve making faster steps, but also adapting foot placement and kinetic energy to the changed dynamics of the body in order to maintain balance. Here, we examine the problem of freely choosing a gait pattern, defined by a combination of step length and cadence, and the resulting gait speed. Our goal is to develop a neuromechanical model capable of walking at any such gait pattern, within the range commonly adopted by humans in normal walking. METHODS: We developed a neuromuscular model of human locomotion that is capable of executing high-level movement plans. The control model comprises a supraspinal layer that generates and updates a kinematic movement plan, that is then transformed into descending motor commands using an internal model. In a spinal layer, the descending commands are integrated with spinal reflex modules to activate 22 Hill-type muscles. We choose parameters for target step time, trunk lean, propulsion and foot placement to achieve the desired step length and cadence. The step time defines the planned duration of one individual step. The reference trunk lean specifies a resting angle of the stance leg hip joint angle. A propulsion module accelerates the trunk CoM by pushing the stance leg off the ground. A target foot placement offset is used to change the lengths offset of the steps. We optimized parameters

to generate a wide range of target gait patterns using covariance matrix adaptation evolution strategy. RESULTS: We were able to successfully control the outcome measures step length and cadence by manipulating only the high-level parameters for target step time, trunk lean, propulsion and swing leg kinematics. Optimizing these parameters, we found gaits spanning the entire step length-cadence range adopted by humans in normal walking, as shown in Figure 1. Furthermore, we were able to generalize between these parameter sets by linear combination of nearest neighbours to generate step length and cadence combinations without further optimizations. The model was also able to transition between the gaits patterns during locomotion in real time. CONCLUSION: We show that it is possible to control the outcome measures step length and cadence by adapting a set of high-level control parameters in a 3D-neuromuscular model of human locomotion.

P1-R-101: *Speed-induced changes in paretic-limb propulsion and holistic gait quality are correlated only in high-functioning stroke survivors*

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BACKGROUND AND AIM: Treadmill training, during which speed is modulated to improve gait, is a promising stroke gait rehabilitation strategy. Post-stroke walking function during training can be characterized using discrete biomechanical metrics, though metrics change differentially across speeds. In particular, peak paretic-limb propulsion is associated with post-stroke walking function and has been used to characterize gait training efficacy. To holistically characterize post-stroke gait, we used a recurrent neural network (RNN) to generate a data-driven model of gait dynamics based on joint kinematics. Model parameters encode individual-specific gait dynamics and define a gait signature, whose multidimensional similarity to able-bodied (AB) adult signatures provides a holistic metric of gait quality. Here, we evaluated the relationship between peak paretic-limb propulsion and gait quality with speed modulation in high- and low-functioning stroke survivors. METHODS: We used marker-based motion capture and an instrumented split-belt treadmill to record 3D gait kinematics and ground reaction forces (GRFs) in 5 AB adults and 7 stroke survivors during 30s bouts of treadmill walking at 6 speeds, ranging from self-selected (SS) to fast. We defined gait signatures using the individual- and speed- specific internal parameters of a 3-layer RNN trained on sagittal-plane joint kinematics across participants and speeds. Gait quality was defined as the Euclidean distance between a participant's gait signature and a centroidal AB signature from k-means clustering. We used linear regression to test the relationship between changes in peak paretic propulsion (anterior GRFs) and changes in gait quality across speeds in high- (SS speed>0.4m/s) and low-functioning stroke survivors. Multivariate linear regression was used to test for effects of baseline gait quality and SS speed on the propulsion-gait quality relationship. RESULTS: In high-functioning participants (N=3), changes in paretic propulsion and gait quality with speed modulation were positively correlated across speeds ($r2=0.72$, $p<0.002$). Conversely, for 2 of 4 low-functioning participants, gait quality degraded and changes in propulsion and gait quality were not correlated. Across stroke participants, interactions between changes in propulsion, baseline

gait quality ($p<0.001$), and baseline speed ($p<0.001$) partially explained speed modulation-induced changes in gait quality ($r2=0.53$). CONCLUSIONS: This work presents an innovative data-driven technique to holistically characterize individualized gait dynamics, revealing that improving paretic propulsion is likely to improve gait quality across gait speeds only in high-functioning stroke survivors. In contrast, low-functioning participants may lack the capacity to increase paretic propulsion while improving gait dynamics, suggesting a tradeoff between mechanical demands of faster speeds and overall gait quality, which should be considered during rehabilitation.

S - Neurological diseases

P1-S-102: ***The association between white matter hyperintensities in different brain areas and balance in older adults with Parkinson's disease***

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Background and aim: White matter hyperintensities (WMH) on MRI in the brain are associated with increased falls risk in older adults. Parkinson's disease (PD) also increases the risk of falling due to its negative impact on balance control; however, it is unknown whether increased WMH burden is associated with worse balance performance in PD. The aim of this study was to investigate the association of WMH in all brain lobes and subcortical regions with balance performance in individuals with PD. Methods: In this cross-sectional study we analyzed a sample of 124 older adults with PD from the Ontario Neurodegenerative Research Initiative (ONDRI). 3T-MRI was used to obtain T1-weighted, T2-weighted, and FLAIR images used to calculate WMH volumes in the whole brain. WMH volumes were then calculated as the percentage of WMH combining right and left sides in brain lobes (4 in total) and in the basal ganglia+thalamus. Balance evaluation was performed in upright position under two conditions for 30 seconds, using a portable force board (Wii, Nintendo Inc.): eyes open-narrow stance and eyes closed-narrow stance. Balance performance was estimated through the root mean square (RMS) of the center of pressure (CoP) displacement in the mediolateral (ML) and anterior-posterior (AP) planes resulting in a total of four balance parameters adjusted for age, sex and height. Canonical Correlation Analysis (CCA) was performed to identify associations between WMH volumes and balance performance. Four brain lobes and basal ganglia were entered in the predictor set, and four balance parameters were entered in the outcome set. These two synthetic variates were then used to assess the canonical correlation between WMH and balance. Statistical significance was set at $p \leq .05$. Data analysis was performed using the IBM SPSS 25.0 software (SPSS Inc.). Results: Participants were predominantly men (77%; mean age 68.10 years), Unified Parkinson Disease Rating Scale -Part III of 22.54 (±11.41), Hoehn &Yahr of 2 (±0.36) points, and disease duration of 4.6 (±1.6) years. Despite a shared variance of 15% between the WMH

and balance sets (Table 1), the canonical association between these variates was not statistically significant (p=0.71). Conclusion: WMH burden and balance performance are not associated in older adults with PD pre-selected for lack of postural instability on clinical examination. Future studies should investigate whether associations become stronger in later stages of PD and whether cognitively challenging balance tasks would reveal stronger associations between WMH burden and balance performance in PD. Acknowledgments and Funding: Research Fellowships Abroad (BPE) Award - FAPESP (The São Paulo Research Foundation, Process number# 2019/24271-0)

P1-S-103: ***Lower-limb concentric isokinetic torque and reactive balance performance post-stroke: a cross-sectional study***

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BACKGROUND AND AIM: Many people with stroke have poor reactive balance control. Poor muscle strength, or asymmetries in muscle strength between limbs may contribute to poor balance control. However, the association between muscle strength and reactive balance control post-stroke has not been studied. The purpose of this study is to determine the relationship between lower limb isokinetic strength and reactive balance performance in individuals with chronic stroke. METHODS: Eight adults with chronic stroke (5 men, 3 women; 44-77 years old; 6 months to 9 years post-stroke) completed 10 forward-directed lean-and-release balance perturbations. Reactive step timing (foot-off and swing time) was extracted from force plates. Concentric isokinetic knee extensor and flexor peak torques were assessed using computerized dynamometry at 60°/s. Strength asymmetries were calculated as the torque ratio between the less affected and more affected limbs. Pearson correlations were calculated, however p-values are not reported due to the small sample size; data from a larger sample will be presented at the conference. RESULTS: There were moderate to strong negative correlations between peak flexion and extension torques and number of steps taken to recover balance when the step reaction was initiated with either limb (r=-0.612 to -0.883). There were moderate negative correlations between strength asymmetry ratio and number of steps taken to recover balance when responses were initiated with the unaffected limb (r=-0.755 to -0.795). There was also a moderate positive correlation between flexion asymmetry ratio and foot off time for reactive steps initiated with the affected limb (r=0.662). CONCLUSIONS: The present findings suggest that greater knee flexion and extension strength may contribute to more effective balance reactions among people with stroke. Specifically, greater asymmetry of knee flexion strength, indicating increased strength of knee flexors on the weight-bearing limb compared to the stepping limb, optimizes step time when steps are initiated with the more affected limb. Conversely, greater strength of the stepping limb compared to the stance limb contributes to more effective step reactions when initiating stepping with the less affected limb. These findings suggest that strength training may be a useful adjunct to balance training to improve control of balance reactions post-stroke.

P1-S-104: ***Can wearable sensors provide insight into delirium in inpatients with Parkinson's disease? A feasibility study***

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BACKGROUND: Delirium is an acute neuropsychiatric syndrome and is associated with altered levels of consciousness, confusion and impaired attention. Sleep-wake cycle disruptions and motor activity alterations are core domains affected. Patients with Parkinson's disease (PD) may be at an increased risk of developing delirium[1]; however, a diagnosis may be missed due to an overlap in symptoms. No existing clinical tools have been validated and used to differentiate PD symptoms from delirium symptoms. Most tools also only provide information for a snapshot of time, which fails to detect the fluctuating nature of delirium. Wearable sensors provide a unique, objective, non-invasive opportunity to continuously monitor activity and sleep patterns in inpatients with PD and delirium. The primary aim of this study is to assess the feasibility of using wearable sensors in this patient population and to quantify clinically relevant digital outcomes to facilitate understanding in PD inpatients with and without delirium. METHODS: Participants are PD inpatients admitted to hospitals in Newcastle-upon-Tyne, recruited as part of a nested study. Participants complete a delirium assessment whilst in hospital taking place over up to five days and in parallel to wearing the sensors. Axivity, AX6 triaxial accelerometer and gyroscope are secured to participants' lower back and/or wrist. Delirium was diagnosed using a standardized assessment based on the Diagnostic and Statistical Manual of Mental Disorders 5th Edition. The feasibility of using wearable sensors was recorded (e.g., duration and location the sensor was worn, and compliance). Walking activity outcomes will be quantified using a validated and secure automatic cloud-based analytical pipeline[2]. Sleep metrics including sleep episodes, night awakenings and rest activity measures will be derived using GGIR analytical package[3]. RESULTS: Data collection is ongoing. Of the 152 consecutive admissions screened, 87 admissions were excluded and 22 declined (figure 1), yielding data collected from 46 admissions from n=27 participants. The mean age of the participants is 76.7±10.5 years. The mean duration for wearing the sensors was 3.5±2.3 days. Of the 46 admissions, n=18 (39.1%) wore both lumbar and wrist sensor, n=27 (58.7%) wore the wrist sensor only. The mean compliance rating for wearing the sensor during the admission period is 8.8±SD for the lumbar sensor and 8.5±SD for the wrist sensor, higher scores indicating better compliance. The sensor was removed without re-securement during 5 admissions. CONCLUSION: To our knowledge, this is the first study to examine the feasibility of using wearable sensors to monitor activity and sleep patterns in inpatients with PD-delirium. This objective and continuous approach appears feasible and will determine digital outcomes of activity and sleep in PD-delirium. Future work will derive digital outcomes which may be useful for improving the identification of delirium and its subtypes, allowing for stratification of patients for future treatment interventions. REFERENCES: [1] Lawson RA et al, 2020, Int J

Geriatr Psychiatry 35(5):547-52 [2] Del Din et al, 2016, IEEE SSP;1-5 [3] van Hees VT, 2015, PLOS ONE, 10(11), p. e0142533.

P1-S-105: ***Quantitative assessment of plantar pressure patterns in people with HMSN and foot deformities***

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BACKGROUND AND AIM: Hereditary motor and sensory neuropathies (HMSN) is a group of progressive diseases characterized by distal muscle weakness, somatosensory impairments and foot deformities that occur over time. This manifests in gait impairments, pain and pressure sores. Clinical examination is used to assess foot impairments. However, there is a need for a quantitative evaluation of impairments, for example when indicating surgery, or when evaluating the effect of interventions. The aim of this study is to perform a quantitative analysis of plantar pressure during walking to assess foot impairments in people with HMSN. METHODS: Plantar pressure patterns of 86 feet of 65 HMSN patients that were measured at our outpatient clinic were included in this retrospective study. The control group consisted of 586 people without foot impairments of which both feet were included in the analysis. Based on clinical examination, four HMSN groups were defined: 1) Deepened first metatarsal, neutral hindfoot (NEU), 2) Deepened first metatarsal, correctable varus hindfoot (VAR_COR), 3) Deepened first metatarsal, uncorrectable varus hindfoot (VAR_UNCOR), and 4) Valgus hindfoot (VAL). All plantar pressure patterns were rescaled to a standard foot and normalized for total pressure. Root mean square differences (RMSD) between individual pressures and the mean pressure pattern of the control group were calculated as a measure of abnormality. Pressure ratios of the lateral, toes, fifth metatarsal head, first metatarsal head, and midfoot relative to the whole foot were calculated as a measure of overloading of a certain area. RESULTS: The RMSD of all HMSN groups differed from the controls (Controls: M=1.94±0.54, NEU: M=2.68±0.85, VAR_COR: M=3.46±1.14, VAR_UNCOR: M=4.32±2.20, VAL: M=2.80±0.81, $p<0.01$). The groups with a varus hindfoot showed increased lateral, fifth metatarsal head, and midfoot pressure ratios and a decreased toes pressure ratio compared to the other HMSN groups and the controls ($p<0.01$, Fig. 1). Yet, the people with an uncorrectable varus hindfoot showed increased lateral and fifth metatarsal head pressure ratios and a decreased first metatarsal head pressure ratio compared to those with a correctable varus hindfoot ($p<0.01$, Fig. 1). Fifth metatarsal head and first metatarsal head pressure ratios were significantly different between the NEU group and the controls ($p<0.05$, Fig. 1). For the VAL group, none of the calculated pressure ratios were significantly different from the control group. CONCLUSIONS: Plantar pressure measurements are useful to quantify foot impairments in people with HMSN. Especially the fifth metatarsal head and lateral pressure ratios seem to be important outcome measures to assess foot impairments in HMSN patients.

P1-S-106: ***Serious games home-based training to treat gait and balance disorders in patients with advanced Parkinson's disease.***

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BACKGROUND AND AIM : Gait and balance disorders are among the most disabling symptoms of Parkinson's disease (PD). These motor signs become doparesistant with the progression of the disease. Exergaming has been proposed to treat these symptoms in PD patients. In this study, we aimed to demonstrate the efficiency of a virtual reality-based rehabilitation program, using the customized video game « ToapRun » at home, for severe PD patients. METHODS : 50 PD patients with gait and balance disorders were included in a parallel randomized single-blind controlled trial with 2 groups : 1) Active-virtual reality (VR) group, using a capture motion camera (Kinect®) with active movements for playing; 2) Control-VR reality group using the computer's keyboard to play. Both groups performed 2-3 sessions per week for 6-9 weeks, with a total of 18 sessions. The primary outcome was the between-group difference in the changes in the Stand-to-Walk-Sit-Test (SWST) duration between inclusion and after the 18 training sessions. Secondary outcomes included motor, cognitive, psychiatric and quality of life scales, and gait kinematics parameters. Safety was also assessed. RESULTS : After 18 training sessions, the changes in the SWST duration were not significantly different between patient's groups (mean change in the SWST-duration [SD] -3.71 [18.06] sec after Active-VR versus -0.71 [3.41] sec after Control-VR training, p=0.61). After 18 sessions, patients trained with the Active-VR sessions had a significant decrease in the severity of gait and balance disorders On-dopa (mean change in the axial score=-1.5, with a between-group difference of 1.2 points in favor of the Active-VR training group, p=0.009; and mean change in the gait and balance scale=-2.7, with a between-group difference of 1.9 points, p=0.18); with significant decrease in the durations of anticipatory postural adjustments (APAs) and double-stance phases and increase in stride length, velocity and cadence. Patients trained with control-VR had a significant improvement in the quality of life (p=0.01) and anxiety (p=0.04) scores, with also a significant increase in the step cadence. CONCLUSIONS : Active training using a customized exergaming and performed at home attenuates gait and balance disorders in patients with an advanced form of PD. Future research is needed to investigate the long-term efficacy of such training program and its possible impact on the progression of these disabling axial motor signs for patients with less severe disease. ACKNOWLEDGEMENTS AND FUNDING: We thank all the patients who participated to this study. This study was supported by France Parkinson foundation, Eurostars programme and the French National Agency for Research.

P1-S-107: ***A novel Real Time Algorithm to Predict Freezing of Gait in Parkinson's Patients Using Wearable Mobility Sensors Data***

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BACKGROUND AND AIM: Parkinson's disease (PD) is a progressive multi-system neurodegenerative disease, that affects people mainly in later years of life. Freezing of gait (FOG) is a common motor symptom of PD which causes the legs to stop walking as if they were "glued" to the ground. FOG is typically triggered by certain walking circumstances including turns, narrow passages, initializing walking or performing another task while walking. Previous studies have shown that FOG events can be detected with high precision by analyzing gait kinematic signals collected through wearable motion sensors. However, until now, very few algorithms aimed at real-time prediction of FOG, i.e., before its occurrence. Here we present a novel algorithm for real-time FOG prediction based on the online monitoring of the coherence between legs' movements as reflected by signals obtained from wearable motion sensors. Since impaired bilateral coordination of gait (BCG) was implicated with FOG, we focused on the coherence signal between the stepping of the two legs as the signal of prediction (see below). METHODS: Thirteen PD patients with FOG wore motion sensors on their shanks while performing walking trials with FOG-triggering events (e.g., turns, narrow passages). Our algorithm calculated the coordination between the legs via wavelet analysis (calculating the cross spectrum of the wavelet transform of gait signals, specifically the anteroposterior angular velocity from sensors on the shanks). Then the algorithm detected within a 2 seconds window, the time points where the legs' coordination was strongly violated and 'flagged' them as FOG-alert events. Here we present preliminary results based on simulated real-time streaming (sample by sample) of the collected data. RESULTS: Out of 145 FOG events that were present in the collected data, the algorithm predicted 133 events (sensitivity of 91.7%), on average 1.5 seconds (SD= ± 0.82) prior to the event (c.f., Fig 1 for an example). The algorithm often flagged also turns (i.e., in 47 out of 87 turns, i.e., 54%). CONCLUSIONS: Our simulations of real time left-right stepping coherence suggest that within a time window of 1.5 seconds it is possible to predict an upcoming FOG event with high sensitivity (>90%). Turning-related false positives remain a challenge for this potential FOG prediction solution. Often, during turning BCG is challenged which potentially increases FOG propensity, thus 'false alarms' in this case are not a major limitation. Overall, these results suggest this algorithm has the potential to be incorporated within a wearable system for FOG prediction, i.e., potential FOG-triggering events are identified by the algorithm, and strategies such as external auditory cueing could be delivered to avert/limit FOG occurrences.

P1-S-108: ***Protocol for the FOG-IT study: the validity of wearable technology for assessing freezing of gait in Parkinson's Disease***

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1) Background and aim Freezing of Gait (FOG) is an intermittent walking disturbance in people with Parkinson's disease (PD), characterized by an inability to move the feet and by a tendency to increase fall risk [Moore, 2007]. Currently, the frequency and duration FOG

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episodes are primarily captured by means of self-reported diaries/questionnaires. However, these methods tend to display a recall bias resulting in a poor reliability [Hulzinga, 2020]. Therefore, time and labor-intensive motion capture (MoCap) along with expert-annotated rating are considered the gold-standard method to quantify FOG severity [Mancini, 2019] Inertial Measurement Units (IMUs) offer inexpensive, fast and potentially automated FOG detection [Pardoel, 2019]. Yet, most of the current IMU-based FOG detection algorithms fail to detect FOG effectively in daily-life circumstances. The FOG-IT study aims to make significant progress in developing automated FOG detection algorithm based on deep learning methods and on integrating several neurophysiological signals. It also aims to design a software platform for personalizing and optimizing the algorithms by expert input with the ultimate goal to enable valid FOG detection in the home setting. 2)Methods Data collection will take place in three phases: 1) in the lab, 2) in a supervised home setting, and 3) an unsupervised free living environment. In the first two phases, participants are tested in both OFF and ON medication to test responsiveness of the methods. FOG provoking tasks- including a Timed up and Go task with 180º turn and a 360º turning in place task- are performed with and without cognitive load. In the lab, data will be collected using 3D marker based optical motion capture system (Vicon), marker less-based motion capture system (Microsoft Azure Kinect cameras), foot pressure insoles, stress signals, 7 IMUs and a video camera for ground truth FOG annotation. At home, the mobile systems will be used only. Additionally, in the 2nd phase participants are tested at a personalized FOG hot-spot, a region at home where participants are prone to experiencing FOG. In the 3rd phase, participants will perform their daily routine while wearing IMUs and video recording from a camera positioned in their homes. The research approach also includes a wide repertoire of multimodal analytical techniques for FOG-detection, based on a historical data set [Filtjens, 2021], and proposes thorough cross-validation on different cohorts. 3)Results: So far, data has been collected from 5 participants in the lab setting and from 3 of them both supervised and unsupervised home setting has been collected. 4)Conclusion FOG-IT is set-up to go beyond the state-of-the-art of current FOG-detection methods by integrating IMU, video and physiological data into a cohesive FOG detection platform for patient-specific algorithms to assess FOG. As such, FOG-IT will address the main bottlenecks for obtaining valid outcome measures for FOG and which are needed for conducting clinical trials and develop novel FOG therapeutics.

P1-S-109: ***Freezing of gait classification during the one-minute DT turning task by means of IMU-based FOG metrics***

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BACKGROUND AND AIM: Freezing of gait (FOG) is a highly debilitating symptom in people with Parkinson's disease (PwPD). Identification of PwPD with FOG is thus crucial for optimal treatment. However, the 'white-coat effect' precludes FOG from occurring in the clinical setting, making FOG identification not trivial. Recently, we showed that a 1 minute alternating

turning at the spot task, while simultaneously performing a cognitive dual-task (DT) is a valid and sensitive task to trigger FOG even in laboratory settings [D'Cruz, 2021]. Yet, it still requires time-consuming video annotations by a clinical rater. To this end, a FOG algorithm was recently developed which calculates several FOG metrics based on wearable sensor data [Mancini, 2017]. In this study, we investigated FOG classification accuracy using the FOG algorithm during the 1 minute DT turning task. METHODS: Fifty-six PwPD were tested in a laboratory setting during their ON medication state as part of the Mobilise-D project. Patients had to make alternating full 360° turns on the spot for a duration of 1 minute. Instructions were to make the turns as fast as safely possible, but without making pivoting movements. The simultaneous cognitive task consisted of an auditory Stroop task. The clinical rater noted if a participant experienced FOG or not during the test. Wearable sensors positioned on the feet and lower back captured the turning performance at 128Hz (OPAL, APDM). The FOG algorithm was used to calculate percentage time frozen (%TF), Mean and Max FOGratio, representing the power spectrum in the freeze vs. the locomotor band, along the Mediolateral (FOGratio_ML_Mean and FOGratio_ML_Max, respectively) and anteroposterior (FOGratio_AP_Mean and FOGratio_AP_Max, respectively) axes. ROC-AUC values were used to determine FOG classification accuracy of the above mentioned FOG metrics. Max Kolmogorov-Smirnov statistics were used to determine the optimal FOG classification metric and accompanied cutoff value. RESULTS: Seven of the 56 PwPD were identified as experiencing FOG during turning. %TF showed to be a non-significant metric for FOG classification (AUC [95%CI]: 0.703 [0.475 - 0.930], p=0.08), while all four FOGratio values were significant FOG classifiers with FOGratio_ML_Max (AUC [95%CI]: 0.793 [0.644 - 0.942], p<0.001) and FOGratio_AP_Mean (AUC [95%CI]: 0.796 [0.645 - 0.946], p<0.001) as the best ones. The FOGratio_ML_Max value of 4.967 was identified as the best cutoff value to differentiate between freezers and non-freezers and this with a sensitivity of 0.857 and a specificity of 0.796. CONCLUSIONS: We showed that the max mediolateral FOGratio during 360° DT turning is fairly accurate to differentiate freezers from non-freezers and has the best cutoff value. However, as only a few PwPD were immediately identified to experience FOG, the results have to be interpreted with caution. Results are preliminary as data collection and in-depth data analysis into FOG severity based on synchronized videorecordings is still ongoing.

P1-S-110: *Impact of neck and back pain on response to a novel wearable postural intervention in Parkinson's*

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BACKGROUND AND AIM: People with Parkinson's disease (PD) commonly suffer from postural malalignments that cause discomfort and pain [1]. Postural malalignments range from kyphotic (flexed) posture to severe lateral or forward lean (e.g., Pisa syndrome), which worsen over time leading to reduced quality of life. Medication and deep brain stimulation are ineffective to improve posture in PD [2]. Physiotherapy is often prescribed for postural

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malalignment to help with pain, but little evidence exists to guide practice. Previously we identified that that vibrotactile stimuli using a wearable device (UpRight Go®) improves posture in PD [3], but it is unknown how neck or back pain influence response. This pilot study aimed to examine whether the response to a wearable postural intervention is influenced by neck and low-back pain in PD. METHODS: Participants (n=25, 69.7 ± 6.4 years, 20 males), 10 of whom presented with severe postural malalignment (8with Pisa Syndrome, 1 with Camptocormia,1 with neck drop), underwent a battery of clinical and postural assessments. The UpRight Go® device was placed approximately over the T4 vertebra and prompted the wearer with a vibrotactile cue of ~100Hz when the angle of their trunk exceeded the pre-determined value of 5 degrees. Pain at the neck and low back was measured via self-report questionnaires (neck disability index, Oswestry low back pain scale (OLBPS)). Postural tilt was measured with and without the device during sitting, standing, and walking for two minutes using inertial measurement units (APDM, Oregon, USA). Relationship between pain and postural response (neck flexion and low back extension) was assessed with Spearman correlations. RESULTS: There was a significant relationship between low back pain and response to the device when standing, but not during sitting or walking. Specifically, OLBPS score was significantly related to the change postural verticality while standing (rho = .412, p = 0.041), indicating that greater change seen in low back extension with the device related to greater low back pain. There were trends for relationships between neck pain and postural response, but there were no other significant correlations between pain and postural response. CONCLUSIONS: Preliminary findings indicate that response to vibrotactile cueing may relate to pain due to postural malalignment, particularly when standing. Further work in a larger sample is required to understand if this wearable postural intervention can improve posture and thus reduce pain. REFERENCES: 1. Ford B. Pain in Parkinson's disease. Movement Disorders 2010;25:S98-S103 2. Bloem BR. Postural instability in Parkinson's disease. Clinical Neurology and Neurosurgery 1992;94:41-45 3. Stuart S, Godfrey A, Mancini M. Staying UpRight in Parkinson's disease: A pilot study of a novel wearable postural intervention. Gait & Posture 2022;91:86-93

P1-S-111: ***Transfer effects of a 4-weeks split-belt treadmill training on turning and over-ground gait performance in Parkinson's disease.***

Femke Hulzinga[1], Jana Seuthe[2], Nicholas D'Cruz[1], Pieter Ginis[1], Moran Gilat[1], Christian Schlenstedt[3], Alice Nieuwboer[1]

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BACKGROUND AND AIM: Adjusting gait and turning are challenging tasks for people with Parkinson's disease (PD) and can lead to freezing of gait and falls. Current rehabilitation such as treadmill training (TBT) can improve gait speed, but does not address complex gait and turning. Split-belt treadmill training (SBT), on the other hand allows the speed of each leg to be adjusted independently and may therefore train gait adaptation and improve turning. Previous studies showed that one session of SBT could improve adaptation on the treadmill as well as generalized to dual-task (DT) turning speed over-ground, effects that were retained for 24 hours. The aim of this randomized controlled trial was to investigate whether

4-weeks of SBT could improve gait and turning performance over and above TBT and whether these effects would be retained. METHODS: Fifty-two PD patients were enrolled in the study and randomly assigned to 4-weeks of either SBT or TBT 3 times per week. Gait and turning performance were assessed before (Pre), one week (Post) and six weeks (FU) after training. Rapid alternating 360-degree turning-in-place performance was quantified with an inertial measurement unit placed on the lower back, while self-paced straight-line gait was captured with 3D motion capture. For over-ground gait analysis, participants walked ten times along a 4-meter track at comfortable pace. All tasks were performed in single task (ST) as well as DT with an auditory Stroop. The primary outcome was ST turning speed. Other outcomes of interest (ST&DT) were gait speed, step length and asymmetry and turning speed, turning speed variability and number of turns. Linear mixed models were used to assess the time*training group interactions. RESULTS: No significant time*group interaction or main effect of group was found (ST&DT) for turning speed or the other outcomes on gait and turning. Consistent main effects of time were observed in a number of outcomes ($p<0.05$) however, which were driven by significant within-group improvements from Pre-Post and Pre-FU in the SBT group, but not TBT group. These within-SBT group changes were significant for gait speed (Pre-Post ST $p<0.01$, DT $p<0.001$, ST&DT Pre-FU $p<0.001$), step length ST&DT (Pre-Post $p<0.01$, Pre-FU $p<0.01$), step length asymmetry (ST Pre-FU $p<0.01$) and number of turns (Pre-FU ST $p=0.037$, DT $p=0.011$). Interestingly, lower p-values were seen at follow-up, indicating a strong retention after SBT. CONCLUSIONS: This randomized controlled trial showed that 4-weeks of SBT did not significantly improve over-ground gait and turning performance compared to TBT. However, most gait outcomes and the number of turns showed consistent within-group improvements and retention effects in the SBT group only. These results suggest that SBT can possibly be a promising tool to improve complex gait in people with PD, but future studies should see if SBT supplemented by task-specific training can enhance transfer to over-ground turning and walking.

P1-S-112: ***Eyes-closed balance deficits are worse in Early Parkinson's patients compared to patients with Early Dementia with Lewy Bodies***

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Background: Parkinson's Disease (PD) and Dementia with Lewy Bodies (DLB) are synucleinopathies that are difficult to distinguish clinically early on in disease course due to shared pathology and symptoms. Although problems with postural instability and impaired balance have been described to a greater extent in PD than DLB, both show pathological changes in pre-cerebellar and vestibular brainstem nuclei (among other affected regions). Proprioceptive deficits and vestibular dysfunction have been noted in PD patients, and likely contribute to their balance impairments. However, it remains unclear whether DLB patients have similar deficits especially early in the disease course. Proprioception and vestibular function are important for postural control and are often assessed by asking asking participants to stand to stand quietly with their eyes closed. Whilst studies have examined balance performance in advanced stages, they were limited to balance assessments that were conducted with the eyes open, which allows vision to compensate for vestibular or proprioceptive deficits. Furthermore, no work has examined differences in balance between PD and DLB early in the disease course (< 5 years of diagnosis). The current study evaluated differences in balance performance during eyes open and eyes closed conditions between individuals with Early PD, Early DLB, and healthy controls (HC). Methods: Forty-two participants (14 HC,14 Early PD and 14 Early DLB) completed a 30-second static balance assessment in two different conditions: (i) with their eyes open and (ii) with their eyes closed. The balance assessment was performed on a Zeno pressure sensor carpet. Variables examined included the distance between feet, Centre of Pressure (COP) sway characteristics (e.g. COP length, COP velocity, x-range, y-range), as well as sway variability (Root Mean Square in both the anterior-posterior and mediolateral directions). Results: Specifically, during the eyes closed condition, Early PD patients demonstrated significantly greater mediolateral sway variability (RMSx) compared to Early DLB patients (p=0.04). COP length and COP velocity showed a condition effect (p=0.003), however there were no differences between the groups. Importantly, there were no significant differences in the distance between the feet across condition or group. Conclusion: Eyes closed balance assessments may be useful for differentiating between Early PD and Early DLB patients, since PD patients may display greater proprioceptive and/or vestibular deficits than Early DLB patients. Further work is needed to tease apart whether the greater sway variability during the eyes closed condition reflects proprioceptive or vestibular dysfunction in Early PD.

P1-S-113: ***Do gait impairments differ between Parkinson's disease patients with and without REM Sleep Behaviour Disorder?***

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Background: There is substantial heterogeneity in clinical features and disease progression among individuals with Parkinson's disease (PD). Recent evidence suggests that single- and dual-task gait assessments may be useful for detecting prodromal PD in patients with idiopathic REM sleep behaviour disorder (iRBD). However, given that RBD does not precede motor symptom onset in all PD patients, if gait is ever to be used as a prodromal marker, it is necessary to determine whether gait impairments differ in PD patients with RBD compared to those without. Only one study to date has examined normal walking behaviour in mild- to moderate PD and found that PD patients with REM sleep without atonia (RSWA) had reduced velocity, cadence and increased stride velocity variability compared to those without RSWA. Aim: The current study sought to evaluate gait differences in PD patients with (PD+RBD) and without (PD-RBD) RBD during simple and dual-task walking conditions. Methods: PD+RBD and PD-RBD within the early (< 5 years since diagnosis) and advanced PD (>6 years since diagnosis) cohorts were matched in age, gender, disease duration, cognition and motor symptom severity. All participants completed the RBD Screening Questionnaire (RBDSQ) and were classified as having probable RBD if they had a score greater than 5. A total of 25 early PD (13 PD-RBD and 12 PD+RBD), as well as 33 advanced PD (16 PD-RBD and 17

PD+RBD) patients walked across a pressure sensory walkway under four conditions: (i) normal self-selected paced, (ii) while subtracting 1s from 100, (iii) while naming animals, and (iv) while subtracting 7s from 100. Spatiotemporal measures of gait were compared between Early PD groups (+/-RBD) and between Advanced PD groups (+/-RBD). Results: During normal self-paced walking, Early PD+RBD had significantly greater step length (p=0.03) than Early PD-RBD. A statistically significant positive correlation was found between step length and RBD severity (rho = 0.40). Likewise, during the dual-task conditions, a main effect of group for step length revealed that Early PD+RBD had significantly greater step length (p=0.05) than Early PD-RBD. Notably, in Advanced PD there were no significant differences between PD with or without RBD during single- and dual-task walking. Conclusion: Whilst these findings suggest that gait may differ in some aspects in those with RBD compared to those without RBD, this is only evident early on in the disease course. As PD progresses no substantial differences in gait impairments were found between PD+RBD and PD-RBD.

P1-S-114: ***Gait and balance characteristics of Apolipoprotein e4 allele (APOE e4) carriers and non-carriers in older adults and Parkinson's disease***

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Background and aim Gait and balance impairments are among the most troublesome and heterogeneous symptoms in Parkinson's disease (PD). The heterogeneity of gait and balance symptoms across people with PD may, in part, reflect genetic variation. The apolipoprotein E (APOE) gene has three major allelic variants (ε2, ε3 and ε4). The APOE ε4 allele is present in about 25% of the population and is also associated with risk of cognitive impairment in PD1,2. Healthy older adult (OA) carriers of the allele (APOE Ɛ4+) demonstrate gait deficits3, but no studies to date have assessed comprehensive gait and balance function in APOE Ɛ4+ individuals with PD. This study aimed to compare gait and balance measures between APOE Ɛ4+ and non-carriers (APOE Ɛ4-) in both OA and people with PD. Methods 334 people with PD (253 APOE Ɛ4- and 81 APOE Ɛ4+) and 144 OA (103 APOE Ɛ4- and 41 APOE Ɛ4+) were recruited to the Pacific Udall Center (PUC), comprised of three sites: VA Puget Sound/University of Washington, Seattle; Oregon Health & Science University/Portland VA Medical Centre, Portland; and Stanford University. Genomic DNA was extracted from peripheral blood samples and APOE Ɛ4 genotyped as previously described1. Gait characteristics representing the Pace/Turning, Rhythm and Variability domains of gait were measured during a two-minute walk whilst wearing six inertial body worn sensors (APDM, Portland, OR). Balance characteristics representing the sway area/jerk, sway velocity and sway frequency domains of balance were assessed during a sixty-second quiet stand. Two-way analyses of covariance (ANCOVA) compared gait and balance characteristics between groups (PD/OA) and carrier groups (APOE Ɛ4+/ APOE Ɛ4-), controlling for age, gender, and data collection site. An $\alpha \leq .01$ was deemed significant due to multiple comparisons. Results

PD participants were of mild-moderate disease severity, but disease severity was not different between carriers and non-carriers (MDS UPDRS III: APOE Ɛ4-= 23.8±12.2, APOE Ɛ4+=25.2±12.3, p=.374). There were significant differences in gait and balance characteristics between OA and PD groups (APOE Ɛ4+ and APOE Ɛ4- combined), demonstrating that those with PD had more impaired gait and balance compared to OA. When comparing gait and balance characteristics between APOE Ɛ4+ and APOE Ɛ4-, there were no differences in either the OA or PD groups. There were also no significant Group*APOE Ɛ4 interaction effects for any measures of gait or balance. Conclusions In this cohort of PD and OA, APOE Ɛ4+ did not demonstrate gait and balance impairments compared to APOE Ɛ4-. This may inform a personalised medicine approach for rehabilitation of gait and balance deficits which ultimately lead to falls. 1. Mata IF, Leverenz JB, Weintraub D, et al. APOE, MAPT, and SNCA genes and cognitive performance in Parkinson disease. JAMA Neurol. 2014;71(11):1405-1412. 2. Jo S, Kim SO, Park KW, Lee SH, Hwang YS, Chung SJ. The role of APOE in cognitive trajectories and motor decline in Parkinson's disease. Sci Rep. 2021;11(1). 3. Biggan JR, Taylor WE, Moss K, et al. Role of ApoE-ε4 Genotype in Gait and Balance in Older Adults: A Pilot Study. Journal of Applied Biobehavioral Research. 2017;22(2):e12061.

P1-S-115: ***Efficacy of reactive balance training using trips and slips in people with multiple sclerosis: A single-blinded randomised controlled trial***

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BACKGROUND AND AIMS: Multiple sclerosis (MS) is an immune mediated disease that causes widespread demyelination of the central nervous system, including areas responsible for balance resulting in increased risk of falls. Training of reactive balance using specific tasks relevant in daily life may reduce falls in people with MS. We tested our hypothesis that people with MS would be able to improve responses to trips and slips through reactive balance training. METHODS: Thirty people diagnosed with MS (18-70 years) participated in a blinded randomized controlled trial (ACTRN12618001436268). The intervention group (n = 14) underwent two 40 minute sessions (total 80 minutes) that exposed them to a total of 24 trips and 24 slips in mixed order, over a week. The control group (n = 16) received sham training (stepping over foam obstacles) with equivalent dosage. The primary outcome was falls (>30% body weight into a harness) when exposed to trips and slips that were unpredictable in timing, location and type at post-assessment. Poisson regression analysis was used to compare the group difference in the rate of falls while adjusting for age and Expanded Disability Status Scale (EDSS) scores. Simple and choice reaction time measures were also assessed at baseline and post assessments. RESULTS: The EDSS scores (0-10) were not significantly different between the intervention group (3.5 ± 0.8) and the control group (3.0 ± 0.7) (P = 0.083). Twelve intervention (86%) and 15 control participants (94%) completed the training protocol. Incidence rate ratios (95% confidence intervals) of the intervention group relative to the control group were 0.57 (0.25, 1.26) for all falls, 0.80 (0.30,

2.11) for slip falls and 0.20 (0.04, 0.96) for trip falls in the laboratory. Intervention group participants also had significantly faster choice stepping reaction times (total and step initiation times) and simple hand reaction times (P < 0.05). CONCLUSIONS: The reactive balance training reduced trip-induced falls in people with MS by 80%. The improved step initiation and hand reaction time suggests faster central processing may have contributed to better balance recovery from trips. Overall, these findings suggest that task-specific training of reactive balance may be useful for people with MS. ACKNOWLEDGEMENTS AND FUNDINGS: This study was funded by the Multiple Sclerosis Research Australia Incubator Grant 2018. We thank all participants and staff who contributed to this study.

P1-S-116: ***Beneficial effects on gait of 4-wheeled walker use in people with Alzheimer's dementia: A pilot study***

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BACKGROUND AND AIM: In people with Alzheimer's dementia, the provision of a mobility aid is a standard treatment for those with impaired gait or balance. However, mobility aid use is independently associated with an increased falls risk in this population. The study objectives were 1) to quantify gait changes for people with dementia who were prescribed a 4-wheeled walker for ambulation compared to no aid use, and 2) to examine the effects of walker use on gait in simple and complex walking situations. METHODS: Adults with dementia were recruited from a specialty day program. Inclusion criteria were: ≥50 years of age, mild-moderate Alzheimer's dementia and currently using a 4-wheeled walker for independent ambulation. Accelerometers recorded gait velocity and stride time variability. Three tasks were assessed: walking without an aid (ST: single-task); walking with a walker (4WW); and walking with a walker while counting backwards by ones (DT: dual-task). Each task was completed over two configurations: straight path and the Figure-of-8 Walk Test. A new variable, termed the Mobility Aid Index, quantified the relative change in performance between the ST and 4WW task with positive scores indicating benefit. Friedman's ANOVAs were used to examine between task differences on gait for each walking configuration separately. Medians and interquartile ranges [25th, 75th percentile] summarized the results. RESULTS: Eleven people (age: 88.7±6.6 years) participated. For the straight path, gait velocity was lowest in DT at 0.44 m/s [0.35, 0.55], and was significantly different to the ST (0.67 m/s [0.54, 0.96], p=0.01) and 4WW task (0.62 m/s [0.59, 0.98], p=0.01). Stride time variability in the straight path was highest for DT (5.69% [4.45, 8.04]), followed by the ST (4.38% [2.31, 4.85]) and 4WW task (3.25% [2.66, 4.71]), but only different between 4WW and DT (p=0.04). For the Figure-of-8 Walk Test, gait velocity was highest in the 4WW task at 0.38 m/s [0.25, 0.54], and was significantly different to the ST (0.29 m/s [0.17, 0.48], p=0.01) and DT (0.27 m/s [0.20, 0.37], p=0.01). The Mobility Aid Index for gait velocity was 4.5% [-6.3, 14.8] in the straight path and 27.5% [15.2, 42.0] for the Figure-of-8 Walk Test, while for stride time variability these values were 16.9% [-35.7, 38.9] and 32.4% [7.2, 41.0], respectively. CONCLUSIONS: Gait velocity increased and stride time variability decreased when using a 4-wheeled walker compared to walking without an aid, and this was most pronounced in the complex path configuration. The study demonstrated that using a walker improved

spatiotemporal gait (i.e., faster pace and reduced gait instability) compared to no gait aid use in simple walking situations. Benefit was not maintained in the complex walking situations requiring greater attentional demands. Future research should evaluate different mobility aid training protocols to improve gait performance. FUNDING: The Ontario Neurotrauma Foundation (2019-PREV-FALL-1070).

P1-S-117: ***Neuroimaging and neurophysiological changes associated with freezing of gait and visual-motor performance improvements following spinal cord stimulation therapy in Parkinson disease patients***

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BACKGROUND AND AIM: Freezing of gait (FOG) is the most disabling and challenging to treat symptom of Parkinson disease (PD), as dopaminergic replacement therapies (e.g. levodopa) have a limited to no response. Environmental factors trigger FOG and sensory cueing alleviate FOG by providing external sensory feedback. These factors suggest that proprioceptive deficits may drive the dysfunctional cortical and subcortical networks underlying FOG. Dopaminergic-resistant FOG may be a sensorimotor processing issue that does not involve basal ganglia (nigro-striatal) impairment. As the mechanism of FOG is multidimensional, an intervention that can access and modulate cortical and subcortical pathways involved in sensory processing, motor planning, and gait execution to alleviate FOG is needed. Recent studies suggest that spinal cord stimulation (SCS) has positive yet variable effects for dopaminergic-resistant FOG in PD patients. The aim of this study was to understand the relationship between FOG, upper-limb visual-motor performance and changes in cortical activity and striatal dopaminergic innervation with up to 6-months of SCS therapy. METHODS: Seven PD participants with significant FOG while on levodopa medication were recruited from the London Movement Disorders Centre. Participants underwent SCS implantation and the stimulation program to best improve FOG, assessed using 360-degree turning on the spot tasks on a Protokinetics gait walkway, was used daily over the 6-month treatment period for each participant. FOG tasks and resting-state electroencephalography (EEG) recordings were collected off and on levodopa at baseline (pre-surgery), and at 3- and 6-months with SCS therapy. Upper-limb visual-motor performance, extracting speed, reaction time and accuracy measures, was assessed by utilizing robotic target reaching choice tasks while participants were on levodopa at all time-points. DaTSCAN imaging to detect striatal dopamine transporter (DAT) binding, a measure of functional dopaminergic cells, was conducted at baseline and at 6-months. The effects of SCS on FOG, relative power (EEG frequency band analysis), DAT, and visual-motor performance were analyzed in separate linear mixed models via the maximized likelihood estimation (R "lmerTest" package). RESULTS: SCS significantly decreased FOG severity, as turning time and centre of pressure path length for both clockwise and counter-clockwise directions were reduced while off and on levodopa. FOG reduction was associated with changes in upper limb reaction time, speed and accuracy. Modulation of sensorimotor cortical activity was significantly associated with FOG reduction while participants were off levodopa. Changes to striatal dopaminergic innervation, DAT binding, were associated with

visual-motor performance improvements and no significant associations were observed with FOG. CONCLUSIONS: SCS may alleviate FOG by modulating cortical activity associated with motor planning and sensory perception. Improvements in upper limb (appendicular) visual-motor performance following SCS is associated to striatal dopaminergic innervation. Thus, SCS may influence both non-dopaminergic and dopaminergic pathways for axial and appendicular motor PD features, respectively.

P1-S-118: ***Feasibility of an eHealth intervention to train motor-cognitive function in the home environment with Parkinson's disease***

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BACKGROUND AND AIM: People with Parkinson's disease (PwPD) can achieve improvements in motor function, such as strength, gait and balance through exercise interventions. However, due to the Covid-19 pandemic, many PwPD now have restricted access to out-patient rehabilitation. eHealth interventions are of increasing interest as they offer the potential to support and motivate evidence-based training in the home environment. Additionally, dual-task ability - the simultaneous performance of two separate tasks with distinct goals - has been shown to improve gait and balance among PwPD in clinical settings. Whether improvements in dual-task ability can be made in the home-setting is less known. The aim of this study is to test the feasibility of a home-based eHealth intervention to deliver motor-cognitive training to PwPD. METHODS: People with mild-moderate Parkinson's Disease were recruited if they were; ≥50 years, stable in their anti-Parkinson's medication and independent indoor ambulators. The 10-week program was individually adapted and targeted motor and cognitive components. Motor components focused on increasing functional strength, cardiovascular fitness, and physical activity level. Cognitive dual-task components targeted aspects of executive function and memory. Participants trained 3 times weekly using a digital application at home. Baseline measurements included 30 seconds chair stand test, Mini-BESTest, 10-meter walk, 2-minute walk test in single and dual-task conditions, as well as global cognition and executive function. Data was collected pre-and post-intervention. Feasibility outcomes included; Recruitment capability; Data collection procedures; Acceptability, Suitability; and Demand of the eHealth tool. RESULTS: Preliminary results from baseline measurements describe the subject sample. Fifteen participants (median age 71 years, 53 % men) commenced the trail. Average PD duration was 7.1 years (range; 2.5− 22). Usual walking speed at baseline averaged 1.17 m/s and fast walking speed was 1.63 m/s. Median score for Mini-BESTest was 20 points. Median score for single-task Timed Up and Go (TUG) test was 10.5 seconds (7.34−39.56), and 12.37 seconds (8.28−136) for dual-task TUG. Preliminary results from the first five weeks regarding the feasibility outcome Acceptability shows that 64 and 44 % of the participants rated the motor and motor-cognitive sessions respectively, as 'enjoyable'. In relation to Suitability, participants rated their average level of exertion as light (11) on the Borg RPE. CONCLUSIONS: This study is currently ongoing and more results will be presented at the

conference. These results will inform the planning and design of a large-scale efficacy trial as well as give useful information for planning and designing other eHealth interventions.

P1-S-119: ***The feasibility of non-invasive vagus nerve stimulation to improve gait in Parkinson's: a randomised sham-controlled trial***

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BACKGROUND: Gait and balance impairments appear early and are ubiquitous in Parkinson's disease (PD). They increase falls risk with negative consequences to quality of life and independence. As therapies to mitigate these are limited, novel interventions targeting gait impairments and their consequences-falls risk-are urgently needed. Non-invasive vagus nerve stimulation (nVNS) is a neuromodulation technique targeting the cholinergic vagus nerve (VN). Recent work suggests that nVNS may reduce inflammation and improve gait variability in PD. AIM: to investigate the feasibility and safety of a multi-dose, multi-session nVNS in PD. METHODS: This will be a single-site, double-blind sham-controlled randomised pilot and feasibility trial in 40 people with PD. Participants will be randomised on a 1:1 basis to receive either active or sham treatment and will be matched on age, sex, global cognition, and UPDRS-III. The sham device is identical in appearance, weight and user controls but does not stimulate the VN. Participants will undergo a baseline assessment followed by a 12-week treatment phase with patient self-administering nVNS at home. Assessments will be repeated at 12 and 24 weeks. Participants will undergo a quantitative gait assessment using an instrumented walkway and body-worn sensors over seven days to record free-living gait characteristics. Falls will be collected using standardised falls diaries. In addition, measures of cognition, autonomic function and blood-based cholinergic plus inflammatory markers will be gathered. RESULTS: The study will report on the proportion of eligible and enrolled patients, and rates of eligibility and reasons for ineligibility. We will report the safety of the intervention and device tolerability in PD by recording all adverse events described by participants. Secondary outcome data will be summarised using descriptive statistics and include the median change in measures of discrete gait that are likely to be underpinned by non-dopaminergic mechanisms-step length and step time variability-and macrostructural characteristics (volume, variability, pattern of walking bouts and steps) pre- and post-treatment. These, in addition to changes in cognition, autonomic function and laboratory-cholinergic and inflammatory-markers, will be analysed using non-parametric Mann-Whitney U and Friedman tests due to the small number of participants in this feasibility study. CONCLUSION: This study aims to generate clinical, digital and laboratory data to assess the safety, tolerability, feasibility, and potential effectiveness of domiciliary multi-dose nVNS in PD. ACKNOWLEDGEMENTS AND FUNDING: This work is funded by Parkinson's UK (G-1903) and Dunhill Medical Trust (RPGF1906\154) and supported by the National Institute for Health Research (NIHR) Newcastle Biomedical Research Centre based at Newcastle upon Tyne Hospitals NHS Foundation Trust and Newcastle University.

P1-S-121: ***The influence of dopaminergic medication on different manifestations of freezing of gait in Parkinson's disease***

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BACKGROUND AND AIM: Freezing of gait (FOG) is an episodic phenomenon in Parkinson's disease (PD), which can manifest itself in 3 different types: 1) trembling, 2) akinetic and 3) festination. Here, we aim to investigate the occurrence of different 'FOG manifestations', and their response to dopaminergic medication during a FOG-provoking protocol in the home setting of patients with PD. METHODS: Fifty-eight freezers performed a home-based FOG-provoking protocol, first after >12h withdrawal of dopaminergic medication (OFF) and repeated 1 hour after regular drug intake (ON). The protocol consisted of: 4 meter walk, Timed-Up and Go single- and dual task (TUG ST & DT), 360°-turns in place (ST & DT), passing a doorway and a personal FOG-provoking condition. Percentage time frozen (%TF) was determined for the different manifestations based on expert video ratings. Episodes with an uncertain character (e.g., stopping due to a dual-task) were not included. RESULTS: Patients were 67.6±7.55 years, had PD for 11.7±6.46 years and had an NFOG-Q score of 20.9±3.80. Overall, 31 freezers had trembling FOG most often, 22 had more akinetic FOG, and 5 had more festination. The relative contribution of the different FOG manifestations for each patient is shown in Figure 1, illustrating that, except for 9 patients, most had mixtures of different manifestations. In OFF, freezers had a median (interquartile range) %TF of: 8.41% (2.51-24.7) for trembling FOG, 3.17% (0.41-12.4) for akinetic FOG, and 0.00% (0.00-1.71) for festination. In OFF, %TF for trembling and akinetic FOG were significantly higher compared to that of festination ($Z=-6.01$; $Z=-3.75$, $p<0.01$). There was no difference between %TF trembling and akinetic FOG ($p=0.45$). In ON, %TF was 2.34% (0.31-15.5) for trembling, 0.45% (0.00-2.78) for akinetic FOG and 0.00% (0.00-1.66) for festination. In ON, %TF trembling FOG was significantly higher compared to festination and akinetic FOG ($Z=-4.50$, $p<0.01$; $Z=-2.41$, $p=0.04$), and there was no difference between the latter ($Z=-1.67$, $p=0.29$). When comparing ON and OFF, %TF akinetic FOG was higher in OFF compared to ON ($Z=-3.69$; $p<0.01$). There was a trend towards higher %TF trembling FOG in OFF, which was not significant after Bonferroni correction ($Z=-2.36$; $p=0.05$). %TF festination was not significantly different in OFF compared to ON ($Z=-0.71$; $p=1.00$). Comparing ST and DT showed only significantly higher %TF akinetic FOG in TUG DT compared to ST in OFF ($Z=-3.55$, $p<0.01$). CONCLUSIONS: Trembling FOG was the FOG manifestation with the highest %TF during a home-based FOG-provoking protocol, although this was not significantly different from akinetic FOG in OFF. Festination was the least common FOG manifestation. Dopaminergic medication had a differential influence on the FOG manifestations. In particular, akinetic FOG appeared more responsive to dopamine. These results suggest that different underlying neural circuitry may be at play in different FOG manifestations.

T - Orthopedic diseases and injuries

P1-T-122: ***Using Phase Portraits and Statistical Parametric Mapping to Evaluate Recovery from Unilateral Hip Surgery***

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Background: Hip arthroplasty is a common technique to relieve the pain and loss of functionality associated with hip osteoarthritis. A wealth of information concerning the effectiveness of the surgery can be obtained by evaluating walking characteristics before and after the operation. This project was designed to identify joint angle recovery curves of individuals who have undergone unilateral hip arthroplasty. Accurate information garnered through a formal evaluation of gait can be used to makes decisions about possible modifications of a rehabilitation program during recovery. Methods: Walking on a motorized treadmill, kinematic gait patterns of 8 unilateral arthroplasty patients (64.9 ± 11.1 years) were evaluated using phase plane area analyses and statistical parametric mapping (SPM). Bilateral lower limb joint kinematics were obtained using a 12-camera motion analysis system during 3 minutes of walking prior to surgery, as well as 3 and 6 weeks and 3 and 6 months after surgery. Data were separated into individual strides and normalized such that each stride was composed of 100 samples. Phase portraits of the hip, knee and ankle joints for both the affected (side of operation) and unaffected leg were developed and total area of the phase portraits were calculated for each data collection session. SPM is a technique that computes the conventional univariate t-statistic between two time series waveforms as calculated at each sample (Robinson, Vanrenterghem, & Pataky, 2015). For each series of group mean joint waveforms, the pre-surgery waveform for each joint was compared to the waveforms obtained during each of the subsequent data collection periods. The resulting SPM data for each comparison were then separated into 3 gait phases and the percentage of samples that were statistically different in each phase was determined for each comparison. The gait phases were loading, single support and limb advancement. Results: The area of the phase portraits for all 3 joints, for both legs, progressively increased as the time from surgery increased. SPM phase analyses revealed that for both hips, the loading phase displayed no differences between pre-surgery and 3 weeks post surgery. However, by 6 months post-surgery, 100% of this phase was significantly different. Further phase analyses revealed that different patterns of joint motion occurred for each joint depending upon which leg was being evaluated. Conclusion: Phase portrait analyses revealed that, at least up to 6 months after surgery, lower limb joints displayed improved function associated with increased walking speeds. Phase evaluation of SPM results allowed for evaluation of how joint gait patterns were progressively modified during the recovery after unilateral hip arthroplasty with individual joints displaying different patterns of change.

U - Proprioceptive function and disorders

P1-U-123: ***Electrotactile velocity ratings on the foot sole are impacted by direction, stimulus interval, and presence of the Cutaneous Rabbit Effect***

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BACKGROUND AND AIM: Postural reflex, balance, and control of gait are modulated by information from the cutaneous afferents on the foot sole. One important aspect of tactile sensation is the proprioceptive sense of velocity (Vel) in the detection of slips and the kinesthetic evaluation of movement. Groups with peripheral neuropathy or sensory deficits may be at higher risk for falls or lower-limb injury due to this important role for skin in both proprioception and exteroception. To address declines in tactile feedback, one avenue of intervention is the natural replication of velocity via electrotactile stimulation. Such interventions will require sensations with spatiotemporal specificity, and as such, the impact of tactile illusions must be noted. The cutaneous rabbit effect (CRE) is a sensory illusion that is characterized by mislocalization of one or more events within a rapid sequence. The CRE has not yet been demonstrated in the glabrous skin of the foot sole. The potential impacts of this illusion on the assessment of an electrotactile train is of interest for sensory interfaces. In this study, we evaluate the impacts of the spatiotemporal components of an electrotactile sequence at the foot sole on the evaluation of sequence Vel. METHODS: 10 participants (5 women) evaluated three-1ms electrotactile pulses across three sites on the foot sole (1-proximal, 2-middle, 3-distal). Pulse sequences varied in interstimulus interval (ISI) (100, 160, 220ms) and stimulus train-loci pattern (sites 1-2-3, 1-1-3, 3-2-1). The stimuli trains were selected to differ in direction and location [Heel-to-Toe (H-T), CRE, Toe-to-Heel (T-H)]. The main outcome measures were visual analog ratings of Vel and a verbal indication of the train's direction and loci. RESULTS: A Generalized Estimating Equation indicated main effects of ISI ($p<.001$) and train ($p<.01$) on Vel rating. Pairwise Vel ratings at each ISI differed significantly (ISI $p<.001$). Pairwise Vel ratings differed significantly between each Train (H-T vs CRE $p<.01$, T-H vs CRE $p<.01$, H-T vs T-H $p<.05$). Participants indicated that the CRE was present in 94% of CRE Train trials and did not differ between ISI conditions. CONCLUSIONS: Different Vel ratings between toe to heel and heel to toe stimulation trains indicates a perceptual bias in the speed evaluation between directions, with toe to heel being rated slower. This may cause participants to underestimate the speed of perturbations that cause toe to heel tactile activation. The CRE trials were evaluated as faster than both directional trials despite being perceived at the same loci. Future directions should aim to assess each individual's threshold of evocation for the CRE in order to curate trains with the desired specificity and Vel.

P1-U-124: ***Proprioceptive Cervicogenic Dizziness Care Trajectory: A Systematic Scoping Review of the Literature.***

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Background and aim: Dizziness is commonly reported by different populations and represent a diagnostic challenge. Cervicogenic Dizziness is caused by a neck-related health problem. In recent years, various subcategories of cervicogenic dizziness have been proposed, with Proprioceptive Cervicogenic Dizziness (PCGD) being the most prevalent. Despite this classification, there is considerable variability in the differential diagnosis and treatment strategy for individuals diagnosed with PCGD. As such, the purpose of this scoping review is to identify subpopulations with PCGD and characterize the specificities of each group. This data will help improve patient treatment and guide future research in the field. Methods: A systematic scoping review of the French, English, Spanish, Portuguese and Italian literature from January 2000 to December 2021 was undertaken in PsycInfo, Medline, Embase, All EBM Reviews, CINAHL Ebsco, Web of Science and Scopus using the PRISMA recommended methodology in covidence with 2 independent reviewers. All randomized control trials, case studies, literature reviews, meta-analysis, and observational studies pertinent to PCGD were retrieved to determine the state of knowledge on how to diagnose, treat and evaluate the effectiveness of treatment in PCGD. Results: The search yielded 165 articles. Preliminary analysis identified four main etiological categories of PCGD: Chronic Cervical Pain, Traumatic, Degenerative Cervical Disease and Occupational (Muscle fatigue/spasm). Additionally, the analysis found six algorithms to aid in diagnostic determination and one clinical prediction rule (CPR). The validity and applicability of the assessment tools used in these algorithms and CPR are discussed in the context of PCGD. Treatment strategies are identified and discussed considering subpopulation-specific factors. Conclusion: Specific characteristics of PCGD patients according to their etiological categories include common encountered pathologies, probable comorbidities, usual red flags and beneficial treatment strategies. This awareness allows to provide adapted care trajectory by optimizing differential diagnosis, treatment, and evaluation of outcome. Nonetheless, significant gaps in the literature were identified, which should serve as a guide for future research. Acknowledgements and funding: Joseph Gill-Lussier received the scholarship of Merit from the Faculty of Medicine and the Recruitment grant: promising student from the School of Rehabilitation of the University of Montreal.

P1-U-125: ***Disturbed proprioceptive weighting during postural control in pregnant women compared to non-pregnant controls.***

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BACKGROUND AND AIM: Falling during pregnancy can seriously harm mother and child, and should thus be avoided. However, 1/4 women report falling during pregnancy. Pregnant women show a decreased postural balance (i.e., greater sway variability and velocity), particularly during the second part of pregnancy. Unfortunately, the underlying mechanisms are poorly understood. Postural balance depends greatly on proprioceptive inputs from e.g., ankle and lumbar muscles. Depending on the postural condition, the brain will adjust the weight assigned to these inputs. For example during standing on unstable support surfaces, healthy individuals up-weight lumbar proprioception and down-weight ankle proprioception.

So far, it remains unclear whether the weighting of ankle and lumbar proprioception during postural control differs in pregnant compared to non-pregnant women. METHODS: We recruited 12 pregnant, multiparous women in the third trimester, and 20 non-pregnant women. Exclusion criteria were a history of surgery/major trauma to spine, pelvis or lower limbs; specific balance or neurological disorders; and acute ankle problems. All women stood on a force plate (AMTI), with the heels 20 cm apart and vision occluded. After 20 s, muscle vibration (60 Hz, 15 s) was applied to the ankle or lumbar muscles. A stable and unstable support surface was used. Center-of-pressure (COP) displacements during vibration, and the Relative Proprioceptive Weighting (RPW) ratio, a measure of ankle vs. lumbar proprioceptive dominance, were calculated. Group differences in age, and pre-pregnancy BMI were determined with Mann-Whitney U tests, differences in COP displacement during vibration, and RPW ratio with mixed-design ANOVAs with "Surface" as the within-subjects factor, and "Pregnant" as the between-subjects factor. RESULTS: Pregnant women were significantly older (31 (30-34) vs. 28 (27-30) years, p= 0.004), and reported lumbopelvic pain more often (7/12 vs. 1/20, p= 0.002) than the non-pregnant controls. Pre-pregnancy BMI did not differ between groups (23.3 (21.4-27.2) vs. 22.4 (21.1-23.8), p= 0.219). For COP displacement during lumbar muscle vibration, a significant interaction effect of "Pregnant x Surface" was found (F= 8.157, p= 0.009). Post-hoc tests showed a significantly larger COP displacement during lumbar muscle vibration on the unstable compared to the stable support surface in the non-pregnant women (p< 0.001), but not in the pregnant group (p= 0.065). CONCLUSIONS: While non-pregnant women adequately up-weighted lumbar proprioception when switching from the stable to the unstable support surface, pregnant women did not show this increase in reliance on lumbar proprioception when needed. Future research must determine whether this decreased ability for proprioceptive re-weighting in pregnant women is already present in early pregnancy or even before conception, and whether it correlates to the presence of lumbopelvic pain and an increased risk of falling. ACKNOWLEDGEMENTS AND FUNDING: The authors wish to thank all participants. Nina Goossens is a beneficiary of an AXA Research Fund Postdoctoral Grant.

P1-U-126: ***Age-related changes in lower limb proprioceptive accuracy in typically developing children: a case series***

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BACKGROUND & AIM: Proprioception plays an integral role in the development of movement skills [1]. Given this importance, proprioceptive maturation has received more attention in the past decades. However, to date, only age-related differences in upper limb proprioception have been determined [2,3] and the current knowledge of how proprioception of the lower limbs evolves is still scarce. Therefore, we aim to provide new information on age-related changes in lower limb proprioception of multiple joints in typically developing (TD) children. METHODS: Lower limb proprioception was assessed in terms of Joint Position Sense (JPS) of the hip, knee and ankle joint in TD children aged 5 to 12 years old. Children were asked to reproduce a passively determined reference joint position as accurately as possible with the same limb in the sagittal plane. Testing was repeated two times for both the dominant and non-dominant leg. The absolute joint reproduction error (JRE, °) between the reference and reproduction joint angle was calculated from 3D kinematics (Vicon, ISB lower limb marker model[4]) and used as a measure of JPS accuracy. RESULTS: Figure 1 shows preliminary data from five TD children (mean age 9.2 ± 2.4 years, 3 boys/2 girls) categorized by age. For all three joints, both on the dominant and non-dominant body side, descriptive analyses suggest (i) a nearly linear decrease in mean JRE from 6 to 12 years old with > 50% reduction (> within-age JRE variability) and (ii) a decrease in within-age JRE variability with increasing age. Regarding limb dominance, the suggested age-related changes show a similar trend for both legs. CONCLUSIONS: Based on this preliminary data it seems that JPS of the ankle, knee and hip becomes more refined with increasing age. The observed changes in JRE between young (6y) and older (9-12y) children, ranging from 4.3° to 9.6°, likely reflect true age-related changes as they are greater than the standard error of JRE (1.8° or less) reported for upper limb joints in TD children [5]. Remarkably, an age-related change in JRE variability is also apparent (i.e., the older the child, the smaller the JRE variability). This suggests greater consistency in proprioceptive performance with increasing age, which is similar to upper limb JPS maturation [2,3]. As peripheral receptors are expected to be mature by 12 months old [6], the continued improvements likely reflect experience-dependent changes in central sensorimotor processes [7]. In this ongoing project, a larger sample will be tested and normative data will be provided against which JPS accuracy in pediatric populations can be compared. REFERENCES: [1] Shumway-Cook, A., et al. (2007); [2] Goble, D. J., et al. (2005); [3] Holst-wolf, J., et al. (2016); [4] Wu, G., et al. (2002); [5] Marini, F., et al. (2017); [6] Boor, R., & Goebel, B. (2000); [7] Nudo, R. J., et al. (2003)

P1-U-127: ***Effects of phasic proprioceptive stimulation on gait kinematics in healthy individuals: a pilot study***

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BACKGROUND AND AIM: Proprioceptive information is essential in the control of gait movement. Yet, proprioceptive stimulations, such as muscle vibrations, have not shown large or systematic effects on gait kinematics in healthy participants. However, most of these stimulations were applied continuously when physiological proprioceptive information is generally brief and phasic, generated by muscle lengthening during movements or external perturbations. Thus, our hypothesis is that short duration, phasic, vibrations could induce larger changes in joint angles, as they mimic physiological proprioceptive information. Therefore, the aim of this study was to compare the effects of short duration vibrations applied unilaterally on knee extensors or flexors, on gait kinematics in healthy individuals. METHODS: Ten healthy individuals walked on an instrumented treadmill (Bertec FIT) while lower-limb, three-dimensional, kinematics (Optotrak Certus) was recorded. Vibratory stimulations were applied for 200 msec periods at random times of the gait cycle or continuously, on knee extensors or flexors muscles. Joint angles were compared between

conditions using non-parametric statistics. RESULTS: Phasic vibrations increased contralateral knee extension (p=0.01) and reduced contralateral ankle dorsiflexion (p<0.001) during swing phase only. No effect was observed on the vibrated side during phasic vibration. Continuous vibrations increased ipsilateral hip extension (p=0.02), ankle dorsiflexion (p=0.02), and contralateral knee extension (p=0.009) and dorsiflexion (p=0.021) during stance phase. Continuous vibration also increased knee flexion (p=0.05) and reduced dorsiflexion (p=0.004) during swing phase. The effects were larger for continuous than phasic vibration in a few conditions. However, the magnitude of the effects was generally low, under 2.5°, and similar for flexor or extensor vibration. CONCLUSIONS: Short duration phasic vibration did not generate larger effects on gait kinematics than continuous vibration during steady-state gait in healthy individuals.

P1-U-128: ***The influence of visual feedback on alleviating freezing of gait in Parkinson's disease is reduced by anxiety***

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Background: Previous research has established that anxiety is associated with freezing of gait (FOG) in Parkinson's disease (PD). Although providing body-related visual feedback has been previously suggested to improve FOG, is remains unclear whether anxiety-induced FOG might be improved with visual feedback. Several studies have indicated that PD patients who experience FOG have greater proprioceptive deficits compared to non-freezers. It is also well-known that proprioception is vital for gait control. Proprioceptive deficits can reduce gait automaticity leading to greater attentional demands that are required to facilitate goal-directed locomotion. Furthermore, proprioceptive deficits have been argued to contribute to FOG in PD as insufficient attentional resources are available to compensate. Hence, anxiety could interfere with the processing of gait relevant information (i.e., visual feedback), where attentional resources have been proposed to be biased towards attending to threatening stimuli. It is also unclear whether visual feedback improves FOG through reduction of anxiety or through compensating for proprioceptive deficits with attention and improving goal directed motor control.Aims: The current study aimed to evaluate whether body-related visual feedback improves FOG consistently across low and high threat conditions.Methods: Sixteen PD patients with FOG were instructed to walk across a plank in a virtual environment that was either located on the ground (low threat) or elevated above a deep pit whilst visual feedback was either available (+) or omitted (-). Visual feedback was manipulated using an avatar to represent their body in the virtual environment which was synchronised in real-time with the participants movements. The virtual environment was delivered using a wireless head-mounted display. Self-assessment manikins were used to evaluated self-reported anxiety after every trial. Gait behaviour was both video recorded and captured using a pressure sensor carpet. FOG episodes were annotated using ELAN software.Results: A significant main effect of threat was found for self-reported anxiety (p<0.001) which showed that all participants reported greater anxiety levels during the elevated plank condition compared to the ground plank condition. There was also a significant main effect of threat for the percentage of trial spent frozen (%FOG) (p=0.016)

which demonstrated that more FOG was experienced during the elevated plank compared to the ground plank. Furthermore, a priori planned comparisons revealed that in the low threat condition (ground plank),%FOG was significantly reduced when visual feedback was provided compared to when visual feedback was absent (p=0.043). However, in the high threat condition (elevated plank), there were no differences in %FOG regardless of whether visual feedback was available (p=0.65). Conclusion: These findings confirm that although visual feedback can aid in the reduction of FOG, however anxiety may interfere with freezers' ability to use sensory feedback to improve FOG and hence, in high threat conditions, visual feedback was unable to aid in the reduction of FOG. Future studies should direct efforts towards the treatment of anxiety to determine if better management of anxiety may improve FOG

P1-U-129: ***Muscle fascicle length does not explain spindle firing rates in passive stretches of rat gastrocnemius with added tendon compliance***

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Background and Aim Tendons grow more compliant with age, but the effect of increased tendon compliance on sensory feedback during movement is poorly understood. Here we investigated how tendon compliance affects muscle spindle feedback during stretch in anaesthetized rat muscle. We added an artificial elastic element in series with the gastrocnemius muscle-tendon unit (MTU) to increase the effective tendon compliance while recording in vivo muscle spindle firing rates. We predicted that muscle fascicle excursion for a given stretch of the MTU would be reduced. Given the conventional understanding of spindles as muscle fascicle length and velocity sensors, we hypothesized that increased tendon compliance would decrease muscle spindle firing rates. Alternatively, based on our recent work, we hypothesized that muscle force would account for differences in spindle firing rates with added compliance. Methods We recorded MTU length change and force, muscle fascicle length change via sonomicrometry, and muscle spindle Ia afferent Instantaneous Firing Rates (IFR) from the dorsal root of the spinal cord. We analyzed peak amplitudes of MTU length change and force, fascicle length change and velocity, and spindle firing rate in fixed-amplitude 2-Hz sinusoidal stretches in rats with and without added compliance. Contractile tissue force was determined by subtracting the estimated non-contractile contribution using an optimized exponential force-length model based on fascicle length measurements. Linear mixed models were used to test the relationships of added tendon compliance, spindle IFR, fascicle length and velocity amplitudes, MTU force, and estimated muscle force; first analyzing changes in these variables with respect to compliance, then analyzing changes in IFR with respect to biomechanical variables, with the animal as a random variable in each. Results Surprisingly, added series compliance had no effect on spindle IFR amplitudes (β = .28, p = .92) even though fascicle stretch amplitude decreased (ß = .14, $p < 2e-16$), fascicle stretch velocity decreased (ß = 1.6, $p < 2e-16$), and MTU force decreased (ß = .15, $p < 2e-16$). There was no relationship between muscle spindle IFR and fascicle stretch amplitude (ß = 25, p = .13). However, there was a significant

relationship between muscle spindle IFR and both the total MTU force (ß = 38, p = 1.1e-3) and the estimated contractile tissue force (ß = 35, p = .021). Conclusions Muscle spindle firing rates did not change in the presence of increased tendon compliance, even though fascicle stretch decreased. The relationships between IFR and both total MTU and estimated contractile tissue force in conjunction with prior work (Blum et al 2017) suggests that force-based models are more appropriate estimators of muscle spindle responses. This evidence also suggests that muscle fascicle length measurements are not suitable predictors of sensory feedback during movement. Acknowledgements This research was funded under NIH R01 HD90642.

P1-U-130: ***Chronic Non-Specific Low Back Pain and Ankle Proprioceptive Acuity in Community-Dwelling Older Adults***

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BACKGROUND AND AIM: For people above 65 years old, low-back pain (LBP) is associated with balance problems and falls. Down-weighting of proprioception due to ageing and LBP may cause such balance problems. While lumbar proprioceptive deficits have been shown in LBP and indications for more generalized deficits have been found, ankle proprioception, which is crucial for balance control, has not been studied in people with LBP. Therefore, the aim of this study was to investigate the difference in ankle proprioceptive acuity between community-dwelling older adults with and without LBP. METHODS: Thirty participants over 65 years old volunteered. Fifteen had LBP (M/F=2/13, age=72.0 (4.6) years), fifteen were back pain-free healthy controls (control group) (M/F=2/13, age=72.1 (4.8) years). Ankle proprioception was measured in normal weight-bearing conditions, using the Active Movement Extent Discrimination Apparatus (AMEDA). Accuracy on the ankle proprioceptive test was expressed as absolute error (AE), constant error (CE) and variable error (VE). RESULTS: AE was significantly larger (P=0.029, 95% CI=[0.00, 0.90]) in the LBP group, CE was also significantly larger (P=0.046, 95% CI=[-0.91, -0.01]), indicating an underestimation of ankle inversion in participants with LBP compared to controls. VE was not different between the two groups (P=0.520, 95% CI=[-0.20, 0.59]). No significant correlation was found between pain intensity and AE, CE or VE (P>0.05). CONCLUSIONS: Acuity of ankle proprioception was decreased in older people with LBP compared to healthy peers, suggesting impaired central proprioceptive processing. Older people with LBP underestimate ankle inversion, which may increase fall risk. Thus, evaluation and training of ankle proprioception may be useful in older people with LBP.

W - Sensorimotor control

P1-W-131: ***Characterising plantar pressure distributions as tactile stimuli during daily activities***

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Background & aim Tactile feedback from the foot sole plays an important role during balance and gait1, as shown by alterations in gait following a reduction in tactile feedback2. Yet little is known about the nature of this sensory feedback, because neural recordings can typically only be obtained under static conditions. Recently developed computational models are capable of simulating neural responses to natural stimuli experienced during daily life3, however require detailed measurements of the associated spatiotemporal pressure distributions as input. So far, research has been limited to investigating quiet standing or walking in a predictable environment. This study aims to expand the range of potential applications by measuring plantar pressures during a range of motor tasks, to characterise the natural pressure experienced at the foot sole during daily life as tactile stimuli. Methods Seven young healthy participants completed up to 15 trials encompassing daily activities, such as walking on different surfaces, jumping, jogging and standing balance (Fig. 1a). Participants wore standardised shoes equipped with TekScan pressure sensitive insoles to record spatiotemporal pressure distributions. Tactile stimuli are classified in terms of complexity using principal components analysis, applied to the time dimension to identify pressure distributions explaining the most variance in the data. The spatial aspect of the stimulus is identified using the weights of each pressure sensor within a component, with higher weights indicating an area of importance. Temporal aspects of the stimulus are identified using the pressure traces at each location of the foot, and are converted into stimulus frequency. The pressure distributions will be used as input to FootSim to stimulate the responses from tactile afferents to understand the tactile feedback during daily activities. Results Preliminary analysis revealed large and consistent differences in both the temporal pressure profiles (Fig. 1b) and spatial pressure distributions (Fig. 1c) across different tasks. Moreover, results showed that walking on a rough and unstable surface elicited more complex spatio-temporal profiles compared to walking on a flat surface. Pressure on the heel, lateral arch and first metatarsal head was consistently identified as making the most important contributions to the overall pressure profile Conclusions & future research Carefully characterising the pressure experienced by the plantar sole in daily life make it possible to begin to discern the role of tactile feedback during such activities. These findings will also have applications in prosthetics research by helping determine the nature of the tactile feedback fed back to amputees to replace lost sensation. Acknowledgements LC is supported by a studentship from the MRC Discovery Medicine North (DiMeN) Doctoral Training Partnership (MR/N013840/1). References 1. Priplata, A. A. et al. The Lancet, 2003; 362:1123-1124 2. Nurse, M. A. & Nigg, B. M. Clinical biomechanics, 2001; 16:719-727 3. Siqueira, R. et al. Society for Neuroscience annual meeting, 2019

P1-W-132: ***Relationship between dynamics of multisensory integration processes and Motion Sickness susceptibility***

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BACKGROUND AND AIM: Numerous empirical and modeling studies have been done to find a relationship between postural stability and the susceptibility to motion sickness (MS). Interestingly, it has been suggested that MS individuals have genuine difficulties in selecting and re-weighting multimodal sensory information. By using Peterka's model of postural control, we investigated the relationship between the dynamics of multisensory integration processes and the MS susceptibility on an individual basis. METHODS: Susceptibility to motion sickness of 43 participants was assessed using the Motion Sickness Susceptibility Questionnaire (MSSQ). Then, the participants stood on a posturographic platform with either eyes open (EO) or closed (EC) for three minutes. The platform was static during the first and last minutes and oscillated during the second minute (0.1, 0.2 or 0.4Hz). The purpose of this transient perturbation was to evoke sensory reweighting strategies to occur. Using novel posturographic analysis techniques, we computed the change in postural oscillation spectrum between the static and perturbation phases during the trial, called hereafter perturbation spectrum differential. We further investigated whether this differential is correlated with MS susceptibility. RESULTS: For each participant, we found that the higher the MSS score, the larger the change in the perturbation spectrum differential between the EO and EC conditions. The time taken to return to the baseline spectrum after the perturbation phase also depended on the reported MS susceptibility. Indeed, the more participants were susceptible to MS, the faster they returned to their baseline postural oscillation spectrum. CONCLUSION: The lower the MSS score, the more similar their perturbation spectrum differential was between the EO and EC conditions (suggesting the use of efficient reweighting strategies). They therefore took longer to return to their baseline postural spectrum, especially with EC in order to recover their initial sensory organization. The more sensitive the participants were to MS, the more likely they were to show differences between EO and EC on their oscillations spectrum and the faster they returned to their initial oscillation spectrum. Thus, people have idiosyncratic ways of performing sensory re-weighting for postural control, these processes being tied to MS susceptibility. On this basis, we now plan to investigate the relationship between initial weights (in low sensory noise condition) and reweighting abilities (in high sensory noise conditions) and how it is linked with sensitivity to motion sickness.

P1-W-133: ***Age Differences in Proactive but not Reactive Inhibition in a Novel Stop-Signal Stepping Task***

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BACKGROUND AND AIM: Falling is associated with reduced executive function in older adults - especially inhibition tasks. Prior work has investigated age effects in 'go/no-go' stepping tasks (measuring response withholding) and Stroop-style stepping tasks

(measuring cognitive interference). Response inhibition (the ability to cancel an initiated movement) may be most applicable to stepping in daily life. The stop-signal task (SST) is the gold-standard paradigm for measuring response inhibition; here we apply the paradigm to stepping for the first time. The aim of this study was to understand how ageing impacts both proactive (i.e., anticipated) stopping and reactive (i.e., unanticipated) stopping in stepping responses, and to determine if response inhibition ability is consistent across upper and lower limbs, with and without balance. METHODS: Healthy young (N = 28, Meanage = 28.89 years, SD = 6.67) and older (N = 28, Meanage = 70.04 years, SD = 4.99) adults completed a SST in three conditions: seated finger responses, seated foot tap responses and forward step responses from quiet standing. In each condition, participants responded as quickly as possible with either left or right limb in response to left- or right-pointing arrows ('Go' cues). An initial block of 32 Go trials established reaction time in each condition. The SST blocks followed (3 blocks x 80 trials x 3 conditions), with a 'Stop' cue (arrow colour change) presented on 25% of trials. The delay between the 'Go' and 'Stop' cue was adjusted with staircase tracking, such that stopping success was ~ 50%, this allowed estimation of reactive inhibition by way of stop signal reaction time (SSRT). Proactive inhibition was calculated as the increase in Go RT in SST relative to initial blocks (i.e., ΔGo). Linear mixed models were conducted to analyse the effect of Age Group and Condition on baseline reaction time, ΔGo, and SSRT. RESULTS Relative to young adults, older adults exhibited slower reaction times across conditions (p <.001). Lower-limb responses were slower than upper limb responses for young and old, and this was particularly evident during stepping (MeanGoFinger = 386.06ms, MeanGoFoot = 455.69ms, MeanGoStep = 699.27ms; p <.001). Older adults engaged proactive inhibition more than younger adults (p = .012). Proactive slowing was more prominent during upper than lower limb responses (p <.001). A significant Age x Condition interaction showed older adults had greater proactive inhibition for finger tap relative to lower limb responses compared to young adults (p = .008). Reactive inhibition did not differ with age (p = .206), but was slower during lower-limb movements regardless of age (MeanStopFinger = 227.20 ms, MeanStopFoot = 332.49ms, MeanStopStep = 380.97ms; p <.001). CONCLUSIONS Although older adults had slower stepping reaction times compared to young adults, their reactive stopping ability was comparable to younger adults. This may indicate a change in the balance of reactive and proactive mechanisms during healthy aging.

P1-W-135: ***Modified visual gain during quiet stance***

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BACKGROUND AND AIM: The visual system plays a vital role in helping to maintain balance during quiet standing tasks [1]. When visual biofeedback is magnified, postural instability has been shown to increase [2,3]; however, there is limited work examining one's postural response through augmenting optic flow. Therefore, by using virtual reality (VR) to apply gain factors to amplify and reduce optic flow, this study aimed to better understand how visual gain contributes to balance control during quiet stance among healthy adults. METHODS: 24 healthy adults (mean age: 23.8, 10 female) were recruited to stand quietly on a force plate or on foam; the order of these two surface conditions was randomized. Each surface condition

included a set of five experimental trials and two baseline trials, each 60-seconds in duration. The baseline trials assessed normal quiet stance (without VR) and were conducted before and after each set of experimental trials. During each experimental trial, participants wore a VR head mounted display (Oculus Rift), exposing them to a full field of view (approx. 110°) virtual environment that replicated a real-world setting. Vizard python programming (WorldViz) was used to apply gain factors of 0.25, 1, 2, 4, or 16 to augment optic flow relative to head motion. For each experimental set, participants were first exposed to normal optic flow in VR (gain value of 1), while subsequent trials were delivered in a counterbalanced order. Centre of pressure (COP) root mean square (RMS), mean power frequency (MPF), and mean power across four frequency bands (LOW: 0-0.1Hz, MED: 0.1-0.5Hz, MED-HIGH: 0.5-1.0Hz, and HIGH: 1.0-5.0Hz) were used to quantify balance. RESULTS: Significant main effects of visual gain were observed across foam conditions in COP MPF ($p<0.001$), RMS ($p<0.01$), and mean power within the MED ($p<0.01$) and MED-HIGH ($p<0.001$) frequency bands. Specifically, on foam MPF was largest at a gain of 16. In contrast, RMS and mean power within the MED and MED-HIGH frequency bands decreased on foam as gain increased. Significant main effects of surface condition were observed across MPF, RMS, and mean power within all frequency bands ($p<0.01$). There were also significant interaction effects between gain and surface condition among MPF ($p<0.01$) and mean power within the MED ($p<0.05$) and MED-HIGH ($p<0.01$) frequency bands. CONCLUSIONS: When there is an increased reliance placed on the visual system, such as by standing on a foam surface, postural stability appears to be significantly influenced by visual gain; this has been shown through a decrease in amplitude and increase in frequency of COP displacement. Lastly, there is evidence that the visual system may be involved in regulating postural sway between frequencies of 0.1-1.0 Hz. Overall, uncovering this relationship between visual gain and balance behaviour can allow us to study the role of visual feedback in balance deficits and fall risk. ACKNOWLEDGEMENTS AND FUNDING: Funded by NSERC (LKL and TWC).
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P1-W-136: ***Perception and Proprioception Changes as Potential Factors for Tripping during Pregnancy***

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Background and Aim: The causes of tripping during pregnancy are unknown but could include multiple intrinsic and extrinsic factors [Dunning 2003]. We have previously shown that all anthropometry combined is only a partial contributor ($r<0.5$) to balance control during pregnancy [Catena 2019]. Understanding the causes of trips and falls will have clinical impacts on the health of pregnant women and health of the fetus. Gestational lumbopelvic change [Whitcome 2007] may predispose the lumbar plexus and sciatic nerve to impingement, degrading lower extremity proprioception. Visual degradation during pregnancy may simultaneously degrade perception [Naderan 2018]. Our goal is to evaluate how perception of the environment and of the body relate to obstacle avoidance through gestation. Methods: We have collected data from fourteen pregnant women, but the data here represents five participants. Starting at 13 weeks gestation, pregnant women were tested five times in 6-week intervals, to 37 weeks gestation. First, obstacle perception (OP) was tested by asking participants to match their foot height to a 10% body height obstacle 2.7 m in front of them with eyes closed and then eyes open. Second, joint position senses (JPS) were tested at the hips and knees by asking participants to actively match their hip and knee angles to a passively created joint angle. Finally, participants walked an obstacle course (OC) at a self-selected speed for 2 minutes. Obstacles randomly set to 5%, 7.5%, and 12.5% of each participant's body height served as distractors. Crossing heights only over the two 10% obstacles and minimum distance to the 10% obstacles were measured for trailing and leading foots. Results: Regardless of visual information, OP significantly degraded through the second trimester of pregnancy ($p=0.003$) (Figure 1). During OC, participants had a 39% reduction in trailing foot crossing height over time ($p=0.009$) and a 33% reduction in the minimum distance of the trailing foot to the obstacle over time ($p=0.045$). OP change, the amount of foot height change over 5 seconds as participants were told to keep their foot matched to the height of the obstacle, was correlated with reduced trailing foot obstacle distance ($\beta=-2.185$, $r=0.572$, $p=0.004$). There were no statistically significant changes in JPS throughout pregnancy ($p>0.194$), but this may be due to a currently low sample of 5, and may change as data from more individuals are analyzed. Conclusion: OP and JPS findings combined currently suggest that that visual perception changes, rather than proprioceptive change, may influence trip rates during pregnancy. Since this is regardless of eyes being open, the problem is not related to working memory. The next step is to dissect early visual processes like visual acuity, alertness, and visuospatial orientation. Also, we must uncover why OP improves in the 3rd trimester, after degrading through the 2nd trimester.

P1-W-137: ***Cutaneous Reflexes at the Calf are Modified by Noisy Vibration***

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BACKGROUND AND AIM: In individuals with leg amputation who use a prosthesis, the skin of the residual limb acts as the interface with the ground. Hairy leg skin is not optimized for this function and would benefit from sensory augmentation. Stochastic resonance (SR) is a phenomenon where the addition of subthreshold noise to a system augments its performance. Imperceptible tactile noise stimuli applied to the skin of the feet improves perception and balance and enhances posture-correcting cutaneous reflexes. It is unknown if these reflexes exist in the thigh and if SR can enhance them. This study looked to determine 1) if calf skin stimulation produces cutaneous reflexes in the quadriceps, 2) if noise can modify the reflex, and 3) if one intensity of noise is most effective. METHODS: In 20 young, healthy adults, 5 trials of 200 electrotactile pulse trains (5x1 ms, 3 ms between pulses, 80-100 ms between trials) at twice perceptual threshold were applied at the calf (10 cm below the popliteal fossa) to evoke a cutaneous reflex, while participants performed isometric knee extension at 15 %MVC. To test for an SR effect, vibrotactile noise was applied at varying levels (0, 20, 40, 60, 80 and 100% of perceptual threshold) at the same location and simultaneously with the electrotactile pulse train. Two trials of 200 pulse trains were given at each noise level and levels were randomized. Muscle activity from the vastus lateralis was analyzed 60-110 ms after stimulation to identify the presence of a middle latency cutaneous reflex (> 2 SD for 5 ms). Reflex ratios were calculated by dividing the reflex peak activity by the pre-stimulation background muscle activity for all trials. RESULTS: A significant reflex response was evoked in 16 of the 20 participants. In 8 participants the reflex was excitatory (ratio = 52.91±34.2%, latency = 80.17±15.4 ms) and in 8 it was inhibitory (ratio = 55.37±16.6%, latency = 82.13±11.6 ms). In all participants, the reflex was modulated at some level of added vibrotactile noise. This varied between participants: in 3, the muscle activity increased to a maximum of ~44% greater; in 6, it decreased to a minimum of ~61% less; in 11, a new response appeared that did not appear in the no-noise condition. There were no significant differences in the change in reflex response across noise levels (facilitation: $p = 0.244$; inhibition: $p = 0.137$). CONCLUSIONS: Calf skin stimulation can evoke cutaneous reflexes in the vastus lateralis, at a middle latency response and at a similar magnitude to those seen from foot sole stimulation. We also showed that added noise was able to significantly alter the reflex magnitude, consistent with a previous study at the foot sole. Further work should investigate the presence of cutaneous reflexes in individuals with amputation, as this work may lay the foundation to develop prosthetic devices to enhance sensation and improve balance control.

P1-W-138: ***Foot plantar information evaluation during a static task***

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BACKGROUND AND AIM: Researchers use foam pads to disturb podal information and challenge the postural control during static and locomotion task [1,2]. However, the disruption tool is not standardized and there is a wide variety of foams in terms of thickness and physical characteristics (e.g., density, elasticity,...). The thickness and hardness of the foam induce different responses on the static balance [2,3]. In clinical routine, podiatrists use foam to evaluate plantar information and its efficiency on a stabilometric platform. In particular, they compute the plantar quotient (PQ) which is the ratio between the oscillation surface of the center of pressure (CoP) with and without the foam. QP allows to identify sub-populations with different plantar integration during mechanical stimulation [4]. Our aim is to evaluate the effect of foam characteristics on PQ and determine oscillation norms in healthy adults This will enable to better understand plantar mechanical integration and to standardize clinical practices with regards to foam characteristics and the identification of non-physiological response. METHODS: 97 healthy participants volunteered to this study.They were asked to stand still on a stabilometric plaform. We manipulated 2 factors, namely vision (eyes open or close) and foam type (control (no foam) or with a foam pad interposed between the feet and the platform: Depron(r) 6mm, Orthomic(r) 5mm or Plastazote(R) 5mm). Each participant performed then in a randomized order 24 trials 2 Vision*4 Foam *3 repetitions.. We computed the 95% confidence area of CoP oscillations as well as within and between subject variability We also computed PQ. RESULTS: No significant effect of foam was observed. CONCLUSIONS: Our results do not confirm previous work with foams in static conditions. Future work is needed to better understand the effect of this insert

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P1-W-139: ***Bayes'd and Confused: Bayesian inference reveals decreased sensorimotor uncertainty as a result of Transcutaneous Electric Nerve Stimulation (TENS)***

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Background and aim Transcutaneous electric nerve stimulation (TENS) is a method of electrical stimulation where the applied current is targeted directly at sensory nerve fibers. When applied to muscles of the lower extremities during mobility and balance related movements, TENS improves clinical metrics of mobility and motor function. However, while TENS primarily elicits activity in the sensory nerve fibers, the underlying perceptual mechanisms that are impacted by this altered somatosensory input leading to improved motor performance are unknown. Bayesian inference is a statistical model of probability that has been applied to motor control to understand how sensory uncertainty influences a person's belief regarding where they are in space as they perform motor movements. The aim of this study was to use Bayesian inference to understand how TENS impacts sensorimotor uncertainty during a full-body stepping movement. We hypothesized that TENS applied to the vastus lateralis and tibialis anterior of each leg during the movement would minimize the uncertainty in the incoming sensory input and lead to decreased uncertainty in body position estimates. Methods Thirty healthy adults completed a motor learning protocol in virtual reality, with and without TENS applied during the assessment, on two separate visits to the lab, each visit separated by at least two weeks. Participants were randomly assigned to one of three groups: TENS on first visit only (TN), TENS on second visit only (NT), or a control group where TENS wasn't applied on either visit (NN). On each visit, participants completed the assessment in virtual reality where they moved their center of mass (CoM) to various targets with a single step. Using methods of Bayesian inference that have been validated in previous research, we calculated the amount of uncertainty in participants' CoM position estimates on each visit. Results A significant group (NN, NT, TN) by visit interaction in CoM position uncertainty provides evidence that the groups responded differently on the two visits. Pairwise comparisons showed that the NN group did not differ between the two visits while both groups that received TENS (NT, TN) decreased their

uncertainty in the second visit. Though not statistically significant, the TN group displayed the least uncertainty among the three groups on the first visit and then significantly decreased their uncertainty in the second visit. Conclusion These results suggest that the observed benefits seen with TENS are due to decreased sensory uncertainty. This promotes less uncertainty in estimates of the involved body positions during mobility. We also provide evidence that the benefit is retained in future movements if TENS is applied early in motor learning. With this knowledge, TENS could be applied in various ways and populations to improve sensorimotor control allowing individuals to improve the quality of their sensory input and, plan and execute more efficient movements.

X - Tools and methods for posture and gait analysis

P1-X-140: ***Sample Size Justifications in Gait & Posture***

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BACKGROUND AND AIM: Context regarding how researchers determine the sample size of their experiments is important for interpreting the results and determining their value and meaning. Between 2018 and 2019, the journal Gait & Posture introduced a requirement for sample size justification in their author guidelines. We aimed to address the following question: How frequently and in what ways are sample sizes justified in Gait & Posture research articles and was the inclusion of a guideline requiring sample size justification associated with a change in practice? METHODS: The guideline was not in place prior to May 2018 and was in place from 25th July 2019. All articles in the three most recent volumes of the journal (84-86) and the three most recent, pre-guideline volumes (60-62) at time of preregistration were included in this analysis. This provided an initial sample of 324 articles (176 pre-guideline and 148 post-guideline). Articles were screened by two authors to extract author data, article metadata and sample size justification data. Specifically, screeners identified if (yes or no) and how sample sizes were justified. Six potential justification types (Measure Entire Population, Resource Constraints, Accuracy, A priori Power Analysis, Heuristics, No Justification) and an additional option of Other/Unsure/Unclear were used. RESULTS: In most cases, authors of Gait & Posture articles did not provide a justification for their study's sample size. The inclusion of the guideline was associated with a modest increase in the percentage of articles providing a justification (16.6% to 28.1%). A priori power calculations were the dominant type of justification, but many were not reported in enough detail to allow replication. CONCLUSIONS: Gait & Posture researchers should be more transparent in how they determine their sample sizes and carefully consider if they are suitable. Editors and journals may consider adding a similar guideline as a low-resource way to improve sample size justification reporting.

P1-X-141: ***Improving gait speed assessment for health screening: An assessment of individualised effects of timing and distance errors associated with different threshold crossing and identification methods***

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Introduction: Gait speed has been proposed as the "sixth vital sign" and is considered one of the best indicators of future health outcomes. However, a major issue is that there are numerous methods of gait speed assessment which produce results which are not directly interchangeable. For example, methods use different a) starting thresholds, for example standing still or flying starts; and b) line crossing thresholds, for example the first part of the foot crossing a line in the air vs. the entire foot crossing the line on the ground. These differences can cause systematic errors, some of which may washout if enough trials are performed; however, this is not typically feasible in public health screening due to time constraints and fatigue. The aim of this study was to examine how common methodological differences in stopwatch-based walking speed assessment impacted outcomes of trials. Methods: 31 people performed 30 walking trials each consisting of two speeds (self-selected and fast) and three different threshold identifiers (toes crossing line, entire foot crossing line, centre of mass crossing line) on two separate occasions. Trials were assessed by two assessors walking with the participant, each with a custom electronic stopwatch, consisting of microcontrollers with non-latching push button switches and real-time clocks. Timings for the first movement of the gait speed trial from a standing position, crossing of a 2m line, and crossing of an 8m line were synchronised with a light detection and ranging (LIDAR) sensor that was used to measure the position of the participant on the walking track. From these data we obtained key variables including the timing and walking distance difference between assessors, within day for each of the splits (1: standing still to identification of the start of the walk; 2: start of the walk to 2m; 3: 2m to 8m) and the same analysis for the difference within assessors, between days. Results: The median 6m walking distance (i.e. flying start 2m to 8m) was 586cm, indicating accuracy at a group level. However, at an individual level the interquartile range (IQR) for the distance measured was inconsistent across threshold identification methods within assessors, ranging from 31cm (5% error) to 43cm (7% error). The toe crossing method was the most consistent (median=13cm, IQR=35cm), with the foot crossing (median=23cm, IQR=44cm) and COM crossing (median=21cm, IQR=52cm) inducing noticeably more variance between assessors. Similar findings were observed for the distance measurement of starting threshold crossing to 2m, with the median measured distance (184cm) having a similar fixed bias with respect to a shorter distance measured than expected. Again, the toe crossing method had the lowest IQR (38cm), followed by the foot (43cm) and COM (50cm). Other results will be presented at the conference. Conclusion: In conclusion, the choice of line crossing thresholds and distance walked is non-trivial and may have a significant impact on gait speed measurement at an individual level.

P1-X-142: ***Effect of subcortical neuromodulation on cortical stimulation induced motor output: a probe of subcortical motor pathways?***

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BACKGROUND AND AIMS: The reticulospinal and vestibulospinal tracts are known to play a key role in the control of posture and balance yet are difficult to directly assess in humans due to their subcortical origin. However, cortico-reticulospinal contributions to responses elicited by dirrect stimulation of the motor cortex are shown to occur ~10 ms later than those driven by corticospinal input in monkeys (2). We hypothesized that the area of late responses (10-30 ms after response onset) but not early responses (0-10 ms after response onset) to cortical stimulation in the upper limb would significantly increase in amplitude when cortical stimulation was combined with acoustic startle (AS); galvanic vestibular stimulation (GVS) or both. METHODS: Transcranial magnetic stimulation (TMS) was applied to the motor cortex of participants (n = 7) targeting the upper-limb. EMG activity was recorded during isometric contractions (5% MVC) of the first dorsal interosseous and biceps brachii muscles. Motor evoked potentials were produced and response area quantified across conditions combining TMS with acoustic startle (115dB), GVS or both.` RESULTS: A one-way repeated measures ANOVA shows that late responses differed significantly across stimulation conditions ($F = 2.81$, $p = 0.027$) whereas early responses did not change. Post-hoc t-tests revealed an increase in the area of the late response when TMS was combined with AS only, and only in the biceps brachii (tstat = -4.32, p = < 0.001). A regression analysis showed that there was no relationship between the change in amplitude of the early and late responses ($R2 = 0.0524$, $p = 0.62$). CONCLUSION: These results support the idea that the reticulospinal tract is activated by TMS in humans and that it is involved in the transmission of the late component of upper limb muscle responses to TMS. TMS may be a viable tool to assess the state of the reticulospinal tract in humans. 1. Peterson, B.W., 1979. Reticulospinal projections to spinal motor nuclei. Annual review of physiology, 41(1), pp.127-140. 2. Fisher, K.M., Zaaimi, B., Edgley, S.A. and Baker, S.N., 2021. Extensive cortical convergence to primate reticulospinal pathways. Journal of Neuroscience, 41(5), pp.1005-1018.

P1-X-143: ***Estimation of spinal alignment during walking based on a single digital video camera: comparison with 3D motion capture***

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BACKGROUND AND AIM:Spinopelvic parameters using whole-spine radiographs with the patient in a standing position have been widely used as the criterion standard for diagnosis, as prognosis values, and as surrogate outcome measures after surgery in patients with adult spinal deformity (ASD). However, their symptoms and posture deteriorate occur while walking, which suggests that the pathology of ASD includes a dynamic factor as a result of their deformity. We consider that static evaluation alone might not be enough to understand the pathology of ASD, and dynamic alignment change is clinically important. Thee-dimensional (3D) gait motion capture analysis has been applied to healthy subjects, and various kinds of spinal deformity including dropped head syndrome, iatrogenic fallback syndrome, and ankylosing spondylitis. In order to complement the radiographic findings in the static standing position for adult spinal deformity and decubitus syndrome, we have been evaluating spinal alignment during gait (Dynamic SVA) using a 3D motion measurement system (Miura et al. 2020). Although optical 3D motion measurement could provide highly accurate information, the amount of work setting up the device and analyzing the measurements poses were a challenge for clinical application. In recent years, based on the development of artificial intelligence and computer performance, quantification of human motion from video camera images has been reported. It will be possible to obtain a wide range of data when such a method used to evaluate Dynamic SVA. In this study, we estimated the Dynamic SVA change based on the human body model automatically recognized from the video camera images and compared it with the 3D motion measurement. METHODS:This study included 8 patients (5 patients of Kyposis, 3 drop head head drop patients). A total of 8 patients (2 males and 6 females), 5 with bent backs and 3 with dropped necks, were included in the study. Continuous walking on level ground was performed until it became difficult for them to continue. Dynamic SVA was calculated from the coordinates of the surface markers on the spinous. Dynamic SVA was calculated from the coordinates of surface markers on the spinous process using 3-D motion measurement (VICON). We captured their saggital video during walking, and used the movie data to recognize the human body motion using VisionPose software. The trunk alignment was calculated by the pixels in the horizontal direction of the image. RESULTS:In 8 cases, the amount of change in Dynamic SVA due to the difference before and after the walking was +6.9,+37.6,+16.2,+8.6,+39.5,+50.9,+17.8,+182.1mm by 3D motion measurement, and -8.7,+18.0,+2.3,+3.1,+15.1,+18.0,+2.5,+38.7 pixels by estimation from video camera images. A correlation was observed in the regression analysis (absolute value: $p<0.01$, $R2=0.815$, increase/decrease: $p=0.023$, $R2=0.779$). CONCLUSIONS:There is a possibility that Dynamic SVA changes during prolonged walking could be estimated using 2D video images. In the future, we will consider the necessity of calibration and the possibility of gait analysis from video camera images based on the consideration of the relationship with pathological conditions.

P1-X-144: ***Automatic freezing of gait annotation with deep learning and simulated inertial measurement unit data***

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BACKGROUND AND AIM: Freezing of gait (FOG) is one of the most debilitating motor impairments of Parkinson's disease (PD). There is broad interest in IMU-based FOG assessment, as it has the potential to assess FOG not only in the lab but also at-home. Existing automatic FOG detection methods employ a sliding-window scheme to segment an IMU sequence into fixed partitions. Next, a single label is predicted for all the samples of a partition. However, the samples within a pre-defined partition may not always share the same label. Therefore, manually defined heuristics are imposed to force all samples to take a single label, most commonly by majority voting. Moreover, the duration of the sliding window

imposes a trade-off between expressivity, i.e. the ability to capture long-term temporal patterns, and sensitivity, i.e. the ability to identify short-duration FOG episodes. To address these issues, we generalized the problem of FOG annotation to that of sample-wise activity segmentation. By generating a prediction for each sample, our frameworks rely only on the observations and their assumed model and not on manual assumptions that are unlikely to generalize across study protocols. METHODS: We included three state-of-the-art deep learning (DL) activity segmentation models. More specifically, bidirectional long short-term memory networks (LSTM) [1], multi-stage temporal convolutional neural networks (MS-TCN) [2], and multi-stage spatial-temporal graph convolutional neural networks (MS-GCN) [3]. The models aimed to transform a given IMU sequence X = x0,...,xT into a predicted output sequence Y = y0,...,yT. An optical motion capture dataset of seven PwPD with FOG was used. The FOG episodes were manually annotated by a clinical expert. The trajectories of seven anatomical landmarks (pelvis, left/right knees, left/right ankles, left/right toe base) were used to simulate IMU data [4]. The deep learning frameworks were quantitively assessed with a segment-wise F1 score (F1@50) and sample-wise Matthew's correlation coefficient (MCC). For the trials with FOG, the mean absolute percentage error (MAPE) between the model and expert percentage time frozen (%TF) was computed per subject. All results were derived by following a leave one subject out evaluation protocol. RESULTS: Of the DL models, the MS-GCN model performed the best across both metrics, with an F1@50 of 80.7 and MCC of 79.5. This is an average percentage increase of 4.8 in F1@50 and 7.4 in MCC compared to the second-best model (MS-TCN). The MS-GCN framework enabled a valid estimation of %TF for 5 of the 7 subjects, with MAPEs < 20%. CONCLUSIONS: The proposed frameworks enable accurate and automated FOG annotation without requiring predefined partitioning of the IMU sequences and form the basis for future analysis of large IMU-based FOG-detection datasets. ACKNOWLEDGEMENTS AND FUNDING: [1] Graves A., and Schmidhuber J.. 2005. Neural Networks 18 (5-6): 602-10. [2] Farha, Y. A., and Gall J.. 2019. arXiv [cs.CV]. arXiv. http://arxiv.org/abs/1903.01945. [3] Filtjens B., Ginis P., Nieuwboer A., Slaets P., and Vanrumste B.. 2021. arXiv [cs.CV]. arXiv. http://arxiv.org/abs/2103.15449. [4] Young, A. D., M. J. Ling, and D. K. Arvind. 2011. IPSN, 199-210.

P1-X-145: ***Comparison of methods for determining parameters related to ankle joint stiffness during quiet standing***

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Human bipedal stance is inherently unstable. The ankle joint plays an important role to control the centre of mass during upright standing. As a result, the overall stiffness of the ankle joint, i.e., "quasi-stiffness", relation between the resultant ankle torque and displacement, can be an important measure that approximately represents the overall ability of the postural control system. Winter et al. (Winter et al., J Neurophsiol 80: 1211-1221, 1998) had estimated the quasi-stiffness (Kqs-1) of the ankle by approximating quiet standing as an inverted pendulum with a mass-spring-damper model. Alternatively, Loram and Lakie (Loram and Lakie, J Physiol 540: 1111-1124, 2022) determined the quasi-stiffness (Kqs¬-2) by decomposing the postural sway into unit sways. Thus, the first aim of this study was to compare these two methods of calculating quasi-stiffness. Another method called stabilogram diffusion analysis proposed by Collins and De Luca (Collins and De Luca, Exp Brain Res 103: 151-163, 1995) has been often used to assess postural control in patient populations using the centre of pressure. The scaling exponent, Hs, captures the short-term dynamics (approximately below 1 sec) of postural sway and has previously shown differences between healthy and at-risk individuals. Hs is thought to be related to differences in stiffness, as lower Hs relates to lower muscle activity and less stiffness or higher Hs and greater muscle activity and stiffness. Thus, the second aim of this study was to investigate whether Hs indeed relates to stiffness by comparing it to both Kqs-1 and Kqs-2. Eleven able-bodied individuals (20.7±3.6 years) were asked to stand quietly with their eyes open (EO) and eyes closed (EC). Body kinematics and kinetics were recorded using a motion capture system and a dual force plate, respectively. From these, the Kqs-1, Kqs-2 and Hs were calculated. To compare these measures, the Pearson's correlation coefficients between Kqs-1 to Kqs-2, and Kqs-1/Kqs-2 to Hs were calculated for both EO and EC conditions. We found that Kqs-1 and Kqs-2 were highly correlated in both EO ($r = 0.844$) and EC ($r = 0.862$) conditions. However, their mean values were found to be different in both EO ($p = 0.003$) and EC ($p = 0.020$) conditions. Additionally, moderate correlations were found between Hs and Kqs-1 for both EO ($r = -0.706$) and EC ($r = -0.674$) conditions. Similarly, moderate correlations were found between Hs and Kqs-2 for both EO ($r = -0.669$) and EC ($r = -0.611$) conditions. A high correlation between Kqs-1 and Kqs-2 was found suggesting that measurements of Kqs-1 and Kqs-2 capture similar stiffness attributes. Additionally, moderate correlations between Kqs-1/Kqs-2 and Hs suggest that the stochastic characteristics of centre of pressure in the short period indeed reflects the overall stiffness at the ankle joint. Further investigations may reveal these measures can be usable to evaluate the postural control system.

P1-X-146: ***Increased rollator handle support requires more complex muscle coordination when standing up***

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BACKGROUND AND AIM: Falls are the leading cause for injuries in older individuals [1] and often occur when standing up [2]. Standing up is physically demanding and less straightforward when getting older as the neuromuscular system deteriorates with age [1]. Walking aids are basically intended to help, but paradoxically increase fall risk [1]. Standing up requires simultaneous coordination of the upper and lower body and thus controlling many redundant degrees of freedom [3,4]. To cope with that, the central nervous system may use a modular control architecture [5]. As the experimental paradigm is novel, we started with young adults to collect baseline data enabling a clear distinction from impaired individuals. This study investigates the effect of handle support on coordination when standing up. We hypothesized that (1) increased handle support increases motor coordination complexity and that (2) cross-condition and condition-specific muscle synergies can be found. METHODS: Ten male and ten female adults (26±5 years) stood up in three conditions: unassisted, touching, and full support of the handles. Thirty EMG electrodes captured full body muscle activity. Muscle synergies were extracted from EMG with NMF [6]. Motor coordination complexity was expressed by the number of muscle synergies required to explain 90% of variance in the EMG data and tested for condition differences with ANOVA and post-hoc t-tests. Muscle synergy similarity was quantified with cosine similarity (r). If r were greater than 0.8, muscle synergies were considered similar and used across conditions. RESULTS: Two to five synergies were required for unassisted standing up, three to five with touching, and three to six with full support. Standing up with full support required more synergies than unassisted standing up ($p=0.004$). Eighteen participants showed a synergy representing knee extension and ankle dorsiflexion across all conditions ($0.88<r<0.97$). Twelve showed a pelvis stabilization and upper body uprighting synergy across the unassisted and touching ($0.83<r<0.96$), and twelve an arm extension synergy across the touching and full support condition ($0.81<r<0.94$). CONCLUSIONS: Standing up with full support from handles may increase motor coordination complexity. The knee extension and ankle dorsiflexion synergies seem to be used regardless the level of support. Pelvis stabilization and upper body uprighting may be coordinated differently with full support. Handle support may require specific synergies, which control arm involvement. Full support may assist standing up with weak leg muscles, but possibly increases the complexity of coordinating the movement. ACKNOWLEDGEMENTS AND FUNDING: This research was funded by the Federal Ministry of Education and Research and the Baden Wuerttemberg Ministry of Science as part of the Excellence Strategy of the German Federal and State Governments and supported by the Heidelberg Karlsruhe Research Partnership (HEiKA). 1 Ambrose et al. Maturitas 75, 51-61, 2013 2 Rapp et al. J. Am. Med. Dir. Assoc. 13, 187.e1-6, 2012 3 Reisman et al. Gait Posture 15, 45-55, 2002 4 Bernstein. Pergamon, 1967 5 Giszter. Curr. Opin. Neurobiol. 33, 156-165, 2015 6 Lee et al. Adv. Neural Inf. Process. Syst. 13, 556-562, 2001

P1-X-147: ***Functional Gait Assessment performance in older adults is associated with wearable sensor derived metrics***

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BACKGROUND AND AIM: Detection of fall risk in older adults is essential for early intervention and prevention. The Functional Gait Assessment (FGA) is a clinical assessment used to evaluate gait steadiness during different tasks and detect fall risk. The FGA has high inter- and intra-rater reliability, internal consistency, and predictive validity for falls. Wearable sensors (e.g. accelerometers) are becoming increasingly popular in monitoring gait. Older adults at high fall risk often have slow gait speed, slow cadence, high step time variability, and less symmetry as measured with accelerometers. The purpose of this study was to investigate the relationship between FGA performance and accelerometer metrics from a 400 meter walking test (400MWT) in low and high fall risk older adults and to compare these approaches for detecting fall risk. METHODS: Data from 36 older adults (61% female, 94% white, 72.9 ± 5.8 years) recruited as part of the larger NIH-funded Move MYHAT study were used in this secondary analysis. Subjects performed the FGA and 400MWT on a level surface around a 40m oval while wearing an accelerometer attached to the low back. The FGA consists of ten tasks reflective of daily walking including gait on level surface, gait with increase in speed, gait with horizontal head turns, gait with vertical head turns, gait with pivot turn, gait with step over obstacle, gait with narrow base of support, gait with eyes closed, gait backwards, and stairs. Each task is rated 0-3 (best) by an observer for quality and speed of movement for a maximum total score of 30. Accelerometer data during the 400MWT were used to determine gait speed, cadence, step time variability, and harmonic ratio (a measure of symmetry). A Box-Cox transformation was applied to non-normal variables. For analysis, participants were grouped as higher fall risk (FGA total ≤ 22) or lower fall risk, based on an established FGA cutoff score to identify fall risk in older adults. One-tailed t tests were performed on accelerometer metrics between groups. The Benjamini-Hochberg correction was applied to reduce the false discovery rate. RESULTS: The higher risk group [H] was significantly older than the lower risk group [L] (76.4 [H], 70.6 [L] years; p<0.01). The higher risk group (N=14) showed significantly slower gait speed (1.0 [H], 1.3 [L] m/s; p<0.01), slower cadence (111 [H], 117 [L] steps/min; p=0.01), increased step time variability (36.3 [H], 30.1 [L] msec; p=0.03), and lower harmonic ratio in the anterior-posterior direction (2.3 [H], 2.9 [L]; p<0.01) compared to the lower risk group. CONCLUSIONS: These results show that fall risk in older adults based on FGA performance is consistent with poorer accelerometer metrics. Thus, identifying higher fall risk in older adults can be done with clinical assessments or wearable sensors. ACKNOWLEDGEMENTS AND FUNDING: Thanks to Jason Weger for assistance. U01 AG061393; R37 AG023651; P30 AG024827

P1-X-148: ***Validation of algorithm using wearable accelerometers for measuring spatiotemporal gait parameters during straight walking and continuous turning***

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BACKGROUND AND AIM: Spatiotemporal gait parameters are important biomarkers of movement disorders and allow for objective measurement of gait performance. Inertial measurement units (IMUs) allow for the study of unconstrained walking in a wide range of environments providing ecologically valid research. However, measurements from IMUs must be validated against a gold standard (e.g. optoelectronic systems). While several studies have validated IMUs for steady state walking on treadmills or in a straight line, few have validated more complex conditions, such as walking while turning. The aim of this study was therefore to validate an algorithm for calculating spatiotemporal gait parameters using measurements from IMUs obtained during both straight walking and walking while turning. METHODS: A total of 9 healthy participants (5 females, age 39.9±8.3 years) were equipped with IMU sensors with 3 degrees of freedom (DOF) accelerometer, 3DOF gyroscope, and 3DOF magnetometer (APDM; Opal, Portland, US) positioned on the lumbar and ankles. The algorithm using IMU sensors were validated against a 12-camera 3D capture system from Vicon (Oxford Metrics, UK). Each participant performed 3 trials of straight walking (approx. 10 m) and 3 trials walking with continuous turns at different walking speeds (approximately

1.2 m/s, 0.9 m/s, 0.6 m/s). The turning condition consisted of a track of cones with 45 and 90 degree turns to the left and right. The participants were instructed to alternate between turning around yellow and orange cones and ignore white cones (Figure 1). Using a single lumbar IMU sensor, heel strike (HS) and toe off (TO) detection using continuous wavelet transform (CWT) was performed on anterior-posterior acceleration data. Spatiotemporal gait parameters were calculated from the timing of HS and TO as well as with an inverted pendulum model in MATLAB (R2021a, MathWorks, US). Intraclass correlation coefficients (ICCA,1) were calculated for absolute agreement between Vicon and APDM measurements (mean of gait cycles) for trials at each different speed. RESULTS: Preliminary results showed excellent agreement between the optoelectronic system and the APDM system for cadence and step time for both straight and turning conditions (cadence ICCs 0.97-0.99 and 0.88-0-94 straight/turning, and step time ICCs 0.98-0.99 and 0.83-0-93 straight/turning), but poor for single support (ICCs 0.25-0.54 and 0.21-0-35 straight/turning) and double support (ICCs ≤ 0.1). Walking speed was underestimated and had poor to moderate agreement for medium and high walking speed trials (ICCs 0.31-0.37 and 0.61-0.73 straight/turning) but very poor agreement for slow trials (ICCs < 0.1). CONCLUSIONS: Valid measurements can be obtained for some gait parameters from single IMUs even in more complex walking conditions, with the turning condition accuracy being only slightly lower than straight walking. However, improvement remains to be found for some temporal parameters as well as spatial parameters which were generally underestimated. ACKNOWLEDGEMENTS AND FUNDING: We thank all participants in the study and the uMOVE core facility at KI. Supported by grants from the Doctoral School in Health Sciences and the Strategic Research Area in Health Care Sciences at KI.

P1-X-149: ***Exploration of single & dual task gait and turning in Sports Related Concussion***

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BACKGROUND & AIM: Sports-Related Concussion (SRC) encompasses symptom, visual, cognitive and motor impairments, where accurate and timely recognition is crucial to reduce incidences of misdiagnosis, which can increase morbidity risk [1]. Yet current non-digital tools, e.g Sports Concussion Assessment Tool (SCAT5) criteria [2] relies on symptom resolution as the main precursor for return to play (RTP) and struggle to monitor subtle impairments (motor e.g., gait) which may remain impaired after RTP. Digital tools (inertial wearables) may detect subtle differences [3]. Here we aim to evaluate differences in inertial gait (with turns) among athletes with a recent concussion compared to none. METHODS: 12 males (20.3±1.1 years: 100.8±17.0 kg, 1.8±0.1 meters) with recent (<12months) concussion (n=5) and without were recruited. Participants completed self-reported symptoms (number and severity via SCAT) and neurocognitive scores (reaction time, amplitude discrimination and reaction time) via BrainGauge (Corticalmetrics, USA). For inertial gait, all participants walked back and forth between two markers (8m) for 2mins under single and dual-task (max reverse digit span). Participants wore inertial wearables (Opals V2; APDM Inc,128Hz) on each foot and lower back which quantified gait and turning outcomes. Gait outcomes

included stance time, step time, stride time, swing time, stride length, stride velocity. Turning included duration, peak and average velocity. RESULTS: There were no significant differences between groups for symptom and neurocognitive scores. Preliminary gait and turning results found no significant differences (p>0.05) between groups during single task assessment. However, under dual-task gait assessment, there were significant differences (p<0.05) between groups for step time asymmetry (p=0.026) and gait speed (p=0.031). There were no differences (p>0.05) between groups during dual-task turning. CONCLUSIONS: Traditional approaches alone [2] may be insufficient for SRC assessment and may need to be supplemented with digital approaches. Preliminary results suggest that dual-task gait may better differentiate those with a recent SRC history. Inertial wearables enables detection of subtle motor deficits which may be unresolved long after RTP. Future research should explore wearables to explore free-living gait to facilitate in-depth monitoring of SRC impairments. ACKNOWLEDGMENTS This work was supported in part by the Private Physiotherapy Education Foundation (PPEF) under Grant RPJ03732. D. Powell holds a PhD scholarship from the Faculty of Engineering & Environment. REFERENCES [1] Stewart at al, Chronic traumatic encephalopathy: a potential late and under recognized consequence of rugby union? (2016). [2] Echemendia et al, The Sport Concussion Assessment Tool 5th Edition (SCAT5): Background and rationale, Br. J. Sports Med (2017). [3] Powell et al, Investigating the AX6 inertial-based wearable for instrumented physical capability assessment of young adults in a low-resource setting, Smart Health (2021).

P1-X-150: ***Assessment of Balance Performance Differences Among Physically Active and Inactive Adults with Obesity***

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BACKGROUND AND AIM: Poor performance during static balance testing has been linked to fall risk and disability development. Adults with obesity have shown to demonstrate poorer balance than their normal-weight counterparts. Further, balance performance is known to decline with aging. Exercise can improve balance performance and decrease injury risk. However, the influence of regular physical activity on balance performance in middle-aged adults with obesity is not well described. This work aims to understand if a standard assessment can detect differences in balance performance between physically active (PA) and inactive (IA) middle-aged adults with obesity. METHODS: Twenty middle-aged adults with obesity (11 PA (6 female): age 50.4±8.0, body mass index (BMI) 37.0±3.7 kg/m2; 9 IA (7 female): age 54.6±6.9 years, BMI 36.8±3.6 kg/m2) were recruited to participate in this study. Participants reported good health and no history of conditions affecting walking or balance. They completed the modified clinical test of sensory interaction in balance (MCTSIB) while center of pressure (COP) was recorded. The MCTSIB contains four conditions: firm surface eyes open (MCTSIB1), firm surface eyes closed (MCTSIB2), foam surface eyes open (MCTSIB3), and foam surface eyes closed (MCTSIB4). COP root mean square (RMS) in the anteroposterior (AP) and mediolateral (ML) directions, and sway velocity were calculated. Two sample t-tests compared RMS-AP, RMS-ML, and sway velocity between groups for each condition. RESULTS: Differences in RMS between groups did not reach statistical

significance for any of MCTSIB conditions in the AP (MCTSIB1: 4.7.1±3.3mm PA vs. 6.5±5.0mm IA, p=0.52; MCTSIB2: 5.0±3.3mm PA vs. 10.1±16.4mm IA, p=0.91; MCTSIB3: 3.7±2.5mm PA vs. 7.5±6.1mm IA, p=0.09; MCTSIB4: 2.8±2.2mm PA vs. 6.6±5.2mm IA, p=0.09) nor ML (MCTSIB1: 4.7±3.1mm PA vs. 5.5±3.7mm IA, p=0.79; MCTSIB2: 4.4±3.0mm PA vs. 11.9±19.1mm IA, p=0.27; MCTSIB3: 3.4±1.6mm PA vs. 6.0±4.8mm IA, p=0.14; MCTSIB4: 4.3±3.0mm PA vs. 4.8±3.1mm IA, p=0.62) directions. Further, no statistically significant differences for sway velocity were found between groups (MCTSIB1: 10.1±4.1mm/s PA vs. 11.6±8.8mm/s IA, p=0.61; MCTSIB2: 16.2±8.5mm/s PA vs. 17.5±9.4mm/s IA, p=0.74; MCTSIB3: 16.5±6.8mm/s PA vs. 20.9±11.8mm/s IA, p=0.30; MCTSIB4: 38.8±22.4mm/s PA vs. 40.1±20.2mm/s IA, p=0.90). CONCLUSIONS: The MCTSIB showed increased RMS and sway velocity under all conditions for the IA group compared to the PA group, though these differences did not reach statistical significance; future work may assess this trend with a larger sample size to mitigate any effects of being underpowered. However, it is also possible the MCTSIB was not challenging enough for these participants to reveal underlying balance deficits. Therefore, future work should assess these differences with more challenging tests of static balance like those with altered bases of support. FUNDING: CTSI TL1 TR001858 and Pitt HLI Pilot & Feasibility Grant.

P1-X-151: ***Characterization of Trial Duration in Single and Multi-Dimensional Postural Control Measures***

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BACKGROUND AND AIM: Quantitative assessments of postural control have become a hallmark of several clinical exams, allowing clinicians and researchers to assess postural dysfunction and evaluate fall risk objectively. Varied technological and practical options for evaluating balance using force platforms are available. Methodological choices inform the outcomes observed and allow practitioners to diagnose balance abnormalities. Past investigations have differed widely on sampling duration, and confidence in stability measures may be lacking where trials were too short for reliable outcomes to be derived. The purpose of this study was to identify necessary trial lengths for common and emerging center of pressure based measures. METHODS: Ninety-seven apparently healthy young adults (68 male and 29 female; 22 ± 6 years) performed quiet standing for 180 s with eyes open and eyes closed on a rigid force platform. Anteroposterior and mediolateral elements of the center of pressure were used to calculate path length, velocity, time-to-boundary, and Hurst exponents (i.e., detrended fluctuation analyses) using 15 s, 30 s, 90 s, 120 s, 150 s, and 180 s of data. Two-way (time, vision) ANOVAs with repeated measures were used followed by Helmert contrasts to identify the trial duration (sampled at 100 Hz) when changes in the dependent measures were no longer observed. RESULTS: Anteroposterior and mediolateral measures of velocity (60 s - 120 s), time-to-boundary (120 s - 150 s), and Hurst exponents (30 s - 120 s) all reach a stable magnitude. Path length continues to aggregate and therefore did not stabilize in the 180 s trial. Velocity measures stabilized quicker with eyes open. In contrast, vision had no effect, or the eyes closed condition was faster to stabilize in time-to-boundary and detrended fluctuation analyses measures.

CONCLUSIONS: We conclude that 150 s of quiet standing data is sufficient to capture a broad range of postural stability outcomes regardless of vision. The recommended minimum acquisition times established by this investigation support velocity, time-to-boundary, and detrended fluctuation analyses as quantitative evaluations for brief clinical assessments (<180 s). Further, these outcomes highlight the need for caution when utilizing path length as a primary outcome measure in balance assessments, specifically when objectively assessing balance in the clinical domain. This is the first investigation to establish minimum trial durations with time-to-boundary outcomes and suggest that future quiet postural evaluations require longer trials than previously collected, regardless of the analysis. ACKNOWLEDGEMENTS AND FUNDING: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

P1-X-152: ***Assessing gaze angles during walking without an eye tracker: validation and limitations***

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BACKGROUND AND AIM: We recently presented a method for measuring gaze location without the need for an eye tracker (Rubio Barañano et al. 2021). The approach determines the assumed gaze angle by tracking the motion of the target that is being viewed relative to the head's orientation. In the current study we determine how closely changes in assumed gaze angle match changes in the gaze angle measured using an eye-tracker. METHODS: Participants wore a headband and a Tobii Pro 3 eye-tracker (Tobii), Fig. 1A. Head orientation was tracked (6-camera motion capture system, Vicon, 100Hz) using markers placed on the headband. To ensure that both gaze assessment approaches had comparable reference frames for gaze outputs, the head's reference frame was relocated to the Tobii's "Scene camera" position and rotated to match the participant's neutral gaze orientation. The gaze angles recorded by Tobii during calibration were recorded as the offset angles. The time-synchrony between Vicon and Tobii signals was ensured by using a TTL signal. This signal, sourced by Tobii, triggered the start of the recording in the 3D motion capture system. Participants walked on a treadmill at a speed of 4 km/h. A smartphone, placed in front of participants at a preferred distance/orientation, consecutively showed single random digits each lasting 750 ms (21 digits in total). The vertical size of these digits represented a visual acuity (VA) of 0.71 LogMAR at 0.4 m. Participants were asked to read aloud the consecutively appearing digits. An audible cue from the phone lasting 1 s, which was accompanied by a primer presented on the screen, indicated the start of the test. Two seconds later, the first digit replaced the primer. The audible cue was recorded by Tobii, and this timeframe was used to define the 15 s analysis period. Gaze data were analysed from the first to the 20th digit (15 s). To determine how closely changes in assumed gaze angle match changes in the gaze angle measured using an eye-tracker, we plotted the trajectory of changes in the assumed Up-Down (UD) and Right-Left (RL) gaze angle against the gaze angle as measured using the Tobii system over the 15 s period. Data have been gathered for two participants. Statistical analysis will be conducted once we have data for a whole group. PREMILINARY RESULTS AND CONCLUSIONS: There was good agreement between the assumed and actual gaze angle in both UD and RL directions (Fig. 1C). Findings highlight that assessing the assumed gaze direction provides a valid surrogate assessment of the actual gaze direction. However, this method only works when there is evidence that the tracked target is being viewed. ACKNOWLEDGEMENTS AND FUNDING: This study was funded by UK College of Optometrists PhD studentship. REFERENCE: Rubio Barañano, A., Faisal, M., Barrett, B.T. and Buckley, J.G. (2021) Using a smartphone on the move: do visual constraints explain why we slow walking speed? Experimental Brain Research (0123456789), Springer Berlin Heidelberg. https://doi.org/10.1007/s00221-021-06267-6

P1-X-153: ***Is a pressure plate an alternative instrument for COP-based balance control asymmetry measures? A validation study in healthy adults***

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BACKGROUND AND AIM: Posturography typically involves a single composite measure of the center-of-pressure (COP) under both feet. Such measures establish stance instability, yet are unable to reveal underlying determinants of compromised balance. Particularly in one-sided conditions such as hemiparesis after stroke, two force plates that measure limb-specific COP profiles are required to investigate asymmetric control strategies(1,2). This requires a well-equipped laboratory limiting its application in clinical settings. A pressure plate may be a portable alternative. Therefore, this study aims to validate COP-based control asymmetry measures in healthy control subjects assessed with a pressure plate as compared to the golden standard, being two force plates. METHODS: Seven young (mean age±SD. 24.6±3.7) and 7 middle-aged healthy adults (54.7±6.9) participated. The bare feet were positioned with 9° toe-out angle on two force plates (Type OR 6-7, AMTI, 220 MA, US; samp freq 1kHz) and a pressure plate (0.5m footscan 3D, RS Scan, BE; 500Hz) at a random order. Per system 6 quiet stance trials, alternately with eyes open or closed, were performed. Limb-specific COP was calculated, low-passed filtered at 10Hz and split into anteroposterior (AP, along the foot axis) and mediolateral (ML) components. As ML COP is less meaningful for bipedal balance control(3), we focus on the AP direction. First, COP amplitude and rms velocity were calculated as descriptive metrics for each side. Second, the following asymmetry metrics were investigated: Between-limb synchronization was calculated by cross-correlating normalized COP profiles(1,3) and to establish each limb's contribution to balance maintenance the dynamic control asymmetry was computed following this equation(2): 2x(rms velocity AP COP left - rms velocity AP COP right)/(rms velocity AP COP left + rms velocity AP COP right). All metrics are averaged over 3 trials for each condition. Finally, mean differences (Wilcoxon signed-rank test) and correlations (Spearman's rho) between measuring systems are analyzed. RESULTS: First, limb-specific COP measured with a pressure plate are significantly smaller in amplitude and velocity irrespective of the condition, yet yield moderate-to-strong correlations as compared with the force plates. Second, asymmetry measures derived from both systems are similar in descriptive metrics, but correlations are stronger for the dynamic control asymmetry as compared to low-to-

moderate coefficients seen for between-limb synchronization (see table). CONCLUSIONS: Significant differences in amplitude and velocity may be caused by neglecting shear forces when measuring COP with a pressure plate. However, this study suggests that a pressure plate may be used as an alternative tool for investigating asymmetric contributions to balance maintenance, but generalization to pathological populations awaits further investigation. FUNDING: JS receives funding by the Fonds Wetenschappelijk Onderzoek (FWO), Flanders, BE (application nr.: 1S64819N). 1. Mansfield A, Mochizuki G, et al. Neurorehabil Neural Repair. 2012;26(6):627-635. 2. Roelofs JMB, van Heugten K, et al. Neurorehabil Neural Repair. 2018;32(11):953-960. 3. Winter DAP, F., Stergiou, et al. Neurosci Res Commun. 1993;12:141-148.

P1-X-154: ***Validity, reliability and interchangeability of a 3D printed electronic grip strength assessment tool with a Jamar dynamometer***

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Introduction: Grip strength is an important measure of physical function that is a strong predictor of poor health outcomes. The most widespread tool used for grip strength assessment is the Jamar dynamometer, for which many cutpoints and databases exist. One problem is that data from other grip strength devices are not easily interchangeable with the Jamar, limiting the ability to swap instruments whilst maintaining existing thresholds. This impedes the use of other devices such as electronic load-cell based systems, which provide advantages including direct electronic records integration, improved sensitivity and customisability. We have built a new custom-device that incorporates 3D printing and off-the-shelf strain gauges and microcontrollers that is cheap and easy to make, light to hold, has greater precision (≈10g) and can export wirelessly and automatically to electronic databases. This study assessed the reliability and validity of the custom device to measure grip strength, and its interchangeability with the Jamar. Methods: Dominant hand grip strength of 31 participants was collected from three trials of each of a calibrated Jamar dynamometer and the uncalibrated custom device in randomised order on two occasions. The custom device was purposefully not calibrated for assessor blinding. Statistical analyses were performed after calibration of the load cell data using Jamovi and consisted of Bland-Altman plots (agreement), ICC absolute agreement (concurrent validity and intra-rater reliability) and standard error of measurement (SEM%: measurement variability). Assessments were performed for the peak of the three scores on each device, i.e. the standard method of grip strength reporting, between devices on day 1 and 2, and within devices between days 1 and 2. Analyses were also performed comparing individual trials within device and between devices to determine trial-to-trial interchangeability. Results: Bland Altman plots revealed no fixed or proportional biases. Concurrent validity between the Jamar dynamometer and custom device was excellent on day 1 (ICC=0.97, SEM=5%) and day 2 (ICC=0.93, SEM=7%). Intra-rater, inter-session (i.e. between days) reliability was excellent for both instruments (both ICC=0.95, SEM=6%). Inter-trial, intra-session reliability was excellent, consistent and similar for within and between device assessments, with no discernible effect of device type (all ICC>0.95, SEM<7%). Conclusion: Our findings demonstrate the validity, reliability and interchangeability between the Jamar dynamometer and the custom device. This allows implementation of this new device whilst maintaining normative data and cutpoints from existing databases. In contrast to the Jamar, the custom device is easily replicable, modifiable and widely accessible as it can be 3D-printed at a low cost, with a freely available design at http://rehabtools.org/grip. The custom device also has further advantages, including the ability to export data directly into an electronic database, eliminating the need to rely on humans to correctly enter scores. Furthermore, the device can be used to communicate with other databases, thus it has the potential to form part of a multi-tool automated assessment system.

Y - Vestibular function and disorders

P1-Y-155: *The Effects of Vibro-tactile Biofeedback Training on Balance Control and Dizziness in Patients with Persistent Postural Perceptual Dizziness (PPPD)*

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BACKGROUND: Patients with PPPD frequently report being "off-balance". Artificial systems can provide sensory augmentation of natural sensory signals using vibro-tactile feedback (VT-fb) of trunk sway. Training with VT-fb is known to improve balance control, on average 20%, in MS patients, and 50% in bilateral peripheral vestibular loss patients. The question arises whether such artificial systems improve balance control in PPPD patients more than the modest 8% changes achieved with cognitive behavioral therapy (CBT) combined with balance physiotherapy. Therefore, we assessed the effects of VTfb of trunk sway on balance control during stance and gait tests, and on perceived dizziness in PPPD patients. METHODS: Balance control in the form of trunk sway during 14 stance and gait tests was scored using a Balance Control Index (BCI) in 12 patients with PPPD of primary (N=5) and secondary (N=7) origin. Tests included standing eyes closed on foam, walking tandem steps, and walking over low barriers. Trunk sway in the pitch and roll planes was measured with a SwayStar SystemTM. The Dizziness Handicap Inventory (DHI) was used to assess dizziness. Patients with central vestibular lesions were excluded as were those unable to walk up and down a set of 2 stairs. Subjects first underwent a standard balance assessment from which VTfb thresholds in 8 directions, separated by 45deg were calculated for each assessment test based on 72% of the maximum peak-to-peak trunk sway in the pitch and roll directions for the test. A headband mounted VT-fb system, connected to the SwayStarTM system, was active in 1 of the 8 directions when the threshold for that direction was exceeded. Subjects trained with the feedback system twice per week for 30 mins over a total of 2 consecutive weeks. The BCI and DHI were reassessed each week and the thresholds reset after the first week. RESULTS: All patients showed improved balance control after 1 and 2 weeks VT-fb training (22% p=0.034, and 26% p=0.008, respectively), regardless of whether the balance control was pathological prior to training. After 2 weeks, BCI values were significant less (p=0.0001) than the upper 95% limit of normal, age matched, reference values. Lower DHI values were also achieved after VT-fb training (p=0.05). A subjective benefit in balance control was spontaneously reported by 9 patients. CONCLUSIONS: These initial results show, as far as we are aware for the first time, that providing VT-fb of trunk to PPPD subjects yields a significant improvement in balance control and DHI assessed dizziness. The effect was present after 1 week of VT-fb training with further improvement after 2 weeks. Additional studies with higher numbers of participants are needed in order to assess whether VT-fb can be recommended for the treatment of PPPD in general or if this intervention benefits a specific subgroup of PPPD patients with a distinct presentation of this functional vestibular disorder.

P1-Y-156: ***Preliminary investigation of the robustness of a gait-based classification model to identify individuals with vestibular deficits***

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BACKGROUND AND AIM: Gait is a marker of functional mobility that can be affected by a variety of sensory, neurological, and/or motor disorders. Machine learning (ML)-based approaches using kinematic measurements from wearable inertial measurement units (IMU) have shown promise for automating gait-based screening. A prior binary classification model developed using ML techniques discriminated vestibulopathic gait from healthy age-matched control gait with good performance (AUROC = 0.81, 95% CI = [0.76, 0.85]). However, the classification model may not have uniquely identified vestibulopathic gait from other pathologies. Therefore, we tested the same model with individuals with multiple sclerosis (MS); MS can present with symptoms common to vestibular dysfunction including dizziness, vertigo, and imbalance. The goal of this preliminary study was to investigate the robustness of an existing classification model to uniquely classify individuals with vestibulopathies with respect to individuals with other gait disorders. METHOD: Thirty-six individuals participated in this initial study (15 age-matched controls, 15 with vestibular disorders, 6 with MS). Participants wore a set of 13 IMUs and were asked to perform a six-meter walk at their normal speed. Kinematic features from the participants with vestibular disorders and age-matched controls were extracted from the IMU data and used to train a random forest binary classifier; features from the left arm (e.g., arm pitch range, arm RMS angular velocity) best discriminated between the two groups. This classifier was then evaluated based on area under the receiver-operating characteristic curve (AUROC) scores following a cross-validation scheme that included participants with MS in the test set. The probability of classifying a participant as having a vestibular disorder was reported for each group (healthy, vestibular and MS). RESULTS: Participants with vestibular disorders were classified as 'vestibular' with higher probabilities compared to age-matched controls (median of 0.71 [IQR: 0.47, 0.80], versus 0.30 [IQR: 0.23, 0.55]). Participants with MS were not clearly separable from either group, resulting in a median of 0.56 a[IQR: 0.31, 0.79]. CONCLUSION: Based on the left arm kinematic data used in this analysis, the ML-based classifier designed to classify participants as either vestibular or age-matched controls did not consistently classify participants with MS. Findings from this analysis indicate that while the binary classification model performed well when discriminating participants with vestibular disorders from age-

matched controls, it was unable to uniquely identify participants with vestibular disorders in the presence of participants diagnosed with another disorder that affects gait (MS). Future work should explore multi-class classification approaches to account for other disorders affecting gait in the context of IMU-based screening.

P1-Y-157: ***Therapeutic effects of large-field visual virtual immersion on balance control in unilateral vestibular patients***

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1) Background and aim. During balance rehabilitation, automatic visual-vestibular compensations occur to reduce the patients' visual dependence due to the vestibular inhibition suppression. This study presents the positive therapeutic effects of interactive protocols based on immersive virtual reality (VR) that restore the reciprocal visual-vestibular inhibition on a short period of two months, and the use of an identification procedure to characterize the relationship between visual stimulation features and the adaptive equilibrium parameters associated to the balance enhancement. 2) Methods. Included in an 8 weeks clinical trial, nine unilateral vestibular patients (42-80 y.o) were immersed into structured large-field visual virtual flows, whose the dynamic constraints and complexity (scroll, radial and rotation visual pattern, stimulation speed, and gaze anchoring) increase throughout the therapeutic session. The analysis focus on the gaze behavior, feet center-of-pressure trajectory (CoPT), disequilibrium indicators (DI), and identification models parameters. 3) Results. The results show that the balance perturbations and the associated compensatory postural strategies are intensified (increasing of the CoPT and ID values) related to the complexity of the virtual pattern and speed, but progressively decrease significantly throughout the sessions, for all the stimulation conditions and scenarios. The methodical repetition of the virtual scenarios, associated to the consistent practice through sessions, strengthened the adaptive balance improvement. Data indicates the balance recovery and a patients' self-confidence due to the reduction of the visual dependence boosted by the visual-vestibular reverse compensation. 4) Conclusions. At a clinical level, our results demonstrate the real and rapid effectiveness of the large-field visual immersion on condition of controlled and repetitive virtual scenario. Despite the lack of long-term effects (reported by patients on a six months period) requiring periodic booster sessions, new rehabilitation strategies including virtual visual immersions have to be preferred comparing to standardized rehabilitation protocols (uncontrolled optokinetic stimulation). At a neuro-functional level, the visual-vestibular-motor adaptation despite the persistence of vestibular deficits indicates the relative reweighting of the visual-vestibular sensory inputs for a functional reciprocal inhibition restoration. New questions on the neural basis of the visual-vestibular plasticity for balance control will be addressed. Finally, our study corroborate the proof of concept of interactive VR-rehabilitation and adaptive control theory modelling, with experimental, practicable and clinical validation.

P1-Y-158: ***The effect of a customized vestibular rehabilitation programme with and without additional dual-task training on treatment outcome in persons with a chronic vestibular disorder. A randomised controlled trial.***

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BACKGROUND: Dual-tasking (DT) training (e.g. incorporating various balance and/or gait exercises with a secondary cognitive or auditory task) has been used in balance programmes for older adults at risk of falling, stroke patients and persons with Parkinson's disease and multiple sclerosis. No studies up to date, have investigated the efficacy of DT training in persons with a chronic vestibular disorder. METHODS: A single-blinded randomized controlled trial investigated the effect of a 12-week customized vestibular rehabilitation (VR) programme incorporating cognitive and auditory DT exercises in 39 persons with chronic vestibular symptoms, aged 18-80 years old, who were randomly allocated to VR without (Group A) or with cognitive DT exercises (Group B). Treatment response was assessed at baseline and end of treatment. Primary outcome measure was Functional Gait Assessment (FGA) and FGA DT with Numeracy, Literacy and Auditory tasks. Secondary outcome measures included physical activity levels and cognitive function assessed with Axivity Wrist Band 3Axis logging accelerometer and Cambridge Neuropsychological Test Automated Battery, respectively, MiniBESTest, and questionnaires for vestibular symptoms and symptom triggers, balance confidence, self-perceived beliefs about health-state and illness, sleep and psychological state. Statistical significance was set at $p<0.05$. RESULTS: This study is ongoing. Group A included 19 participants (9 females, mean age ±SD= 53.05±12.51 years) while Group B included 20 participants (14 females, mean age ±SD= 43.70±15.08 years). Significant within-group improvements were noted in Group A for FGA Literacy and Numeracy (17.78±5.48 versus 23.89±7.64, 19.00±5.22 versus 23.22±6.12, respectively) and Group B for FGA Auditory, Numeracy and Literacy (22.44±5.10 versus 26.11±5.88; 16.33±4.87 versus 23.22±6.06; 18.67±5.03 versus 24.44±5.48, respectively). Group B showed significant improvement for patients' perceived dizziness (47.25±13.90 versus 26.75±18.20), vertigo (0.81±0.59 versus 0.55±0.50), and visually induced dizziness (1.55±0.93 versus 1.12±1.09). Group B showed trends for improvement in cognitive domains examining visual memory and new learning (79.30±26.13 versus 82.1±8.95; 24.60±18.39 versus 16.50±15.28, respectively). CONCLUSIONS: Preliminary data suggests that the addition of DT exercises to a VRT programme may be useful for improving specific cognitive domains associated with visual memory and new learning in people with a vestibular disorder. Practising DT exercises may provide a greater change in patients' perceived handicap from dizziness, vertigo symptoms and visually induced dizziness. Numeracy and Literacy cognitive DT FGA performance does not appear to require additional DT exercises to improve.

P1-Y-159: ***2BALANCE: cognitive-motor dual-tasking in persons with vestibular dysfunction***

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Background and aim. Bilateral vestibulopathy (BVP) is a chronic vestibular syndrome that originates from bilaterally reduced or absent vestibular function. These patients are mainly characterized by postural imbalance, gait disturbances, and oscillopsia. Additionally, a broad spectrum of other characteristics can be observed. These characteristics include a variety of cognitive complaints including memory loss, "brain fog", and attentional deficits. 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 (CMI) might occur. CMI can be assessed by performing dual-tasks, consisting of the simultaneous performance of a cognitive and a motor task. However, standardized and validated dual-task protocols were lacking in the vestibular population. Therefore, the 2BALANCE protocol was developed, specifically for persons with vestibular dysfunction. The current presentation focuses on presenting the 2BALANCE protocol and the dual-task performance of a group of persons with bilateral vestibulopathy compared to a healthy cohort. Methods. The 2BALANCE protocol consists of seven different cognitive tasks, comprising all cognitive domains which are suspected to be impaired in persons with vestibular disorders. These tasks are 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 group of persons with bilateral vestibulopathy and normal hearing (n=20) was compared to a healthy age, gender, and educational level matched control group (n=20). Cognitive and motor dual-task cost were calculated as the difference in performance on the single compared to dual-task conditions. Results. Data collection was delayed because of COVID-19 measures. Therefore, data analysis is still ongoing, but will be presented. Conclusions. The 2BALANCE protocol will give a more accurate and daily life representation of cognitive and motor deficiencies and their interaction in the vestibular-impaired population. This might enable objectifying subtle cognitive and motor complaints, for which single tasks might not be sufficiently sensitive. Additionally, the current study will also highlight task prioritization in the healthy, compared to the vestibular-impaired population.

Poster Session 2

A - Activity monitoring

P2-A-1: *Does walking capacity contribute to walking performance in people with Parkinson disease?*

Terry Ellis[1], Jenna Zajac[1], James Cavanaugh[2], Teresa Baker[1], Ryan Duncan[3], Daniel Fulford[1], Jaimie Girnis[1], LaValley Michael[1], Timothy Nordahl[1], Franchino Porciuncula[1], Kerri Rawson[3], Marie Saint-Hillaire[1], Cathi Thomas[1], Gammon Earhart[3]

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BACKGROUND AND AIM: Walking has been identified as the greatest priority among persons with Parkinson disease (PD). Clinicians routinely use capacity-based measures in a clinic setting to make inferences about walking performance in the real-world; however, the validity of this approach has not been clear. Therefore, the aim of this study was to understand better how walking capacity contributes to both actual and perceived walking performance in PD. METHODS: We conducted a cross-sectional analysis of baseline data from a multi-center randomized controlled trial of ambulatory persons with PD. Walking capacity was evaluated clinically using 6-minute walk test (6MWT) distance and 10-meter walk test (10MWT) fast-pace gait speed. An accelerometer subsequently measured actual walking performance over 7 consecutive days, from which we calculated mean values for daily steps and moderate intensity minutes (>100 steps/minute). Perceived walking performance was evaluated using the Parkinson Disease Questionnaire-39 (PDQ-39) mobility score. Descriptive statistics were used to characterize the sample. Univariate linear regressions were used to determine the contribution of walking capacity to daily steps and the PDQ-39 mobility score. Logistic regressions were used to determine the odds of accumulating 30 or more moderate intensity minutes per week based on walking capacity. Regression analyses were conducted using the full sample (n=93) as well as sedentary (<7,500steps/day) (n=46) and active (≥7,500 steps/day) (n=47) subgroups. RESULTS: Participants had mild to moderate PD (Modified Hoehn-Yahr scale [H&Y] 2: n = 45; H&Y 2.5: n = 36; H&Y 3: n = 12), were aged 67.3±8.4 years and were 57% male. For the full sample, 6MWT and 10MWT variables were significant predictors of daily steps (R^2=.12, p=<.001; R^2=.10, p=.002, respectively), moderate intensity minutes (Exp(β)=1.01, p=<.001; Exp(β)=11.10, p=.004, respectively), and PDQ-39 mobility score (R^2=.23, p=.000; R^2=.22, p=.000, respectively). For sedentary and active groups, 6MWT distance was a significant predictor of moderate intensity minutes (Active [Exp(β)=1.01, p=.046; Sedentary (Exp(β)=1.01, p=.017]); both 6MWT distance (Active [R^2=.10, p=.031; Sedentary [R^2=.28, p= <.001]) and 10MWT speed (Active [R^2=.17, p=.004; Sedentary [R^2=.23, p= <.001]) significantly predicted PDQ-39 mobility score. CONCLUSIONS: Walking capacity was a statistically significant contributor to actual and perceived performance, regardless of activity level; however, a large portion of the variance in walking performance was unexplained, suggesting that walking capacity (as measured in the clinic) is not a surrogate for walking performance. Moreover, improvements in walking capacity through intervention may not

seamlessly translate into improvements in real-world walking performance. Therefore, interventions targeting walking performance in the community may be required to optimize outcomes in persons with PD. ACKNOWLEDGEMENTS AND FUNDING: NIH (R01HD092444-01A1), FPTR PODS I Scholarship

P2-A-2: ***Beyond Step Counts: Low Intensities of Real-World Walking Prevail in Parkinson Disease***

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BACKGROUND AND AIM: Decreased walking activity in persons with Parkinson disease (PD) is associated with difficulty engaging in meaningful activities. Daily steps are commonly measured to capture walking activity; however, steps alone limit a more complete picture of natural walking behavior. Walking at higher intensities may produce greater benefits. Little is known about patterns of daily walking intensity in PD. Therefore, we sought to describe the extent to which persons with PD naturally walk at various intensities in their customary environments and to investigate whether persons with relatively active or sedentary baseline activity levels engage in different patterns of walking behavior. METHODS: This was a secondary analysis of baseline walking activity data collected from persons with idiopathic PD participating in a multi-center randomized controlled trial. Participants wore a StepWatch Activity Monitor (SAM) for 7 consecutive days. Mean values were calculated for: (1) daily steps; (2) daily minutes of walking at various intensity levels; and (3) duration of the longest bout of sustained walking at each intensity level. Intensity level was categorized as the number of steps contained in each active minute (1-19, 40-59, or ≥100 steps). Only participants who wore the SAM for the full 7-day period were included. Analyses were conducted using the whole sample (n=82), sedentary (<7,500 steps/day) (n=43) and active (≥7,500 steps/day) (n=39) groups. RESULTS: The sample included individuals with mild to moderate PD (Hoehn and Yahr 2: n=39; 2.5: n=32; 3: n=11) with a mean age of 67.5±8.4 years and was 58.5% male. Participants were relatively active (7864±3645 steps/day). Most daily walking occurred at lower intensities with decreased time spent walking at higher intensities (157.3±58.1 min of 1-19 steps; 38.2±21.3 min of 40-59 steps; 7.3±9.6 min of 100+ steps). Longest daily bout durations were relatively low across intensity levels (15.9±5.2 min of 1-19 steps; 4.7±1.8 min of 40-59 steps; 4.8±7.5 min of 100+ steps). The active group had more daily minutes of walking (189.4±61.4 min of 1-19 steps; 51.7±22.0 min of 40-59 steps; 12.2±11.3 min of 100+ steps) and higher longest bout durations (17.9±5.4 min of 1-19 steps; 5.8±1.7 min of 40-59 steps; 7.7±9.4 min of 100+ steps) relative to the sedentary group (minutes of walking [128.2±36.0 min of 1-19 steps; 25.9±10.7 min of 40-59 steps; 3.0±4.6 min of 100+ steps]; longest bout durations [14.0±4.2 min of 1-19 steps; 3.8±1.2 min of 40-59 steps; 2.1±3.6 min of 100+ steps]). CONCLUSIONS: Participants spent few minutes each day walking at higher intensities and engaged in relatively short bouts of sustained walking. The active group engaged in more active minutes and longer durations of sustained walking; however, minimal activity occurred at higher intensities. Results highlighted the importance

of measuring walking intensity in conjunction with daily steps in persons with PD. ACKNOWLEDGEMENTS AND FUNDING: National Institute of Child Health and Human Development (NICHD), #1R01HD092444-01A1.

P2-A-3: ***Evaluating wrist accelerometer estimates of physical activity intensity during walking in persons with Parkinson's disease***

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BACKGROUND AND AIM: Wrist-worn sensors are ubiquitously used to estimate free-living physical activity (PA) intensity. Although the benefits of PA extend to persons with Parkinson's disease (PD), use of wrist-based PA intensity measurements may be confounded by PD-specific features that affect the upper limbs such as asymmetry or muted arm swing (1). These symptoms may impact wrist accelerometer estimates of PA during whole body activities such as walking, leading to potential discrepancies in both PA intensity and total volume since walking is the most reported PA in adults (2) and often represents moderate intensity (3). Accurate measurement of PA is paramount to understand the relationship between PA and PD (4, 5). The aim of this work is to quantify wrist-derived PA intensity estimates during everyday walking in persons with PD. METHODS: Ten participants (40% female) with PD [medians: age 65 (58-75) years, time since diagnosis 5 (1-10) years, MDS-UPDRS Part III score 24 (15-30)] wore GENEActiv accelerometers bilaterally on ankles and wrists for 7 days (6). Custom software was used to detect stepping and classified gait bouts using ankle accelerometer data. To exclude ADL stepping (i.e., intermittent, low cadence), only bouts ≥ 15 seconds with a cadence of ≥ 80 steps/min were included in the analysis. Wrist accelerometer average vector magnitudes (AVM) were calculated for each gait bout and intensity thresholds (7) were applied to a) the least affected (based on Part III of the MDS-UPDRS) (8) or b) dominant wrist (in absence of asymmetry). RESULTS: Gait bout detection resulted in a median of 142.5 (25-335) walks per participant. Remaining data are presented as median (range) of participant means. Wrist AVM across gait bouts was 93.1 (42.7-136.3) milligravity and cadence was 90.7 (86.5-97.4) steps/min. Activity intensity during gait was highly variable, with 17.1 (4.0-91.3) % of gait bouts classified as sedentary, 32.9 (7.5-48.0) % classified as light intensity, and 43.6 (1.2-80.7) % classified as moderate intensity. CONCLUSIONS: Relying on wrist accelerometer-derived PA intensity estimates in persons with PD during free-living wear can misclassify activity and will tend to underestimate walking intensity. Therefore, a multi-sensor approach, including ankle sensor, may be warranted. Future work will examine if discrepancies in PA intensity classification exist in a larger PD sample, and explore factors that may influence the variability between free-living wrist- and ankle-derived estimates of intensity. REFERENCES: 1) Kalia & Lang. (2015). Lancet. 386(9996):896. 2) Dai et al. (2015). J Phys Act Health. 12 Suppl 1(01):S128. 3) Hall et al. (2013). Med Sci Sports Exerc. 45(3):574. 4) Lord et al. (2013). J Neurol. 260(12):2964. 5) von Rosen et al. (2021). BMC Neurol. 21(1):71. 6) Godkin et al. (2021). J Neurol. (Epub). 7) Fraysse et al. (2021). Front Sports Act Living. 2:579278. 8) Elkurd et al. (2021). Front Neurol. 12:711045.

P2-A-4: ***Gait classification in aged residential care: a computationally inexpensive and orientation independent algorithm with a single 3-axis accelerometer on the trunk***

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BACKGROUND AND AIM: Measurement of walking activity in long-term residential care environments is important for understanding mobility, assessing the effects of interventions, tracking disease progression, and identifying unmet mobility needs [1]. Previous research has shown that gait classification algorithms can identify multiple gait characteristics like walking speed, gait asymmetry, and stride length with a single 3-axis inertial measurement unit (IMU) worn on the lower back [2]. Gait classification in a long-term residential care environment is challenging due to slow walking speeds, halting gait patterns, and reliance on walking aids which alter gait characteristics. The aim of this study was to develop a computationally inexpensive algorithm to classify gait in a residential care environment. To improve robustness of the gait classifier, we aimed to make the algorithm independent of the IMU orientation, ensuring that improper placement of the IMU would not lead to significant data loss. METHODS: Data were collected from 27 ambulatory residents in long-term care. A clinician secured the IMU to the fifth lumbar vertebrae with a hydrogel adhesive. Participants were asked to walk around the care home, stand, and sit during a 5-15-minute period. The researcher recorded the order of activities and time taken for each activity, with sit-stand and stand-sit transfers counting as activities. We also recorded a video of the participants feet during the data collection. The IMU sampled data at 100 Hz. Acceleration data were first adjusted by subtracting the low pass filtered data, we then transformed all 3 linear accelerations into a single magnitude signal. Thereafter, we classified each timepoint as walking or not-walking using thresholds, and removed small gaps in activity with a smoothing technique. We excluded walking bouts less than 2 seconds. We compared the algorithm classification to the clinician labelled data at each timepoint to find accuracy, sensitivity, precision, specificity, and F1 score. We averaged these scores across participants. RESULTS: Our algorithm performed well with an average accuracy of 79% ±19 standard deviation (s.d.). Sensitivity was also 79% (±27 s.d). Precision was 83% ±25, specificity was 82% ±11, and F1 score was 80% ±26 (mean±s.d). Fig. 1 illustrates a comparison of the clinically labelled classification and the algorithm classification. CONCLUSIONS: We validated a computationally inexpensive and orientation independent algorithm for classifying gait in a long-term care environment. Our results show the algorithm worked relatively well across participants. The importance of an easy to use, computationally inexpensive technique to classify gait was accentuated by the ability of our algorithm to identify bouts of walking that were not labelled as such during the data collection, although the video data exhibits walking. ACKNOWLEDGEMENTS AND FUNDING: The study has been funded by a Health Research Council of New Zealand project grant (reference 18/414). The study funder had no role in study design, data collection or analyses. REFERENCES: 1. Barber SE, et al., J Aging Phys Act. 2015, (23) 2. Del Din S, et al., IEEE J Biomed Heal Informatics. 2016, (20)

P2-A-5: ***Continuous remote monitoring of physical activity in people with cognitive impairment: a systematic review***

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BACKGROUND AND AIM: Participating in regular physical activity can support people with cognitive impairment to maintain independence and functional abilities for longer. Physical activity refers to any movement produced by skeletal muscles which requires energy expenditure. It does not have to be planned or structured. With technological advances such as wearable technology and ambient environments, habitual physical activity can be measured objectively and continuously, capturing metrics relating to volume, intensity, pattern and variability of activity. By continuously monitoring physical activity remotely in people with cognitive impairment, we may be able monitor progression of dependency and disability, and measure efficacy of clinical interventions. To provide a foundation for this work, this systematic review aims to (1). identify common digital tools and (2). metrics used to measure habitual physical activity, and (3). describe the volumes, intensities, patterns and variability of habitual physical activity in people with dementia and mild cognitive impairment living in the community. METHODS: 2975 titles were systematically reviewed, leaving 267 abstracts for screening. 85 full-text articles were reviewed for inclusion, with 30 articles confirmed. Articles were included if they reported quantifiable physical activity metrics derived from digital devices or other relevant technology, and if participants were community-dwelling with a diagnosis of dementia or mild cognitive impairment. Articles were excluded if they only reported self-report measures, only provided end-point interventional data, only included mixed groups of cognitively impaired and cognitively intact participants, or if they were in aged residential care settings. All articles were peer-reviewed and published in English. RESULTS: From the 30 confirmed articles, accelerometers were the most common digital tool used for remotely monitoring physical activity (67% of studies). Across all studies, 57 discrete metrics were used to measure physical activity (Figure 1). The most common metrics per physical activity domain included: steps per day (volume; 43% of studies, mean range: 1509-13268 steps/day), moderate-to-vigorous activity (intensity; 13% of studies, mean range: 9-48 mins/day), mean bout length (pattern; 13% of studies, mean range: 11-17 seconds), and bout length variability (variability; 10% of studies, mean range: .819-.829). Comparisons with cognitively intact older adults indicated that people with cognitive impairment participate in lower volumes and intensities of physical activity, with inconclusive findings regarding differences in pattern and variability. CONCLUSIONS:This review highlights the need for a standardized set of outcomes to measure that describe physical activity in people with cognitive impairment, which would provide clinically-relevant information about functional status, disease progression and intervention efficacy. FUNDING: Ríona Mc Ardle (NIHR Advanced Fellowship, NIHR301677) is funded by the National Institute for Health Research (NIHR) for this research project. The views expressed in this publication are those of the author(s) and not necessarily the Department of Health and Social Care.

B - Adaptation, learning, plasticity and compensation

P2-B-6: ***Rapid balance skill learning and motor cortical activity in healthy young adults***

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BACKGROUND AND AIM: Only 20 minutes of balance skill learning can improve balance performance. Manual skill learning is associated with an initial increase in cortical activity during the rapid skill acquisition phase. It seems likely but remains largely unexamined if improvements in balance skill and motor cortical modulation co-occurs following short-term balance skill practice in healthy young adults. Electroencephalography (EEG) allows us to determine the power of the EEG signal in different frequency bands. A reduction in alpha power during motor learning is thought to represent an increased cortical activity. The aim of this study was 1) to determine the effects of a two-day balance intervention on balance performance assessed in the training task and 2) to examine if these rapid adaptations in balance performance are accompanied by a rapid increase in motor cortical activity, i.e., a reduction in task related alpha power in the motor areas representing lower extremity muscles. METHODS: Healthy younger adults (n=24) were randomly assigned to a balance intervention (BAL, n=12 (6 males), age: 22.7±3.0 years, height:1.76±0.08 m, weight:74.2±10.1 kg) on an unstable board (Miniboard, Sensamove®, Groessen, NL) or seated rest (CON, n=12 (6 males), age: 23.1±2.3 years, height:1.74±0.11 m, weight:69.5±13.8 kg), the control intervention. All participants visited the lab on two intervention days with ~1 day of inter-visit rest and on a 3rd day, the retention test, ~7 days after visit 2. Balance performance was assessed by determining the time in standing balance on an unstable balance board before and immediately after each intervention session and during the retention test. During the performance of the balance task, EEG was recorded. After pre-processing the EEG data, the power of the balance task relative to quiet standing was calculated for the alpha band over the primary motor area. RESULTS: Time in balance on the unstable board compared to baseline increased by 15.9% in BAL and by 5.0% in CON following a single balance training session (Group x Time: $F(1,22)=4.93$, $p=0.037$, partial eta square=0.183). A second balance training day increased balance performance by an additional 8.1% in BAL and 1.1% in CON (Group x Time: $F(1,22)=5.33$, $p=0.031$, partial eta squared=0.195) and the acquired skill was retained after a ~7 day-long no-training period. A preliminary analysis in BAL (n=4) indicated that the improvements in balance performance were accompanied by reductions in task related alpha power. CONCLUSIONS: The preliminary analysis seems to suggest that balance skill can be learned in minutes and such skill acquisition, akin to manual motor skills, is retained at least for 7 days after practice. The rapid skill acquisition and modulation of a specific brain activation marker seems also to co-occur. The presentation will include analysis of the complete dataset.

P2-B-7: ***The influence of age on feedforward locomotor (de)adaptation***

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BACKGROUND AND AIM: Humans quickly learn to adapt their movements in response to perturbations. This is a process known as motor adaptation and allows the performer to adjust their movements in a predictive, 'feedforward' manner, rather than relying on sensory feedback to correct movement after the perturbation has occurred. However, if deployed inappropriately, feedforward control can disrupt motor performance. It is therefore important that feedforward motor patterns can be quickly updated in situations where they are no longer appropriate. We investigated how age affects such process. METHODS: Young (n=11) and older (n=18) adults performed a locomotor adaptation task in which they learned how to safely step onto a moving surface (the speed of which was modified based on individual walking ability). After the adaptation phase, participants then performed a de-adaptation phase, in which they stepped onto the same surface which was now stationary. Participants were unequivocally reassured that the surface would not move during these de-adaptation trials. RESULTS: Young and older participants each displayed a pronounced 'locomotor after effect' in the first de-adaptation (stationary platform) trial. This was characterised by participants initiating - in a feedforward manner - the postural response (increased gait velocity and lower-leg muscular activation) required to step safely onto the moving surface in the previous trials. However, older adults displayed a persistence of these inappropriate feedforward locomotor behaviours into the second and third de-adaptation trial, whilst young adults were able to de-adapt after a single stationary trial. CONCLUSIONS: These findings highlight that the ageing process can disrupt locomotor (de)adaptation, leading to the persistence of inappropriate feedforward behaviour. We propose that these findings may be a consequence of age-related multisensory decline, leading to older adults prioritising feedforward (rather than sensory feedback) control mechanisms.

P2-B-8: ***Effects of Simulated Gravitational Loading on Lower Limb Kinematics During Walking***

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BACKGROUND: Gravity is a major factor in human gait and movement. Changes in weight can drive adaptations in leg speed, joint angles and muscle activity during walking. However, it is unclear how quickly the body adapts to new gravitational environments and, in particular, if these adaptations are consistent and robust at certain gravitational levels. This project examined walking kinematic adaptations to varying levels of gravitational load. Better understanding of the effects of specific levels of unloading will aid future rehabilitation techniques, as well as improve our general understanding of how gravity influences human locomotive adaptations. METHODS: 14 participants (18-35 years) walked in an unloading treadmill for trials of 1 minute at 2.0 m/s. During these trials, each participant experienced a series of unloading steps from 100% to 20% unit earth gravity, in 20% increments. There was no delay between unloading conditions. Inertial measurement units captured joint angles of the left hip, ankle and knee. Data for each participant were separated into strides, time normalized, and averaged by joint. The resulting mean hip, knee and ankle waveforms were then compared using statistical parametric mapping (SPM) f-tests. Difference waveforms were also created for each joint between adjacent levels of unloading (e.g., the 100% load waveform minus the 80% load waveform, 80-60%, 60-40% and 40-20%) and compared using SPM f-tests. Post-hoc testing was performed using individual SPM t-tests with correction for multiple comparisons. Phase diagrams (angle versus velocity) were created, and their areas were calculated for each joint at each level of unloading. RESULTS: SPM f-tests revealed differences between conditions and difference waveforms for the hip and ankle. Testing of the knee did not reveal any significant differences. Post-hoc testing between conditions showed 20% was significantly different from all other levels of unloading for the hip; additionally, hip angle waveforms for 100% and 80% were both different than 40%. Post-hoc SPM t-tests for the hip difference waveform and revealed the 100/80% and 40/20% waveforms were significantly different from all other levels of unloading. Tests of the ankle revealed the 80/60% and 40/20% waveforms were significantly different from all other waveforms. Phase diagrams of the hip were visually similar for levels of unloading between 100% and 40% with marked visual changes at the 20% level from all other levels. Area calculations of the phase diagrams showed small reductions as loading decreased and a larger reduction from 40% to 20% load. CONCLUSIONS: These findings suggest that greater gravitational unloading primarily influences hip kinematics and can influence the coordinative structure of hip movement. The rate of change in joint angles between certain levels of load also appear non-linear. This is further supported by phase diagrams for each joint that show non-linear differences in area - corresponding to the statistically significant findings in the SPM outcomes- as the level of unloading changes. Though 60% load was not significantly different than other levels of loading, this appears to be an inflection point below which the effects of unloading are increasingly apparent.

P2-B-9: ***Effects of Simulated Gravitational Loading on Lower Limb Neuromuscular Activation***

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BACKGROUND: Gravity is a major factor in human gait and movement. Changes in weight have been shown to drive adaptations in leg speed, foot placement and pressure distribution, as well as affect joint angles and muscle activity during walking. However, there are still unanswered questions about how different levels of simulated gravitational loading can influence muscle activity; it is unclear if muscle activity scales with the level of loading or if the amount of muscle activity is consistent at a particular level of unloading. Understanding these differences can shed light on rehabilitative methods, as well as improve our understanding of the effects of gravity on locomotion. METHODS: 14 participants (18-35 years) walked for trials of 1 minute duration in a positive pressure unloading treadmill. Walking speed was 2.0 m/s for all participants. Each participant experienced a series of unloading steps from 100% to 20%-unit earth gravity, in 20% increments. There was no delay between conditions. Electromyography was used to assess the sensors activation of the left hamstring (HS), rectus femoris (RF), medial gastrocnemius (MG), and anterior tibialis

(AT). For each condition, data for each participant were separated into strides, time normalized and averaged by muscle. Waveforms were then compared using statistical parametric mapping (SPM) f-tests. Post-hoc testing was performed using individual SPM t-tests with correction for multiple comparisons. Difference waveforms were also created for each joint between adjacent levels of unloading (e.g., the 100% load waveform minus the 80% load waveform, 80-60%, 60-40% and 40-20%) and compared using SPM f-tests. Integrated areas were calculated for each condition. RESULTS: SPM f-tests revealed differences between conditions and for difference waveforms for the HS, RF, and MG. The AT was not significant for either condition or difference waveform. Post-hoc testing revealed significant differences between multiple loading levels by both condition and rate of change. Area under curve calculations for HS and RF showed positive trending as load was decreased, which reversed direction at 20% load; conversely, MG showed negative trending as load was decreased, which became positive at 20% load. CONCLUSIONS: This study found that simulated gravitational unloading modified neuromuscular activity for all but the AT. The difference waveforms between adjacent levels of unloading for these muscles were not equivalent. This suggests that while unloading does influence muscle activity, it appears to be limited to anti-gravity muscles. The differences between muscle activity at particular levels of unloading do not scale linearly and each muscle displays a distinct pattern of adaptation. Further, trends in overall muscle activity with unloading reverse at 20% load, suggesting a change in muscle coordination.

P2-B-10: ***Guided exploration through the dual-axis framework for running styles: moving from the lab to the field***

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BACKGROUND AND AIMS: Different runners exhibit different running styles. Instead of guiding them towards one general, optimal running style, a more personalized approach may be more suited. According to the dual-axis framework [1], the running style at a certain running speed can be comprehensively described using two variables, each representing an axis of a plane. The horizontal axis represents the step frequency and the vertical axis represents the duty factor, i.e. the ratio of stance time to flight time. Each extreme of the resulting two-dimensional framework corresponds to a running style (named Bounce, Stick, Hop and Push) with a characteristic motion of the center of mass (proximal mechanics) and, by hypothesis, of the runner's limb movements (distal mechanics). Our lab-based studies [2-3] showed that runners can be guided through the four running styles of the dual-axis framework by instructing them to change their step frequency and duty factor. The aim of this follow-up research is threefold, namely: (1) to test whether the proximal and distal mechanics of those running styles were indeed in accordance with the predictions of the model; (2) to examine if the idea of guided exploration through instructions is applicable while running in the field, where instructions may be less effective as they may result in variations in speed, and (3) to chart long-term effects of guided exploration through the running styles on runners' self-selected running styles. METHODS: We will create a guided exploration protocol using verbal instructions combined with acoustic pacing, which instructs

runners to explore the different running styles of the dual-axis framework. We will assess the effect of this protocol on timing and kinematic aspects of the running technique in the lab, to validate the predictions about proximal and distal mechanics of the dual-axis framework. Finally, we will invite runners to train according to the protocol for a period of 4 weeks and analyze the training records they will collect using a smartwatch for the period prior to, during and after these 4 weeks. For the 4-week training period, we will analyze the changes in speed, cadence, and duty factor in relation to the instructions to assess the effectiveness of such instructions in the field. We will also compare self-selected running styles before, during and after the 4-week training period to appraise the effects of such instructions over a longer period of time. RESULTS: The measurements for these studies are currently ongoing. CONCLUSIONS: This ongoing research will verify or falsify the predictions made by the dual-axis framework and evaluate the effectiveness of guided exploration through the dual-axis framework in the field. REFERENCES: 1. van Oeveren, B.T.; de Ruiter, C.J.; Beek, P.J.; van Dieën, J.H. The biomechanics of running and running styles: a synthesis. Sport. Biomech. 2021. 2. Nijs, A.; Roerdink, M.; Beek, P.J. Cadence modulation in walking and running: Pacing steps or strides? Brain Sci. 2020, 10, 273.

P2-B-11: ***Guided exploration of the duty factor during running: Instructing stance time or flight time?***

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BACKGROUND AND AIMS: The dual-axis framework [1] suggests that running style at a certain running speed can be described using only the cadence and the ratio of stance time to flight time, called the duty factor (Figure 1a). The extremes along both axes of the resulting two-dimensional framework correspond to particular running styles (Figure 1a). This framework can be used for an instruction-based guided exploration of running style allowing individual runners to find a suitable running style with effective instructions to modulate both axes. Acoustic pacing is a known effective method for cadence modulation [2], i.e. along the horizontal axis. Our research question was therefore: Can runners be guided along the vertical axis of the dual-axis framework by instructing them verbally to change their stance time or flight time? METHODS: Twelve healthy participants ran on an instrumented treadmill and completed four training blocks starting with a baseline and ending with a performance trial in which they followed verbal instructions to increase/decrease their stance/flight time. Acoustic pacing at their preferred cadence was present during the first half of each trial. We calculated the duty factor and the cadence for each baseline and performance trial and assessed the effectiveness of the instructions by comparing the duty factor in the performance trials to the baseline trials. Next, we calculated the change in duty factor and the change in cadence and compared the different instructions and the effect of the presence of acoustic pacing. RESULTS: The changes in duty factor from the baseline to the performance trials are shown in figure 1b. The duty factor changed significantly in expected directions with verbal instructions to increase/decrease the stance/flight times ($p<0.05$), although none of the instructions proved more effective than the others in this regard ($p>0.05$). The instructions also led to a change in cadence for some participants, most notably in the absence of acoustic pacing (F(1,10)=24.41, p=0.001, ηp2=0.71). CONCLUSIONS: Runners can change their duty factor with verbal instructions about stance or flight times. In the lab, a combination of verbal stance/flight-time instructions (to modulate duty factor) and acoustic pacing (to either maintain or modulate cadence) can thus be used to guide runners through different running styles of the dual-axis framework. REFERENCES: 1. van Oeveren, B.T.; de Ruiter, C.J.; Beek, P.J.; van Dieën, J.H. The biomechanics of running and running styles: a synthesis. Sport. Biomech. 2021. 2. Nijs, A.; Roerdink, M.; Beek, P.J. Cadence modulation in walking and running: Pacing steps or strides? Brain Sci. 2020, 10, 273. Figure 1. a. Visual representation of the dual axis model. The horizontal axis represents the cadence, with a high cadence on the left side, and the vertical axis represents the duty factor, with a high duty factor on the bottom. b. The changes in duty factor from the baseline trial (B) to the performance trial (P) for the four instructions, with (dark) and without (light) acoustic pacing.

P2-B-12: ***Changes in locomotor adaptation throughout the adult life span***

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Changes in locomotor adaptation throughout the adult life span S.B. Swart*, A.R. den Otter* and C.J.C. Lamoth* *University of Groningen, University Medical Centre Groningen, Department of Human Movement Sciences, Groningen, The Netherlands Background: Adaptability of walking is an important aspect of locomotor control as it allows us to walk on different types of footwear or on different surfaces, such as uneven terrains. Age-related changes in the sensory and motor systems, such as reduction in muscle strength, may reduce motor adaptability in older adults [1]. As previous studies have predominantly assessed the effects of older age [e.g., 2, 3], the effects of age on locomotor adaptation are not fully understood. Therefore, the aim of this cross-sectional study was to determine the effects of age on locomotor adaptation. To this end, spatiotemporal step parameters during split-belt adaptation were assessed in subjects across the adult lifespan. Methods: Data in this cross-sectional study were collected from a sample (N = 72, age range: 18-79) of 12-13 healthy adults per decade [see 4]. The protocol consisted of two 3-minute bouts of tied-belt walking at 1.4 and 0.7 m/s, respectively, a 10-minute bout of split-belt walking, and finally, a 6-minute bout of tied-belt walking at 0.7 m/s. Step length of the fast side (SLF), step length of the slow side (SLS), and step length asymmetry (SLA) were computed. A nonparametric approach called Singular Spectrum Analysis was applied to identify adaptation trends [5]. In each adaptation trend, we assessed the amount of change relative to late slow baseline (40 steps) during early adaptation (5 steps) and early washout (5 steps). Linear regression models were fitted to assess the effect of age on these early adaptation and washout magnitudes. Results: Figure 1 shows the early adaptation and washout magnitudes for SLA, SLF and SLS. The early adaptation magnitude of SLA showed a small decrease ($p>\alpha$) with advancing age (Fig. 1a). In the individual legs during early adaptation, the SLF decreased more (p<α), while the SLS increased less (p<α) with advancing age (Fig. 1b, c). Early washout magnitudes of SLA showed an increase (p<α) with advancing age (Fig. 1d). In the individual legs during early washout, the SLF increased less (p<α), while the SLS decreased more (p<α) with advancing age (Fig. 1e, f). Conclusion: The present results showed that the ability to adapt remains persevered, but with age subjects seem to use different spatiotemporal stepping strategies to meet the imposed task demands. References: [1]: Vandevoorde, K., & Orban De Xivry, J. J. Neurobiol. Aging, 80, 138-153 (2019). [2]: Bruijn, S.M., et al., (2012). J. Neurophysiol, 108(4), 1149-1157. [3]: Malone, L.A., & Bastian, A. J. Neurobiol. Learn. Mem., 128, 1-6 (2016). [4]: Vervoort, D., et al., Med. Sci. Sports Exerc., 52(10), 2270-2277 (2020). [5]: Swart, S.B., et al., Biomed. Signal Process. Control, 71 (2022).

C – Aging

P2-C-13: *Age-related difference in modulation of margin of stability during curb descent in response to a subsequent precision stepping demand*

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BACKGROUND AND AIM Community ambulation requires negotiating surface elevations and precision stepping. Compared to level-ground walking, kinetic energy increases when descending steps, and demands greater stability control. Furthermore, since stability control is primarily achieved via foot placement [1], environmental constraints on foot positions challenge stability. We quantified investigated control over several steps in a multi-feature environment in healthy adults. The purpose is to examine age-related changes in stability control for curb descent in response to a subsequent precision stepping task. METHODS 18 young (24±4 yrs) and 10 older adults (70±6 yrs) walked on an 8 m walkway and stepped down a 15 cm curb halfway down the walkway. Two blocked conditions were examined: Baseline (no target; used to identify preferred foot placement) and Target (located at preferred foot placement, visible throughout trial, Fig. 1A). Kinematic data was used to compute the margin of stability (MOS) in AP and ML directions at foot contact for 6 foot placements (fp-3,-2,-1,1,2,3). Greater positive MoS indicates higher passive dynamic stability. RESULTS We observed a significant Foot placement x Age x Block interaction for MOSml ($F_{5,4598}=2.3$, $p=0.04$). MoSml for fp 1,2 are smaller than other foot placements. Older adults have larger MOSml than young adults for fp 1,2 for the target condition only. MOSml increased for target condition compared to baseline for fp -2 and -1 for young adults but for fp -1,1,2, and 3 for older adults. We observed significant Foot placement x Block ($F_{5,4598}=9.7$, $p<0.01$) and Foot placement x Age ($F_{5,4598}=45.1$, $p=0.01$) interactions for MOSap. MOSap for fp 1 is smaller than all other foot placements, and it increased for fp -2,-1,1,2 or the target condition for both groups. Older adults had larger MoSap than young adults for fp 1. CONCLUSION Lower passive stability while stepping down (fp 1) indicates utilization of the kinetic energy gained during descent to passively propel the body forward in both groups. However, older adults prioritized safety over energy efficiency. Higher MOS for fp1 in older adults provides a stronger buffer against external perturbations and helps counter age-related declines in muscle strength. MOS for the target condition increased for steps leading up to the target, even when the target was placed at the preferred foot location, indicating more rear and medial CoM position and/or lower CoM velocity. These changes increase the space and time available to accurately position the foot on the target. Higher MOS during the approach suggests that these gait characteristics must be altered over multiple steps. The preparatory modulation in MOSml is delayed in older adults. This delay may reflect decline in adaptability with ageing [2], or a superior strategy for achieving precision. Further investigation is required to distinguish between these possibilities. REFERENCES: [1] Winter 1995; [2] Caetano et al. 2016

P2-C-14: ***Physical fitness moderates the effect of age on the association between executive functioning and mobility.***

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BACKGROUND AND AIM: In older adults, executive functions are important for daily-life function and mobility. Evidence suggests that the relationship between cognition and mobility is dynamic and could vary according to individual factors, but whether physical fitness reduces the age-related increase of interdependence between mobility and cognition remains unexplored. METHODS: 195 participants (50-87) were divided into three groups Middle-aged (MA;<65), young older adults (YOA; 65-74), and old older adults (OOA; ≥75). Participants performed Timed-up and Go (TUG) and executive functioning assessments (oral Trail making test and phonologic verbal fluency) remotely under videoconference. Participants completed the Matthews questionnaire to estimate their physical fitness (VO2 max in ml/min/kg). A three-way moderation was used to address whether physical fitness interacts with age to moderate the relationship between cognition and mobility. RESULTS: Results showed that the physical fitness x age interaction moderated the effect of executive functioning on mobility (β = -.05, p = .047) (R^2 = .18, p <.0001). At lower levels of physical fitness (<19.16 ml/min/kg), executive functioning significantly influenced YOA's mobility (β = -.48, p = .004) and to a greater extent OOA's mobility (β = -.96, p = .002). CONCLUSIONS: Our results support the idea of a dynamic relationship between mobility and executive functioning over aging, and suggest that physical fitness could play a significant role in reducing their interdependency. ACKNOWLEDGEMENTS AND FUNDING : The Mirella and Lino Saputo Research Chair in Cardiovascular Health and the Prevention of Cognitive Deficits supported this research.

P2-C-15: ***The effects of walking speed on quantitative and qualitative gait measures in younger and older adults are outcome dependent***

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Background and aim: Walking speed predicts many clinical outcomes in old age, but a comprehensive assessment of the effect of age and walking speed on quantitative and qualitative measures is lacking. This is needed to obtain insights into whether changes in quantitative and qualitative gait outcomes with aging are the result of differences in walking speed or are an inherent property of the neuromuscular system. Therefore, the aim of the study was to examine the relationship between walking speed and quantitative and qualitive gait outcomes, and to examine whether this relationship differs between younger and older adults. Methods: Younger (n=27, age: 21.6) and older adults (n=27, age: 69.5) walked for 340 steps on a treadmill at speeds from 0.70 m·s-1 with increments of 0.15 m·s-1to a maximum of 1.75 m·s-1. Generalized additive mixed models were applied to determine the relationship between walking speed and quantitative (stride length, stride time, stride frequency and their variability) and qualitive (stride regularity, stability, smoothness, symmetry, synchronization, predictability) gait measures extracted from trunk accelerations in vertical (V), anterior-posterior (AP), medio-lateral (ML) directions. Results: The relationship between walking and almost all gait measures (quantitative and qualitative) was characterized as logarithmic, where speed-effects were more prominent below 1.20 m·s-1. The relationship between walking speed and stride time variability, gait synchronization (ML-V), stride regularity (V) and gait stability (V) was the same in younger and older adults (example A). This suggests that these measures are sensitive to speed but not to aging. For stride length and its variability, frequency variability (V, ML,AP), gait symmetry (V,ML,AP), gait smoothness (AP), gait synchronization (AP-ML), gait predictability (ML) and stride regularity (AP), we found a similar type of relationship with walking speed, but found differences in the intercept. This implies that these age-differences are present independent of speed (example B). Finally, for stride time, stride frequency, gait smoothness (V, ML), gait synchronization (AP-V), gait stability (ML,AP), gait predictability (V,ML), the type of relationship with walking speed was different for younger and older adults (example C). This reveals that these measures are differently affected by speed in younger and older adults. Conclusion: We found that for quantitative and qualitative gait measures, the type of relationship with walking speed and the effects of age on this relationship, are outcome-dependent. This implies that when examining the effects of age on gait function, gait measures that have a similar speed effects in younger and older adults should be considered (example B), over those measures that are sensitive to speed but not to aging (example A) or measures that are differently affected by walking speed in both age groups (example C).

P2-C-16: ***How Older Adults Adapt Stepping On Narrowing Walking Paths***

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BACKGROUND & AIM: Paths we walk on daily require us to continually adjustment locomotor trajectories. Humans must adapt mediolateral stepping variability and readily correct stepping errors to accommodate changing path features (e.g., path width). Older adults' abilities to achieve such adaptations may be impaired. Further, older adults may opt to avoid especially-narrow paths entirely, limited by physical and/or perceived balance abilities (Butler et al., J. of Gerontology, 2015). Here, we evaluated how older adults adapt mediolateral foot placement to traverse a constantly-narrowing path. We then determined how age, along with physical and self-perceived balance abilities, influenced stepping adaptations. METHODS: 18 older (OH; aged 65-86) and 20 young (YH; aged 18-24) adults walked on a virtual path that gradually narrowed from 0.45m to 0.05m. Participants chose when/how to switch to an adjacent, wider 'easier' path. At each step, mediolateral left (zL) and right (zR) foot placements and path widths were recorded, then compiled into YH and OH groups. Across path widths, we characterized mediolateral foot placement variability in [zL, zR] using fitted 95% prediction ellipses. Variability ellipse features were quantified relative to orthogonal constant body positon (zB) and constant step width (w) Goal-Equivalent Manifolds (GEMs). We quantified the step-to-step error correction of zB and w enacted at different path widths by computing linear rates of correction for each variable. We then evaluated the effects of participants' ages, and physical and self-perceived balance abilities, on their variability and error correction at the instants they chose to leave the narrowing-paths. RESULTS: To stay on narrowing paths, participants considerably reduced foot-placement variability by increasing the correction of both zB and w, while exhibiting more-isotropic variability in the [zL, zR] plane. Across path widths, OH consistently adapted mediolateral foot placements that exhibited greater, but less isotropic, variability, together with reduced zB and w error correction relative to YH. OH left narrowing paths when variability was greater and more isotropic than YH (all $p < 10\text{-}8$), while under-correcting for errors in zB and w (all $p < 10\text{-}9$). Variability and error correction at path switch were strongly influenced by age, but also predicted by participants' physical and self-perceived balance abilities. CONCLUSIONS: Both OH and YH adapted foot placement variability and error correction to stay on narrowing walking paths. But, OH consistently demonstrated an impaired capacity to adapt to changing path limitations. OH not only opted off of the narrowing-paths earlier, but demonstrated limitations in mediolateral stepping adaptability at these instances, including limited ability to correct zB and w stepping errors. These limitations were explained by interactions of age, and physical and self-perceived abilities. FUNDING: NIH R01-AG049735; R21-AG05347.

P2-C-17: ***Effects of perceptual inhibitory control on step initiation in young and older adults***

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BACKGROUND AND AIM: Executive functioning is associated with an increased fall risk in older adults. Inhibitory control (IC), one of the core components of executive functioning, is essential for adapting mobility related tasks. Recent studies demonstrated an association of reduced IC with impaired gait adaptation, balance recovery, and fall risk. A scoping review of studies analysing IC during balance tasks in older persons demonstrated that the few

available studies show a heterogeneity of experimental conditions and outcome measures, and that more experimental studies are needed. As part of a larger study aiming to understand the impact of age-related changes in IC on balance control, the present study analyses effects of different conditions of perceptual inhibition on step initiation. METHODS: First results are based on kinetic and kinematic data of 7 young (3F, age 26 ± 3 (YA)) and 7 healthy older adults (4F, age 69 ± 3 (OA)) who performed 3 stepping tasks (Simon, Flanker, SimonFlanker (SF)). Each task required a person to step in response to congruent (CON) and incongruent (INC) visual cues that were generated by a Matlab script. Tasks were conducted in a randomized order, and each task consisted of 20 CON and 20 INC trials in four step directions. Step responses were analysed based on the onset of changes of the centre of pressure (COP) position (measured by a force plate (Bertec, 1000 Hz)) and onset of step movement (measured by a motion capture system (Qualisys, 100 Hz)). A three-factor analysis of variance with repeated measures evaluated age effect (YA and OA) as a between-subjects factor, and task effect (Simon, Flanker, SF) and inhibitory condition effect (CON, INC) as within-subject factors, followed by a Bonferroni post-hoc test. RESULTS: Both COP and step onset were significantly affected by age effect ($F(1, 12) = 12.11$, $p = .005$, $F(1, 12) = 14.39$, $p = .003$, respectively) and by task and inhibitory condition effects. COP onset during Flanker task significantly differed from Simon but not SF task (Flanker: 431.2 ± 16.8, Simon: 407.5 ± 18.8, SF: 460.0 ± 30.2 (ms)). Step onset during Flanker task significantly differed from SF but not Simon task (Flanker: 693.0 ± 22.6, Simon: 660.0 ± 25.2, SF: 732.1 ± 26.1 (ms)). Condition effect on step onset was significantly changed by age effect ($F(1, 12) = 13.85$, $p = .003$). Whereas COP onset showed no interaction effects, inhibitory condition effect on step onset was significantly different by task effect ($F(1.39, 16.66) = 4.29$, $p = .043$) and this had an interaction with age effect ($F(1.39, 16.66) = 4.89$, $p = .031$). CONCLUSIONS: Our preliminary results indicate that OA demonstrated a task dependent prolonged duration of COP and step onsets during step initiation tasks that require perceptual inhibitory control. Our further analyses will focus on age-related attenuation in IC based on the associations between different IC tasks and results of cognitive tests in a larger group of OA.

P2-C-18: ***RE-BALANCE- REcovering BALance After an uNexpeCted pErtubation- Testing Different Motor Learning Paradigms for Improving Balance Recovery Ability during Walking in Older Adults - A Pilot Randomized Controlled Trial***

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BACKGROUND AND AIM: Falls are the leading cause of fatal and nonfatal injuries among older adults. Balance recovery abilities after unexpected loss of balance decline with age and, as a result, there is an increased risk of falling. Studies show that older adults can reduce the risk of falls after participation in a Perturbation-Based Balance Training (PBBT) - a relatively novel approach that challenges reactive balance control. However, it is still unknown whether blocked practice is better than random practice. We compared two perturbation motor learning paradigms with different challenge level of the practice condition (i.e., blocked practice vs random practice). Objective parameters of reactive and proactive balance function were measure before and after 1-month training. Our hypothesis was that older adults would significantly improve their reactive and proactive balance function following exposure to both random and block PBBT, with no beneficial effect of one training method over the other. METHODS: A double-blinded randomized control trial was performed. Twenty community-dwelling older adults were recruited and randomly allocated to a random PBBT group (n=8) or a block PBBT group (n=12) (due to the Corona virus crisis, we were not able to complete the trials). Both the random and block PBBT groups received eight training sessions over a four-week period that included machine-induced perturbations of balance during hands-free treadmill walking. The random PBBT group were exposed to a random unannounced perturbations in terms of direction and timing, while the block PBBT group were exposed to perturbations in one direction only in each training session while the timing of perturbations were announced. Intensity was customized to the participant's abilities in both groups. The generalization and transfer of learning effects were measured by assessing the reactive and proactive balance control during standing and walking before and after one month of PBBT. RESULTS: Both PBBT groups improved multi-step threshold and ability to cope with higher perturbations post training. Both groups also showed a reduction in CoM path displacement and an improvement was found in cognitive performance as the total numbers counted while perturbed walking/standing was significantly higher post training. There were no improvements in the kinematics of rapid leg movements during reactive stepping, in voluntary stepping, nor in postural stability measures post training. CONCLUSIONS: The results suggest that both PBBT methods, random and block, showed a very specific improvements in balance reactive parameters (e.g., improved multiple-step threshold, higher perturbation achieved, improvement in the control of the CoM path) with no superiority of one training method over the other. Also, the PBBT showed no transfer to proactive stepping and balance control suggesting that PBBT able to specifically improve only balance reactive function. The improvement in cognitive performance in both groups, suggests a transfer effect post training, regardless of training method.

P2-C-19: ***Age-related differences in walking to a beat among healthy young, middle-aged, and older adults***

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BACKGROUND AND AIM: The stability of walking is central to the safety of Canadian seniors. Reduced walking stability has been associated with risk of falling, and older adults show greater costs to walking performance compared to younger adults when simultaneously performing a secondary task. However, performance costs are not always observed under dual-task conditions, and may depend on the complexity of the secondary task. A considerable body of research has shown that walking to a regular beat can benefit walking performance in patients with Parkinson's Disease. Less well-known is how walking to a beat and the complexity of a secondary task interact to impact walking performance across the adult lifespan. The purpose of this study was to examine whether walking to a beat can benefit walking performance healthy young, middle-aged, and older adults. A second aim was to assess whether task complexity modulates the effect of rhythmic auditory stimulation on walking. We predicted that 1) walking to a simple beat (i.e., a metronome) will benefit gait

and 2) gait variability will increase with increasing complexity of the auditory task, particularly for older adults. METHODS: Young (n = 22), middle-aged (n = 20), and older adults (n = 20) performed a walking task in silence and under three dual-task conditions: participants were asked to synchronize their steps to a series of low tones (Simple condition); to a series of low and high tones (Moderate); to a series of low and high tones while detecting a particular pattern of tones (Complex). RESULTS: The outcome measure was step time Coefficient of Variation in percent (% CoV). Walking to a beat was found to benefit walking performance compared to walking in silence ($F(1, 59) = 11.06$, $p = .002$, $\eta^2p = .16$). Pairwise comparisons showed a benefit for middle-aged (mdiff = 0.33 % CoV, p = .026) and older adults (mdiff = 0.40 % CoV, p = .007), but not younger adults (mdiff = 0.09 % CoV, p = .518). When comparing all levels of complexity, a cubic pattern emerged ($F(1, 59) = 4.46$, $p = .039$, $\eta^2p = .07$) such that, across age groups, the Simple condition (m = 2.482 % CoV) resulted in more stable walking compared to walking in silence (m = 2.757 % CoV) and compared to the Moderate (m = 2.631 % CoV) and Complex (m = 2.555 % CoV) conditions. A main effect of Age Group was also found ($F(2, 59) = 10.95$, $p = <.01$, $\eta^2p = .27$) such that, across levels of complexity, older adults (m = 3.032 % CoV) showed less stable walking compared to young (m = 2.547 % CoV) and middle-aged (m = 2.239 % CoV) adults. CONCLUSIONS: Walking to a simple rhythmic beat facilitated walking performance compared to walking in silence in older and middle-aged adults, but not younger adults. When the auditory task became more complex, the benefit to walking performance disappeared. Understanding when a secondary task benefits versus interferes with walking may help individuals optimize their environment to reduce risk of falls. FUNDING: NSERC, Concordia University

P2-C-20: ***Judgment of the chaseability of a moving object in older adults: less dependence on the optical expansion of the target***

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TITLE： Judgment of the chaseability of a moving object in older adults: less dependence on the optical expansion of the target BACKGROUND AND AIM： To both chase a moving object and avoid colliding with it during locomotion, it is necessary to predict the timing and location of possible interceptions (or collisions) based on various optical variables. A recent study proposed an "affordance-based model" (Steinmetz et al. 2020), in which three optical variables are to be used for judging whether to pursue or abandon the chase of a moving target: the lateral optical angle formed by the leading edge of the target and the locomotor axis(α), the horizontal angles of the edges of the obstacle (φ), and the longitudinal angle between the target-ground contact and the point on the target at the actor's eye height. To address whether this model would be helpful for understanding the age-related deterioration of judging the chase-ability of a moving object, the present study tested older and younger adults to investigate the impact of perturbation in the optical angles of a moving object (γ and φ) on their judgment. We hypothesized that only younger adults could be negatively affected by the perturbation, given that older adults are less dependent on these optical variables. METHODS： Sixteen older adults (74.0 ± 4.3 years) and fifteen younger adults (23.5 ± 3.8 years) participated. The experimental task was an interception task performed in a virtual reality environment, which was a reproduction of that used in Steinmetz et al. (2020). Participants wore a head-mount display and tried to intercept moving targets. As soon as they judged that the moving target was not catchable, they stopped their movement for interception (termed "give up"). Performance scores were calculated based on the success rate and time required to intercept the target or decide to give up. The signal detection power (d') was also calculated based on the signal detection theory. To investigate whether the deterioration of cognitive functions would explain the difficulty in performing an interception task, older participants' MMSE and TMT scores were also used. RESULTS AND CONCLUSIONS: Both performance scores and signal detection power were significantly higher for the younger group than for the older group. In the younger group, perturbation to φ negatively affected their performance scores, while perturbation to γ negatively affected both their performance scores and signal detection power. In the older group, no significant impact of perturbations was found. These results suggest that older adults are likely to be less dependent on the optical expansion of a moving target. We also found that TMT scores, but not MMSE scores, were related to performance; that is, older adults with lower TMT scores (i.e., impaired executive cognitive function) had difficulty performing the task. This suggests that age-related dysfunction of executive functions (more specifically, task-switching ability) may lead to difficulty in judging whether to pursue or abandon the chase of a moving target.

P2-C-21: *Age related postural responses during repeated virtual stimulation: traditional analysis and analysis of the complexity*

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BACKGROUND AND AIM: Traditional postural parameters used in VR experiments show that postural control is challenged in users. However, additional postural parameters could broaden our understanding of the mechanisms underlying postural control. This study investigated age-related postural changes in a standard population using repeated VR stimulation. The aim of this study was to investigate whether age influences traditional and complexity-based postural parameters when exposed to repeated VR stimulation during stance. We hypothesized that age and repetition influence postural control during exposure to VR stimulation. Postural responses were analyzed using traditional measures and measures of complexity. Research question: Are age, repetition and translations influencing traditional and complexity-based postural parameters when exposed to repeated virtual stimulation? METHODS: Eighty-four healthy individuals (age 21 to 86) were exposed 5 times to the same VE. The VE was designed in first-person perspective and generated forward and backward translations. We recorded participants 'Center of Pressure (CoP) on a force platform during a 10-second pre-translation period and a 10-second post-translation period. Traditional and complexity-based balance parameters were measured from the CoP positions. RESULTS:Covariance analysis showed an effect of age and repetition on several but not all traditional and complexity-based measures. Mean velocity increased with age before and after both the translations for all participants. On the first repetition, fractal dimension decreased after both the translations and increased with age. Percent recurrence

increased over repetition, increased after the translations and on the first repetition decreased with age after the translations. CONCLUSIONS:VR stimulation may trigger postural imbalance, but repeated exposures allow the elderly to adjust their postural responses after a translational motion. Using complexity-based measures such as fractal dimension or percent recurrence allows a different analysis of the influence of age on postural control in VR environments. When exposed to VR translations, complexity analysis shows that age challenges posture. However, as the exposure is repeated the measures of complexity shows that the disturbances are being processed. In addition to a traditional analysis of balance, we suggest including a complexity analysis in further research studies with the elderly and VR to assess the effects of age and repetition on postural control. ACKNOWLEDGEMENTS AND FUNDING: The authors would like to thank all the volunteers in this study.

P2-C-22: ***Effects of Aging and Parkinsons Disease on the Cognitive Component of Gait Initiation***

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Background and aims: The volitional decision to start to walk is followed by a subconscious movement planning stage in which movement does not occur. This first phase of gait initiation (GI) is a form of reaction time. However, it is not yet clear how to characterize this planning stage. To gain insight into this first phase of GI, we compared its duration to that of upper extremity simple (SRT) and complex reaction time (CRT) tasks and evaluated the effects of aging and neurodegeneration. Methods: 25 healthy young adults YA (age: 28.2±5.7, 48% F), 17 healthy older adults OA (age: 67.8±4.9, 41% F), and 26 patients with Parkinson's disease PD (age: 67.5±8.9, 19% F; 8.3±1.2 yrs disease, H&Y stage median 2) were studied. A Stick Drop Test (JT Eckner et al., 2009) tested upper extremity reaction time: SRT: the subject grasps the stick as quickly as possible each time it is released; CRT: using a go/no go paradigm requiring a response within 400 msec, the subject grasps the stick as quickly as possible during the random 50% of trials when LED's on the stick illuminate. Off Accuracy: the % of the trials in which the stick was correctly not grasped. The tasks were repeated 10 times. Gait initiation was tested by asking the subject to start walking after hearing a tone (E Gazit et al., 2020). The time to anticipatory postural adjustment (time-to-APA) was averaged over three walks. Within and between group effects were evaluated using Kruskal-Wallis, One-way ANOVA, and RM ANCOVA, controlling for gender. Results: Time-to-APA was lowest in YA, slightly longer in OA ($p=0.087$), and longest in PD ($p<0.05$) (Fig 1A). CRT was shorter in PD compared to YA ($p=0.008$), but not compared to OA ($p=0.062$). Off accuracy was lower in OA and PD, compared to YA ($p<0.001$, Fig 1B), and a shorter CRT was associated with a lower accuracy rate ($r_s=0.46$, $p<0.001$). In all 3 groups, CRT was longer than SRT ($p<0.001$). In YA, time-to-APA was longer ($p<0.001$) than SRT and shorter ($p<0.001$) than CRT. In contrast, in OA and PD, time-to-APA was longer ($p<0.001$) than SRT but similar to CRT. There was a significant time ($p<0.001$) and time*group interaction ($p=0.001$). Between SRT and CRT, time was significant, however, between CRT

and time-to-APA, both time and time*group were significant (Fig 1A). Conclusions: Time-to-APA is longer than SRT in YA, OA, and PD. Among the OA and PD, time-to-APA can be approximated by a CRT that requires immediate response inhibition for accuracy. GI in OA with and without PD is longer than in YA, perhaps reflecting that inhibition is a more challenging or less efficient task for them. Although patients with PD had the shortest CRT duration, they also had the lowest accuracy as maybe the short CRT values reflect an inability to inhibit. One interpretation of these results is that gait planning requires inhibition of the motor pattern used for quiet standing before the initiation of walking and this cognitive "effort" increases with aging and PD.

P2-C-23: ***Perception of using a customized safety harness augmented rehabilitation using home-based dance-based exergaming intervention among people with chronic stroke***

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Background: Previous evidence from dance-based exergaming (DBExG) trials in people with chronic stroke (PwCS) have shown promising results on motor and cardiovascular fitness in people with chronic stroke (PwCS). Safe translation of such training for at-home use could be done with assist of in-home low-cost, commercial safety harness systems. However a needs assessment on if PwCS would be interested in receiving such training at their home and willingness to install a fall protection safety harness in their homes must be conducted. Objective: The purpose of this study was to qualitatively explore PwCS's preference in using a customized safety harness augmented rehabilitation using DBExG (ShA- DBExG) to provide home-based rehabilitation. Methods: Participants were included in this survey study if they have had a stroke, lived in the community, and understood English. Participants completed a study-specific safety harness survey via mail, in-person, or online. The survey was comprised of questions regarding their perception on the following: receiving a home-based training paradigm using DBExG, using of fall protection safety harness while receiving an home-based rehabilitation using a DBExG paradigm, After which they provided their opinion on the selection of type of safety harness, type of safety harness buckle, method of harness-wearing information, permission requirement to install harness, level of independent living, and required logistics (home inspection and modifications of the home environment). Descriptive statistics were used to characterize the sample and survey responses. Results: One hundred two survey responses were returned. It was observed that 51% of participants voted for door mountable harness and 58% voted for side release style buckle, along with 51% participants demonstrated an increased preference for receiving a manual of how to use the harness. Seventy-eight percent of the participants required permission to install or use a harness system in their home. Further, more than half of the participants preferred exhibiting independence by strapping the harness themselves (68%), along with choosing to live independently (the ability to live in one's own home and community safely, independently, comfortably, and can also perform their activities of daily living, regardless of physical ability level) (89%). Conclusions: People with chronic stroke opted to use safety

harness augmented (ShA) DBExG at their home. The current survey serves as a guideline to develop, customize, and prescribe home-based ShA DBExG rehabilitation.

P2-C-24: ***Modeling lifespan changes in postural control and multitasking***

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BACKGROUND AND AIM: While the trajectory of lifespan development of postural stability appears as an inverted U-shaped function with the lowest levels of performance at both ends of the lifespan, the behavioral performance in children and elderly might arise for different reasons. We designed a study to map out the age-related differences in postural control under varying task conditions aiming to determine age-differential short and long timescale postural control mechanisms. We accomplish this by combining the stabilogram diffusion analysis as pioneered by Collins & De Luca with a more recent proposal to estimate piecewise regressions by Muggeo. In addition, we aim to determine age-differential effects of multitasking on postural control performance. METHODS: To this end, we applied the adjusted stabilogram diffusion analysis to center-of-pressure (CoP) trajectories from a lifespan sample of 301 participants ranging from 7-81 years old. They performed postural control tasks in three conditions. Task difficulty was manipulated by compromising vision or narrowing the base of support. In ongoing work, we apply the same methods of data analysis to age-comparative multitasking research combining postural control with an ecologically relevant auditory-cognitive task. RESULTS: To this end, we conducted statistical analyses using linear mixed-effects models on the lifespan sample of participants. The analyses support the hypothesis of age-differential postural control mechanisms. Short timescale displacement was largest in the older adults, especially when the base of support was narrowed. On the other hand, children showed a disproportionally poor long timescale error correction when vision was compromised. In addition, results of our ongoing work indicated that multitasking significantly affected postural control. Apart from the anticipated effects on long timescale error correction, short timescale displacement was also affected. CONCLUSIONS: Similarities in postural control performance of children and older adults arise for different reasons. Children showed poor long timescale error correction when vision was compromised. On the other hand, poorer performance in older adults mainly originated from excessive short timescale displacement, which was most pronounced under conditions where the base of support was compromised. These findings are in line with the hypotheses of immature sensory reweighting in children and compensatory muscle coactivation in older adults. In addition, multitasking significantly affected both short and long timescale postural control mechanisms.

P2-C-25: ***The multiscale dynamics of beat-to-beat blood pressure fluctuation mediated the effects of hypertension on walking speed in older adults***

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BACKGROUND AND AIM: Older adults with hypertension often had diminished walking performance. The underlying mechanism through which hypertension affects walking performance, however, has not been fully understood. The blood pressure is regulated by multiple underlying neurophysiological elements over multiple scales of time; therefore, the multiscale dynamics of the continuous beat-to-beat blood pressure (BP) fluctuations are "complex", containing rich information pertaining to the characteristics of those elements. We here thus measured the degree of complexity of the beat-to-beat systolic (SBP) and diastolic (DBP) blood pressure fluctuation and explored its relationship to the grade of white matter lesions (WMLs), and cognitive function, two main contributors to the diminished walking performance in older adults. We further used the structural equation modeling (SEM) to examine the interrelationships between hypertension, BP complexity, WMLs, cognitive function, and walking speed in single- and dual-task conditions in a group of older adults. METHODS: A total of 152 older adults with age > 60 years (90 hypertensive and 62 normotensive participants) completed one MRI scan of brain structure, a finger BP assessment of at least 10 minutes, Mini-Mental State Examination (MMSE) to assess cognitive function, and two trials of the 10-meter walking test in each of single- (i.e., normal walking) and dual-task (i.e., walking while performing a serial subtraction of three from a random 3-digit number). The grade of WMLs was assessed using the total score of Fazekas scale; the complexity of SBP and DBP was measured using multiscale entropy (MSE); and the walking performance was assessed by walking speed in single- and dual-task conditions as measured by a wearable sensor system. RESULTS: As compared to normotensives, hypertensive older adults had significantly slower walking speed as reported in previous publications, lower complexity of SBP and DBP, greater grade of WMLs and poorer cognitive function ($p<0.03$). Those with lower BP complexity ($\beta>0.31$, $p<0.003$), greater WMLs grade ($\beta<-0.39$, $p<0.0002$), and/or poorer cognitive function ($\beta<-0.39$, $p<0.0001$) had slower walking speed in single- and/or dual-task condition. The SEM model demonstrated significant total effects of hypertension on walking speed and such effects were mediated by BP complexity only, or BP complexity, WMLs grade and cognitive function together (Figure 1). CONCLUSIONS: This study demonstrates the association between the complexity of continuous beat-to-beat BP fluctuation, WMLs grade, cognitive function and walking speed in hypertensive and normotensive older adults, revealing a potential mechanism that hypertension may affect walking performance in older adults through diminished BP complexity, increased WMLs grade, and decreased cognitive function; and BP complexity is an important factor for such effects. AKNOWLEDGEMENS AND FUNDING: This study is supported by Basic Research Project of Shenzhen Natural Science Foundation, Shenzhen Science and Technology planning project (JCYJ20170818111012390, JCYJ20190807145209306), and Shenzhen Key Medical Discipline Construction Fund (No. SZXK012, No. SZXK005).

D – Biomechanics

P2-D-26: ***Background muscle activity decouples muscle fascicle excursion from joint rotation and drives long latency feedback response during support surface translations***

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BACKGROUND AND AIM: To maintain balance in unfamiliar and challenging situations, people typically increase their background leg muscle activity; which is a feedforward strategy that stiffens muscles. Due to in-series tendon mechanics, background muscle activity likely changes muscle stiffness more than that of the encompassing leg joint(s). Thus, perturbations that rotate leg joints likely stretch muscles less with increased background muscle activity, perhaps altering the sensory feedback that drives balance correcting responses. The Aim of this study was to determine how background muscle activity affects muscle fascicle mechanics during perturbations to standing balance. We hypothesized that during backward support surface translations, increased background muscle activity would 1) decrease soleus fascicle stretch (feedforward response), and 2) reduce reactive balance responses in soleus reactive activity and the corresponding fascicle shortening (feedback response). METHODS: Seven participants maintained standing balance while experiencing backward support surface translations at 4 different magnitudes (12 to 22 cm). Before each translation, we instructed participants to either 'relax' (stand naturally) or 'activate' (maintain joint angles and use visual feedback to activate leg muscles so that their soleus muscle activity was 250% of their relaxed value). Participants experienced 4 trials of support surface translations at each magnitude in the relaxed and activated conditions. From the same leg, we recorded ankle angle using motion capture, soleus fascicle length using ultrasonography, and soleus activity using surface electromyography. RESULTS: Overall, participants increased their background soleus activity 76% prior to experiencing support surface translations during the 'activated' vs. 'relaxed' condition (p=0.036). Across translation magnitudes, peak ankles dorsiflexion was 17% less in the activated vs. relaxed condition (2.9 vs. 3.5°, respectively; p<0.001). Yet, initial soleus fascicle stretch following perturbation onset was not statistically different between conditions (across magnitudes, fascicle strain decreased 9-15% in the activated vs. relaxed condition; p=0.176). Average soleus muscle activity 80-220 ms following perturbation was 21% greater in the activated versus relaxed condition (p<0.001). Over the same duration, muscle fascicles shortened 53% more in the activated condition (both p<0.001), consistent with a greater feedback response to the support surface perturbation. CONCLUSIONS: Background muscle activity varies across daily situations and across people, and our study shows that it affects both feedforward (joint-level) and feedback neuromechanics during reactive balance. Namely, despite a similar fascicle stretch across conditions, increased background activity facilitated the long latency feedback response to support surface perturbation in the soleus muscle. FUNDING: McCamish Parkinson's Disease Innovation Program and NIH R01 HD90642

P2-D-27: ***Is curvilinear walking able to detect subtle walking impairments in people with Multiple Sclerosis: an explorative study based on wearable sensors***

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Introduction Walking impairment is one of the most common functional deficits in people with Multiple Sclerosis (PwMS) [1] and a sentinel characteristic of the later stages of the disease [2]. The ability to turn is very important for autonomy maintenance in everyday life: curved paths put at strain body control, requiring cognitive to motor adaptations which could be really challenging for people with neurological impairments [3]. In addition, despite curved paths could be adopted to detect subtle gait impairments not revealable during easier motor tasks, like linear walking [4], to the author's knowledge, gait impairments in PwMS have never been explored with an approach based on curvilinear walking. Therefore, this study sought to determine if inertial measurement units (IMUs) could detect subtle differences in terms of gait quality in PwMS with different levels of walking impairment. Methods Thirty-three PwMS (15 moderate - PwMS-M, 0 < Expanded Disability Status Score (EDSS) < 3.5, 49 ± 9,9 yrs and 18 severe - PwMS-S, EDSS = ≥ 4, 50,2 ± 9,4 yrs) and 20 healthy adults (control group, CG, 47,3 ± 7,2 years) performed a 10 meter (10mWT, linear walking) and a Figure-of-8 Walk Test (F8WT, curved walking) while wearing five IMUs (APDM, Opal, 128 Hz) on both lateral malleoli, pelvis, sternum, and head. Spatio-temporal parameters (stride frequency and stride duration), as well as gait quality indices related to stability, symmetry and smoothness of gait, were obtained. A Kruskal-Wallis H-test was performed on the estimated biomechanical parameters to investigate if significant differences existed among the different levels of walking ability ("group" factor: CG, MS-M, or MS-S). Results Body-worn sensors captured significant differences in terms of gait quality parameters not only between healthy adults and PwMS, but also between PwMS_M and PwMS_S even when classic spatio-temporal parameters could not (Figure 1). In details, during the 10mWT statistically significant differences between the two groups of PwMS were highlighted for some parameters related to stability (at head and pelvis levels) and symmetry of gait; during the F8WT differences in terms of stability were observed at the three upper body levels (pelvis, trunk, and head) and in terms of smoothness of gait. Discussion The introduction of complementary tests based on both linear and curvilinear trajectories allowed to evidence that only gait quality parameters and not the timed measures (such as spatio-temporal parameters) could detect objective differences in PwMS with different walking ability levels. In conclusion, the quantitative IMU-based approach could be adopted to reveal subtle gait dysfunctions and the curvilinear approach seems to be more sensitive to detect walking impairments. References [1] Angelini L. et al., Sensors, 79; 2019 [2] Moti R.W. et al., Neuropsychiatr Dis Treat, 6: 767-774, 2010 [3] Front Neurol, 24;10:532; 2019 [4] Belluscio V. et al., Sensors; 20; 2020

P2-D-28: ***Walking with a rigid trunk reduces step width, but not the margin of stability in healthy adults***

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BACKGROUND AND AIM: People with Parkinson's Disease (PD) typically walk with a narrow base of support [1]. The underlying mechanism is yet unknown. We hypothesize that trunk rigidity in people with PD reduces the mediolateral extrapolated center of mass (XCoM) excursions during gait, and these subsequently reduce the required base of support to maintain the same margin of stability [2] as when walking with normal trunk movements. As a proof of principle, we tested whether walking with reduced trunk movement in healthy people results in a reduced step width, without altering the margin of stability. METHODS: Fifteen healthy adults walked on a treadmill at comfortable walking speed in two conditions: NORMAL without any instructions, and RIGID TRUNK with the instruction: 'Keep your trunk as still as possible'. Both conditions lasted three minutes; the final two minutes were selected for analysis. An instrumented dual-belt treadmill measured 6D ground reaction forces (N, Nm) and 2D center of pressure positions (m). 3D kinematics (Vicon Plug-in-Gait) were measured to calculate trunk obliquity (deg) and trunk rotation (deg). Maximum range of motion in trunk obliquity and trunk rotation was calculated to define trunk motion for each stride. Step width (m) was calculated as the distance between the left and right lateral malleolus marker position at toe-off for each step. Mediolateral XCoM excursion (m) was defined as the difference in mediolateral XCoM position between left and right toe-off for each stride. The mediolateral margin of stability (m) was calculated at contralateral toe-off for each step [2]. The average value over all strides in each parameter was calculated for each participant. Paired t-tests were used to compare parameters between the NORMAL and RIGID TRUNK condition, with a Bonferroni corrected alpha of 0.05 to correct for multiple comparisons. RESULTS: At group level, paired t-tests showed a significant decrease in trunk obliquity (Fig 1A, mean decrease: 1.65 deg, $t=6.15$, $p<0.001$), trunk rotation (Fig 1B, mean decrease: 1.99 deg, $t=3.79$, $p=0.002$), step width (Fig 1C, mean decrease: 0.015m, $t=5.46$, $p<0.001$) and mediolateral XCoM excursion (Fig 1D, mean decrease: 0.028m, $t=7.1$, $p<0.001$), but not mediolateral margin of stability (Fig 1E) in RIGID TRUNK compared to NORMAL. CONCLUSIONS: Healthy adults are able to walk with reduced trunk motion. In line with our hypothesis, reduced trunk motion resulted in reduced mediolateral XCoM excursion and a narrower base of support, without altering the mediolateral margin of stability. These findings may explain why people with PD - who typically have reduced trunk movements because of trunk rigidity - often walk with a narrow base of support. Future work in people with PD is needed to further test our hypothesis. REFERENCES: [1] Nonnekes et al. (2018) Nat. Rev. Neurol. [2] Hof et al. (2005) J. Biomech.

P2-D-29: ***The relationship between arch height and sagittal plane ankle joint landing kinetics during single-leg hopping in collegiate athletes***

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BACKGROUND AND AIM: Attention is often directed towards propulsion mechanics of competitive athletes for its direct implications on performance. However, research on landing mechanics within this population, particularly with regard to the ankle, stands to offer valuable information pertinent to both performance and injury risk. While previous literature has indicated that foot arch height influences landing mechanics [1-4], many of these studies are based on drop landings, which is a motion that occurs rarely during sports. Hopping is a fundamental motor skill that includes a landing phase that occurs in sequence with rapid initiation of propulsion. Furthermore, the applicability of this fundamental movement to various sports provides a strong platform from which to assess the relationship between arch structure and the mechanical response of the ankle amongst highly skilled movers. Thus, the purpose of this study was to investigate the relationship between arch height and the kinetic strategies of the ankle observed in the sagittal plane during single-leg hopping. METHODS: Twenty-four healthy, collegiate male athletes (Mass: 88.7 ± 11.7 kg; Height: 1.84 ± 0.06 m) completed a stationary hopping task which consisted of hopping ten consecutive times on their dominant limb. Foot anthropometric assessments were obtained to compute arch height index (AHI) and ranged from low to neutral [5]. Average data from the middle three hops of three trials were statistically analysed in SPSS. Kendall's correlations were run (alpha = 0.05) to determine the relationship between AHI and peak vertical ground reaction force, ankle joint stiffness, peak ankle joint power, and net ankle joint work during the landing phase of the hopping task. RESULTS: Arch height was found to be significantly correlated with peak vertical ground reaction force (τb = 0.363, p = 0.014), ankle joint stiffness (τb = 0.304, p = 0.041), and peak ankle joint power (τb = 0.297, p = 0.044). CONCLUSIONS: The moderate to high strength of these correlations suggest that the lower the arch of a competitive male athlete, the less the impact load experienced during landing and the lower the ankle joint stiffness and ankle joint power required to resist dorsiflexion motion during the eccentric phase of hopping. This project was one of the first to look at peak ankle kinetics during the landing phase of single-leg hopping amongst a skilled population with low to neutral arches. References: [1] Powell D et al., 2016. Hum Mov Sci. 49: 141-147. [2] Wilder J et al., 2021. J Electromyogr Kinesiol. 56: 102504. [3] Hovey S et al., 2019. Sports Biomech. 20: 543-559. [4] Niu W et al., 2011. Hum Mov Sci. 30: 614-623. [5] Butler R et al., 2008. J Am Podiatr Med Assoc. 98: 102-106.

P2-D-30: ***Examining the muscular contribution for slip recovery***

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BACKGROUND AND AIM: Slips have been identified as a leading cause for falls and serious injury in Canada for young and older adults (Moyer et al. 2006; Wilkins & Park, 2004). Reactive balance responses and foot stabilization may reduce heel displacement during a slip and minimize the chance of experiencing a fall (Moyer et al. 2009). Currently, there are many studies that have examined slip recovery strategies by investigating the activation patterns of thigh and shank musculature via surface electromyography (EMG), but there are no studies that have examined muscle activity from deep muscles within the shank and foot during gait perturbations, such as a slip. The aim of this study is to examine the muscular activity during slip recovery, specifically, to identify the role of the deep muscles in the shank and muscles within the foot via fine-wire intramuscular EMG. METHODS: Five young adult participants (2 males, 3 females) have participated in this ongoing study. High friction sandpaper placed at each foot contact was secured along the walkway during non-slip trials. Waxed paper adhered to the underside of a sandpaper sheet was exchanged on the force plate to elicit an unexpected heel contact slip perturbation. Unexpected slips were presented after a predetermined number of level walking trials. Muscle activity was collected from ten lower limb (tibialis anterior, peroneus longus, flexor hallucis longus, and tibialis posterior) and foot muscles (abductor hallucis, extensor hallucis brevis, and the transverse head of adductor hallucis) using surface and fine-wire intramuscular EMG. Force plate data was used to record initial contact during the slip (muscle onset was measured relative to this time). A one-way ANOVA was used to assess condition (No slip, slip trials) of muscle onset and magnitude (normalized as a percent of the muscle's peak activation during each trial). RESULTS: Muscle magnitude was increased by 31% (p=0.048) in the transverse head of adductor hallucis (AddT) with a slightly delayed onset (10% of the contact phase, p=0.121) during a slip perturbation compared to level walking. No significant differences (p>0.05) were observed in muscle onset or magnitude in any of the deep muscles of the shank (flexor hallucis longus) and foot (extensor hallucis brevis and abductor hallucis) observed during the different conditions (no slip, slip). CONCLUSIONS: The deep muscles of the shank and foot may play an important role in successful balance recovery from a slip perturbation. Increased activation and delayed onset observed in AddT may indicate weaker propulsion due to the lack of friction experienced during a 'toe-off' slip perturbation. Further data collection and analyses is anticipated to demonstrate more differences in muscle activity that may help further our understanding of the role of leg and foot muscles during a slip, with potential application to foot deformities.

P2-D-31: ***Relationship Between Arch Height, Ankle Kinetics, and Electromyography During A Lateral Hopping Task***

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Relationship Between Arch Height, Ankle Kinetics, and Electromyography During A Lateral Hopping Task Christopher M. Wilburn1, Brandi E. Decoux2, Jennifer Mead3, Portia T. Williams3, and Wendi H. Weimar1 1Auburn University, Auburn, AL, 2 Southeastern Louisiana University, Hammond, LA,3 Bridgewater State University, Bridgewater, MA,4 North Carolina A&T State University, Greensboro, NC email: czw0043@auburn.edu Background and Aim: The presence of lower extremity skeletal misalignments have been considered to serve as a major contributor toward adaptive locomotive mechanisms. Alterations in structures, such as arch height (AH), have correlated to pathomechanics that result in segmental mechanical insufficiencies and increase injury susceptibility (1). While a major emphasis has been placed on dynamic AH mechanisms during walking and running tasks, the altered segmental positioning provide potential biomechanical advantages tasks observed in the athletic setting. Specifically, segmental positioning and landing biomechanics observed in lower arches may improve muscular demands and elicit greater success when completing tasks that require a change in the mediolateral direction (2). This study investigated the association between AH, ankle kinetics and electromyography during a mediolaterally dominant task. Methods: 12 neutral arch (NA) and 12 lower arch (LA) division I athletes (height: 1.84 ± 0.06 m; mass: 91.66 ± 18.39kg), without lower extremity musculoskeletal injuries, completed a lateral hopping task. During the LH task, participants completed the following rhythmic sequence: jumping from the dominant leg to the non-dominant leg, to the dominant leg and back to the non-dominant leg. A force platform was used to investigate peak sagittal and frontal ankle power and peak sagittal and frontal ankle work. Further, surface electromyography was used to examine average amplitude of the medial gastrocnemius and soleus. Results: The results of a Kendall's correlation indicated a strong correlation between LA and mean gastrocnemius amplitude ($\tau b = -.338$, $p = .021$), NA and peak sagittal ankle power ($\tau b = .432$, $p = .003$), and NA total sagittal ankle power ($\tau b = .410$, $p = .005$). Conclusions: These relationships demonstrate the more everted position of LA place a greater demand on the gastrocnemius associated with the eccentric forces during landing. Additionally, the segmental dynamics found in NA require the development of greater peak sagittal ankle work and total sagittal ankle power. Further consideration should be placed on the contributions provided by proximal segments to determine if adaptations or compensations are being made to account for the difference in foot architecture. References: 1. Hollander et al., 2019. Gait Posture. 72: 100-122. 2. Jones et al., 2014. AM J Sports Med. 42.9: 2095-2102. 3. Butler et al., 2008. J Am Podiatr Med Assoc. 98.2: 102-106. 4. Powell et al., 2016. Hum Mov Sci.49: 141-147. 5. Weimar et al. ASB 2021. Virtual.

E - Brain imaging/activation during posture and gait

P2-E-32: ***Prefrontal cortex activity during walking in people with Parkinson`s disease who have marked executive dysfunction***

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BACKGROUND AND AIM: Decline in gait and cognition are common in people with Parkinson`s disease (PD). Walking deficits in people with PD are characterized by a shift in locomotor control from healthy automaticity to compensatory executive control, largely located in the pre-frontal cortex (PFC). Although recent studies found an increased PFC activity during gait in people with PD compared to healthy controls, it is unknown if increased PFC activity is more pronounced in people with PD who have marked executive dysfunction. Thus, we aimed to investigate the influence of executive dysfunction on PFC activity during gait and gait quality in people with PD. METHODS: Forty-seven people with PD were distributed into 2 groups based on executive dysfunction. A cutoff of ≤12 points on the Frontal Assessment Battery (FAB) was used to classify executive dysfunction. Out of 47 individuals with PD, 12 (MDS-UPDRS-III=43.3) had signs of executive dysfunction and 35 (MDS-UPDRS-III=37.2) showed normal scores in the FAB. Participants were asked to stand still for 20s prior to starting to walk. They walked over a 9-m straight path (with a 180° turn at each end) for 80 seconds. Two conditions were tested off medication: single- and dual-task walking (i.e., with a concomitant cognitive task). A portable functional near-infrared spectroscopy system recorded PFC activity while walking (including turns). Wearable inertial sensors were used to calculate spatiotemporal gait parameters. RESULTS: Generally, there were no differences in PFC activity and gait quality between groups ($p>0.05$). Both groups

decreased gait speed (p<0.01) and stride length (p<0.01) during dual-task walking compared with single-task walking. However, only people with executive dysfunction showed a reduction in PFC activity during walking in dual-task compared to single-task (p=0.02). CONCLUSIONS: PFC activity is reduced during dual-task walking, but only in people with executive dysfunction. These results suggest that when the executive load of the task is increased (dual-task walking) the compensatory mechanisms (increased PFC activity) become inefficient, likely due to the limited executive function. People with executive dysfunction may have reached a ceiling of executive resources available during dual-task walking.

P2-E-33: *Decreased mesencephalic locomotor region activity explains the loss of presynaptic inhibition in parkinsonian people with freezing of gait*

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BACKGROUND and AIM: Our group recently observed that people with Parkinson's disease (PD) who experience freezing of gait (freezers) have loss of presynaptic inhibition (PSI) during the preparatory phase of step initiation (APAs). However, people with PD without freezing (non-freezers) and healthy controls have PSI during step initiation. The loss of PSI was associated with freezing of gait (FOG) severity. PSI is centrally modulated to allow execution of supraspinal motor commands at the spinal level for postural preparation. Freezers have decreased blood oxygenation level dependent (BOLD) signal within the mesencephalic locomotor region (MRL), as area related to APAs preceding step initiation. We tested the hypothesis that low MLR neuronal activity in an-event related fMRI protocol during APAs would explain the loss of PSI during APAs in freezers. METHODS: Objective measure of FOG severity, PSI of the soleus muscle, APA amplitude, and beta of BOLD signal change of areas known to initiate and pace gait (e.g., MLR, supplementary motor area, and subthalamic nucleus) were assessed in 34 freezers (UPDRS-III score=49.9) in the ON-medication state. RESULTS: The linear multiple regression model showed that only decreased BOLD signal change of the right MLR (R2=0.32, P=0.0006) and decreased APA amplitude (R2=0.13, P=0.0097) significantly explained 45% of the loss of PSI during step initiation in freezers. CONCLUSIONS: Our results suggest that freezers have less central (MLR) inhibition when standing to allow for step initiation. This is reflected in loss of spinal inhibition (PSI) during postural preparation for a step. Deficit in central and spinal inhibitions during step initiation may be related to FOG pathophysiology.

P2-E-34: *Corticomotor control of lumbar erector spinae in preparation of a postural motor tasks*

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BACKGROUND: Anticipatory postural adjustments (APA) are critical for postural control and inherent to most voluntary movements. Lumbar erector spinae (LES) are activated in advance of ballistic shoulder flexion. Different neural circuits are involved in preparation and execution of LES. Roughly, premotor regions are involved in motor preparation and the primary motor cortex (M1) is involved in movement execution. Transcranial magnetic stimulation (TMS) may activate different neuronal circuits by changing the direction of the coil. While the posteroanterior electrical current in the brain (PA) depolarizes mainly interneurons in M1, an anteroposterior current (AP) is suggested to probe neurons from premotor cortices. The corticospinal excitability of the LES during motor preparation and execution of APA may be different when assessed with PA- and AP-TMS. OBJECTIVE: The study aims to determine the effect of the current direction (PA- vs, AP-TMS) on the corticomotor control during motor preparation and execution of a task eliciting APA of LES. METHODS: Eight healthy participants have been recruited. Electromyographic (EMG) electrodes were positioned on the LES. PA and AP-TMS were tested during a 'motor planning' paradigm. A Warning signal informed participants to prepare to flex their shoulder at the Go signal occurring 1500 ms later. Single-pulse TMS (120% of active motor threshold [AMT]) and paired-pulse TMS (conditioning and test stimuli at 80% and 120% AMT respectively, with interval interstimulus of 3ms) were applied while waiting for the Warning signal (baseline), at 250ms before the Go signal (Motor preparation period) or 30ms before the onset of the EMG burst of the LES (Motor execution period). RESULTS: Similar motor evoked potential (MEP) amplitude modulation was observed between PA and AP-TMS for single and paired-pulse TMS. For single pulse, MEP amplitude was smaller in the Motor preparation (0.12(0.05)mV - p=0.01) and larger in the Motor execution (0.18(0.06)mV - p=0.01) compared to baseline (0.13(0.06)mV) regardless of current direction (main effect: Condition | F=12.41; p<0.001). MEP amplitude was larger in the Motor execution compared to the Motor preparation period (p<0.001). For paired-pulse TMS, less SICI was observed during Motor execution (87.10(15.30) %test) compared to Motor preparation (70.25(16.15) %test - p=0.03) and to the baseline (65.89 (15.21) %test - p=0.01) regardless of the current direction (main effect: Condition | F=8.30; p<0.001). In addition, less SICI was present in PA- than in AP-TMS regardless of the conditions (main effect: Direction | F=6.44; p=0.01). DISCUSSION: The neural circuits recruited by PA- and AP-TMS behave similarly during preparation and execution of a movement eliciting APA of LES. AP- and PA-SICI circuits could be involved in the regulation of corticospinal excitability. Studies with a larger sample size may confirm if AP- and PA-SICI have a similar functional role in motor preparation/executi

P2-E-35: ***Neural correlates of split-belt walking adaptation***

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BACKGROUND AND AIM: Every day we adjust our symmetrical straight line walking pattern to be asymmetrical using different step lengths to react to environmental changes. In the lab, we can study this ability to adapt new gait patterns using a split-belt treadmill, where the speed of each belt can be controlled independently. Although we have a broad understanding of the kinetic and kinematic changes to the gait pattern that occur across the split-belt treadmill gait adaptation process, we have a limited understanding of the brain dynamics underlying adaptation. METHODS: To determine the brain areas and networks involved in locomotor adaptation, we recorded high-density electroencephalography (EEG) and motion capture from 30 healthy, young adults during split-belt treadmill walking. To decrease motion and muscle artifact that contaminate EEG, we incorporated a dual-electrode EEG system and neck electromyography. We hypothesized that relative to normal walking, split-belt walking will elicit gait-related 1) decreases in beta (13-30 Hz) and alpha (8-12 Hz) band synchronization in sensorimotor and posterior parietal cortices, 2) increases in beta band power in prefrontal cortices that will gradually decrease throughout adaptation. RESULTS: EEG source analysis revealed several clusters of independent neural sources, whose centroids were plotted on a standard MRI image (see attached figure). Multiple brain regions were correlated with split-belt walking adaptation. Sensorimotor and posterior parietal cortex had spectral power decrease in the alpha and beta bands during early adaptation to split-belt treadmill walking adaptation that gradually returned to baseline levels by late adaptation. The anterior cingulate cortex did not show significant changes in alpha or beta spectral power, however there was an increase in theta (4-7 Hz) spectral power during early adaptation and early post-adaptation compared to baseline walking. CONCLUSIONS: These results suggest that the sensorimotor, posterior parietal, premotor, and anterior cingulate cortices may be involved in adjusting gait parameters in response to environmental changes experienced while walking on a split-belt treadmill. Our findings highlight the role supra-spinal mechanisms play in regulating locomotor adaptation, which could lead to a better understanding of the neural basis of gait asymmetries and the development of more effective rehabilitation strategies. ACKNOWLEDGMENTS AND FUNDING: Research was supported by the National Institute of Health (R01-NS104772 and T32-NS082128). We thank Nicole Esposito for her assistance in data collection

P2-E-36: ***Reactive balance control and functional connectivity networks in older adults with mild cognitive impairment***

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BACKGROUND AND AIM: Mild cognitive impairment, a prodromal stage of dementia, is often associated with two-folded increased risk of falls compared to those with intact cognition. This increased risk could be attributed to impaired balance recovery responses, the primary defense mechanism (i.e., reactive balance control) against falling. While changes in functional connectivity (FC) networks in self-initiated balance control tasks have been well highlighted, the relationship between these changes and reactive balance control has not been examined. Therefore, this study aims to explore the relationship between FC networks and reactive balance control in OAwMCI. METHODS: Eleven OAwMCI (< 24/30 on MoCA, > 55 years) underwent functional magnetic resonance imaging (fMRI). Participants were asked to relax but not fall asleep and stare at the "x" in the screen (resting state) for 8 minutes. All imaging was acquired using a 3T GE discovery MR750 system (Milwaukee, WI) with a 32-channel head coil. These older adults were then exposed to slip-like perturbations on the

Active step treadmill in standing. Individual intra and inter FC strength (Z score) scores in default mode (DMN), frontoparietal, and cerebellar networks were extracted from the CONN software after completing the necessary steps (importing functional and structural data, preprocessing, setup and denoising, and computing seed-based correlations). Reactive stability, i.e., dynamic center of mass motion state (i.e., its position and velocity) was computed to determine reactive balance control performance. Bivariate Pearson's correlation analysis was performed between FC networks and postural stability using SPSS software. RESULTS: Individuals (MoCA = 21.63 + 1.8) with greater FC in DMN-cerebellum (r2=0.43, p<0.05), DMN-vermis (r2=0.81, p<0.05), precentral gyrus-cerebellum (r2=0.54, p<0.05), and sensorimotor-cerebellum (r2=0.41, p<0.05) network exhibited lower reactive stability. Further, people with lower FC in middle frontal gyrus (r2=0.57, p<0.05), paracingulate gyrus-cerebellum (r2=0.23, p<0.05), frontoparietal-cerebellum (r2=0.79, p<0.05) and cerebellar-brainstem (r2=0.49, p<0.05) and precuneus-cerebellum (r2=0.54, p<0.05) networks exhibited lower reactive stability. CONCLUSION: Our results are in line with previous findings in OAwMCI that demonstrated excessive activation of DMN FC at resting state and such greater FC has been associated with decreased balance control. Specifically, our results showed greater FC between DMN and cerebellum, and DMN and vermis to be significantly associated with decreased reactive balance control. The FC strength associated within cortico-cerebellar (motor planning) and cerebellar-brainstem (movement initiation and modulation) networks could affect reactive responses, thus, attributing to the increased fall risk among OAwMCI. While this was based on preliminary findings, future studies must examine underlying the neural mechanisms associated with reactive balance control with a higher sample size to validate these findings.

P2-E-37: ***Localizing EEG Recording of the Startle Reflex During Unexpected Postural Translations***

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Background and Aim: Balance perturbations are accompanied by specific global cortical activation within 90 ms after perturbation onset. Termed perturbation evoked potentials (PEP), these responses are widely distributed over frontal, central, and parietal cortex and can be identified through a single electrode site (Ditz et al. 2020). Predictability of the disturbance modifies EEG activity related to balance adjustments (Mochizuki et al. 2010), but specific measurements sites for a stereotypical startle response have not been identified. We hypothesized that a subcortical sensor location may be used as a specific marker for the startle response during postural events. Methods: Five healthy adult (20.8 ± 2.9 yrs) and 3 healthy elder (71.7 ± 4.2 yrs) subjects provided informed consent to participate. Subjects wearing a safety harness were instructed to maintain upright stance on a dynamic platform with eyes open and feet placed shoulder-width apart. Thirty-four 20 cm translations at 100 cm/sec were presented: 29 in the posterior direction and 5 anterior translation catch trials. Trial 1 was considered an unpredictable posterior translation due to auditory distraction. Active electrodes over an EasyCap (Brain Vision, NC) were located according to the international 10-20 system at positions Fz and Cz. Also 2 channels from cEEGrids (TMSI, Netherlands) were patched over the right mastoid. Reference electrodes were placed at FCz and AFz. Raw EEG data and 3-axis accelerations of the head were sampled at 1000 Hz, filtered offline with a 2nd order Butterworth bandpass filter (2.5Hz-30Hz) and a 60Hz notch filter. Signal onset was identified as activity 3 standard deviations greater than the mean of pre-perturbation activity. Onset latencies were compare across young and elderly using a t-test ($p<0.05$). Platform acceleration sampled at 150 Hz (Delsys, Inc., MA), and EEG data were synchronized using TTL. Results: Significant differences between the onset latencies of young and elderly individuals were not consistent. Across both young and elderly participants, sensors located over the mastoid bone responded earlier and with much less variability than those placed cortically (mean latencies 108 /-9 ms vs. 137 /- 22 ms). Predictable perturbations elicited shorter latencies (101 ms /- 15 ms) at mastoid sensors than unpredictable events (116 ms /- 13 ms) whereas cortical recordings were not consistently differentiated by expectation. Conclusions: Prior work with seated postural disturbances have verified that a single EEG sensory site can be used to reliably indicate the onset of a PEP. We have found that although cortical PEP are reported as slowing in the elderly (Duckrow et al. 1999), subcortical (mastoid sensor) activity emerged with the shorter latencies and decreased variability expected of a reflex response (Nonnekes et al. 2014). We hypothesize that this sensor location may serve as a specific marker for the startle response during postural events.

P2-E-38: ***Individual differences in neural connectivity from prefrontal cortex to cortical and spinal motor circuits during tandem stance are associated with balance ability***

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BACKGROUND AND AIM: The dorsolateral prefrontal cortex (dlPFC) is differentially engaged during challenging balance tasks. But, how the dlPFC modulates motor pathways that control standing balance, i.e. primary motor cortex (M1) and spinal circuits is unclear. Here we used paired neural stimulation to measure effective neural connectivity from dlPFC to M1 (dlFPC-M1) and to spinal circuits (dlPFC-H). Data were collected during easy and difficult standing balance conditions to identify M1 and spinal excitability changes modulated by dlPFC and balance challenge. Due to the dlPFC's known inhibitory effects on M1, we hypothesized that dlPFC conditioning would decrease M1 excitability and that dlPFC-M1 connectivity would be stronger in individuals with lower balance ability. We further hypothesized that dlPFC conditioning would increase spinal excitability and that dlPFC-H connectivity would be stronger in individuals with lower balance ability. Finally, we hypothesized differences in connectivity with balance ability would only be evident during challenging balance tasks that engage the prefrontal cortex. METHODS: We plan to test 20 young (18-35 years) able-bodied adults during easy (quiet standing or QS) and difficult (tandem stance or TS) standing balance. To assess dlPFC-M1 and dlPFC-H connectivity, a conditioning transcranial magnetic stimulation (TMS) pulse was sent to the dlPFC prior to either a secondary TMS pulse to M1 or a peripheral nerve stimulus (PNS) to the tibial nerve, respectively. The secondary TMS and PNS pulses elicit motor evoked potentials (MEPs) and Hoffman reflexes (H-reflexes), respectively, which measure motor excitability and inform connectivity. dlPFC-M1 connectivity was calculated as: 100*(conditioned MEP/unconditioned MEP), while dlPFC-H connectivity was calculated as: 100*(conditioned H-reflex/unconditioned H-reflex). A narrowing beam walking test was used to assess individual differences in balance ability. RESULTS: Interim analyses (n=5 healthy young adults) show that dlPFC conditioning decreased MEP amplitude and increased H-reflex amplitude compared to unconditioned MEPs/H-reflexes in each balance condition. dlPFC-M1 and dlPFC-H connectivity did not differ between QS vs TS conditions. Greater dlPFC-M1 and dlPFC-H connectivity was correlated with individual balance ability during TS but not during QS. CONCLUSIONS: Measuring dlPFC conditioning during functionally relevant conditions provides a unique task-specific probe into the modulatory role of non-motor cortical circuits on hierarchical motor circuits in the cortex and spinal cord implicated in standing balance control. Once established, these measures of prefrontal connectivity to balance circuits may be a useful neurophysiologic assessment for older individuals with low balance ability. ACKNOWLEDGEMENTS AND FUNDING: NIH NICHD R01 1R01HD095975-01A1 (PI Kesar)

P2-E-39: ***Higher pre-stimulus sensorimotor beta activity during standing balance perturbations is associated with worse whole-body motion perception***

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BACKGROUND AND AIM: The ability to perceive the direction of whole-body motion (WBM) during standing may play a critical role in maintaining balance. WBM perception thresholds vary across individuals, and in older adults, higher (i.e. worse) thresholds are associated with worse balance ability. Here we sought to identify the underlying neural correlates of WBM perception. Beta oscillatory activity, a hallmark of sensorimotor processing, increases following a balance perturbation and scales with balance ability. However, in unisensory perceptual studies in the absence of movement, pre-stimulus beta activity reduces detection accuracy. Whether pre-stimulus beta activity plays a role in multisensory processing necessary for WBM perception is unknown. We hypothesized that pre-stimulus beta activity would be higher in individuals with worse WBM perception, and that worse perception would be associated with worse balance ability. METHODS: WBM perception during backward support-surface perturbations to standing balance was tested in 12 healthy young adults while recording electroencephalography. We used a 2-alternative forced choice paradigm in which participants reported whether pairs of perturbations were in the "same" 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 determined online using an adaptive psychometric algorithm. Responses were fit to a psychometric curve to quantify two parameters: threshold, or angle that is accurately detected half of the time; and sensitivity, or slope at the threshold. Baseline beta power (13-30 Hz) was extracted from the central midline electrode (Cz) before each perturbation (-1000-0 msec). Balance ability was quantified via the distance traversed on a narrowing beam. Pearson correlations were performed between perceptual ability and baseline beta power, as well as balance ability. RESULTS: Lower WBM threshold (i.e., better perception), but not sensitivity, correlated with lower beta power (r= 0.74, p= 0.006). Sensitivity decreased (i.e., worsened) as balance ability decreased (r= -0.41), but did not reach statistical significance (p= 0.10). Further, individuals with higher balance ability had lower WBM perception threshold (6.73°) and higher sensitivity (3.71°) compared to those with lower balance ability (threshold: 8.84°; sensitivity: 5.64°). CONCLUSIONS: The positive association between baseline beta power and WBM perception suggests that beta activity may represent a sensory gating mechanism, such that lower beta activity enhances the perceptual salience of somatosensory signals. Overall, sensorimotor beta may have different roles in multisensory processing needed for WBM perception and reactive balance recovery. Future work is needed to understand the causal role of cortical information processing represented by beta activity for WBM perception and balance ability. ACKNOWLEDGEMENTS AND FUNDING: 1F32HD105458-01 (JLM)

P2-E-40: ***Prefrontal cortex activity during gait in females with and without a concussion history, a pilot study***

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BACKGROUND AND AIM: A concussion is a diffuse cortical injury that results in gait deficits that usually resolve in 30 days. However, recent evidence suggests that subtle gait deficits can persist >30-days post-concussion under complex gait conditions that tax the prefrontal cortex (PFC). Compared to males, females seem to exhibit greater neurological deficits which potentially prolongs concussion recovery. Despite these differences, females remain understudied in concussion literature. Therefore, this pilot study aimed to quantify PFC activity during gait with and without a secondary task in females with and without concussion history. We hypothesize that compared to females without a concussion history, previously concussed females will have worse gait performance and increased PFC activity during gait, particularly during gait with a secondary task. METHODS: 20 females, 11 controls (20.6[1.5]yrs) and 9 concussed (22.2[3.7]yrs; 4.0[4.5]yrs post-concussion), completed the post-concussion symptom scale. Six wearable sensors quantified gait (speed [m/s], stride length [m], and turn velocity [°/s]). Functional near-infrared spectroscopy quantified left and right PFC activity (changes in oxyhaemoglobin concentrations; $O2Hb$ [μM/L]). Gait and PFC activity were quantified during two, 2-minute walks under single- (ST) and dual-task (DT) conditions, with the secondary task being Serial-7's. Independent samples t-tests compared gait, L and RPFC activity, and total symptom scores between groups. An a priori $\alpha = 0.05$ was used. Means, standard deviations and Cohen's effect sizes (ES) are reported. RESULTS: There was no significant difference between groups total symptom scores (control: 5.7[6.1]; concussed:10.1[9.3]). There were no significant gait differences between groups for ST speed (control:1.1[0.1]; concussed:1.1[0.1]; ES=0.17), stride length (control:1.2[0.1]; concussed:1.2[0.1]; ES=0.40), and turn velocity (control:201.6[30.7]; concussed:213.9[20.0]; ES=0.48); as well as for DT speed (control:0.9[0.1]; concussed:0.9[0.2]; ES=0.22), stride length (control:1.1[0.1]; concussed:1.1[0.2]; ES=0.29), and turn velocity (control:194.9[21.6]; concussed:204.4[28.6]; ES=0.38). No significant differences were found between groups for

ST RPFC activity (control:0.64[3.50]; concussed: -0.42[3.00]; ES=0.33) and LPFC activity (control:0.11[0.85]; concussed:0.11[0.62]; ES=0.00); as well as DT RPFC activity (control:1.28[1.79]; concussed: -0.16[5.20]; ES=0.37) and LPFC activity (control:1.12[1.96]; concussed:0.71[0.62]; ES=0.28). CONCLUSIONS: The lack of group differences in this preliminary study suggests that young adult females with a concussion history who do not complain of persistent concussion symptoms appear to have no PFC activity or gait performance deficits. These results begin to address how a concussion history affects cortical activity and gait in females. Future research should add a male group and increase the sample size to confirm these pilot results.

G - Cognitive, attentional, and emotional influences

P2-G-41: ***Affective and motor symptom changes over time in individuals who develop freezing of gait in Parkinson's disease***

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BACKGROUND AND AIM: While the cause of Freezing of gait (FOG) in Parkinson's disease (PD) is unknown, evidence suggests that motor and affective symptoms may precede FOG onset and contribute to its development. Few studies have examined longitudinal changes to motor and affective symptoms in those who develop FOG and consensus has not been reached. This study aimed to compare affective and motor symptom progression over 2 years between those who developed FOG over the course of this study (tFOG: Transitional Freezers) with Non-Freezers (FOG-) and Freezers (FOG+). METHODS: Affective, gait and motor severity data were obtained from the Ontario Neurodegenerative Disease Research Initiative 4-year, longitudinal dataset [Farhan et al 2017]. 120 participants with PD were categorized as FOG- (n=71), tFOG (n=25), FOG+ (n=25) based on the FOG Questionnaire (FOG-Q). The tFOG were defined as those who scored ≥1 on FOG-Q item 3 after previously scoring 0. Due to attrition at the 3- and 4-year follow-ups, clinical features were examined across the groups at: baseline, 1- and 2-year follow-up. Affective symptoms were examined using the Quick Inventory of Depressive Symptomology (QIDS) and Generalized Anxiety Disorder Assessment (GAD7). Gait and motor severity was examined using Unified Parkinson Disease Rating Scale part III (UPDRS-III) and gait velocity. RESULTS: Of 25 tFOGs, 9 transitioned at 1-year, 13 at 2-year and 3 at 3-year follow up. FOG had significantly greater depression compared to FOG- at baseline (p=0.001), 1-year (p=0.003), and 2-year follow-up (p=0.002). There were no significant differences at baseline between tFOG and FOG-. However, tFOG had significantly worse depression compared to FOG- at 1-year (p=0.014) and 2-year (p=0.025). Depression significantly worsened over time specifically within the tFOG group (p=0.002). Despite being similar in anxiety at baseline, FOG+ had greater anxiety than FOG- after 1-year (p=0.006) and 2-year (p=0.004) follow-ups. Anxiety

significantly worsened over time specifically within the FOG+ group (p=0.009). Anxiety for tFOG was not different from either group at any time point, and although it increased slightly over time, this was not significant. There were no significant parallel changes for motor symptoms severity (i.e. gait velocity, UPDRS-III) over this 2-year duration, although an interaction between group and time for UPDRS-III approached significance (p=0.07) suggesting that FOG- and FOG+ had greater UPDRS-III after 2 years. CONCLUSIONS: This study shows no significant affective differences between tFOG and FOG+ despite a greater change in depressive symptoms in tFOG compared to FOG+ and FOG-. Importantly, tFOG developed greater depression after 1-year, which remained greater after 2-years compared to FOG-. These findings suggest that affective disturbance may precede the development of FOG in PD. Given that FOG+ had greater anxiety than FOG-, further work should consider if treating anxiety improves FOG.

P2-G-42: ***Does aging change standing balance control and increase postural threat?***

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Background and aim: Postural threat associated with standing on elevated surfaces reportedly shifts the mean position posterior, increases the frequency, and decreases the amplitude of the center of pressure (CoP). Fear of falling (FoF) has often been shown among older adults, and its relevance in terms of balance impairments was also reported earlier. Therefore, height threat and associated changes in postural control may be higher among older adults than younger adults. This study investigated the characteristics of changes in postural control among older adults due to standing on elevated surfaces compared to younger adults. Methods: This study was conducted on 10 healthy young adults (YA) and 17 healthy old adults (OA). Participants performed 30-second standing trial on a stabilometer set up on the floor (LOW condition) and on a 60 cm elevated platform (HIGH condition). After each trial, FoF was assessed using a 100 mm visual analog scale (VAS). The participants were categorized into "fearful" or "non-fearful" based on a 10 mm scale at HIGH condition. The trajectory of CoP was recorded using a stabilometer (100 Hz), and CoP mean position (MP), CoP mean power frequency (MPF), and CoP root mean square (RMS) in the anterior-posterior direction were calculated. The percentage of fearful participants was compared between YA and OA. The effect of surface height on variables related to CoP was also compared between YA and OA. Results: There was no significant difference between YA and OA in the proportion of fearful participants in the HIGH condition. MPF was significantly higher among OA than in YA. The change with surface height was significantly larger in OA than in YA. MP and RMS did not differ significantly between YA and OA with surface height. Conclusions: This study was found that the psychological change associated with standing on elevated surfaces was not related to age. However, MPF with elevating surface increased among OA than YA. Therefore, postural control strategies in OA could be more affected by surface height than YA. This study examined the effect of surface height only on static balance in OA. Future studies must examine the effect of surface height on dynamic balance in OA since falls often occur during dynamic activities, such as walking.

P2-G-43: ***Age Differences in Working Memory and Cue Utilization During Postural Recovery***

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1. Background and aim: The known involvement of executive functions in gross motor control may partially explain the age-related declines in motor skills, such as postural control. However, the identification of specific executive functions involved in postural control, and the effect of aging in this context remain elusive. The Dual Mechanisms of Control (DMC) model is an executive functions framework that has demonstrated established age differences on cue differentiation using a continuous performance task (AX-CPT). These age differences were thought to be secondary to normative age-related decline in three central executive functions (working memory, inhibition, and attentional control), with a particular emphasis on working memory due to its necessary role in cue utilization. The current study aims to apply the DMC framework in a postural recovery paradigm in both young (YAs) and older adults (OAs). 2. Methods: 15 YAs and 15 OAs underwent a novel, modified perturbation paradigm (Balance AX-CPT). Participants received a letter cue, signaling the presence (A) or not (B) of an impending perturbation (forward translation of 6 cm), which could be valid (A - perturbation, B - no perturbation) or invalid (A - no perturbation, B - perturbation). Participants were expected to retain the cue for a variable period of time and utilize the information to maintain posture in the face of both predictable and unpredictable platform perturbations. The primary outcome measures were anticipatory postural adjustments (APAs), operationalized as lower limb muscle activation using electromyography, and kinematic data on the hip, knee, and ankle angles, during a one-second window prior to the onset of each platform perturbation. Background neuropsychological measures and the cognitive AX-CPT were also administered. Participants with higher working memory, inhibition, and attentional capacities were expected to utilize and discriminate the cues more effectively, resulting in overall higher APAs and balance control in YAs. 3. Results: Both EMG and kinematic data provided evidence that YAs demonstrated significantly better cue differentiation than OAs, supported by their overall higher APAs and lower compensatory postural adjustments to predictable perturbations when A-cues were presented. Measures of working memory were significantly and positively associated with APAs in the kinematic data; while working memory, inhibition, and attentional control measures were positively associated with APAs in the EMG data. Better performance on the cognitive AX-CPT was also associated with better Balance AX-CPT performance. 4. Conclusions: The current findings provide preliminary evidence for the involvement of the DMC framework in postural recovery, as YAs utilized their working memory to better prepare for perturbations than OAs. Additionally, working memory, inhibition, attentional control, and AX-CPT were all individually predictive of Balance AX-CPT performance, suggesting the importance of effective cue utilization in postural control. Future work will consider dual-task conditions to further limit working memory capacity and examine the age differences contributing to effective cue use in perturbation paradigms.

P2-G-44: ***Impact of Fear of Falling on Turning Performance in Post Stroke Patients***

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Background and Aim: Turning difficulties has been reported in stroke patients but previous studies indicate that falls experience might not be a significant contributor to the turning performance among stroke patients. Fear of falling (FOF) is common after a fall although it can occur without a fall experience. Turning is a complex and demanding task, individuals with FOF may need to approach more cautiously and change turning strategies. Therefore, the purpose of this study was to investigate the impacts of FOF on turning performance in chronic stroke patients. Methods: Participants with aged 20-99 years and a single unilateral stroke with hemiparesis experienced at least 6 months prior to their participation in the study were recruited. They were instructed to perform the 180° turning while walking and the 360° turning in place at a self-selected pace, which was recoded using APDM Opal wireless sensors and Mobility Lab software. Duration (s) and the angular velocity (°/s) of the turnings were analyzed. Fear of falling was evaluated by the Falls Efficacy Scale- International (FES-I). Falls history occurred 12 months prior to the assessment was recorded. Participants were identified as non-fallers, single-fallers and multiple-fallers (≥2) based on the number of falls. Results: A total of 97 chronic stroke patients were recruited in the study. A higher score on FSE-I was significantly correlated with a decline in angular velocity in all turning tasks adjusting for age, sex, height, weight, post-stroke duration, paretic side, and stroke type. The models remained significant after further controlling falls history. Further analysis was conducted to compare turning performance between the levels of fear of falling. Participants with a high level of concern for falling had significantly slower angular velocity during all turning tasks compared to those with a low level of concern for falling. Participants with a moderate level of concern for falling was also found to have significantly slower angular velocity than those with a low level of concern for falling when performing a 360° turning to paretic side. No significant effects were found between the levels of fear of falling and turning duration. Conclusions: Our findings revealed that a higher level of fear of falling, regardless of falls history, was significantly related to a reduced angular velocity in all turning tasks. Moreover, a significant dose response was observed when comparing angular velocity across the levels of fear of falling, such that the angular velocity in all turnings reduced as the levels of fear of falling increased. Turning performance may not affected by falls experience. Anxiety about falling may be more important than actual falls.

P2-G-45: ***A novel way of measuring dual-task interference: the reliability and construct validity of the dual-task effect battery in neurodegenerative disease***

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BACKGROUND AND AIM: Decreased automaticity is common among individuals with neurodegenerative disease and is often assessed using dual-task (DT) paradigms. However, the best methods for assessing performance changes related to DT demands remain inconclusive. We aimed to investigate the reliability and validity of a novel battery of DT measures (DT Effect - Battery (DTE-B)) encompassing three domains: task-specific interference (comprised of motor and cognitive DT effects (DTE)), task prioritization (task prioritization category and modified attention allocation index), and automaticity (combined DTE (cDTE)). METHODS: Data for this cross-sectional study included 125 participants with Parkinson's disease (PD), 127 participants with Alzheimer's disease (AD), and 84 healthy older adults. Reliability analyses were conducted using a subset of each population. DTE-B measures were calculated from single and DT performance on the Timed Up and Go test (TUG), and a serial subtraction task. Motor performance was characterized by time to complete the TUG in seconds, and cognitive performance by a modified correct response rate (seconds per correct response) Construct validity was evaluated via associations within the DTE-B and with theoretically supported measures as well as known-groups validity analyses. RESULTS: Good to excellent reliability was found for DTE-B measures of task interference (motor and cognitive DTEs) (ICCs≥.658) and automaticity (cDTE) (ICCs≥.938). The minimal detectable change was smallest consistently for the motor DTE (8.9 in the healthy older adult group to 21.0 in the PD group) and largest for the cDTE (18.2 healthy older adult group to 92.4 in PD group) Evidence for convergent validity was found with associations within the hypothesized constructs. Known-groups validity analyses revealed differences in the DTE-B among the healthy group and PD and AD groups (ps≤.001), excepting task prioritization (ps≥.061). CONCLUSIONS: This study provides evidence to support the DTE-B as a reliable measure of multiple constructs pertinent to DT performance. The cDTE demonstrated evidence to support its validity as a measure of automaticity. Further investigation of the utility of the DTE-B in both PD and AD, as well as other populations, is warranted. ACKNOWLEDGMENTS: This study was partially funded by an Institutional Development Award (IDeA) from the National Institute of General Medical Sciences of the National Institutes of Health: #P20GM109025.

P2-G-46: ***Cognitive-motor dual task interference in Alzheimer's disease, Parkinson's disease, and prodromal neurodegeneration: a scoping review***

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BACKGROUND AND AIM: Cognitive motor interference (CMI) is a common deficit in Alzheimer's (AD) disease and Parkinson's disease (PD) and may have utility in the identification of prodromal neurodegeneration. There is a lack of consensus regarding the measurement of CMI resulting from dual task paradigms. The aim of this scoping review was to determine how individuals with AD, PD, and prodromal neurodegeneration are impacted by CMI as measured by DT performance. METHODS: A systematic literature search was performed in six datasets using the PRISMA guidelines. Studies were included which included samples of participants with AD, PD, or prodromal neurodegeneration and reported

at least one measure of cognitive-motor DT performance. RESULTS: 4741 articles were screened and 95 included as part of this scoping review. Articles were divided into three non-mutually exclusive groups based on diagnoses, with 26 articles in AD, 56 articles in PD, and 29 articles in prodromal neurodegeneration, and results were presented accordingly. CONCLUSIONS: Individuals with AD and PD are both impacted by CMI, though the impact is likely different for each disease. We found a robust body of evidence regarding the utility of measures of DT performance in the detection of subtle deficits in prodromal AD and some signals of utility in prodromal PD. There are several key methodological challenges related to DT paradigms for the measurement of CMI in neurodegeneration. Overall, DT paradigms show good potential as a clinical method to probe specific brain regions, networks, and functions; however, task selection and effect measurement should be carefully considered. ACKNOWLEDGEMENTS: None.

P2-G-47: ***Visuospatial working memory and obstacle crossing 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. 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 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.

P2-G-48: ***Sex differences in balance control during a visual attention dual task pre- and post-high intensity treadmill running in varsity athletes.***

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BACKGROUND AND AIM: Sport competition requires increased demands on visual attention (e.g., dynamic visual acuity [DVA]) and balance during high levels of physical exertion. Previously, athletes obtained superior DVA scores during moderate intensity treadmill exercise compared to non-athletes. However, it is unknown whether sex differences and higher intensity exercise have effects on dual task performance in athletes. The aim of this study was to determine how near maximal treadmill exercise affects balance control and performance during a DVA visual attention task between male and female athletes. METHODS: Young adult athletes (N= 17, age= 19.8 ±1.4years, females= 10) were recruited from varsity teams (e.g., hockey, rugby, and soccer). Athletes were excluded from the study if they reported recent concussion (e.g., < 3 years post-injury), vestibular-ocular motor, and/or binocular vision disorders. The DVA task involved a Tumbling "E" target moving randomly at a speed of 2.31m/s on a 55" LED monitor viewed at 4m. Participants stood in a sharpened Romberg stance on a Bertec® force platform (100Hz) for 45 seconds while completing the DVA task pre- and post-treadmill test. The treadmill protocol involved participants running at a constant speed (between 5.0-7.0mph) with increasing incline by 2% every two-minutes for a total of 8 minutes. The treadmill test was completed when athletes reached approximately 85% of their maximum heart rate and/or reported a rating of perceived exertion of 8/10 at which time they completed a three-minute cooldown. Athletes performed the visual attention task in four conditions, 1) resting state, 2) immediately post-cooldown, 3) 10-minutes and 4) 20-minutes post-exercise. Balance control was analyzed as RMS of COP displacement (dCOP) in A/P and M/L directions. The DVA task was scored as the log of the minimal angle of resolution (LogMAR) of the smallest recognizable target achieved. RESULTS: There were no interaction effects of sex and time pre-/post-exercise for DVA score ($F(1,15)= 0.47$, $p= .702$) and dCOP (A/P dCOP: $F(1,15)= 0.65$, $p= .495$; M/L dCOP: $F(1,15)= 0.34$, $p= .800$). In addition, there were no main effects of sex on DVA score ($F(1,15)= 3.67$, $p= .075$) or dCOP (A/P dCOP: $F(1,15)= 3.39$, $p= .086$; M/L dCOP: $F(1,15)= 2.41$, $p= .141$). However, there was a main effect of time for M/L dCOP ($F(1,15)= 3.81$, $p< .05$) indicating that balance control worsened from pre-exercise to post-exercise for all time points up to 20-minutes of recovery. CONCLUSIONS: There were no sex differences in

healthy athletes for balance or DVA performance pre- and post-high intensity treadmill running. Athletes performed consistently on the visual attention task; however, balance had a greater dual task cost that persisted post-exercise. These findings may provide normative data to characterize dual task performance at sport competition levels of exertion to compare with athletes who experience sensorimotor impairments after a sport-related concussion.

P2-G-49: ***Evaluating the impact of depression on gait variability over time in Parkinson's Disease***

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BACKGROUND AND AIMS: Depression is the most common affective disturbance faced by individuals with Parkinson's Disease (PD). Whilst a growing body of work has examined the relationship between walking ability and emotional disturbance in young and older adults, less work has focused on individuals with PD, despite a prevalence of approximately 35% in PD compared to 15% in the general population. Depression is associated with PD axial symptoms and often more frequently observed in the "postural instability and gait disturbance" phenotype of PD. Yet, few studies have quantitatively examined the influence of depression on gait in PD, nor its impact on gait changes over time. This study aimed to examine the influence of depression in PD on gait variability (i) during single task walking, (ii) during dual-task walking in PD, and (iii) after 1 year. METHODS: Thirty-nine participants with PD who completed a gait and clinical assessment at baseline and 1-year follow-up were selected from the Ontario Neurodegenerative Disease Research Initiative study [Farhan et al 2017]. Eighteen PD participants scored >6 on the Quick Inventory of Depressive Symptomatology (QIDS) and were grouped as PD with depression (PD+dep), while 21 PD patients scored between 0-5 on the QIDS and were grouped as PD without depression (PD-dep). At each visit (i.e. baseline and 1-year follow-up), participants walked under four conditions: (i) ST: single-task walking at a self-selected pace, (ii) DT-S1: dual-task walking while subtracting 1s from 100, (iii) DT-An: dual-task walking while naming animals, (iv) DT-S7: dual-task walking while subtracting 7s from 100. Spatiotemporal gait parameters were recorded using a GAITRite® pressure sensor mat. RESULTS: PD+dep displayed increased variability in step length ($p=0.016$), step width ($p=0.042$), and stride velocity ($p=0.014$) during ST walking compared to PD-dep, despite being matched in age, gender, cognitive function, and motor symptom severity. As expected, a main effect of DT condition was found for step time, length, and width variability which showed that both groups increased step-to-step variability as the DT difficulty increased (DT-S1→ DT-An / DT-S7). An interaction between DT condition and group revealed that stride width variability increased as the difficulty increased specifically in the PD+dep group. Finally, greater change over time was found in the PD+dep versus PD-dep group, specifically for step length variability ($p=0.015$) and step width variability ($p=0.045$) during ST walking, but not across the DT conditions.

CONCLUSIONS: These findings align with previous reports that PD+dep have increased step-to-step variability during ST and DT walking compared to PD-dep. Furthermore, PD+dep also showed greater changes in gait variability after 1-year, which may put them at greater risk for falls. Future studies should examine strategies for managing affective disturbance to reduce gait decline and mitigate fall risk.

P2-G-50: ***Evaluating the influence of dopamine on limbic network connectivity at rest in Parkinson's disease patients with freezing of gait***

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Background: Freezing of gait (FOG) is difficult to treat due to its poorly understood pathophysiology. Recent work has linked anxiety to FOG with data suggesting that Freezers may have dysfunctional fronto-striato-limbic circuitry compared to Non-Freezers. Specifically in relation to anxiety, there appears to be reduced connectivity between the fronto-parietal attentional network (FPN) and limbic regions that is coupled with increased connectivity between limbic regions and the putamen. Whilst resting state fMRI studies have found that dopaminergic replacement therapy (DRT) has a significant influence on functional brain organization in PD, its specific effect on fronto-striato-limbic functional connectivity in Freezers remains unclear. Aim: To investigate the effect of DRT on the resting state functional connectivity (rsFC) across the fronto-striato-limbic circuitry in PD patients with FOG. Methods: Twenty-three PD patients with FOG were recruited for a resting state fMRI study and were randomised to be scanned in both their OFF and ON dopaminergic medication states. The brain scans were pre-processed with FMRI-prep, and CONN toolbox was used to denoise and analyse the data. The selected regions of interests, including the FPN, putamen, caudate, nucleus accumbens, amygdala and hippocampus were obtained from the Harvard Oxford atlas. A seed-based analysis was performed and RSFC contrasts were made between OFF and ON states. Correlation analyses evaluated the relationship between trait anxiety and the change in rsFC from OFF to ON. Results: Freezers OFF had significantly increased positive rsFC between the right Caudate and the right Hippocampus ($p=0.009$), and increased negative connectivity between the left Putamen and left FPN posterior parietal cortex ($p=0.042$). However, these results did not survive FDR corrections. In relation to anxiety measures, a significant negative correlation was found between the rsFC OFF-ON change in the left Amygdala and the left FPN lateral prefrontal cortex ($r=-0.423$). This indicated that with the increase of trait anxiety, there was a greater shift towards positive connectivity between these regions when patients went from the OFF to the ON state. A significant positive correlation was also found between the rsFC OFF-ON change of the left Putamen and left FPN posterior parietal cortex and anxiety ($r= 0.486$), where as trait anxiety increased, there was a greater shift towards negative connectivity between these regions from the OFF to the ON state. Conclusion: Dopaminergic medication does not significantly alter the frontoparietal-limbic-striatal circuitry. However, in relation to trait levels of anxiety DRT modulates shifts in rsFC, such that medication could improve disrupted connectivity patterns across the FPN-limbic circuitry. As increased positive connectivity between the FPN and limbic network improves the regulation of emotions, this would reduce

the limbic load on the striatum, increasing resources for gait, hence reducing the occurrences of FOG. Thus, the impact of medication on frontoparietal-limbic connectivity may depend on whether Freezers are of an anxious subtype, future studies could investigate this heterogeneity in dopaminergic responsiveness with anxious and non-anxious freezer groups.

P2-G-51: ***Effect of biological sex on static postural control and the influence of postural threat***

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BACKGROUND AND AIM: Biological sex influences the likelihood, context, and outcomes of falls. Contributions from balance or responses to stress and anxiety may contribute to these sex differences, emphasizing a need to consider sex in balance research. Exposure to postural threat induces robust changes to balance and emotional-cognitive state; however, less is known about how sex influences this behaviour, especially across different types of postural threat. This study investigated the effect of biological sex on static balance control, emotional-cognitive state, and threat-induced changes in these outcomes. METHOD: Data from 321 healthy participants (145 male, 176 female, mean age=22.9) were aggregated from 7 prior studies that conducted quiet stance trials under low and high postural threat (high height or unpredictable balance perturbation). Questionnaires measured biological sex and personality traits (trait anxiety, movement reinvestment, physical risk taking). Balance outcomes included anterior-posterior center of pressure mean position (MPos), root mean square, mean power frequency (MPF) and power within low (0-0.05Hz), medium (MF;0.5-1.8Hz), and high (HF;1.8-5Hz) bands. Emotional-cognitive outcomes included mean electrodermal activity and self-reported balance confidence, anxiety, and attention focus (e.g. attention to balance, threat, etc.). Three-way mixed ANOVAs were conducted with threat (low/high), threat type (height/perturbation), and sex (male/female). Interactions were followed with planned comparisons between threat conditions within each sex and threat type. Multiple linear regressions (MLR) were conducted to determine if sex and personality traits predict threat-related changes in balance and emotional-cognitive state. RESULTS: Main effects of sex ($p<0.05$) revealed higher balance confidence, MPF, MF, and HF for males than females. A sex × threat interaction was found for HF ($p<0.01$); HF increased with threat with a larger effect for males than females ($d=-0.82$ vs -0.67). Three-way interactions ($p<0.05$) were found for MPos and attention to balance. Threat-related shifts in MPos were dependent on threat type, with larger effects for males than females in both height ($d=1.34$ vs 1.07) and perturbation ($d=-0.071$ vs -0.62). Attention to balance increased with threat ($p<0.001$), with larger effects for females to height threat ($d=-1.11$ and -0.80), for males to perturbation threat ($d=-0.98$ and -0.71). The MLR model predicted threat-related changes in several variables; however, male sex was only a predictor of higher HF ($\beta=0.16$, $p<0.05$). CONCLUSION: Biological sex differences are evident in aspects of static balance and emotional-cognitive state. When postural threat is introduced, additional differences between sexes also emerge. These findings highlight the need to collect sex-based demographics,

maintain equal group sizes, and disaggregate data by sex when appropriate. FUNDING: Project supported by NSERC grants to ER MZ AA CT & MC.

P2-G-52: *Changes to cortical potentials time-locked to discrete postural events during postural threat exposure*

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Background and aim: Height-related postural threat has been shown to influence standing balance control; however, the neural mechanisms underlying these balance changes remain unclear. Previous work has shown that perturbation-evoked cortical potentials are facilitated when standing at the edge of an elevated surface [1,2], suggesting there may be a shift toward greater cortical involvement during reactive balance. However, it is unclear if there are similar changes in cortical engagement during static balance [3]. This study investigated how postural threat modulates cortical potentials time-locked to discrete centre of pressure (COP) events during unperturbed stance. A secondary aim was to determine if threat-related changes in cortical engagement could be modulated by repeated threat exposure. Methods: 27 healthy young adults completed a series of 90-s quiet standing trials at two conditions of height-related threat (LOW: 0.8 m above ground, away from edge; HIGH: 3.2 m above ground, at edge). Three trials at the LOW condition were completed before and after fifteen consecutive trials at the HIGH condition. Throughout all trials, participants stood on a force plate while electroencephalographic activity (EEG) was recorded from an electrode placed over the primary sensorimotor cortices (Cz). To examine changes in cortical activity in response to discrete postural events, prominent forward and backward peaks in anterior-posterior centre of pressure (AP-COP) displacement were identified [4]. EEG data were then triggered-averaged to these events and the amplitude of event-related cortical activity was calculated. COP summary measures derived from force plate data were calculated to quantify changes in standing balance control. Emotional state was quantified from electrodermal recordings and multiple self-report questionnaires. Results: At the LOW condition, event-related potentials were generally small or not detectable, regardless of the direction of the peak COP event (forward vs backward). However, once individuals stood at the HIGH condition, clear ERPs became evident, which were larger in response to forward (edge-directed), compared to backward, COP events. Despite significant habituation of the emotional response to threat following repeated exposure, threat-related increases in the amplitude of ERPs did not significantly change. Conclusions: This study demonstrates that postural threat induces the recruitment of cortical networks for the control of standing balance. This increased cortical engagement appears resistant to habituation, and may contribute to threat-related balance changes which also show no adaptation with repeated threat exposure [5]. References: [1] Adkin et al. 2008, Neurosci. Lett. 435, 120-125; [2] Sibley et al. 2010, Exp. Brain Res. 203, 533-540; [3] Tokuno et al. 2018, J. Neurophysiol. 120, 1010-1016; [4] Varghese et al. 2015, Neurosci. Lett. 590, 18-23; [5] Zaback et al. 2021, Sci. Rep. 11, 384

H - Coordination of posture and gait

P2-H-53: *Differences in avoidance and gaze behaviours when circumventing a virtual pedestrian for athletes vs non-athletes*

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BACKGROUND: When steering to a new direction, individuals systematically coordinate the reorientation of the head and body in space by first initiating eye movement towards the new travel direction, followed by head yaw, and then trunk yaw. Since steering sequences are common, other pedestrians perceive these behaviours to determine where an approaching person may be headed. However, athletes in certain sports are offensively instructed not to pass in a predictable manner by continuously looking at the intended teammate, and to defensively anticipate an opponent's movements by looking at their hips. Therefore, the purpose of this study was to identify differences in the avoidance and gaze behaviours of young non-athlete adults and elite-level soccer players during a collision avoidance paradigm with a virtual pedestrian who unpredictably steered to a new direction in different steering sequences. METHODS: To date, 6/16 female varsity soccer players (22.5±2.5 yrs), and 8/11 non-athlete females (22.1±2.7 yrs) have been analysed. In a virtual shopping mall (HTC Vive Pro Eye; 90Hz), participants walked 8m towards a goal while avoiding a virtual pedestrian who would approach and steer towards the participant's left or right under six conditions related to body reorientation cues ranging from normal (eyes first, head second, trunk last) to ambiguous (eyes and head affixed forward). Clearance Distance and variability at the time of crossing (Vicon; 90 Hz) as well as the proportion of time participants spent fixating the pedestrian and its segments during the approach (Integrated eye tracker; 90Hz) were collected. RESULTS: Preliminary results revealed a significant interaction between group and reorientation condition on Clearance Distance variability at the time of crossing, $F(5,60)=4.09$, $p=.003$, $f=.48$. Non-athletes (M=17.1cm) had significantly more clearance variability than the athletes (M=9.8cm) during the most ambiguous reorientation condition. Moreover, there was a significant interaction between group and proportion of time spent looking at each segment of the pedestrian, $F(3,30)=3.86$, $p=.019$, $f=.50$. Athletes spent an equal amount of time looking at the head (M=39.4%) and trunk (M=41.0%), whereas non-athletes focused primarily on the head (M=68.6%) throughout the approach. CONCLUSIONS: Non-athletes' fixation on the pedestrian's head movements is consistent with how individuals would expect another person to steer to a new direction. This likely lead to an increase in non-athletes' clearance variability during the most ambiguous condition when the pedestrian's head movement was uninformative of future path direction. Soccer players gathered pertinent visual information from the pedestrian's trunk movements during the approach to produce more consistent clearance across all conditions. Athletes and non-athletes utilize different visual information about an approaching pedestrian's reorientation sequence in daily avoidance behaviours.

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P2-H-54: ***Stay out of the blast radius: Influence of surgical masks on virtual pedestrian interactions***

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BACKGROUND AND AIM: While government responses to combat COVID-19 vary, recommendations such as social distancing and the use of facial masks were nearly universal. Such public health recommendations, as well as the anxiety generated by the pandemic, are likely to have influenced pedestrian interactions. Indeed, studies suggest that larger interpersonal distances are maintained from individuals wearing a facial mask. However, the extent to which the effect of facial masks also influences circumvention strategies and gaze behaviour remains unknown. Furthermore, pre-pandemic studies suggest that individuals with increased social anxiety prefer larger interpersonal distances, but it is unclear if that also extends to locomotion. We aimed to estimate the extent to which circumvention strategies and gaze behaviour differ when interacting with masked vs. unmasked virtual pedestrians. We further explored the extent to which obstacle circumvention control is associated with anxiety related to the COVID-19 pandemic. METHODS: Using virtual reality, obstacle circumvention strategies in response to approaching pedestrians with and without facial masks were assessed in a sample of 11 healthy young individuals. Measures describing circumvention strategies and gaze behaviour were extracted from a head-mounted display with integrated eye-tracking. Additionally, a questionnaire was developed and used to examine participants' behaviours during and after a period of confinement that was in effect before the summer of 2020. RESULTS: When circumventing a masked virtual pedestrian, trajectory deviations were initiated at greater distances ($p<0.01$). However, there was no significant difference between masked and unmasked conditions for other measures describing participants' circumvention strategies (i.e., minimum distance and maximum deviation). Gaze behaviour (i.e., fixations on the approaching pedestrian, other pedestrians, and on the head of the approaching pedestrian) also did not reveal differences between the masked and unmasked conditions. It appears that participants did fixate their gaze on their goal (i.e., straight ahead) more frequently than on the approaching pedestrian. For the masked condition, we observed a strong positive correlation between minimum distance and anxiety associated with the COVID-19 pandemic ($r=0.75$, $\rho<0.01$). In both the mask and unmasked conditions, similar positive associations were observed between onset distance and anxiety ($r=084-0.86$, $p<0.01$). CONCLUSIONS: Our findings provide evidence that the wearing of a mask by others results in larger interpersonal distances distancing during pedestrian interactions, which highlights the positive influence of wearing a mask on physical distancing. Furthermore, results demonstrated the effects of social anxiety on pedestrian interactions. Altogether, these results highlight the potential of virtual reality to study the influence of social and psychological factors on pedestrian avoidance. ACKNOWLEDGEMENTS AND FUNDING: This work was supported by the Natural Sciences and Engineering Research Council (Grant RGPIN/04471-2016) and M.A.B. was supported by the Fonds de recherche du Québec - Santé.

P2-H-55: ***Subtle changes in pedestrian circumvention due to the Covid-19 pandemic: Considerations for continuing fundamental and clinical research***

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Background: Due to the COVID-19 pandemic, many parts of the world requested physical distancing and limited community displacement or even enforcing confinement. Physical distancing measures may have an impact beyond reducing the spread of COVID-19 by also possibly influencing the way one navigates around other pedestrians. Understanding how the pandemic and the regulations surrounding it affect locomotor navigation is also critical for interpreting the results of future research. However, to our knowledge, no data are available on how pandemic regulations might affect pedestrian circumvention. Thus, we aimed to measure potential pandemic-related influences on locomotor navigation and avoidance behaviours to inform future fundamental and clinical research. Methods: Participants from two ongoing projects that examined the circumvention of virtual pedestrians (VPs) prior to the pandemic were invited to return and repeat the experiment during the pandemic, after the first confinement period. Ten healthy young adults were retested between June 8 and September 25, 2020. The tasks involved the circumvention of a head-on approaching VP within virtual public spaces, which were presented in a Vive Pro Eye head-mounted-display. Percent change in onset deviation distance, minimal clearance and maximum path deviation between visits were analyzed. Participants also completed a questionnaire regarding personal displacement habits following the first confinement and on COVID-19-related anxiety. Nonparametric Analysis of Longitudinal Data were used to compare for the factor of "time" related to before pandemic and post-confinement. Results: Onset deviation distance with respect to the VP was slightly but significantly shorter ($p=0.043$) post-confinement and minimal clearance remained unchanged ($p=0.923$) with no association to anxiety scores. Overall, there was no effect of time for maximum path deviation ($p=0.094$). Six out of the 10 participants, however, increased their maximal deviation on the 2nd visit. These were the first four participants that were tested early post-confinement as well as the two participants who presented the highest anxiety scores. Conclusions: Slight decrease in onset deviation distance independently of self-perceived COVID-19 related anxiety level could be explained by the fact that participants were more comfortable interacting with the VP on their second visit. Maximum path deviation, however, appears to have increased following a strict confinement period. Although this tended to normalize quickly depending on the participant's level of anxiety. Based on these observations, we believe it would be prudent to document one's perceived level of anxiety about the pandemic and any epidemiological situations in pedestrian circumvention research continuing or starting post-pandemic. Acknowledgments: We would like to thank Nicolas Robitaille, Samir Sangani, Christian Beaudoin for programming, as well as Frédéric Dumont for technical assistance and Jean Leblond for statistical analysis support. Funding: This project was funded by Natural Sciences and

Engineering Research Council of Canada (BJM: NSERC RGPIN/191782-2017; AL: RGPIN/04471-2016) and FF received a bursary from the Fonds de recherche du Québec en Santé (FRQS).

P2-H-56: ***Interlimb joint coordination is affected by a visuospatial dual-task in Parkinson's disease***

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BACKGROUND AND AIM: The neurodegeneration of the basal ganglia in Parkinson's disease (PD) is responsible for numerous pathological movement characteristics. One of these deficits is reduced interlimb coordination, of both spatial and temporal varieties, within and between the upper and lower limbs. Multi-tasking during gait is common during real world activities, and tasks often have of a visuospatial component. Some studies have shown reduced coordination in the upper or lower limbs during dual tasking (DT) in PD, but no previous studies have investigated gait coordination in PD within and between the upper and lower limbs while DT. METHODS: Volunteers with mild to moderate PD participated in gait trials using an Extended-CAREN system, which includes a treadmill, 12-camera Vicon motion capture, and a 180° field of view virtual reality projection screen. After a treadmill/VR familiarization period, participants completed a single 3 min single task trial, and a 2 min DT trial; both trials at participants? preferred walking pace. The DT was a visuospatial word recognition and acknowledgement task where every 2-4 s a new random word, among a bank of 12 words, was shown for 3 s at eye level at a random angle between 20-70° left or right of center. Spatial coordination was measured as peak flexion, range of motion (ROM), and asymmetry of each, for the shoulder and hip flexion/extension angles. Temporal coordination was measured using continuous relative phase between all pairs of shoulder and hip joints to find the average phase offset and intercycle phase variability. Single and DT were compared with a paired t-test. RESULTS: Twenty subjects met initial inclusion criteria, but 3 were excluded due to dyskinesia or missing data. The remaining 17 subjects (11M, 65±8 yrs, 173±8 cm, 74±20 kg, UPDRS III 10±5) showed decreases in the less affected (LA) shoulder ROM by 1.5° and the LA hip ROM by 1.1° during DT ($p<.04$, $dz>.47$). LA shoulder peak flexion also decreased by 1.1° during DT ($p=.01$, $dz=.61$). The more affected (MA) shoulder had a larger lag against the LA hip by 5.3° during DT ($p=.04$, $dz=.48$) with matching trends ($p<.06$, $dz>.41$) for larger lag compared to the LA shoulder and MA hip. CONCLUSIONS: Small, but detectable, reductions in LA hip and shoulder ROM support the results of previous studies regarding the presence of active compensation for reduced arm swing that can be disrupted by a common DT. Phase relations and variability between the shoulders and hips are generally preserved and unaffected by DT. However, the increased phase offset between MA shoulder and LA hip during DT parallels findings comparing PD to healthy age matched controls. In addition, the lack of an equal and opposite lag increase in the contralateral pair suggests that axial rigidity is not a likely cause. Future work should determine if correlations between phase offsets and lateral bradykinesia or rigidity might be responsible for the increased lag.

P2-H-57: ***Gait Differences in a Virtual compared to Real Laboratory***

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BACKGROUND AND AIM: As virtual reality (VR) technology continues to grow, the accessibility of once a novel experience is growing. More researchers and clinicians are utilizing rehabilitation and experimental tools that incorporate VR to examine gait performance in adults. However, there is limited research that has investigated whether VR impacts gait behaviour. One study performed gait on a treadmill in real, virtual, and augmented reality (AR) conditions of a laboratory environment showed that healthy adults displayed increased cadence and decreased in step length in VR and AR compared to real-world walking. As VR technology expands beyond the laboratory and treadmill, it is important to also investigate how gait behaviour may be impacted during overground walking. The aim of this study was to investigate the influence of VR on overground walking. METHODS: Twelve healthy young adults performed 120m of walking over a ZenoTM Walkway gait carpet under two counterbalanced conditions: (i) within a virtual environment (VE) that simulated the laboratory, and (ii) in the laboratory real environment (RE). A virtual replication of the lab was created using Unity3D. Prior to the assessment, participants were given time to walk and explore the virtual environment in order to minimize novelty effects of the VR stimuli. During the VE condition, participants wore a wireless HTC Vive Pro Eye as they performed walking trials. Participants were instructed to walk at their natural self-selected pace in both the VE and RE. Gait parameters included cadence, step length, gait velocity, step width, double support (DS) (%), single support (SS) (%), and step length variability. Paired sample t-tests were used to evaluate differences in gait parameters between the two conditions. Results: Participants showed a significant reduction in cadence (p=0.0025), step length (p=0.0007), velocity (p=0.001), and %SS (p=0.0002) while walking in the VE compared to RE. Participants also increased %DS (p=0.0003) and step length variability (p=0.043) while walking in the VE compared to the RE. No significant differences were found in step width. CONCLUSIONS: This study shows several changes to gait during over ground walking in a virtual environment, which appears to suggest that healthy young adults adopted a more cautious gait despite being given time to explore the virtual lab setting. Importantly, these findings illustrate how walking in a virtual environment may subtlety alter healthy users gait compared to real-life and represents an important confounder to consider for future research. ACKNOWLEDGEMENTS AND FUNDING: Funded by NSERC.

P2-H-58: ***Predicting travel direction from biological motion: How segment information influences accuracy and response time***

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BACKGROUND AND AIM: Biological motion research suggests that humans can readily perceive human walking profiles on point-light display (PLD). By presenting an arrangement of moving point-lights located at human anatomical landmarks, an observer can make accurate judgements of person-specific characteristics such as sex, age, emotion, and identity. Recently, studies have manipulated body segment information using virtual pedestrians and identified certain body segment movement patterns that help guide navigational decisions. However, it is unknown what body segment(s) enable humans to accurately identify changes in human movement walking direction. Therefore, the purpose of this study was to investigate whether individuals could use full-body PLD to make accurate anticipatory decisions about future travel paths of an approaching humanoid and which body segments were most informative. It was hypothesized that individuals would experience greater than chance anticipatory success during the task and that the head would be the most informative segment due to its leading role when steering within an environment. METHODS: Forty-four young adults, aged 21-32 years old ($\bar{x}$=23.5±2.7) completed a remote, computer task where a PLD humanoid walked toward them for 4s, followed by a potential change in travel path (left, right, or straight). Within 100ms of the change/no change in path direction, the screen went blank and participants were asked to determine the future travel direction using their keyboard arrow keys. Body segment information of the PLD humanoid was manipulated, creating four conditions: full-body, head-only, upper body, and lower body. Response Time (s, following blank screen) and Accuracy (%, correct decisions) were recorded. RESULTS: Analysis revealed the full-body PLD condition resulted in excellent performance (Mean Response Time=0.96s, Mean Response Accuracy=88%). Two 4x3 repeated measures ANOVAs revealed main effects for body segment and path direction for Response Time and Accuracy. Post-hoc analyses determined that the head-only condition had the fastest response time (M=0.83s, p=.022) and was the most accurate (M=92%, p=.016), while the left path direction had the fastest response times (M=0.83s, p=.002) and greatest accuracy (M=91%, p=.005). CONCLUSIONS: Observers were able to make accurate anticipatory decisions about future travel paths of approaching PLD humanoids. Additionally, the head segment provided the fastest and most accurate source of visual information likely because individuals are familiar with observing others steering to a new direction, which is initiated with the reorientation of the eyes and head. Furthermore, participants were best at predicting when the humanoid was going towards their left likely due to cultural norms. Overall, these results further our understanding of how people are able to avoid others in environments, specifically that information about body segment movement patterns are used to determine how and when to avoid others and that cultural biases may also contribute to these behaviours.

P2-H-59: ***The impact of eye movement on postural control depends on the type of oculomotor behavior and the visual task***

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Recent evidence suggests that performing a visual task inducing eye movements, either through saccade or visual pursuit, will improve stability in healthy young adults when compared to static fixation or random looking. However, these studies assume the linearity of postural control by only interpreting the area of displacement and/or the velocity of the center of pressure (COP). Conversely, non-linear measures could bring a better understanding of postural control. For example, a wavelet discrete transform can be applied to the COP signal to decompose it in multiple bands showing the contribution of different sensory systems to the control of posture. The aim was to examine the effect of eye movements on different linear and non-linear measures of postural control. 21 healthy young adults (24.0 ± 3.3 years) were asked to stand quietly on a force platform with their feet together and look at the monitor in front of them. Five conditions were tested: eyes closed, random looking, fixed static point, saccade, and visual pursuit. Five trials of 60 seconds per conditions were performed. A one-way ANOVA with repeated measures was completed for each postural control measures in each direction: antero-posterior (AP) and medio-lateral (ML). The saccade condition led to greater stability than the random looking condition, as evidenced by a smaller sway area ($p = 0.05$, $\eta p2 = 0.563$) and reduced sway velocity (AP: $p = 0.045$, $\eta p2 = 0.733$; ML: $p = 0.015$, $\eta p2 = 0.737$). Conversely, the visual pursuit condition led to decreased stability compared to the random looking condition, as evidenced by a larger sway area ($p = 0.002$, $\eta p2 = 0.563$) and an augmented sway variability (AP: $p = <0.001$, $\eta p2 = 0.665$; ML: $p = 0.03$, $\eta p2 = 0.498$) and velocity (AP: $p = <0.001$, $\eta p2 = 0.737$; ML: $p = <0.001$, $\eta p2 = 0.733$). The energy contained in the ultra-low band, which indicates the contribution of the visual system, was highest in the fixed static point condition when compared to the eye closed (AP: $p = <0.001$, $\eta p2 = 0.257$; ML: $p = <0.001$, $\eta p2 = 0.398$), visual pursuit (AP: $p = 0.006$, $\eta p2 = 0.257$; ML: $p = <0.001$, $\eta p2 = 0.398$), and random looking conditions (AP: $p = <0.001$, $\eta p2 = 0.257$; ML: $p = 0.014$, $\eta p2 = 0.398$). Interestingly, the energy contained in the very-low band, which indicates the contribution of the vestibular system, was highest in the visual pursuit condition when compared to the eyes closed (ML: $p = 0.027$, $\eta p2 = 0.279$) and fixed static point conditions (ML: $p = <0.001$, $\eta p2 = 0.279$). The findings support that the visual system is an important contributor to stability. More specifically, different eye movements result in distinct postural responses with the saccade and the visual pursuit causing a decrease and an increase in sway, respectively. However, the increased sway in conditions that required visual pursuit could be explained by an increase in head movement which would also elucidate the heightened contribution of the vestibular system. Acknowledgement : NSERC funded.

P2-H-60: ***Effect of a visual search dual-task and absent arm swing when recovering from a trip perturbation in people with PD***

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BACKGROUND AND AIM: Parkinson's disease (PD) can involve both cognitive and functional declines which directly impact walking. The asymmetric onset of PD impairs interlimb coordination, and the progression into absent arm motion during later stages of the disease further limits typical arm swing pattern during gait. PD-related cognitive declines also hinder motor planning and performance. These impairments often result in more rigid movement coordination strategy in PD, which limits the number of available response strategies to respond to perturbation of the center of mass, maintain postural balance, and ultimately avoid falling. Simulation of PD-like motor deficits such as reduced arm motion and increased attentional demand when walking require young adults to adopt compensatory gait strategies and increase postural control to maintain stability. However, the interplay between the attentional requirements and postural adjustments necessary during a visual search, as well as the mechanical contribution of arm motion to postural stability when responding to a large perturbation such as a trip, have yet to be explored in individuals with PD. The results of this study will examine the mechanical and attentional demands of a visual search dual task and absent arm swing on dynamic stability when responding to a trip perturbation in individuals with PD. METHODS: Twenty people with PD will walk with two arm swing conditions (absent and normal) with and without a secondary visual search dual task on a split-belt treadmill. Participants will encounter trip-like perturbations induced on both the least and most affected side. Data will be collected on the CAREN-Extended System (Motek Medical, Amsterdam, NL). RESULTS: Outcome measures will include margin of stability, linear and angular trunk velocities, as well as spatiotemporal parameters (step length, time, and width). We will examine data for the tripped step as well as the recovery step. Separate repeated measures ANOVA will be used to examine differences between arm swing and visual search dual task for the most and least affected side with statistical significance set at $p < .05$. CONCLUSIONS: The results of this study will advance the development of fall prevention research and rehabilitation for people with PD through identifying the whole-body strategies used by people with PD to restore dynamic balance after a trip perturbation. Moreover, it will help determine if PD-related reduction in arm motion is critical to biomechanical models when assessing dynamic stability in individuals with PD. Finally, determining how visual search impacts coordination and perturbation response in this population while walking will further explain the strategies employed by people with PD in challenging situations and thus advance rehabilitative aims.

P2-H-61: ***How well do tasks conditions, measurement methods, & analyses reveal a person's balance control ability?***

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BACKGROUND AND AIM: Accurate assessment of static balance performance may be important as a tool to evaluate balance control and to aid fall-risk prediction. The clinical application of such assessments, where the focus is on the individual, requires improved understanding of the individual determinants. To do this, the current work seeks to advance understanding of individual differences among a 'homogeneous' cohort of young healthy adults. It is hypothesized that, among young healthy adults, there will be person-specific characteristics of static balance control that can be revealed by comparing performance across static balance tasks of varying challenge. 1. Determine whether the balance performances of individuals are correlated across multiple task conditions, and if so, 2. Can individuals be uniquely identified from their static balance performance? METHODS: Seventy-seven healthy, young adults (ages 18-35), free from any neurological or neuromuscular disorders, performed a series of static standing balance trials. Four task conditions, Base of Support (standard and narrow) and Vision (open and closed), were performed five times, each for thirty seconds. Balance was measured kinetically using two force plates in the floor, and kinematically using three inertial measurement units placed on the head, sternum, and lumbar region of the back. Linear and non-linear measures within the time domain, and frequency-domain measures summarized the each trial. Linear mixed-effects models and correlations were used to compare individual performances, relative to the sample population, across task conditions. A multi-layer perceptron using prototypical loss was used to identify individuals based on their balance performances. Identification accuracy required choosing the correct individual from either 5 or 20 possible individuals, with random chance being 5-way: 20%; 20-way: 5%. RESULTS: Individual balance performances, relative to the sampled population, displayed moderate to excellent correlations (r > 0.75) across task conditions. These correlations were observed in specific measures across all modalities of analytical measures. For example, using kinetic data, the α summary value identified individuals with accuracies of 51.99% and 30.60% while COP RMS had accuracies of 51.36% and 21.49%, 5-way and 20-way respectively. Using kinematic data, the α summary value identified individuals with accuracies of 60.78% and 22.56% while RMS of Linear Acceleration had accuracies of 86.03% and 39.87%. CONCLUSIONS: The correlational analysis shows that individuals, relative to a young, healthy population, perform consistently across tasks conditions. The strength of these correlations is dependent on task condition, method of measurement, and analytical measure. Using the neural network, individuals can be identified at a rate greater than random chance. These findings strongly suggest the existence of distinct, person-specific characteristics of balance control.

P2-H-62: ***Obstacle avoidance training using virtual obstacles with mechanical feedback can enhance motor learning: A proof-of-concept study***

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BACKGROUND AND AIMS: Obstacle avoidance training can be safely conducted using virtual reality (VR) but lack of mechanical feedback diminishes its utility as a rehabilitation and training tool. This proof-of-concept study examined the utility of providing immediate mechanical feedback using treadmill perturbations during VR obstacle avoidance training. METHODS: Fourteen healthy young adults (22.1 ± 4.5 years, 35% female) walked on an instrumented treadmill (M-Gait, Motek) while wearing a VR head-mount display (HMD, Oculus rift S), full-body safety harness and 35 reflective markers for 3D motion analysis (8 Bonita cameras, Vicon). Participants were instructed to step over ~80 virtual obstacles projected on a simulated ground plane while collecting ~200 virtual approaching balls with their hands. This protocol was conducted in two conditions: (1) a no-perturbation (NP) condition, where only visual feedback was provided when a virtual obstacle collided with a foot (i.e., the obstacle turned red); (2) a perturbation (P) condition, where visual and mechanical feedback (rapid belt acceleration 3 m/s2) were given immediately upon an obstacle-foot collision. Conditions lasted for 8 minutes and were randomized in order.

RESULTS: Compared to the NP condition, the obstacle collision rate was significantly lower, step length and obstacle clearance of the leading foot were significantly higher in the P condition (P<0.05, Figure 1). When each condition was divided into quarters (2 minutes each), obstacle clearance of the trailing foot significantly decreased over time in the NP condition (P<0.01) but not during the P condition. Furthermore, the anteroposterior margin of stability (MoS) at the foot-strike of the leading foot significantly improved over time in the P condition only (P<0.01). CONCLUSIONS: These findings suggest immediate mechanical feedback via treadmill belt accelerations can provide the somatosensory sensation of balance loss and in consequence improve dynamic stability and enhance obstacle avoidance in VR. Future research is required to determine whether these findings generalize to population groups at increased risk of falls. ACKNOWLEDGEMENTS AND FUNDINGS: This study was funded by the UNSW Ageing Futures Institute Seed Funding. We thank all participants and staff who contributed to this study.

P2-H-63: ***Deficits in motor control and visual attention impair gait coordination in stroke***

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Background and aim: Walking requires rhythmic, anti-phase coordination between lower limbs. Despite regained ability to walk independently, deficits in gait coordination are often persist after stroke, and increase the risk for falls. Identifying stroke-specific impairments that affect gait coordination is essential for developing targeted interventions for safe mobility. Recent evidence shows that decline in force modulation and attention negatively affects mobility outcomes after stroke; however, whether these impairments impact gait coordination is not known. Thus, the aim of our study was to determine the contribution of bilateral force coordination and selective attention to gait coordination in stroke survivors. Methods: Chronic stroke survivors (N = 14; 66.31 ± 13.04 years) and controls (N=11; 66.87 ± 11.13 years) performed - 1) overground walking at preferred speed, 2) bilateral ankle force tracking task that required anti-phase coordination between isometric ankle dorsiflexion forces generated with each leg, and 3) visual search task involving a rapid response to a target stimulus embedded within distractors. We measured gait coordination during overground walking with phase coordination index (PCI) such that higher PCI values indicated poor gait coordination. We measured cross-correlation coefficient and time lag between two legs in bilateral force tracking task. Positive values for cross-correlation coefficient and higher values for time lag indicated poor bilateral force coordination. We measured response time on the visual search task. Longer response times indicated poor selective attention. Results: Stroke group showed increased PCI ($p = 0.01$) compared with the control group. Stroke group had less negative cross-correlation coefficient ($p = 0.001$) and increased time lag ($p = 0.05$) between bilateral forces. The stroke group demonstrated longer response times than controls ($p = 0.01$) during visual search. In the stroke group, PCI was positively correlated with cross-correlation coefficient ($r = 0.57$, $p = 0.02$) and the response time ($r = 0.53$, $p = 0.03$). For all participants, hierarchical multiple regression was performed with PCI as dependent variable. Cross-correlation coefficient entered at stage 1 accounted for 40.9% variance in PCI ($p < 0.01$). Adding response time to the model explained an additional 10.5% of variance in PCI ($p < 0.05$). In the final model, we included group (stroke or control) as an independent variable and found that group was not a significant predictor of PCI ($p > 0.05$). Thus, cross-correlation coefficient and response time together predicted PCI in the stroke and control groups. Conclusion: Poor gait coordination in stroke survivors is associated with decline in motor and cognitive functions. Specifically, impairments in bilateral force coordination and selective attention affects gait coordination. Improving the ability to coordinate forces and attention may improve gait coordination and thereby, safe mobility after stroke.

P2-H-64: ***Postural control deficits in adults with Myotonic Dystrophy type 1, Steinert disease***

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BACKGROUND AND AIM: Myotonic dystrophy type 1 (DM1) is characterized by progressive distal muscle atrophy and myotonia [Petitclerc et al, 2017]. In daily clinical practice, gait and balance impairments resulting in falls are frequently reported in this population [Wiles et al, 2006; Missaoui et al, 2010; Hammarén et al, 2014]. However, the extent to which individuals with DM1 rely more on a specific sensory system for balance control than asymptomatic individuals (AI) is unknown. A better understanding of the mechanisms related to balance performance is of utmost importance to improve therapeutic approaches in people with DM1. The aim of this study was to evaluate postural control performance in individuals with DM1 and its dependence on vision compared to AI. METHODS: Twenty participants with DM1, divided into two groups based on their diagnosis, i.e. adult or congenital phenotype, and 12 AI were included. Quiet standing postural control was assessed in two visual conditions: eyes-open and eyes-closed using a force platform embedded in the floor (AMTI, Watertown, MA, USA). Their feet were placed at hip width in a natural position. The position of the feet was the same throughout the tests and postural control tests were conducted barefoot. The outcome measurements were the center of pressure (CoP) mean velocity [Prieto et al, 1996], CoP range of displacement in anteroposterior and mediolateral axes, and the 95% confidence ellipse's surface [Rocchi et al, 2005]. Friedman and Kruskal-Wallis analysis of variance were used to compare outcomes between conditions and groups, respectively. If tests were significant, post hoc Wilcoxon or Mann-Whitney U were used for paired and unpaired comparisons, respectively. RESULTS: No significant difference was observed between groups for age ($p=0.223$), body mass ($p=0.455$), and body mass index ($p=0.050$). The AI group was significantly taller than the congenital phenotype group ($p=0.005$) but not than the adult phenotype group ($p=0.729$). As expected, a significant condition effect was observed on the CoP range in the mediolateral ($p=0.011$) and anteroposterior axis ($p=0.011$) and on the mean CoP velocity ($p<0.001$), with higher values in the eyes-closed conditions. No significant condition effect was observed on the ellipse's surface ($p=0.068$). Group effects are presented in Figure 1. No difference between the two DM1 groups was observed. The adult and the congenital phenotype groups had significantly lower performance than the AI group in almost all postural control parameters.

CONCLUSION: The results showed that individuals with DM1, in both the congenital and the adults phenotype groups, had poorer postural control performance than AI. The two DM1 groups showed similar decrease in performance than AI in eyes-closed condition, suggesting no excessive visual dependency. Figure 1. Boxplots of postural control parameters for the two visual conditions considering the three groups, i.e. asymptomatic individuals, adult phenotype and congenital phenotype of myotonic dystrophy type 1. The results of the Kruskal-Wallis one-way ANOVA are presented in the figure representing the group effect for each condition.

P2-H-65: *Breast-torso coordination during treadmill running as a function of breast support*

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BACKGROUND: A time-lag between the breast and torso during running has been shown to be one of the variables most effected by breast support [1] and can result in a "breast slap", which may be related to breast pain [2]. Formal methods of calculating relative phase between the continuous motion of oscillators are well-established and may offer deeper insight of breast-torso coordination than discrete time lag. Vector coding is one such method that has the advantage of being inherently interpretable [3]. AIM: To quantify breast-torso coordination in running in three different breast support conditions METHODS: Twelve healthy female participants with a breast size of UK 34D (age=23±5 years, height=1.70±0.04 m, mass=70±6 kg, mean±SD) ran on a treadmill at 10 km.hr-1. Nipple and torso positional data were recorded for 10 seconds at 240 Hz using electromagnetic sensors (Micro Sensor 1.8, Liberty, Polhemus, USA). Participants ran with an encapsulation style sports bra and a compression style sports bra in a random order and then with no bra. Data were filtered using a Lowpass Butterworth filter at 13 Hz. Vector coding analysis was performed on data divided into cycles. Coordination patterns were categorised into bins of breast dominancy ($67.5° \leq \mu < 112.5°$, $247.5° \leq \mu < 292.5°$), torso dominancy ($0° \leq \mu < 22.5°$, $157.5° \leq \mu < 202.5°$, $337.51° \leq \mu < 360°$), in-phase ($22.5° \leq \mu < 67.5°$, $202.5° \leq \mu < 247.5°$) and anti-phase ($112.5° \leq \mu < 157.5°$, $292.5° \leq \mu < 337.5°$) [4]. Breast support conditions were compared using one-way repeated measures ANOVA ($\alpha = 0.05$) for each bin. RESULTS: Figure 1. shows greatest difference in mean phase angle between no bra and both sports bra conditions occurred at ~40%-70% and 90% of the gait cycle. There was a main effect of bra support on the coordination pattern frequencies for each phase bin ($p<0.001$). The breast and torso were significantly more in-phase in both sports bras compared to no bra and in the encapsulation style bra vs. the compression style bra. CONCLUSIONS: There was an effect of breast support on phase angle across the gait cycle, advocating the value of examining continuous breast-torso coordination rather than at only discrete time points. In both sports bras there was a transition after 40% and 90% of the gait cycle, at approximately take-off with each foot, to another state of in-phase coordination in the flight phase. Whereas the breast and torso were barely in-phase during the flight phase of the gait cycle with no bra.
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P2-H-66: ***How Young Adults Negotiate Varying Paths***

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BACKGROUND AND AIM: Healthy humans regulate lateral stepping using multi-objective control of step width and lateral body position when walking straight-ahead on relatively wide paths (Dingwell & Cusumano, 2019). In daily life however, people encounter paths that vary in multiple ways: e.g., numerous widths, and varying degrees of curvature. To understand how humans adapt their stepping strategies when walking on paths of varying width and shape, we designed walking paths to explicitly manipulate lateral body position and step width. Here, we quantified how people adapted their lateral body position and pelvic orientation to negotiate these paths. METHODS: 25 young healthy adults (aged 18-35) each walked on 6 different paths projected onto a treadmill surface. Paths varied in shape and were either straight, slowly oscillating, or quickly oscillating, and paths varied in width and were either wide (0.6 m) or narrow (0.3 m). We collected kinematic data for 2, 4-minute trials on each path for each participant. Pelvis markers were used to estimate lateral body position and pelvic rotation about the transverse plane. We calculated means and standard deviations of each measure on each path. Statistical analyses followed a two-factor (3 shape x 2 width) design. RESULTS: On average over each 4-min trial, mean positions and orientations were approximately zero for all conditions: i.e., people walked in the middle of the treadmill and straight-ahead. However, variability of both position and orientation each exhibited significant (shape x width) interaction effects ($p<0.001$). Across path shapes, position variability was least on the straight paths, higher on the quickly oscillating paths, and greatest on the slowly oscillating paths. Across path widths, position variability was greater on the wider straight path, but less on the wider slowly and quickly oscillating paths. Conversely, orientation variability remained consistently greater for all narrower paths and increased from straight to slowly oscillating to quickly oscillating. CONCLUSIONS: Participants clearly adopted very different movement strategies to negotiate the different aspects (width vs. shape) of the different paths they walked on. Participants varied their lateral body position more to negotiate the slowly oscillating paths than the quickly oscillating paths. Conversely, they varied their pelvic rotations about the transverse plane more to negotiate the quickly oscillating paths than the slowly oscillating paths. Subsequent analyses will quantify the specific stepping regulation strategies these participants used to enact these changes in lateral body position and pelvic rotation for each of these paths. Overall, this work aims to quantify how people adjust this stepping regulation to simultaneously balance the competing objectives of maneuvering a challenging environment with maintaining lateral balance during walking. ACKNOWLEDGEMENTS AND FUNDNG: NIH R01-AG049735 & R21-AG053470

P2-H-67: ***Uncontrolled manifold analysis for understanding whole-body coordination to stabilize foot position for stepping over an obstacle in older adults***

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BACKGROUND AND AIM: Stepping over obstacles involves coordinating whole-body movement to produce a trajectory of the feet to avoid collision while maintaining balance. Since stepping over obstacles is a common cause of falls, many studies have discussed differences in the kinematics between older and younger adults. These studies frequently reported that older adults tend to show exaggerated foot clearance (referred to as a conservative strategy, Lu et al., 2006). Although the strategy would be useful for preventing trips, exaggerated behavior irrespective of obstacle height prevents older adults from finely tuning their foot elevation in response to environmental changes, which may eventually lead to decreased adaptability. Uncontrolled manifold (UCM) analysis has been used to evaluate ability to fully use the kinematic redundancy of the motor system by deriving the variance of the elemental variable (e.g., joint angles) that stabilizes and destabilizes the performance variable (i.e., movement of interest) (Scholz and Schöner, 1999). We conducted UCM analyses to address whether whole-body coordination to stabilize foot position during stepping over an obstacle would be affected by age (older or younger) and limb (leading or trailing limb). We also investigated whether the ability to fully use kinematic redundancy and the degree of foot clearance were correlated. METHODS: Twenty-six older adults (70.9 ± 7.4 years) and 21 younger adults (25.4 ± 5.0 years) participated. Participants walked for 3 m and crossed an obstacle 8 cm in height. Foot positions at the moment when leading and trailing limbs crossed the obstacle were analyzed using UCM analysis, in which segment angles of the whole-body were used as elemental variables. Synergy indices (ΔV_z) were calculated during obstacle crossing. A higher ΔV_z reflects more solutions utilized to stabilize performance variables. The foot clearance between the vertical foot position and the obstacle was measured. RESULTS AND CONCLUSIONS: No significant age differences were found in the foot clearance and the ΔV_z for the foot position. The ΔV_z for the leading limb crossing was higher than that for the trailing limb crossing. This suggests that the foot position of the leading limb is better controlled by a multi-joint kinematic synergy than that of the trailing limb. Moreover, the ΔV_z and foot clearance were negatively correlated, regardless of the limb. This indicates that the higher foot clearance was, the less adaptable the foot trajectories were. In conclusion, the present findings show that, irrespective of age, a conservative strategy, represented by higher foot clearance, may decrease the ability to use the kinematic redundancy of the motor system to stabilize foot position.

P2-H-68: ***Relationship between electromyographic activity and the visual feedback test during the maintenance of the center of gravity***

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Relationship between electromyographic activity and the visual feedback test during the maintenance of the center of gravity. 【Introduction】 While body sway is a natural part of postural control, the precise way in which the maintenance of the center of pressure by lower limb muscles changes across different age groups is currently little known. In this

study, we investigated the relationship between the activity of the lower limb muscles and body sway using the Visual Feedback Test（VFT） and simultaneous measurement of the electromyogram. 【Participants Subjects and methods】 The participants were 36 healthy young adults (19 men , 17 women; average age, 30.8 years) and 18 healthy older adults aged 65 and over (9 men, 9 women; average age, 75.3 years). All the participants had right-foot dominance. The VFT was recorded for 60 s and sampled at a rate of 20 Hz. For the visual feedback test, the participants were instructed to consistently maintain their center of gravity in the aiming circle of 2.5 cm diameter shown on the display. The lower limb electromyogram was measured at the same time as VFT. EMG surface electrode were placed on the left and right tibialis anterior muscles and the left and right lateral gastrocnemius. Their activity rates (%) were calculated at 100% MVC (% maximum voluntary contraction) and no load (seated). 【Result】 We evaluated the proportion (%) of the center of pressure (COP) that entered the aiming circle during the test. The mean percentages were 83.7% in young adults and 57.2% in the older adults, with significant differences ($p<0.01$). The mean activity rate of the four muscles during the VFT was 11.3% in young adults and 17.4% in the older adults, with significant differences ($p<0.01$). There was a significant difference ($p <0.01$) between the left and right muscle activity rates in young adults, 9.3% on the left side and 6.5% on the right side. In contrast, there was no significant difference in muscular activity between the left (19.6%) and right (15.2%) limbs among the older adults. As for the activity rate of each of the four muscles, the left lateral gastrocnemius muscle tended to be more active in both young and older adults. 【Discussion and conclusion】 Lower limb muscle activity may increase during postural control in the older adult group because of an increased need to monitor posture voluntarily. Muscle activity rate during the VFT was lateralized, which was considered to be related to the dominant foot. That is, our results suggest that the left lower limb has a major role in the maintenance of the center of pressure, thus acting as an axis around which body sway is compensated. As all participants had right-foot dominance, we consider that muscular activity of the left lower limb that performs as an axis became stronger because it was used to adjust the center of pressure and therefore compensate for body sway.

P2-H-69: ***Cortical contributions to locomotor primitives in toddlers and adults***

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Deciphering the neural organization underlying muscle synergy formation is timely and urgent. The early development of these synergies may shed light on this organization [1]. In newborns' stepping, two muscle synergies with alternating sinusoidal-like patterns, peaking at mid-stance and mid-swing, can be identified [1]. They are likely to arise from brainstem and local spinal circuitries. At the onset of independent walking in toddlers, four muscle synergies can be observed: two supplementary muscle synergies that peak around the bilateral foot contacts emerge and are added on top of the two that resemble the neonatal ones [1]. Such developmental changes may be the result of structural and functional developments of the motor cortex and cortico-spinal tract. The differential muscle synergy organization suggests that the supplementary synergies have a counterpart in motor areas. By contrast, the two synergies that resemble newborn stepping are not expected to have a cortical representation. We focused on two groups, both expected to display four muscle synergies: eighteen toddlers (mean±SD; 19.7±2.0 months) and adults (21.8±6.4 years). Participants were asked to walk over-ground and on a treadmill at comfortable speeds. We recorded muscular activity of trunk and leg muscles using 24-channel electromyography (EMG) and cortical activity using 32-channel electro-encephalography (EEG). For both toddlers and adults, multivariate EMG was decomposed using non-negative matrix factorization into four muscle synergies. We employed DICS-beamforming to source localize cortical areas that exhibited maximal coherence between EEG and (proxies of the) muscle synergies (proxies because we included their high-frequency components). We also estimated time-frequency cortico-synergy coherence. Both analyses were spectrally limited to the beta frequency band (13-30 Hz) which is known for its contribution to gait control. Significant beta-band sources were limited to the two supplementary synergies time-locked to bilateral foot contact in toddlers and adults alike. Coherences with these synergies were primarily located around (primary) motor and sensory areas of the cortex. Adults exhibited more frontal coherence than toddlers, as reflected in between-group contrasts. Time-frequency coherences between motor cortex and these two synergies revealed cycle-dependent modulation with peak coherences aligned to the synergy amplitudes and double support phases. Between-group statistics revealed more focal coherence around the double support phases in adults compared to toddlers. These findings support the view that locomotor muscle synergies rely on distinct neural circuitries. In our study, cortical counterparts of the muscle synergies were only found for the two supplementary synergies, and not for the congenital ones. The use of cortico-synergy coherence analysis enabled us to dissociate cortical and sub-cortical processes involved in the formation of muscle synergies. [1] Dominici, N., et al. (2011). Science, 334(6058), 997-999.

L - Devices to improve posture and gait

P2-L-70: *The effects of a powered ankle exoskeleton on postural control*

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BACKGROUND AND AIM: Robotic exoskeletons can provide assistive forces, which have been shown to be beneficial in treadmill and real-world walking. Previous work has predominately focused on tuning the exoskeleton to minimize energetic cost. However, it is unclear how an exoskeleton tuned for walking interacts with posture. Since activities of daily living involve both gait and posture, and fall risk is critical, it is important to examine how exoskeletons affect postural control. We hypothesized that the initial period of learning to control the exoskeleton would predominately decrease the reliance on the somatosensory system causing participants to be more reliant on visual and vestibular information. METHODS: The experiment consisted of a VR based test of sensory integration in balance (VRSIB), where the visual information was perturbed by a swaying scene aligned with the

dorsoplantar flexion rotation axis (20 degrees, 0.25 Hz). Subjects completed the protocol with their regular shoes, exoskeleton in zero-torque mode, and exoskeleton powered. The exoskeleton was cable-driven, myoelectrically-controlled, and provided plantarflexion assistance. We collected data from 8 subjects with no history of neurological or musculoskeletal impairment. To measure performance, we computed COP velocity, sway area, equilibrium scores, sensory ratios, and joint kinematics and kinetics. We collected EMG signals from 6 muscles in the dominant leg. RESULTS: Our results show that in the VR-unstable-support condition, subjects saw a reduction in their equilibrium scores when the exoskeleton was powered vs the regular shoes and zero-torque conditions. The relationship was persistent across the two days, but there was an improvement in the exoskeleton powered condition on day 2 vs day 1. In all other conditions, the differences were minor, including the eyes-closed-unstable condition. In most of the trials, subjects adopted an ankle strategy. The exoskeleton on and zero-torque conditions caused a decrease in the vestibular sensory ratio, and the visual sensory ratio. The vestibular and preference sensory ratios improved across days. CONCLUSION: Our results suggest that our powered ankle exoskeleton, tuned as for level walking, has no effect on postural stability during stable support conditions compared to the exoskeleton in zero-torque mode. One explanation is that in the stable condition, the passive stiffness of the device dominates postural balance. During the unstable support conditions, with the VR and eyes closed, both the exoskeleton powered, and zero-torque had a negative effect on postural balance. In the exoskeleton powered condition (VR-unstable-support) subjects performed significantly worse than with regular shoes and with the exoskeleton in zero-torque mode. Our preliminary conclusion is that when subjects perceive a mismatch between vestibular and visual information, the plantarflexion assist-only device becomes detrimental to their postural balance.

P2-L-71: ***Effects of Vibrotactile Sensory Augmentation during At-Home Balance and Coordination Training in Individuals with Cerebellar Ataxia***

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BACKGROUND AND AIM: Inherited cerebellar ataxias are degenerative neurological disorders that lead to decreased coordination and unsteadiness in gait and posture. Balance and coordination training is a standard of treatment in individuals with cerebellar ataxia. The effectiveness of this treatment is reliant on intensive and continuous training at home. Vibrotactile sensory augmentation (SA) during training has the potential to enhance the benefits of training as a number of studies have shown additional improvements in balance performance beyond training alone for older adults and individuals with vestibular deficits. The goal of this pilot study was to examine the effects of at-home balance and coordination training with and without vibrotactile SA on postural stability for individuals with cerebellar ataxia. METHODS: Seven individuals diagnosed with cerebellar ataxias were recruited to participate in a 12-week at-home balance and coordination training program (five sessions/week, 30 min each). A crossover study design was adopted whereby participants were randomly assigned to two groups and each group underwent two six-week training

blocks with and without vibrotactile SA. Vibrotactile SA was provided during static and dynamic standing exercises through a smartphone-based balance trainer. The balance trainer measured trunk kinematics through a belt-mounted iPod-embedded IMU and provided vibrotactile cues to participants to minimize their sway during at-home exercises. Participants' balance and coordination performance was assessed in the laboratory immediately before, halfway through, and immediately after the 12 weeks of at-home training through commonly used clinical outcome measures (e.g., SARA, mCTSI, and 5xSST). Linear mixed-effects models were used to assess the effects of training with and without vibrotactile SA. The significance level was 0.05. RESULTS: Findings from this study indicated that training for six weeks with vibrotactile SA significantly improved participants' balance and coordination as captured through SARA scores compared to their performance immediately before the six-week block of training (b=-0.98, t(7)=-2.60, p=0.03) but no other assessments showed significant differences. The six weeks of training without vibrotactile SA did not significantly improve SARA scores. The total 12-weeks of training resulted in no statistically significant overall change in performance, indicating that participants maintained the same balance and coordination skills throughout the 12-week experiment. CONCLUSIONS: This preliminary study provided initial evidence of the potential benefit of introducing vibrotactile SA during in-home balance and coordination training for individuals with cerebellar ataxia. While the findings from this study indicate some motor learning and postural stability improvements among individuals with cerebellar ataxia following training with vibrotactile SA, further research with larger participant populations is needed to assess the generalizability of these findings.

P2-L-72: ***Development of closed-loop functional electrical stimulation controller for standing balance training***

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BACKGROUND AND AIM: Individuals with incomplete spinal cord injury (iSCI) demonstrate impaired standing balance control, resulting in increased Fall risk. Fall risks can be reduced via standing balance training. Two noteworthy balance training include visual feedback training (VFT) and functional electrical stimulation (FES) therapy. VFT involves the participant performing weight-shifting tasks with one's centre-of-mass displayed on-screen. FES therapy involves applying electrical current to the lower-limb muscles, inducing muscle contractions. Both VFT and FES therapy, independently improved standing balance for those with iSCI. We expect that combining VFT with FES therapy would synergistically improve balance control for those with iSCI. Hence, the purpose of this study was to develop closed-loop FES controller that can deliver physiologically relevant stimulation to ankle plantar- and dorsiflexors during VFT. The proposed controller is an enhanced version of the previously designed controller [1]. METHODS: The proposed closed-loop FES controller has three sections: 1) neural and mechanical controllers that generate requested ankle torque, 2) mapping function that converts requested ankle torque to ankle muscle stimulations and 3) directional biasing function that scales the stimulations asymmetrically to the left and right

ankle muscles. We recruited 10 young adults. The participants performed quiet standing (QS), limits-of-stability (LOS) test and four tasks for VFT: 1) bullseye, 2) hunting, 3) colour-matching and 4) ellipse (Figure 1). During these tasks, kinematic, kinetic and ankle plantar- and dorsiflexor muscle activities were recorded using motion capture system, force platform and surface electromyogram (EMG). Data from QS and LOS test were used to design the closed-loop FES controller. The simulated stimulation intensities, calculated via the FES controller, were correlated with the recorded EMG from soleus (SOL) and tibialis anterior (TA) muscles during VFT. RESULTS: Using the identified FES controller, the average Pearson correlation between the simulated stimulation intensities and recorded EMG data during 1) bullseye task was: SOL=0.08±0.11; TA=0.04±0.16, 2) hunting task was: SOL=0.76±0.08; TA=0.70±0.12, 3) colour-matching task was: SOL=0.78±0.08; TA=0.81±0.06, and 4) ellipse task was: SOL=0.83±0.11; TA=0.71±0.27. CONCLUSIONS: The identified closed-loop FES controller was able generate SOL and TA stimulations that mimicked the physiological muscle activities, which were shown by high correlation between the recorded EMG and the simulated stimulation intensity. We expect that the addition of FES can improve VFT performance and that VFT FES system can contribute to improving standing balance for individuals with iSCI. REFERENCE: [1] Grabke EP, et al. A novel therapeutic tool for standing balance: a case study. In: Proceedings of the 22nd Annual Conference of the International Functional Electrical Stimulation Society. (2018).

P2-L-73: ***Assessing the role of visual pursuit and shift in attentional focus in the improvement of postural control during a visual feedback paradigm***

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BACKGROUND AND AIM: A real time visual feedback (vFB) of the center of pressure (COP) displacement has often been shown to improve postural control in quiet stance. The general idea is that the vFB can provide information that can be used to adjust the posture. However, some may suggest that this improvement might be explained by a shift of attention away from the body caused by the need of concentrating on the COP displacement, which favors automatic controls of the posture (Wulf, 2013). More recently, Bonnet al. (ex. 2016) suggested that during an active visual task like a visual pursuit, the central nervous system can reduce postural sway to improve the visual task. Using an erroneous vFB, the aim of this study was to assess if the improved postural control during a vFB can be associated with a change in attentional focus or the execution of a visual pursuit. METHODS: This pilot study was conducted on nine healthy young adults (26.11 ± 2.71 years). Participants were asked to stand as still as possible on a force platform (100 Hz) for trials of 60s. For the first four trials (baseline), participants had to look at a static target displayed at eye level. Four trials with a real time accurate vFB of the COP displacement and four trials with an erroneous vFB were then randomly performed. The erroneous vFB consisted of displaying the COP displacement of one of the baseline trials, which was irrelevant to the task. To force a visual pursuit, participants had to follow with their eyes the cross representing the COP movement. Participants only knew that what was displayed on the screen could or could not be useful for the task. Postural control was assessed using the area of the 90% confidence interval, the standard deviation, the path length and the sample entropy of the COP displacement in the anterior-posterior (AP) and medial-lateral (ML) directions. Statistical analyses were performed using one-way repeated measures ANOVAs. RESULTS: Statistical analyses show that the type of vFB had different effect on postural control, even though only two participants reported realizing that there were sometimes two types of vFB. Sway area and COP variability in ML were lower during the accurate vFB than the erroneous vFB. The sample entropy value in ML was higher during the accurate vFB. The sway path was higher in ML for the accurate vFB and in AP for the erroneous vFB compared to baseline. CONCLUSION: Postural control was better during the accurate vFB than the erroneous vFB. Considering that participants were generally unaware of the condition, it might be that postural control is unconsciously influenced by the meaning of the visual information. As such, our results tend to suggest that the improved postural control generally seen during an accurate vFB might not be related to a shift in attentional focus or the need to stabilize the body sway to improve the visual task. ACKNOWLEDGEMENTS AND FUNDING: Primary author has the NSERC Postgraduate Scholarship.

M - Effect of medication on posture and gait

P2-M-74: ***Measuring the effect of medication on Parkinson's disease motor symptoms using wearable technology: A systematic review***

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BACKGROUND AND AIM: Parkinson's disease (PD) is a neurodegenerative disorder consisting of both motor and non-motor features. Motor symptoms (tremor, bradykinesia, rigidity) are typically treated via dopamine replacement therapies. Medication response can be highly variable, leading to symptom fluctuation over the course of the day ("on" vs. "off" medication), compromising function and quality of life. Responses to medication are typically measured either via subjective clinical scales such as the MDS-Unified Parkinson's Disease Rating Scale (MDS-UPDRS) or via complex supervised assessments (e.g. on vs. off medication) in controlled laboratory settings, using expensive tools such as the three-dimensional motion capture systems. It is also common for the effect of medication to be assessed via a one off levodopa challenge test, where symptoms are measured after overnight withdrawal from levodopa before a supramaximal dose is prescribed and motor function is reassessed. These factors impact on the ecological validity of these investigations. With the technological advance of wearable systems, motor functionality and medication intake timing can be continuously and objectively measured in a remote manner, whilst patients go about their everyday lives. The key aim of this review is to identify and synthesise the literature examining the effects of medication on motor symptoms in patients with PD, evaluated using wearable technologies. METHODS: Two reviewers (HB & RR) systematically reviewed 1802 abstracts during title and abstract screen. Ninety-seven articles are currently undergoing full text review. Studies were included if they reported motor outcomes, derived from wearable technologies, which quantify the effect of medication on motor symptoms and mobility impairments in PD. Articles were excluded if they report the effect of medication on non-motor symptoms or derive variables from systems other than wearable technology. All articles included were peer-reviewed and published in English. RESULTS: This ongoing review will report: (1) the technologies and techniques used to assess motor outcomes and medication intake, (2) the variety of motor symptoms investigated, (3) key findings and future recommendations regarding the investigation of the effect of medication on the motor symptoms affecting patients with PD using wearable technologies. CONCLUSIONS: This review will inform the development of future studies investigating the effect of medication and medication adherence on motor symptoms in patients with PD. The current literature will be synthesised and current trends and gaps in the literature will be identified. The review will recommend developments for future research aimed at increasing understanding in this area, in particular highlighting the unmet needs towards measuring motor outcomes and medication adherence in a remote and objective manner.

P2-M-75: ***Measuring the effect of medication on mobility in people with Parkinson's disease through remote monitoring: A proof of concept study.***

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BACKGROUND AND AIM: Covid-19 has reinforced the need for remote patient management. The technological advances of wearable technology (WT) such as body worn sensors, smart watches and smartphones may provide the tools to address this need. Dopamine replacement therapy is used to mitigate motor symptoms in people with Parkinson's disease (PD) but may require complex regimens over a 24-hour period. Modification to medication usually follows one-off consultations with clinicians in combination with subjective patient feedback. The use of WT to collect mobility and medication data provides an opportunity to objectively quantify the effect of medication on patients' motor performance during day-to-day activities. This may be used to inform clinical decision-making and tailor patients' pharmacological management and personalise patient care. This study aims to develop a connected WT system capable of acquiring real-world data to assess medication adherence, quantify digital mobility outcomes (DMOs) and create valid data-driven models to demonstrate that DMOs can monitor and predict motor response to medication. METHODS: Thirty people with PD (H&Y I-III) will be recruited (REC: 21/PR/0469). Participants will be assessed once using a battery of general and PD specific clinical measures to determine functional performance, disease severity, physical and cognitive function. Participants will undertake a 7-day real-world assessment using a WT system: an Axivity AX6 sensor (tri-axial accelerometer and gyroscope) to collect mobility data; a

smartphone to collect contextual factors (Aeqora App), and a smartwatch (Mobvoi, Ticwatch Pro 3) featuring a custom designed application which notifies patients of their medication dose/time and allows the patient to acknowledge intake timing. Validated algorithms will identify DMOs based on features of gait, such as walking speed, gait rhythm (e.g. step time), variability and asymmetry [1]. Changes in DMOs will be analysed via time series analysis between medication intake timings. At the end of the 7-day assessment, participants will complete a usability questionnaire [2] to describe the acceptability of the WT system. RESULTS: Data collection is ongoing (n = 13 participants recruited, Age: 62 ± 10 years, 9 males, 4 females). The study will report on: (1) the relationship between medication intake times and DMOs collected in real world environments using WT, (2) the patient experience and usability of the new WT system. CONCLUSIONS: This study aims to utilise remote assessment of mobility and medication adherence to describe the effects of medication on DMOs in people with PD. Usability of the WT system developed for monitoring people with PD will also be assessed. This will provide an essential step towards real-time remote monitoring through connected WT systems and analytics to support personalised medicine and care. REFERENCES: [1] Del Din et al., (2016) IEEE J Biomed Health Inf 68: 838-847 [2] Rabinovich et al., (2013) Eur Respir J 42: 1205-1215

P2-M-76: ***Can the Interactive Walkway detect effects of sleep medication on (adaptive) walking?***

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BACKGROUND AND AIMS: Sleep medication is a risk factor for falls. In early clinical sleep-drug development, body sway during quiet upright stance provides a sensitive biomarker [1], but the relation with fall risk during walking remains unclear. Walking adaptability may yield a construct that is better related to (medication-induced) falls, most of which occur when walking, often involving inadequate gait adjustments to environmental context. In a recent clinical study, the Interactive Walkway (IWW) outcome measures were able to discriminate between prospective fallers and non-fallers in a population of healthy controls, Parkinson's disease patients and stroke patients [2]. The goal of this study is to evaluate if IWW walking-adaptability outcome measures are sensitive to medication effects. Specifically, the aim of this pilot study is to evaluate the effect of two types of sleep medication, zolpidem (a drug known for affecting fall risk) and suvorexant (a recently developed drug expected to have a lower impact on fall risk), on IWW walking-adaptability outcome measures. METHODS: In this randomized, double-blind, placebo-controlled, three-way crossover study, 18 healthy elderly (age: 65-80 years) subjects received an oral dose of 5mg zolpidem, 10mg suvorexant or placebo. All assessments were performed twice pre-dose as baseline, and at 1-, 2-, 3-, 5-, 7-, 8- and 9-hours post-dose. IWW assessments included: 8-meter walking test, goal-directed stepping, obstacle avoidance, and tandem walking. Other pharmacodynamic measurements included: (fast) Timed Up-and-Go (TUG) test, adaptive tracker, and body sway. RESULTS: A decline in performance ($p<.05$) was observed for both zolpidem compared to placebo and zolpidem compared to suvorexant in the first three hours post-dose in all IWW-tests, both

TUG-tests, the adaptive tracker and body sway (Table 1). A decrease in walking speed (among others) was observed in all IWW-tests. IWW-tests were not affected for suvorexant compared to placebo at any timepoint. However, an increase in body sway was observed for suvorexant compared to placebo up to 3 hours post-dose (p=.02). CONCLUSIONS: The IWW can detect the effects of sleep medication on (adaptive) walking and differed in expected directions between two sleep inducing agents with different modes of action: zolpidem and suvorexant. IWW outcomes may therefore provide useful biomarkers for studying sleep-medication effects in healthy elderly volunteers. The IWW could qualify as a useful instrument for a targeted fall-risk assessment in early clinical drug development. References [1]. Cohen AF, Burggraaf J, van Gerven JMA, Moerland M, Groeneveld GJ. The Use of Biomarkers in Human Pharmacology (Phase I) Studies. Annu Rev Pharmacol Toxicol. 2015;55(1):55-74. [2]. Geerse DJ, Roerdink M, Marinus J, van Hilten JJ. Walking adaptability for targeted fall-risk assessments. Gait Posture. 2019;70:203-210.

P2-M-77: ***Margins of stability before and after pain suppression in people with gonarthrosis***

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BACKGROUND AND AIM: According to the World Health Organization (WHO), 4% of the world's population suffers from osteoarthritis (OA), which means more than 250 million people. Among them, 83% suffer from knee osteoarthritis (KOA) which is the most disabling and painful form of OA. In its early stages, the management of OA consists of trying to reduce or even eliminate the pain to provide more comfort to the patient. However, since pain is a body's protective mechanism, its suppression could be deleterious to KOA patients' biomechanics and lead to disease progression's causes exacerbation; but pain suppression exact effect on knee biomechanics remains unknown. Thus, the main objective of our research study is to measure and verify whether pain suppression has an impact on the gait mechanics in people with KOA, as quantified by the margin of stability at different instants of gait cycle. METHODS: Fourteen 14 adults with painful patellofemoral osteoarthritis were included, with or without femorotibial osteoarthritis involvement. The experiment took place before and 15 min after pain relief induced by intra-articular injection of 5 mL Xylocaine (1%) into the knee. Participants walked on an instrumented treadmill during 45 seconds at comfortable speed. We processed the ground reaction force data collected from these participants. The center of pressure (CoP), the center of mass (CoM), and the extrapolated center of mass (XCoM) were calculated to estimate the margin of stability (Hof et al., 2007) for different gait cycle instants (ToeOff, HeelStrike, minimal) in medio-lateral (ML) and antero-posterior (AP) directions. RESULTS: 92% of participants presented 100% pain reduction. For each trial, we isolated the 15 most reproducible gait cycles for each leg using repeatability of ground reaction forces. A paired student test was performed on each participant to compare pre- and post- injection margin of stability. After injection of the anesthetic, the ML margin of stability at ToeOff has significantly increased in 2 patients and decreased in 2 patients on the ipsilateral side. There was no significant change on both legs in 8 patients. ML margin of stability at HeelStrike significantly increased in 2 patients and decreased in 5 for the ipsilateral knee. 6 patients had no significant change on both legs. AP margin of stability at ToeOff increased in 6 patients and decreased in 4. There was no significant change on both legs in 4 patients. AP margin of stability at HeelStrike increased in 2 patients and decreased in 2. It didn't significantly change on both legs in 5 patients. CONCLUSION: Considering the total population, there was no significant general behavior on ML and AP margin of stability evolution once the pain has been reduced - or eliminate. However, when considered individually, some patients present either increased or decreased margin of stability. This suggests that patients react in different ways when their pain is suppressed.

P - Falls and fall prevention

P2-P-78: ***The association between self-reported fatigue and obstacle contacts in older adults***

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BACKGROUND AND AIM: Falls are the number one cause of fatal and non-fatal injuries among older adults [1]. Tripping over large objects is a common cause of falls [2], and tripping occurs when the swing foot contacts an obstacle. When a person is fatigued, lower limb variability increases and motor control is impaired [3-5], which likely increases the risk of tripping. Understanding the association between trips and fatigue can inform interventions to prevent falls. METHODS: Forty-one older adults (age: 76.6±6.9 years, 25 females) were recruited. Inclusion criteria: independent in daily activities; exclusion criteria: walking aid, orthopedic or neuromuscular disorders. Participants walked down a 6 m walkway and stepped over an obstacle placed at 4 m (obstacle height 25% of leg length); the task was repeated 100 times. If a person contacted the obstacle, it would fall forward like a hurdle, and would not interrupt the swing limb, ensuring participant safety. Obstacle contacts were noted and confirmed later with video review. Two minutes of rest were provided every 25 trials. The gait trials took about 30 minutes, and total distance walked was about 1.3 km. Self-reported fatigue (0-10 scale, [6]) was assessed five times: before the gait trials, and after each block of 25 obstacle crossing trials. RESULTS: Fifteen participants (37%) contacted the obstacle at least once; 29 contacts were observed (0.7% of all trials). 52% of contacts occurred with the lead limb (first limb to cross the obstacle). There was no difference in the frequency of contacts between males and females. Fatigue increased from trial 0 to trial 100 (1.2 vs 3.5, $p<0.001$; Fig. 1A). Maximum fatigue was lower in participants with zero contacts versus those with one or more obstacle contacts (3.0 vs 4.7, $p=0.022$). Participants who reported higher ratings of fatigue were more than twice as likely to contact the obstacle (Fig. 1B). CONCLUSION: Inadvertent trips are not uncommon in older adults, even when the obstacle is visible and the participant has successfully cleared the obstacle multiple times in previous trials. The inadvertent contacts observed here are consistent with the observation that tripping is a common cause of falls [2]. It is notable that self-reported fatigue increased significantly in the first 25 trials, after only 10-15 minutes of walking/interacting with experimenters. Therefore, the effect of fatigue induced by the walking task should be considered in gait studies. Given the association between fatigue and tripping, improving endurance is an important factor to target in fall intervention programs. REFERENCES [1] Bergen et al.. 2016. MMWR, 65: 993-998. [2] Blake et al., 1988. Age Ageing, 17(6): 365-372. [3] Johnston et al., 1998. Med Sci Sports Exerc, 30(12): 1703-7. [4] Helbostad et al., 2007. J Gerontol A Biol Sci Med Sci, 62(9): 1010-1015. [5] Barbieri et al., 2014. Gait Posture, 39(3): 985-990. [6] Mickelwright et al., 2017. Sports Med, 47(11): 2375-93.

P2-P-79: ***The association between self-reported fatigue and obstacle contacts in older adults***

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BACKGROUND AND AIM: Falls are the number one cause of fatal and non-fatal injuries among older adults [1]. Tripping over large objects is a common cause of falls [2], and tripping occurs when the swing foot contacts an obstacle. When a person is fatigued, lower limb variability increases and motor control is impaired [3-5], which likely increases the risk of tripping. Understanding the association between trips and fatigue can inform interventions to prevent falls. METHODS: Forty-one older adults (age: 76.6±6.9 years, 25 females) were recruited. Inclusion criteria: independent in daily activities; exclusion criteria: walking aid, orthopedic or neuromuscular disorders. Participants walked down a 6 m walkway and stepped over an obstacle placed at 4 m (obstacle height 25% of leg length); the task was repeated 100 times. If a person contacted the obstacle, it would fall forward like a hurdle, and would not interrupt the swing limb, ensuring participant safety. Obstacle contacts were noted and confirmed later with video review. Two minutes of rest were provided every 25 trials. The gait trials took about 30 minutes, and total distance walked was about 1.3 km. Self-reported fatigue (0-10 scale, [6]) was assessed five times: before the gait trials, and after each block of 25 obstacle crossing trials. RESULTS: Fifteen participants (37%) contacted the obstacle at least once; 29 contacts were observed (0.7% of all trials). 52% of contacts occurred with the lead limb (first limb to cross the obstacle). There was no difference in the frequency of contacts between males and females. Fatigue increased from trial 0 to trial 100 (1.2 vs 3.5, $p<0.001$; Fig. 1A). Maximum fatigue was lower in participants with zero contacts versus those with one or more obstacle contacts (3.0 vs 4.7, $p=0.022$). Participants who reported higher ratings of fatigue were more than twice as likely to contact the obstacle (Fig. 1B). CONCLUSION: Inadvertent trips are not uncommon in older adults, even when the obstacle is visible and the participant has successfully cleared the obstacle multiple times in previous trials. The inadvertent contacts observed here are consistent with the observation that tripping is a common cause of falls [2]. It is notable that self-reported fatigue increased significantly in the first 25 trials, after only 10-15 minutes of walking/interacting with experimenters. Therefore, the effect of fatigue induced by the walking task should be considered in gait studies. Given the association between fatigue and tripping, improving endurance is an important factor to target in fall intervention programs. REFERENCES [1] Bergen et al.. 2016. MMWR, 65: 993-998. [2] Blake et al., 1988. Age Ageing, 17(6): 365-372.

[3] Johnston et al., 1998. Med Sci Sports Exerc, 30(12): 1703-7. [4] Helbostad et al., 2007. J Gerontol A Biol Sci Med Sci, 62(9): 1010-1015. [5] Barbieri et al., 2014. Gait Posture, 39(3): 985-990. [6] Mickelwright et al., 2017. Sports Med, 47(11): 2375-93.

P2-P-80: ***Effects of lower limb's muscle-tendon units' properties on balance following a slip with forward loss of balance in young and older participants***

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Research on balance recovery following a simulated slip with forward loss of balance (FLB) showed that young and older adults develop larger than normal lower limb joint moments following the slip initiation. For older participants whose muscle-tendon units (MTUs) properties are likely altered, this may represent an additional challenge. This study aimed at understanding whether and how the age-related decline in MTUs properties of older participants altered their capacity to recover their balance following a single slip with FLB. Fourteen young (25.3±3.9 years) and fourteen older (62.8±7.1 years) male and female participants who volunteered for this study had their balance recovery and MTUs properties evaluated. A slip was triggered by briefly accelerating the ipsilateral belt to the stance foot of an instrumented treadmill when participants were walking at 1.2m·s-1. Balance was measured as the margin of stability at heel strike and averaged over the first three recovery steps. Knee extensors and ankle plantarflexors strength (KEMAX and PFMAX) and power (KP and AP) were evaluated using an isokinetic dynamometer during ramped isometric and maximum concentric contractions respectively, at joint angles and angular velocities corresponding to those measured following the onset of the slip. Joints' rate of moment development (RMD) and electromechanical delay were measured during maximal isometric contractions. Patellar and Achilles tendons' stiffness was measured by synchronising the dynamometer with ultrasounds and 2D videos thereby measuring tendons' lengthening and moment arm. Tendon force was estimated by dividing the joint moment corrected for the effects of gravity and antagonist moment by the tendon's moment arm. We used Mann Whitney tests to evaluate the effect of age on our variables (α=0.005 for MTUs properties) and bivariate Kendall's tau correlations to establish the links between the MTUs properties of our participants and their balance. Older participants' PFMAX, KP, AP, knee extensors and plantarflexors' RMD were significantly lower than those of younger participants. There was no effect of age on participants' balance. No significant correlation was detected between the MTUs properties and participants balance ($p>0.05$). This study showed for the first time that balance recovery following a slip with FLB does not rely on the maximal strength, power, RMD, EMD or tendons' stiffness of participants. These findings suggest that exercise interventions aiming at improving the MTUs properties of older participants may not directly affect their balance following a slip with FLB. As we previously showed that both young and older participants improved their balance recovery following exposure to repeated slips with FLB, these findings further reinforce the implementation of task-specific rather than exercise interventions to improve balance recovery following a slip with forward loss of balance.

P2-P-81: ***Type II muscle fibre properties are not associated with balance recovery following large perturbations during walking in young and older adults***

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BACKGROUND AND AIM: Muscle strength has been associated with falls incidence in older adults and a link has been reported between hip fracture history and Type II muscle fibre size (Kramer et al. 2017). Muscle fibre characteristics may be an important factor in balance performance but this has never been directly examined. In this study, we address whether Type II muscle fibre characteristics associate with reactive balance during walking. METHODS: This cross-sectional study included 48 participants (12 young [mean age: 23.9y; 7 male, 5 female]; 36 older [mean age: 69.2y; 21 male, 15 female] adults). Biopsy specimens were taken from the vastus lateralis and immunohistochemistry staining was performed. Muscle fibre size was determined by measuring the cross-sectional area (CSA) and fibre type distribution was expressed as a percentage with respect to the number of fibres and as a percentage of CSA (% fibre type I/II area relative to total CSA). Treadmill belt acceleration perturbations (simulating the effects of a trip) were applied once to the right leg and once to the left leg during walking and the margin of stability concept (using motion capture and a force plate-instrumented treadmill) was used to estimate the number of recovery steps required to recover and return to steady-state walking. Walking stability was normalised to ensure individuals were perturbed at a similar stability state (McCrum et al. 2019). Spearman correlations between the Type II fibre parameters and the number of recovery steps were conducted. RESULTS: The participants were diverse in terms of physical function (assessed by SPPB), steps per day and amount of high intensity physical activity (5 days ActivPAL activity monitoring), as well as in the muscle fibre characteristics and number of recovery steps needed. Despite this, no significant associations were found between the recovery steps needed post-perturbation and the type II fibre characteristics: Type II fibre percentage, Type II fibre CSA and the percentage of total CSA taken up by Type II fibres ($-0.125 \le r \le 0.202$, $0.17 \le P \le 0.86$). To check if the younger adults' data were unduly influencing these results, we repeated the analyses with only the older participants and found similar results, with only one of 12 associations being significant. Correlations between reactive balance recovery and upper leg muscle volume (assessed by MRI) and knee flexion and extension torque (assessed with a dynamometer) also only revealed one significant correlation out of 20. CONCLUSION: Type II muscle fibre proportion and dimension are not significantly associated with reactive balance recovery following walking perturbations. These results have implications for muscle strength testing and training in fall prevention, as muscle tissue properties may not be key factors in balance recovery. REFERENCES: Kramer et al. 2017 J Gerontol A Biol Sci Med Sci. 72(10):1369-1375. McCrum et al. 2019 J Biomech. 87(18):48-53.

P2-P-82: ***Effects of Trip Training in Older Adults on Gait Asymmetries: A Secondary Analysis***

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Background and aim: Gait asymmetries are the bilateral difference of the lower extremities during walking. Gait asymmetries are linked to decreased gait velocity and balance control, and increased metabolic cost and fall risk. Several training programs have been developed to enhance gait asymmetries, including split-belt treadmill training. However, the extent to which these training programs may positively influence gait asymmetries in an older adult population is unknown. Trip training is a program that allows for training adaptive responses to perturbations and shows increased reactivity in older adults and clinical populations. Thus, trip training can decrease fall risk. However, spatiotemporal gait asymmetries after trip training have not been examined. This study's aim was to compare the effect of trip training on gait asymmetries in older adults. It was hypothesized that trip training would enhance gait asymmetries in the post training period compared to the pre training period. Methods: Forty older adults aged 70 and older (75.2±4.9 years) with no neurological injuries participated in this study. The control group had 10 participants, the intervention group had 30 participants, which was further divided into fallers (n=6) and non-fallers (n=26). The dependent variables were step width and length asymmetries (m). Motion capture data were taken at 100 Hz. Participants walked on the ActiveStep Treadmill for (1) 15 minutes unperturbed walking, (2) 10 minutes trip training (10 minutes unperturbed walking for controls), and (3) 15 minutes unperturbed walking. Five minutes of rest was given between each set of walking. The intervention group was tripped eight times during the trip training. Results: In the non-fallers group, step width asymmetry and step length asymmetries significantly increased from pre training (M=25.07, SD=27.98; and M=8.33, SD=7.79 respectively) to post training (M= 26.71, SD=28.83, $p<0.001$; and M=10.30, SD=18.53, $p<0.001$ respectively). In the faller group, step width asymmetries significantly increased from pre training (M=19.25, SD=16.85) to post training (M=23.07, SD=20.34 , $p<0.001$); however, step length asymmetries significantly decreased from pre training (M=8.85, SD=7.21) to post training (M= 7.80, SD=6.83, $p<0.001$). Trip training has a small effect on step width and length asymmetries (effect size of Hedges g= 0.15 and Hedges g= 0.18 respectively). Conclusion: Trip training has a small effect on gait asymmetry post training and can increase gait asymmetries in fallers and non-fallers. However, the faller group exhibited a decrease in asymmetry after the training, suggesting the adoption of a more stable gait pattern. Trip training is known to improve reactive responses to perturbations and reduce fall risk. However, trip training can induce gait asymmetries post training, and greater gait asymmetries are associated with increased fall risk. This suggests that gait asymmetries are an important metric in addition to primary measures such as gait velocity and balance to assess fall risk.

P2-P-83: ***Free-living digital biomarkers and domains with high predictive values for falls***

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BACKGROUND AND AIM: To address the problem of falls in older adults, a growing body of literature has focused on wearable sensor-based methods for fall risk assessment (FRA) in free-living conditions. These studies investigated the relationships between falls and free-living digital biomarkers (FLDBs) including micro (e.g., step length, index of harmonicity) and macro (e.g., sitting duration, quantity of daily steps) extracted from inertial data. Considering that many of the explored FLDBs exhibit inconsistent fall predictive values across free-living FRA studies [1], the identification of FLDBs and domains that consistently show strong links to falls, regardless of inter-study differences (e.g., demographics, number of days of activity monitoring), may address new solutions for fall prevention in older adults. Therefore, by exploring the proposed free-living FRA approaches in the literature, the aim of the present study was to identify FLDBs and domains that generally exhibit high fall predictive values. METHODS: FLDBs were extracted from twenty out of twenty-four free-living FRA studies that met the inclusion criteria in our previous literature review [1]. Based on the available evidence, a conceptual model was first proposed to facilitate the categorization of the extracted FLDBs into discrete domains. Subsequently, the fall predictive power scores of domains and FLDBs were quantified. RESULTS: Among macro FLDBs, gait bout duration and gait bout duration variability (from gait bouts >3 steps) showed strong associations with falls. Domains such as rhythm, pace, and complexity/stability exhibited promising fall prediction results. Among micro FLDBs, step/stride time, stride frequency, step length, step time variability, the amplitude of dominant frequency (vertical and mediolateral), and harmonic ratio (vertical and anteroposterior) showed promising results for the identification of fallers. Moreover, micro FLDBs extracted from the vertical inertial signals were generally more sensitive to fall-related changes than mediolateral and anteroposterior features. CONCLUSIONS: Although micro FLDBs have been investigated in fewer free-living FRA studies, they generally exhibited more promising results for fall prediction than macro outcomes, and thus, may be considered more robust against sources of inconsistency. [1] Nouredanesh, Mina, Alan Godfrey, Jennifer Howcroft, Edward D. Lemaire, and James Tung. "Fall risk assessment in the wild: A critical examination of wearable sensor use in free-living conditions." Gait & Posture 85 (2021): 178-190.

P2-P-84: ***Distinct perturbation-evoked cortical potentials associated with balance recovery during unexpected slipping while walking in healthy young: a feasibility study***

Rudri Purohit[1], Shuaijie Wang[1], Samir Sangani[2], Joyce Fung[2], Tanvi Bhatt[1]

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Background: Cortical contributions to reactive balance control have recently been suggested through electroencephalography (EEG) based analysis of beta oscillations and large-amplitude N1 perturbation-evoked potential (PEP) in response to unexpected surface translations in standing. We have previously identified peripheral biomechanical and kinematic differences between falling and recovering from overground gait-slips. However, cortical dynamics involved in such real-life like unpredicted environmental perturbations during walking has never been studied. Aim: The present study examines PEPs (early and late) via surface EEG in response to large-size overground slip-perturbations in walking to contrast between balance recoveries and falls in healthy young adults. Methods: Twenty healthy young adults (12 female/8 male; ages 18-35) were exposed to a single, novel, unannounced large-size (slip distance=65cm) right-sided overground gait-slip. Analysis of cortical responses from 32 wireless EEG channels acquired at 500Hz and filtered with a band pass filter (2-60Hz) was focused over supplementary motor (Cz) and posterior parietal area (Pz). EEG responses were analyzed corresponding to perturbation onset (PO) and recovery stepping to identify P1 (30-90ms after PO), N1 (80-150 ms after PO), P2 and N2 (200-350ms after PO). Independent t-tests were used to find differences in PEPs (amplitude and latency) between fallers and non-fallers. Results: All participants experienced a backward loss of balance (BLOB) upon a novel slip exposure. N1 responses were larger in amplitude (Cz: -148.40±114.62μV, Pz: -138.25±59.67 μV) for participants who experienced a fall as compared to those who successfully recovered without falling (Cz:-32.89±22.13μV, Pz: -17.56±38.19 μV, p<0.05). N2 responses were larger in amplitude for non-fallers who executed a backward stepping response (Cz: 73.32 ± 44 μV, Pz: 78.57±33.54 μV) as compared to non-fallers who aborted their step (Cz: 28.75 ±24.17 μV, Pz: 22.85± 25.18 μV, p<0.05). There were no significant group differences in early and late PEP latencies between fallers and non-fallers (p>0.05). Conclusion: Distinct early and late perturbation-evoked cortical potentials can be identified in healthy young adults using single-trial analysis of an unpredicted overground slip. The N1 cortical potential postulated to be involved in error-detection of expected versus actual postural states was significantly larger in fallers compared to non-fallers. The N2 polysynaptic cortical potential postulated to reflect executive cognitive control was found to be larger in non-fallers that executed a backward step compared to those who aborted their step for recovering from balance loss. The results suggest influence of cortical control to modulate reactive balance control and slip fall/recovery outcomes.

P2-P-85: *Differences in reactive gait stability to overground slip perturbations between cognitively intact older adults and those with mild cognitive impairment.*

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Background: Older adults with mild cognitive impairment (OAwMCI) exhibit two-fold increased fall-risk compared to cognitively intact healthy older adults (HOA). Such heightened fall-risk can be attributed to subtle balance control and gait deficits in functional activities. Of them, the primary defense mechanism against falling, i.e., reactive balance control is shown to be significantly deteriorated in this population as compared to their healthy counterparts. While such findings were based on treadmill-induced stance perturbations, alterations in response to real-life like environmental perturbations (slips or trips) during functional activities like walking has not been studied. Aim: The present study aimed to examine the differences in reactive balance control measures in response to a novel, unexpected, overground gait-slip in older adults with and without mild cognitive impairment. Methods: Twenty-eight OAwMCI (67.70±5.85 yrs., Montreal cognitive assessment: MoCA 21.71±1.80) and twenty-eight age-matched HOA (68.10± 6.68 yrs., MoCA 27.37±1.44) were exposed to a single, novel, unannounced right-sided (slip distance=60cm) overground slip in walking. Reactive gait stability, i.e., shortest distance of dynamic center of mass (COM) state (computed from instantaneous COM position and velocity) from the theoretical threshold boundary was calculated at the instances of pre- and post-slip recovery/trailing foot touchdown (TD). Slip velocity) was also calculated at the instance of post-slip TD. Reactive gait stability and slipping kinematics were compared between the two groups using Independent samples t-test and bivariate Pearson's correlation was used to determine possible associations between reactive stability and slipping kinematics. Results: All participants experienced a backward loss of balance (BLOB) upon an unexpected slip exposure. There were no group differences in pre-slip stability ($p>0.05$). OAwMCI displayed greater falls (71.42% vs 32.10%, $p<0.05$) and reduced reactive stability at post-slip TD (M=-0.58, SD= 0.20) as compared to HOA (M =-0.44, SD= 0.20, $p<0.05$). Additionally, reactive stability at post-slip TD was negatively correlated with slip velocity ($r2= 0.73$, $p<0.05$) at post-slip TD. Conclusion: The findings suggest that proactive control of gait stability is not much affected by cognitive decline however, post-perturbation reactive control of gait stability is significantly impaired. The study results are in line with our previous study that demonstrating deterioration of reactive response to stance perturbations in OAwMCI. Aging with MCI can significantly deteriorate reactive responses to unpredicted perturbations in walking thereby escalating fall-risk in OAwMCI. While these are preliminary findings, further investigation is needed to acquire better understanding of impaired reactive balance control in OAwMCI.

P2-P-86: ***The combined effect of number of falls recalled in the past year and self-reported balance confidence predicts the occurrence of injurious falls in lower limb prosthesis users***

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BACKGROUND AND AIM: The proportion of lower limb prosthesis (LLP) users who report one or more injurious falls a year has remained between 18 and 29% over the past 25 years. Injurious falls are associated with significant financial costs, activity restrictions, and reduced quality of life. Several personal characteristics (e.g., gender) have been associated with an increased risk for injurious falls by LLP users. To date however, none have been used to effectively predict the occurrence of injurious falls. The objective of this study was therefore to develop a model that could predict the number of injurious falls LLP users will experience over the subsequent six months. METHODS: Sociodemographic, health, balance, and mobility-related characteristics were recorded at baseline from 60 LLP users. Participants were then followed for the next 6 months while the occurrence of any falls, along with their circumstances and consequences (i.e., injury), were recorded during monthly telephone calls. Initial associations between injurious falls and baseline characteristics were identified using bivariate negative binomial regression. Bivariate associations with p-values $< .20$ were considered candidate predictor variables and carried forward into the development of a multivariate negative binomial regression model intended to predict the number of injurious falls expected over the next 6-months. Candidate predictor variables were retained in the final multivariate model if their p-value was $\leq .15$. RESULTS: Bivariate negative binomial regression identified four candidate predictor variables; gender, balance confidence (i.e., ABC scores), number of falls recalled in the past year, and balance ability (i.e., Narrowing Beam Walking Test score). After model reduction, two of the candidate predictor variables, number of falls recalled in the past year and balance confidence, were retained in the final multivariate model. Within the final model, the number of falls recalled over the past year, but not balance confidence, was a statistically significant predictor of the number of injurious falls (number of falls recalled p = .045, ABC: p = .120). Viewed jointly within the final model (EQ. 1), the combined effect of balance confidence, and the number of falls recalled in the past year on predicting the number of future injurious falls was statistically significant (X2(2) = 8.15, p = .017). EQ. 1: # of injurious falls expected over the next 6 months= exp ((-.519*ABC score)+(.271* # falls in past year)+.321) CONCLUSION: The findings suggest that together, the number of falls recalled in the past year and ABC scores may be used by clinicians to estimate the number of injurious falls a LLP user may experience in the next 6 months. For example, a LLP user who recalls 3 falls in the past year, and has an ABC score of 2.90, is predicted by the model to have 0.7 injurious falls in the next 6 months.

P2-P-87: ***Predictors of fall risk in a middle-aged population***

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BACKGROUND AND AIM: Falls have been investigated widely and described in older populations (65+ years). The same level of exploration into the associated risk factors for falls during the middle stage of an adult's lifespan are less well developed. Numerous functional tests have been developed to assess balance, mobility and fall risk in older adults, however, few tests have demonstrated the ability to predict fall risk in middle-aged adults (45-64 years). The characterisation of fall risk in a middle-aged population is imperative to prevent injurious falls during later life stages. The present study aimed to determine potential risk factors for falls within a middle-aged sample of fallers and non-fallers. METHODS: 33 middle-aged adults, 13 fallers (56.0 ± 6.9 y) and 20 non-fallers (54.8 ± 5.6 y) underwent testing that examined potential differences in body composition, strength, functional performance, gait, and fear of falling (FOF). Dual Energy X-Ray Absorptiometry (DEXA) provided data for lean muscle mass (LM), fat mass (FM) and total body fat percentage (BF%). Isokinetic dynamometry provided maximal voluntary contraction plantar flexor (PF) and dorsi flexor (DF) strength values at a range of six joint angles (-5°, 0°, 5°, 10°, 15° and 20°). A single leg hop protocol and the Mini-BESTest determined participants functional performance. The Icon-FES was implemented to examine FOF and the gait characteristics of all participants were obtained via a 7-day daily-life-gait quality assessment using accelerometery. RESULTS: Body composition, strength, functional performance, and fear of falling all significantly differed between fallers and non-fallers ($p < 0.05$). Daily-life gait characteristics did not significantly differ between fallers and non-fallers ($p > 0.05$). CONCLUSIONS: Our results identified that body composition and strength appear to differ between those who fall during middle-age and those who do not. These findings may potentially explain the differences observed in functional performance between groups, however, both the physiological and psychological differences observed did not significantly

alter the gait characteristics of fallers when compared to their non-falling counterparts. The study highlights some of the potential fall risk predictors that can be taken forward to identified those at risk of future falls during middle-age. Earlier assessment of these fall risk factors during middle-age may prevent recurring, injurious falls in later life years.

P2-P-88: ***External validation and further exploration of fall prediction models based on questionnaires and daily-life trunk accelerometry in older people***

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Q - Habilitation & rehabilitation

P2-Q-89: ***Analysis of gait motion changes by intervention using robot suit hybrid assistive limb (HAL) in myelopathy patients after decompression surgery for ossification of posterior longitudinal ligament***

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BACKGROUND AND AIM: The ossification of the Posterior Longitudinal Ligament (OPLL) is a degenerative spine disease that can cause motor disorder. Surgical decompression is usually applied to patients who developed myelopathy or severe stenosis. Even appropriate decompression operation has been successfully carried out, there are some residual motor impairments in some cases. The exoskeleton robot suit, The Hybrid Assistive Limb (HAL, Cyberdyne, Japan.) is a wearable powered suit to assist and support users voluntary control of hip and knee joint motions by detecting bioelectric signals (muscle action potentials) from surface electrodes and from force/pressure sensors in the shoes during their movement (Kawamoto et al., 2005). Recently, HAL has been reported to be feasible and effective for functional recovery and rehabilitation of patients with gait disturbance after neurological disorders such as spinal cord diseases and cerebral vascular diseases. METHODS: Twelve patients diagnosed as OPLL associated with severe motor impairment followed by decompression surgery joined the present study. Six patients (3 men, 3 women, mean age 57.8 years, 25 days after the start of HAL) went through the HAL intervention in the acute stage of postoperative gait disorder. Nine patients (9 males, 68.3 years, 1023.2 days after the start of HAL) went through the intervention in the chronic stage. Ten sessions of HAL gait intervention were provided for each patient of both groups, and gait was measured before and after intervention (VICON MX, Plug-in Gait). In addition, MMT and EMG were compared before and after the fourth and seventh sessions. RESULTS: In the acute phase, we observed significant improvements in walking speed 25/54 (pre/post) m/min ($p<0.01$), cadence 36/50.7 steps/min($p<0.1$), stride length 71/103cm($p<0.05$), range of motion (ROM) of the hip joint 34/43 degrees ($p<0.05$), ROM of the knee joint 42/57 degrees ($p<0.05$), and double knee action (DKA) 3.2/5.5 degrees ($p<0.05$). In the chronic phase patients, there were significant improvements after HAL in walking speed 47/54 m/min ($p<0.01$), ROM of hip joint 36/40 degrees ($p<0.05$), DKA 4.8°/7.2°($p<0.05$). ROM of foot joints was 25.5°/26.7° without statistical significance. Based on MMT, and EMG result after the session, it could be considered that HAL training had some immediate effect on gait control. CONCLUSIONS: The patients of both acute and chronic groups gained faster gait with improved double knee action achieving smoother gait, with greater hip joint range of movement and higher toe lift during swing after the HAL intervention. Improvement of double knee action, hence alleviation of back-knee which is commonly observed in the gait of myelopathy patients, was considered effective for prevention of knee joint osteoarthritis in later years.

P2-Q-90: ***Ankle-foot orthoses alters joint motions in patients with peripheral artery disease***

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BACKGROUND AND AIM: Lower extremity peripheral artery disease (PAD) is a cardiovascular condition caused by narrowed or blocked arteries supplying the legs. Claudication is a cramping pain in the legs of patients with PAD, brought on by exertion and relieved with rest. Gait is also impacted by PAD, as the result of the established myopathy, and patients with PAD walk slower. Ankle foot orthoses (AFOs) have been shown to enhance movement ability and gait stability in neurological populations. Using AFOs may be a useful intervention to assist gait and prolong the distance patients can walk before the onset of pain. This study investigated the effect of AFO on the joint movement during overground walking in patients with PAD. METHODS: Fourteen patients with PAD (Age (72.57±6.48 years), height (172.46±8.29 cm), and body mass (92.04±21.03 kg) were evaluated before and immediately after a three-month AFO intervention. Participants walked overground with and without an AFO, while gait was recorded with motion analysis cameras to assess the lower extremity joint kinematics. The peak value for joint kinematics were measured for the sagittal plane during the stance phase of gait for both legs. Results were analyzed using a 2×2-repeated-measure-ANOVA (intervention: before/after three-month intervention, and condition: with/without AFO) as within subject factors. RESULTS: Using the AFO prevented excessive ankle dorsi and plantar flexion angles before and after three months intervention (p's<0.001). This reduction reflects movements closer to normal ankle motion in healthy controls. Walking with the AFO led to decreased knee flexion (p=0.041), and extension (p=0.01) angles. Moreover, after three-month intervention, knee flexion (p=0.005) and extension angles (p=0.027) were reduced compared to baseline. Reducing the sagittal peak knee angles in patient population could be considered as a cautious mechanism to reduce the peak joint angular acceleration. After three months of intervention, hip extension decreased during waking. Although increased hip extension was reported in healthy walking pattern in young population, there might be a compensatory strategy in adjustment for other joint motions, which led to decreased hip extension in patients with PAD after intervention. CONCLUSIONS: Previous work identified excessive plantarflexion or "foot drop" just after heel contact in patients with PAD. Walking with the AFOs helped resist immediate foot drop before and after the 3-month AFO intervention. We observed improved knee outcomes including reduced peak flexion angle after the AFO intervention. Reduced knee and hip extension peak angles following the intervention seems to reduce knee and hip hyperextension during single support and propulsion phases of gait, respectively. These reductions in excessive movement may help decrease osteoarthritis risk in patients. ACKNOWLEDGEMENTS AND FUNDING: Study funded by the NIH Grant-R01-HD090333, and Merit Review-I01RX003266.

P2-Q-91: ***Individuals and Physical Therapists Rating of Balance Exercise Intensity***

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BACKGROUND AND AIM: While clinical balance training is frequently used to improve balance performance, unsupervised balance training, particularly in a remote setting, has the potential to improve access. However, unsupervised balance training has been shown to be less effective than supervised balance training. Because the efficacy of balance training is dependent on the training occurring at or near the limits of the individual's ability (i.e., the appropriate dosage), it is important that all factors contributing to dosage be assessed. Training frequency, time, and type are all easily quantified and therefore can be assessed remotely. However, intensity depends on both the difficulty of the exercise and the balancing ability of the individual, which makes it difficult to quantify and particularly difficult to assess remotely. Exerciser self-ratings of intensity can inform recommendations for training dosage and exercise progression within a remote setting; however, the differences between self-ratings and physical therapists' ratings are not well understood. The goal of this study was therefore to assess rater reliability and rating differences for physical therapist and exerciser self-ratings of static standing balance exercise intensity to support the development of remote balance training approaches. METHODS: Ten participants with age or vestibular disorder-related balance concerns (66±16 yr, four females) completed standing balance exercises and rated the intensity of each balance exercise trial using a 5-point scale. Eight physical therapists specializing in balance rehabilitation also rated intensity and gave recommendations for the relative intensity of subsequent trials. Linear mixed effects models were used to evaluate the reliability of the exerciser and the physical therapist ratings, compare the exerciser and physical therapist ratings, and correlate intensity recommendations to the ratings. The significance level was 0.05. RESULTS: The physical therapist intensity ratings were of good inter and intra-rater reliability (ICC=0.83) and correlated significantly with recommended relative intensity ($p<0.001$), supporting that there exist observable aspects of balance performance that physical therapists can consistently translate into an evaluation of intensity. Exerciser ratings were of good intra-rater reliability (ICC=0.88); however, the exercisers rated exercises as significantly less intense than physical therapists ($p<0.001$). Furthermore, the difference between exerciser and physical therapist ratings varied enough to likely result in different intensity recommendations and potentially yield different exercise prescriptions. CONCLUSIONS: While exerciser self-ratings of balance exercise intensity may be reliable, they differ from physical therapists' ratings. Using self-ratings as a substitute for physical therapist evaluation of balance intensity (or performance) during remote training should therefore be done with caution.

P2-Q-92: ***Feedback for the prevention and rehabilitation of musculoskeletal disorders.***

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BACKGROUND AND AIM: Despite progress in their management, work-related musculoskeletal disorders (WRMSDs) continue to generate important socio-economic burdens. Sensorimotor disturbance may be a neglected impairment that could be important to consider for the prevention and management of WRMSDs. The use of extrinsic feedback has been suggested for the prevention of WRMSDs and for rehabilitation to reduce the disabilities of WRMSDs. However, there are few systematic reviews on the effectiveness of using extrinsic feedback for the prevention and treatment of WRMSDs. The aim was to perform a systematic review investigating the effect of extrinsic feedback on the function of individuals with and without WRMSD during work tasks. METHODS: A systematic review of five databases (CINAHL, Embase, Ergonomics Abstract, PsycInfo, PubMed) was performed. Two independent reviewers screened the potential articles, performed data extraction, and evaluated the risk of bias of included studies. They included studies with various designs assessing the effects of extrinsic feedback during work tasks in the context of prevention and rehabilitation of WRMSDs. Function was used as the primary outcome to determine the effect of extrinsic feedback for the prevention (e.g. risk/incidence of injury, rate of safety performance) and rehabilitation (e.g. disability/pain/work ability index) of WRSMDs. RESULTS: Fifteen studies were included, for a total sample of 923 participants (including 372 injured) who performed work-related tasks in the workplace (11 studies) or in controlled environments (e.g., clinic or research laboratory; 4 studies). The source (e.g. various sensors, ergonomic counseling), modality (audio, tactile, visual, mixed) and frequency (continuous, intermittent, faded, final) of the extrinsic feedback were heterogenous. The use of extrinsic feedback was found to be effective on function for short-term prevention in controlled environments (very limited evidence) and in the workplace (moderate evidence), and in rehabilitation in controlled environment (moderate evidence). There was conflicting evidence for the effect of the extrinsic feedback in the rehabilitation in the workplace, where the main control intervention were ergonomic interventions (the reference intervention). CONCLUSIONS: Clinician should use the extrinsic feedback to preserve and improve the function in the WRMSDs context. Feedback is in fact a complementary tool for the prevention of WRMSDs in both environments. For the rehabilitation of WRMSDs, extrinsic feedback is mainly effective in controlled environments. Indeed, for the rehabilitation in the workplace, the ergonomic adjustments should be the first intervention and could explain theses discrepancies of results. More evidence is needed concerning the long-term effect of extrinsic feedback for the prevention of WRMSDs and for the adding value in rehabilitation in the workplace after the ergonomic interventions. ACKNOWLEDGEMENTS AND FUNDING: The authors would like to thank Marie-Marthe Gagnon for offering her expertise as a librarian. AF was supported by a scholarship from the Center for Interdisciplinary Research in Rehabilitation and Social Integration. J-SR is supported by salary awards from the Fonds de recherche du Québec-Santé.

P2-Q-93: ***Assessment of Walking after Unilateral Hip Arthroplasty***

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Background: A common treatment approach for osteoarthritis of the hip is arthroplasty. Hip arthroplasty surgeries have progressively increased in the United States with some predictions expecting as many as 572,000 procedures to be performed yearly by 2030. One way to assess surgical outcomes is to evaluate patients' walking ability before and after surgery. Understanding each patient's mobility can then be used to guide rehabilitation. Methods: Eight participants (64.9±11.1 years) underwent unilateral hip arthroplasty. Participants walked at self-selected speeds on a motorized treadmill for 3 minutes. Assessments took place 2 weeks before surgery and at 3 and 6 weeks and 3 and 6 months after surgery. Bilateral lower limb kinematics were collected with a 12-camera motion capture system and joint angles were obtained with a custom Matlab script. Kinematic data were separated into individual strides, and time normalized to 100 samples. Bilateral stride, stance and swing times as well as range of joint motion (ROM) for the hip, knee and ankle, in the sagittal plane, were obtained for each collection session. To evaluate potential changes in within-limb coordination strategies, discrete relative phase (DRP) relationships between the hip and knee (minimum hip and maximum knee), and knee and ankle (minimal ankle and maximum knee) were calculated. Means and standard deviations were calculated for all variables. Repeated measures ANOVA were used to determine if significant differences existed between the different data collection sessions. Results: Stride and stance time for the affected leg (side of surgery) and unaffected leg progressively and significantly decreased after surgery. Swing times were unchanged after surgery relative to pre-surgical values. Overall, all three joints progressively and significantly increased their ROM from pre-surgery until 6 months after surgery. There were no significant changes in any of DRP measures. The variability of the DRP measures for the hip and knee was considerably different than the DRP measures for the ankle and knee. The increased variability in the second set of DRP measures resulted from the fact that some participants had a negative DRP value (anti-phase) while others had positive values (in-phase). Conclusions: The results indicate that unilateral hip arthroplasty is effective in improving participants' walking abilities. This is reflected in decreased stride times (i.e. increased velocity) and increased ROM for both limbs. The progressive decrease in stride times is a function of decreasing stance times, as swing time was unaffected surgery. It is possible, if not likely that stance time reduction, during the recovery period, is due in part to decreased pain during load bearing and increased muscular strength resulting from with their rehabilitation program. The lack of within-limb changes in DRP indicate that basic coordination patterns are unaffected by surgery. This suggests that prior to surgery, despite pain, the participants were able to utilize effective coordination patterns and these patterns, as reflected by DRP, persisted after surgery.

R – Modeling

P2-R-94: ***Automatic Detection of Daily-Living Gait from a Wrist-Worn Sensor: Preliminary Results Using Machine Learning in Older Adults and Patients with Parkinson's Disease***

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BACKGROUND AND AIM: Wearable sensors are widely used to monitor daily living activity. Gait measures can be extracted from these activities to obtain insights into aging and movement disorders such as Parkinson's disease (PD). Wrist-worn sensors, equipped with an accelerometer, are commonly used by the average person, are a convenient tool for research use with high compliance from patients. However, detecting gait from a wrist sensor is challenging relative to other locations due to the many degrees of freedom that the wrist has and because the hand is often not coordinated with the gait cycle (e.g., when holding a smartphone or walking with hands in pockets). Previous related works focused on a healthy population in which gait is less distorted than in PD patients. Thus, development and validation of gait detection algorithms from a wrist sensor in the daily living of patients with PD are needed. We aimed to compare three machine learning (ML) methods for gait detection from a wrist sensor worn during daily living. METHODS: 18 individuals with PD (mean age=72.7, SD=8.4; 8 women; mean disease duration=5.56, SD=4.05) and twelve healthy control (mean age=76.1, SD=7.3; 9 women) wore a tri-axial accelerometer on their wrist and the lower back for seven days. Labeling the dataset was conducted based on gold-standard annotations from a sensor placed on the lower back. The signal from the lower back is less noisy than the wrist and has validated algorithms for detecting gait with high results. We split the data in the supervised models into training and test sets (80:20 ratio for the DCNN and leave-one-out for the LSTM). In this work, we compared three different algorithms for gait detection from the wrist: 1. Unsupervised model using autoregressive infinity hidden Markov model (AR-iHMM; Y Raykov et al. 2021) 2. Deep Convolutional Neural network (DCNN) for "semantic segmentation" gait from non-gait (Q Zou et al. 2020) 3. Deep residual Bidirectional Long Short-Term Memory (Bidir-LSTM) for Human Activity Recognition (Y Zhao et al. 2018). RESULTS: Figure 1a shows the association between the algorithm's output and the gold standard, and figure 1b summarizes the confusion matrix results of the three models. CONCLUSIONS: These results suggest that detecting gait from a wrist-worn accelerometer can be done with some limitations. The imbalance embedded in a daily-living dataset (much more non-gait than gait) is expressed in our results by high specificity and accuracy but low precision and sensitivity. Hence, for identifying all walking bouts during daily living, the current results need additional work. Still, for some purposes, the current results may already be adequate. For example, if the goal is to evaluate gait quality, it might be sufficient to use a model with high precision (i.e., a few false positives) to correctly identify some of the gait segments, even though not all the segments are identified (i.e., low sensitivity).

P2-R-95: ***Towards long monitoring of Gait and Mobility MS patients using a wristwatch***

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BACKGROUND AND AIM: Gait analysis is a very powerful diagnostic tool that can be used for assessing the subject's condition and progression of diseases such as multiple sclerosis (MS) or Parkinson's and even assist in evaluating the effectiveness of a treatment or intervention. Gait analysis is traditionally performed at the lab, but it is might be affected by the time of the day it is performed, time from taking medication, and the white coat syndrome. To address these limitations, in the past several years, attempts to perform long-term monitoring using IMUs are becoming more frequent. The majority of the work focus on using one sensor on the lower back or hip and very few were published using a wrist-worn sensor. Measuring gait and specifically gait speed from a wrist-worn sensor is more challenging. To the best of our knowledge, works about long-term monitoring on MS patients using a wrist worn watch are currently not available. We presents a feasibility pilot, performed on MS patients and healthy controls at the lab, aiming to show that measures calculated from a wristwatch can detect differences between these groups. METHODS: 42 MS patients (age: 41.0±11.8, EDSS: 1.6±2.1) and 33 healthy controls (HC, age 37.2±10.9) performed a 6-minute walk test while wearing an "Opal" sensor on the right wrist, recording the 3D data at a sample rate of 128Hz (APDM Inc, Portland, Oregon). The subjects walked back and forth along a 25 meters corridor for 6 minutes with the instruction to achieve the longest distance that they could. PCA analysis was used to decompose the 3D acceleration signal and the signal with most of the information was used for the analysis to assess gait quality. Measures including stride regularity, RMS, sample entropy, and in the frequency domain the frequency and amplitude of the strongest peak. RESULTS: stride regularity (MS: 0.58±0.17, HC: 0.67±0.10; p=0.02), RMS (MS: 3.2±0.98, HC: 3.9±1.5 [m/s^2]; p=0.01) and sample entropy (MS: 0.44±0.10, HC: 0.48±0.07; p=0.02) differed between the two groups. CONCLUSIONS: The results demonstrate that the MS patient's arm movement, during the 6 minutes test, has lower regularity than the HC. They had a lower tilt of their hand as seen in the RMS measure and the lower sample entropy suggests a more impaired system compared with the HC. More generally, the results suggest that it is possible to extract measures of gait quality from a wrist-worn sensor in patients with MS. The ability to differentiate between MS and HC subjects, using a wrist-worn sensor, is encouraging and suggests that this method could be applied for long-term monitoring for MS patients.

P2-R-96: ***Modeling muscle's intrinsic resistance to stretch: implications for simulations of perturbed posture***

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BACKGROUND AND AIM: Healthy humans are adept at stabilizing against everyday postural perturbations. However, the role of muscle's intrinsic properties in postural control is poorly understood. Recently, De Groote et al. (2017) found that a neuromechanical model only matched empirical kinematic behaviour when the Hill-type muscle model was augmented with a phenomenological model of transient force response to stretch--a muscle property including short range stiffness. Short range stiffness is an emergent property of muscles measured as an increased muscle stiffness for a short period of time following a stretch. In contrast to Hill-type muscle models where the short range stiffness arises due to the relationship between muscle force, length, and velocity at steady state, Huxley-type biophysical muscle models exhibit short range stiffness due to cross-bridge dynamics. Given this difference in the muscle models, here we compared the short range stiffness between a Huxley-type biophysical muscle model and a Hill-type muscle model. We used MATMyoSim--an open source biophysical muscle model--to estimate the muscle force-length and force-velocity relationships at the maximum activation level. We then used these relationships in a Hill-type muscle model. We predicted that the short range stiffness would be much higher in the biophysical model where force depends on the stretch of bound cross-bridges. We also hypothesized that the biophysical model, which has most attached cross-bridges near optimal fibre length, would have relatively higher stiffness near the optimal fiber length compared to the Hill-model, which has maximum stiffness on the ascending limb of the force-length curve. METHODS: To estimate short range stiffness, we subjected both models to a stretch of 1% L0 at a velocity of 15% L0/s initiated from two lengths (65%L, 95%L0), where L0 is the optimal fiber length. We quantified short range stiffness as the slope of the muscle stress-strain curve in the 2ms after stretch onset. RESULTS: We found that the biophysical model had a short range stiffness ~10 times higher than the Hill-type model in each condition. Further, the Hill-type and biophysical models had opposite relationships between initial length and stiffness. The Hill-type model had a higher stiffness for stretches starting from a lower initial length, on a steeper part of the force-length relationship. In contrast, the biophysical model exhibited higher stiffness near optimal fiber length due to the larger number of attached cross-bridges contributing to muscle stiffness. CONCLUSIONS A Hill-type model ignores the direct contribution of cross-bridges to muscle stiffness when a muscle is stretched. Therefore, using Hill-type models to model perturbation responses vastly underestimates intrinsic muscle contributions to balance and likely overestimates muscle activity and neural contributions. ACKNOWLEDGEMENTS AND FUNDING: NIH R01 HD90642

S - Neurological diseases

P2-S-97: ***Parkinson Disease's related impairment in the synergy between gaze shift and body movements as in relation to postural instability***

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Background and aim: Patients with Parkinson's Disease (PD patients) exhibit singular impairments in postural control, in gaze shift and in attention, among others. Our objective was to test if PD patients exhibited impairments in the synergy - or coordinated control - between gaze shifts and body movements to perform goal-directed visual tasks in the standing position. Methods: Nineteen PD patients (mean age : 58.47±10.9 year, Hoehn and Yahr stage I and II, MDS-UPDRS mean score: 23.37±2.79, MoCA score > 25, mean disease duration: 7.36±4.12 years, on-drug) and twenty healthy controls (mean age : 62.15±8.55 year with also similar bodyweight, height than PD patients) participated in the study. Both groups of participants explored large images of rooms in houses (visual angle: 100°) and performed two sorts of task: a goal-directed search task (localisation of visual targets) and a control free-viewing task, each with 5 trials, 45 sec per task. We measured eye movements (SMI eye tracker), head, upper back and lower back movement (Polhemus markers). Subjective mental workload was evaluated with the National Aeronautics and Space Administration Task Load Index (NASA-TLX). Results: the PD patients showed a higher amplitude in gaze shifts and body movements than the healthy controls. The NASA-TLX was a significant covariate and was significantly higher for the PD patients. In fact, the larger the PD patients explored images, the more they oscillated their body and were destabilized, especially so in the goal-directed visual task (p=0.002), which relation was associated with higher subjective mental workload (p=0.001). Conclusions: Our results were indicative of PD related impairements in behavioral synergic control between gaze shifts, body movements and subjective mental workload. Previous studies in healthy young adults already showed that these young participants exhibit functional behavioral synergic control between gaze shifts, body movements and both subjective and objective attentional resources. Overall therefore, Parkinson's Disease, and also at a lower level the effect of age, both affect functional behavioral synergic control. Visuo-postural exercises of physical therapy are required, at least in PD patients, and even so at an early stage of the disease, to improve postural stability in relation to visual interaction with the environment. These trainings should reduce the risk of postural instability and falls and should increase success in tasks performed in ongoing life activities.

P2-S-98: ***Scoping Review on Sex and Gender in Walking Research among People with Parkinson's Disease***

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Background: Walking is an important activity of daily living (ADL) and is essential for success throughout the lifespan. Parkinson's Disease (PD) symptoms (i.e., tremors, stiffness) can negatively impact quality of life, walking balance and, in turn, ADLs (i.e., homemaking, feeding). Walking balance for people with PD (pwPD) is important to support ADLs and continued functional independence (1). Walking balance is commonly evaluated for pwPD using the Unified Parkinson's Disease Rating Scale (UPDRS) (2). Research on walking balance and pwPD are well understood (3)(4); however, the specific impact and differences between sex (i.e., females walk with higher cadence and shorter stride length) and gender (i.e., women walk more to undertake errands) are less understood (5). It is important to consider sex and gender in walking PD research because it provides context to researchers and clinicians to interpret information and implement in practice. Sex- and gender-based analyses (SGBA) provide the opportunity to understand the influence of sex and gender on health and health-related outcomes. Proper use of sex- (i.e., male, female, other) and gender-based (e.g., men, women) terms are important to understand whether outcomes are attributed to biological (i.e., biomechanical) sex or sociological (i.e., roles, identity) gender differences for research results. Incorrect and interchangeable (e.g., women, female) use of

these terms results in improper interpretation of research findings. Aim: The objective of this scoping review was to determine the frequency of SGBA and use of sex- and gender-based terms in recent walking balance research among pwPD. Methods: Six online databases were searched. Inclusion criteria consisted of pwPD, walking outcomes (i.e., kinetic, kinematic, and neurological variables), and publications in 2020. Articles that used clinical and/or walking balance scales only or included participants <18 years were excluded. Articles (n=1799) were double screened based on title, abstract and inclusion/exclusion criteria. Two researchers then independently screened full texts (n=58) and extracted data (n-=38). A third reviewer resolved conflicts when necessary. Data extraction examined the frequency (count) of SGBA, the use of sex and or gender terms, and if these concepts were factored into the statistical analysis (i.e., t-test, ANCOVA). Results: Eight articles (21%) included sex and/or gender in the statistical analysis. No articles (0%) conducted a SGBA. Sixteen articles (42%) used sex and gender terms correctly (i.e., sex; male, female) whereas fifteen articles (39%) used the terms interchangeably. Six articles (16%) did not use sex and gender terms to describe participants. Conclusion: There is a lack of SGBA in current walking research among pwPD. Sex and gender terms are used interchangeably or not at all in the articles that were reviewed. It is important to distinguish sex and gender differences appropriately and correctly to determine best practices for research and clinical practice for pwPD. (1) Parry et al., Neural Plast. 2019; 41(23) (2) Goetz et al., Mov. Disord. Clin. Pract. 2008; 23(15) (3) Hubble et al., PLOS ONE. 2015; 10(4) (4) Kelly, et al., Parkinson's Dis. 2012; 1(1) (5) Ko et al. J,. Biomech. 2011; 44(1)

P2-S-99: ***Near-falls among people with multiple sclerosis: potential contributors and consequences***

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BACKGROUND AND AIM: Falls are highly prevalent among people with multiple sclerosis (pwMS). They cause debilitating injuries, decreased mobility and gradual loss of independence. A near fall (NF) occurs when a person loses balance and starts to fall but manages to recover. Recent studies investigating the role of NFs suggest that they may be a more common, early sign of actual falls. Here, we aimed to gain a better understanding of the factors that contribute to NFs and their consequences among pwMS. METHODS: 40 people with relapsing-remitting MS (mean age=41.2±11.6 yrs; 29 women; median Expanded Disability Status Scale, EDSS=2, 0-5.5) were studied. Self-report of NFs was collected via calendars over 3 months. Subjects with multiple NFs (2 or more) were compared to those with 1 or no NFs. The timed 25-foot walk, six-minute walk distance, Timed Up & Go times (both single and dual-task) and tandem walk "mistakes" were evaluated as potential contributors. Fear of falling measured using the FES-I, and daily-living step counts (mean over 7 days) were evaluated as possible consequences. RESULTS: As expected, the EDSS was higher in PwMS with Multiple NF. The two groups were similar in age and gender but differed significantly in the possible contributors and consequences (See Table 1). The number of NFs was correlated with EDSS (r=0.57). When adjusting for disease severity, as measured using the EDSS, the association between the possible predictors in Table 1 and NF group was no longer significant. CONCLUSIONS: These results suggest that multiple measures of gait and mobility differ in pwMS with multiple near falls, compared to those who have only a few NFs. If these factors can be modified via intervention, perhaps near fall frequency can be lowered, reducing the putative negative consequences of near falls and lowering fall risk. In the future, it may help to also examine the role of cognitive and sensory function in NFs. Nevertheless, these findings should be interpreted with caution since we can only speculate about cause and effect in this cross-sectional analysis.

P2-S-100: ***Freezing of gait is associated with strong cardiovascular changes that can differentiate it from voluntary stopping.***

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BACKGROUND: Freezing of gait (FOG) is a short period of immobility despite the intention to walk, that is experienced by at least half of persons with Parkinson's disease in later stages of the disease. To detect FOG or to predict symptoms to guide us to potential new treatment strategies, a better understanding of the complex interplay between body movements, brain activity, and systemic physiology is needed. METHODS: We collected two datasets comprising data of sixteen and twenty-five Parkinson's patients with daily freezing, respectively. They completed a gait trajectory including turns, narrow passages, starting and stopping. In the first dataset, we measured the freezing index, a frequently used FOG detection metric, based on an accelerometer on the right shin, and the heart rate based on a 3-lead electrocardiogram. The second dataset contained whole-body movement data from 17 inertial measurement units and functional near-infrared spectroscopy (fNIRS) data over multiple brain areas. All experiments were recorded on video and annotated for the occurrence of FOG and other gait events. RESULTS: In total, we captured 845 and 550 FOG events in the two datasets, respectively. The first dataset showed the freezing index to work well in differentiating between FOG and normal gait, but not between FOG and stopping. In contrast, the heart rate, which increased during FOG, was significantly different from the steep decrease in heart rate that was observed during stopping (figure 1). For the second dataset, we found an increase of the fNIRS signals during FOG and a decrease during stopping, with a temporal evolution that closely resembled the heart rate of the first dataset. Moreover, the same patterns were seen over all the fNIRS channels, including short separation channels that only measure superficial scalp hemodynamics, suggesting a systemic origin of the observed fNIRS signals. CONCLUSIONS: FOG is associated with strong systemic changes that can be used for FOG detection, namely to differentiate FOG from voluntary stopping. Furthermore, we recommend being careful with the interpretation of FOG-related fNIRS studies that do not include short channels, as systemic changes might affect the observed hemodynamic responses.

P2-S-101: ***Changes in sensory deficits during balance over time in individuals who develop freezing of gait in Parkinson's disease***

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BACKGROUND AND AIM: Freezing of gait (FOG) is experienced by up to 80% of people with advanced Parkinson's disease (PD). Proprioceptive and vestibular deficits have been noted in patients with FOG, and likely contribute to their balance impairments, particularly when vision is removed. To date, no studies have examined whether sensory deficits precede the development of FOG. The aim of this study was to compare the progression of sensory deficits between persons with PD who develop FOG and those who do not. METHODS: Eighty-three persons with PD from the four-year Ontario Neurodegenerative Disease Research Initiative study who participated in assessments at baseline and 1-year follow-up were included in this analysis [Farhan et al 2017]. Transitional Freezers (tFOG, n=21) were defined as persons who started the study as a Non-Freezer, however, reported FOG (i.e. ≥ 1 on the FOG-Q item 3) at any of the 3 yearly follow-up appointments. Non-Freezers (NFOG, n=62) reported no FOG at all visits. Measures of standing balance, used as quantitative assessment of sensory processing/integration, were completed on Wii Balance Boards (WBB). Tasks included standard and narrow stance for 30 seconds under eyes open (EO) and eyes closed (EC) conditions. Overall center of pressure (COP) and COP root mean square (RMS) in the anterior-posterior (AP) and medial-lateral (ML) directions were compared between groups. RESULTS: During standard stance, a significant interaction between condition (EO/EC), group (tFOG/NFOG), and time was found for RMS-AP, which revealed that at baseline, there were no differences between groups during the EO or EC condition. However, at 1-year follow-up, tFOG had significantly greater sway variability in the AP direction during the EC condition compared to NFOG ($p=0.01$) and compared to their baseline performance ($p=0.003$). An interaction between time and group was also found for RMS-ML, which showed that only at follow-up, tFOG displayed greater sway variability in the ML direction compared to NFOG ($p=0.01$). A main effect of condition for COP-AP sway showed that all participants displayed greater AP sway during the EC condition compared to the EO condition ($p<0.001$). There were no significant differences during narrow stance. CONCLUSIONS: In the absence of vision, Transitional Freezers showed greater sway variability in AP direction than Non-Freezers at the one-year follow-up despite no differences between groups at baseline. Similar results were found in the ML direction regardless of condition. These findings suggest that proprioceptive and/or vestibular dysfunction may not precede the onset of FOG, rather sensory deficits may develop in parallel with FOG during the transitional period. To our knowledge, this is the first study to examine sensory deficits longitudinally in Transitional Freezers

P2-S-102: ***Novel deep brain stimulation patterns for treatment of Parkinson's disease***

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BACKGROUND AND AIM: Parkinson's disease (PD) is a neurodegenerative disorder characterized by both motor and non-motor symptoms. While dopamine replacement therapy and dopamine agonists remain the initial standard-of-care and very effective in treating the motor symptoms of PD, medication side effects, motor fluctuations, and lack of symptom control are nearly universal after 4-5 years of diagnosis. Therapeutic deep brain stimulation (DBS) is a procedure employed when motor fluctuations appear, medications are not effective at controlling tremor, and/or medications result in side effects that interfere with quality of life. DBS leads to a reduction in the pathological synchronization seen in subthalamic nucleus (STN)--a highly interconnected node in the basal ganglia. While continuous high frequency stimulation is effective, we hypothesize that stimulation patterns (e.g., electrode switching patterns) designed to better target excessive synchrony in a patient-tailored manner may result in more efficient and effective therapy with fewer side effects. This overarching hypothesis is supported by prior foundational preclinical and clinical research. The aim of the study is to determine the effects of a new DBS pattern on the motor symptoms associated with PD. METHODS: Study design. We plan to enroll and complete investigations in 10 study subjects. This is an open-label, non-randomized, proof-of-concept comparison of clinical vs. research stimulation patterns in patients with PD being treated with DBS through the Medtronic Percept PC DBS device. This clinical trial is approved by the UNMC IRB and registered as ClinicalTrials.gov Identifier: NCT04799470. Assessment of local field potentials in STN. We are using a novel research-enabled pulse generator (Percept PC; Medtronic) that has the capability of sensing and storing local field potentials (LFPs) recorded from implanted electrodes in STN, in addition to providing research stimulations patterns. Assessment of movement-based biomarkers. The protocol involves clinical assessment of patient limb movements, postural sway, walking and turning using wearable sensors. Participants are outfitted with nine inertial sensors (Opals, APDM Inc.) attached to the head, sternum, midline lumbar region, legs, feet, and wrists. RESULTS: Figure 1 shows a recording of one of the clinical hand pronation-supination movement assessments of the most affected hand, OFF and ON clinical stimulation. There is a noticeable decline in movement velocity over time in both conditions, yet reduction of movement amplitude only occurs in the OFF-stimulation condition. CONCLUSIONS: Building on the next generation of investigational DBS technology, which allows decoding the unique electrophysiological brain rhythms associated with parkinsonian motor symptoms, we aim to explore novel DBS stimulation patterns to restore motor function in people with PD.

P2-S-103: ***Dual-task abilities during activities representative of daily life in community-dwelling stroke survivors***

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BACKGROUND: Being able to walk in the community is one of the main rehabilitation goals of people who have sustained a stroke. However, this activity may represent a real challenge for these individuals. In addition to several physical skills, walking independently and safely in the community requires the ability to divide attention between walking and other tasks performed simultaneously. The aims of the present study were to measure cognitive-locomotor dual-task (DT) abilities in stroke survivors and to compare them with age- and gender-matched healthy individuals. METHODS: Locomotor and cognitive DT abilities were assessed in community-dwelling adults who sustained a stroke and healthy individuals matched for age and gender. Participants walked along a virtual shopping mall corridor and memorized a 5-item shopping list (DT conditions). Two levels of task complexity were used for the walking task (with or without virtual agents to avoid) and the cognitive task to recall a list of items (with or without a modification at mid-course). The assessment was conducted using an omnidirectional platform and participants were immersed in the virtual environment with a virtual reality (VR) headset. Locomotor and cognitive DT costs (DTC) were calculated as the percent change from single-task (ST) performance. Walking speed and fluidity, as well as minimal distance between the participant and the virtual agents during avoidance were used to characterize locomotor performance. Cognitive performance was assessed by the number of correctly recalled items. One-sample Wilcoxon tests were used to determine the presence of DTCs and Mann-Whitney tests were performed to compare DTCs between the 2 groups. RESULTS: Twelve community-dwelling stroke survivors (median age: 60.50 years old [25th-75th percentiles: 53.50-65.75]; 5 women; 13.41 months post-stroke [5.34-48.90]) and 12 age- and gender-matched healthy individuals were recruited. Significant locomotor (2.34% to 10.78%; p: .006 to .041) and cognitive (10.56% to 33.33%; p: .002 to .037) DTCs were observed in participants with stroke in all DT conditions, except the simplest (no virtual agents, no modifications to the list). For the control group, DTCs were observed only during DT conditions that included the complex modified cognitive task. A group difference was detected in cognitive DTCs during the most complex DT condition (virtual agents and list modifications; p=.02). Stroke survivors had greater cognitive DTCs than the control group. CONCLUSION: DT interferences were observed when community-dwelling stroke survivors performed activities representative of daily living in DT. According to the complexity of the DT condition, locomotor-related cognitive interferences or mutual interferences were observed. Cognitive DTC measured under the more complex DT condition appeared to distinguish stroke survivors from controls, contrary to TUG-DTC. ACKNOWLEDGEMENTS AND FUNDING: The authors would like to thank Nicolas Robitaille for valuable assistance in the development of VR-based assessment protocol. This work was supported by the Team of researchers in Immersive Technology in Rehabilitation (ITR) of Cirris. ADB received Ph.D. studentships from the Cirris, Université Laval, and the Fonds de Recherche du Quebec

P2-S-104: ***Towards the objective assessment of Physical Fatigue and Fatigability in MS: gait or HRV, what is the best way to go?***

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BACKGROUND AND AIM: Fatigue is one of the most common and difficult symptoms in people with multiple sclerosis (pwMS). This MS hallmark has been primarily evaluated using self-report questionnaires. Yet, fatigue among pwMS is also related to performance fatigability such as that seen during the six-minute walking test (6MWT). A link between autonomic nervous system (ANS) impairment and fatigue in pwMS was also reported. Still, fatigability during gait has not been assessed in terms of cardiac or ANS function in pwMS. Here, we explored the associations of heart rate (HR) and heart rate variability (HRV) with fatigue and fatigability during a 6MWT, compared to gait and self-report. METHODS: People with relapsing-remitting MS (n=39, 42 ± 1.9yrs, 75% female) and age and gender-matched healthy controls (HC) (n=21, 37±2.7yrs, 56% female) completed the 6MWT. HR was measured via a POLAR H10 strip while seated 5 min before the 6MWT, during, and 5 min after the 6MWT while seated. Gait was measured using OPALs (APDM Inc). Fatigue was evaluated using the physical component of the MFIS questionnaire. Perceived fatigue was evaluated via a VAS scale (0-10) at each time point. Changes in the measures from the beginning to the end of 6MWT were defined as fatigability. Man-Whitney and Wilcoxon tests compared pwMS to HC at all time points. Custom negative regression was used to estimate perceived fatigability (change in VAS) using HR, HRV gait speed, and cadence. Spearman correlations evaluated the associations between fatigue, HR, HRV, gait, and VAS at 2-min time points of the 6MWT, and estimated fatigability compared to the perceived fatigability. RESULTS: At baseline, both HC and pwMS had similar perceived fatigue (VAS: pwMS: 3 (0-9); HC: 0.5 (0-7); p=0.141), heart rate (HR: pwMS: 95.0+/-16.4 bpm; HC: 97.8+/-16.0 bpm; p=0.539), but significantly higher HRV in HC at baseline (pwMS: 23.2+/-27.7 bpm; HC: 35.4+/-30.9 bpm; p=0.02). At the end of the 6MWT, pwMS reported significantly higher VAS compared to controls (pwMS: 4 (0-10); HC: 2 (0-8); p=0.016). Moreover, pwMS had a slower gait speed and cadence at baseline, during and at the end of the 6MWT, compared to controls (p<0.01). Surprisingly, change in gait speed and HRV between every two minutes of the test did not differ between the groups. However, HRV in the last 2 minutes was higher than at the beginning was significantly higher in pwMS (p=0.023), but not in HC. In pwMS, HR and gait measures were most strongly associated with MFIS, while perceived fatigue had the lowest correlation (Fig. 1A). Estimate of fatigability by HRV, HR, and gait was moderately associated with fatigability (change in VAS fatigue) (Fig. 1B). CONCLUSIONS: HRV and gait are associated with fatigue and perceived fatigability during the 6MWT. Our findings also support the idea that fatigue and fatigability are related but not similar and that HR, HRV, and gait may be used for objective monitoring of fatigue in pwMS. ACKNOWLEDGEMENTS AND FUNDING: The study supported by Israel Innovation Authority

P2-S-105: ***A motor-cognitive intervention impacts daily-living gait and activity in Parkinson's disease fallers differently than a motor intervention: analysis using a machine learning approach***

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BACKGROUND AND AIM: In the V-TIME project, treadmill training (TT) with virtual reality (TT+VR) reduced fall rates in patients with Parkinson's disease (PD) more than TT alone. Given this effect and since TT+VR targets both motor and cognitive aspects of mobility, we speculated that fall rate reduction would be related to specific daily-living gait and physical activity measures among those who responded to the intervention in the two groups. We applied machine learning (ML) models to identify if there were clusters of daily-living gait and physical activity measures that differed among responders to the two interventions of the V-TIME project. METHODS: 103 PD patients reported 2 or more falls in the 6 months before the intervention and were randomly assigned to one of two active interventions: TT alone or TT+VR. After 6-weeks of training, subjects wore a 3D accelerometer on the lower back for 1 week. Measures of daily-living gait quality and activity were extracted. ML models were trained on this data, with the task of classifying responders/non-responders. Subjects were considered as responders if they did not fall in the 6 months post-intervention, or if the fall rate was at least 75% lower than the pre-intervention value. RESULTS: At baseline, TT and TT+VR subjects had similar age, gender, and disease duration (TT: n=53, 71.2±6.2 yrs, 39.6% women, duration: 9.0±7.4 yrs; TT+VR: n=61, 70.8±6.4 yrs, 39.3% women, duration: 9.1±5.4 yrs). ML achieved good classification of responders/non-responders (n=13, 43) for the TT+VR subjects (sensitivity: 0.85±0.16, specificity: 0.86±0.07, auc: 0.94). In the TT group, the ML was not successful in classifying responders/non-responders (n=14, 33) (sensitivity: 0.62±0.18, specificity: 0.60±0.11, auc: 0.7). In the TT+VR ML models, the salient features were in domains of gait variability, amplitude, and physical activity (e.g. % of active time during the day); models for TT were mostly related to rhythm features (e.g. step time). CONCLUSIONS: Applying ML to daily-living measures of gait and activity revealed clusters of measures that responded to TT+VR, with a disparate set related to TT. This training-specific effect may reflect the richness of TT+VR. While TT focused on rhythm, the TT+VR also targeted walking in cognitively challenging conditions. This might explain the change in a cluster of behavioral measures among the responders in the TT+VR group.

P2-S-106: ***Reliability and Validity of Functional Mobility and Postural Control in Parkinson's Disease***

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Background: The neuromotor deficits associated with Parkinson's Disease (PD) impact a myriad of neuromuscular functions (e.g., diminished lower extremity strength, impaired postural stability) resulting in difficulties when performing daily living activities and increased risk of falls. Recent evidence suggests that exercise attenuates PD progression with short-

term (12 weeks) training, but the long-term adaptations to exercise remain unclear due to challenges in traditional randomized controlled trials (e.g., requiring large samples, increased cost in larger sample, inability to capture heterogenous characteristics of PD). The use of a multiple baseline design has the ability to overcome many of these challenges and provide valuable insight into intervention methodologies. The aim of this study was to assess group and intra-subject reliability of postural control and functional mobility in people with PD using a multiple baseline research design. Methods: Six subjects with PD were recruited from the local community. Three baseline testing sessions were one week apart. Each session consisted of three trials of Five Times Sit to Stand Test (FTSTS) and two trials of modified Romberg balance tests (eyes open, eyes close, and eyes open on foam mat). The group and intra-subject Intraclass Correlation Coefficients (ICCs) of three baseline sessions were calculated for the Peak Ground Reaction Force (GRFp), Rise Time (RT) and Average Rate of Force Development (RFDavg) in FTSTS, and for group ICCs on Center of Pressure (COP) Area, Detrended Fluctuation Analysis-Anterior Posterior and -Mediolateral (DFA-AP and DFA-ML) in modified Romberg tests. Results: The group ICCs of FTSTS variables were 0.85 for the GRFp, 0.83 for the RT, and 0.79 for the RFDavg. The intra-subject ICCs of FTSTS variables were 0.05 to 0.62 for the GRFp, 0.16 to 0.66 for the RT, and 0.17 to 0.75 for the RFD. The group ICCs for COP Area were 0.68, 0.71, and 0.82 for eyes open, eyes close and on a foam mat. The ICCs for DFA-AP were 0.94, 0.97, 0.97, and 0.77, 0.92, 0.84 for DFA-ML for eyes open, eyes close and on a foam mat, respectively. Conclusions: The findings revealed that the group measurement of FTSTS reliability was higher than the intra-subject ICCs which may be due in part to different sample sizes. Among the postural control variables, the non-linear metric showed higher degrees of reliability than the linear variable of COP Area suggesting greater consistency across all balance tests in the structure (spatio-temporal characteristics) rather than the magnitude of postural sway variability in this PD population. Overall, the three baseline sessions provided good to excellent reliability and appeared to be adequate for the implementation of a multi-baseline design.

P2-S-107: ***Is real-world step length associated with motor disease severity in Parkinson's disease?***

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Background and aim: The current gold standard to evaluate motor disease severity in Parkinson's disease (PD) is the Movement Disorder Society Unified Parkinson's Disease Rating Scale part III (MDS-UPDRS III), however, its use alone is limited. Cardinal PD motor symptoms include bradykinesia and hypokinesia, which are reflected in gait impairments such as reduced step length which can be measured in the real-world using wearable devices. Thus, the real-world measurement of step length (RWL), could serve as a sensitive and reliable measure of motor disease severity. The aim of this study was to explore the cross-sectional and longitudinal relationship between RWL and the MDS-UPDRS III. Methods: 88 PD participants were recruited from the Incidence of Cognitive Impairment with Longitudinal Evaluation - GAIT (ICICLE-GAIT) study. Participants underwent assessment of MDS-UPDRS III and RWL using a triaxial accelerometer (Axivity AX3) on the lower back every 18 months, for 6 years. RWL was estimated in accordance with the inverted pendulum model, where we aggregated RWL at the following walking bout (WB) thresholds; all WBs, < 10 seconds, 10-30 seconds, 30-60 seconds and > 60 seconds. We employed linear regression to explore the cross-sectional relationship between RWL and MDS-UPDRS III at the 36-month time point and mixed effects models to investigate the longitudinal relationship between change in RWL and change in MDS-UPDRS III over 54 months. Results: Cross-sectionally, no significant associations were found from MDS-UPDRS III score RWL aggregated at all WBs, < 10 seconds and > 60 seconds. However, we did observe significant associations when aggregated at 10 to 30 seconds ($\beta = -11.19$, $P = 0.01$, $R2 = 23\%$) and 30 to 60 seconds ($\beta = -14.46$, $P = 0.003$, $R2 = 20\%$). Longitudinally, a shorter RWL was significantly associated with an increase in MDS-UPDRS III, at each aggregation level, with the strongest association at WBs 10 to 30 seconds ($\beta = -10.74$ points per 18 months, $P = <0.001$, $R2 = 68\%$). Conclusion: RWL was related to the MDS-UPDRS III at WB thresholds. It is known that real-world mobility is comprised from WBs which differ in their duration and context. It is known that RWL is reduced during shorter WBs, where activity is more demanding, in comparison to longer bouts which capture steady state gait. Here we demonstrate how RWL captured during 10 to 30 and 30 to 60 seconds length WBs provide the most sensitive picture of motor disease severity cross-sectionally. This finding highlights the importance of consideration toward WB thresholds. Longitudinally, we demonstrated that a deterioration in motor disease severity was significantly associated with reduced RWL. This consistent finding demonstrates how RWL could be used to compliment the MDS-UPDRS III to track motor disease severity.

P2-S-108: ***Gait and motor recovery in early acute ischemic stroke patients after intensive rehabilitation***

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Background and aims: Majority of ischemic stroke (IS) patients have some walking disability, which limits their independence in everyday activities. Gait independency and lower limb motor function improvement are main goals of poststroke rehabilitation. The aim of this study was to assess a gait and a motor recovery after intensive rehabilitation in the first ever IS patients. Methods: Consecutive patients with IS in anterior circulation (included in the pilot analysis of the GAITFAIST trial, NCT04824482) were participating in this study. All patients had impaired gait as consequence of IS and were hospitalized at Rehabilitation Department for intensive rehabilitation including assisted gait training. Gait recovery was in both groups evaluated using the Functional Ambulatory Category (FAC, score range 0-5) and 10 meters-walking test for comfortable speed (10MWT). Motor recovery was evaluated using Fugl Meyer Assessment for Lower limb (FMA-LL). All tests were performed before and after intensive rehabilitation. Patients were divided into the group of dependent walkers (DW, categorized according to FAC with score 1-3) and the group of independent walkers (IW, categorized according to FAC score 4). Nonparametric tests were used to compare outcomes between DW and IW, and to compare outcomes for both groups before and after rehabilitation (p≤0.05). Results: Sixteen patients (8 men, mean age 72 ± 8.4 years) with median FAC score 3 (1-3) was enrolled in the DW group and 11 (5 men, mean age 62 ± 9 years) with median of FAC score 4 in the IW group. Rehabilitation started in both groups 12 ± 5 days after stroke onset and lasted for 14 ± 5 days. The DW walked before rehabilitation at slower speed (0.75 m/s±0.28 m/s) in comparison to IW (0.95±0.23 m/s; p≤0.05). After rehabilitation the difference between DW (0.89±0.28 m/s) and IW (1.14±0.31 m/s) did not differ. The IW group did not improve in gait speed significantly after rehabilitation instead of DW. Motor function according to FMA-LL was lower in DW both before (score 23±5) and after (score 26±4) rehabilitation (p≤0.05) in comparison to IW who perform better on FMA-LE before (score 28±3) and after rehabilitation (30±2). Both groups improved in FMA-LE motor domain before and after rehabilitation (p≤0.05). No differences were found between both groups in sensation domain in FMA-LE. Patients in both groups became independent walkers after rehabilitation. Concuclusions: Gait and motor recovery after rehabilitation was observed in both groups. Only DW improved significantly in the gait speed after rehabilitation. DW as well as IW patients may have potential to improve more gait independency and lower limb motor function during rehabilitation if starts early after stroke onset. Acknowledgement: The study was supported by Ministry of Health, Czech Republic (FNOl, 0098892).

P2-S-109: ***Exploring the frequency of sex- and gender-based analysis and consistency of sex and gender terminology use in standing balance research for people with Parkinson's Disease: a scoping review for the year 2020.***

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BACKGROUND AND AIM: Postural instability informs clinical decision making for persons with PD (pwPD)1. While sex and gender can impact the onset and progression of PD, women with PD might be more prone to developing postural instability2. The sex- and gender-based (SGB) influences on the assessment of postural stability for pwPD is not clear. Sex- and gender-based analysis (SGBA) integrates SGB concepts into research design and analysis and can produce more accurate and replicable research findings which could better inform research and clinical practice3. Sex is based on anatomical and physiological attributes with terms including male and female, while gender is based on socially constructed roles, relationships, and behaviours with terms including man and woman4. Infrequent SGBA and inconsistent term use (e.g., gender-based terms to describe sex) limits understanding of how SGB impacts behaviour3. This scoping review explored the frequency of SGBA and consistency of SGB term use in recent standing balance research involving pwPD. METHODS: Searches were conducted in seven databases (Medline, PubMed, Embase, APA PsycInfo, SPORTDiscus, Web of Science, and Scopus) for peer-reviewed articles published in 2020. Titles and abstracts (n=2427) and full texts (n=877) were screened and data were

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extracted by two reviewers with a third resolving conflicts. Inclusion criteria were: a) standing balance was a dependent variable measured by a biomechanical construct for pwPD5; and, b) articles were available in English. Exclusion criteria were: a) study population <18 years of age, b) only time-based measures or clinical/balance scales used, c) case studies/series, and d) the study focus was on psychometric testing, machine-based learning, finite element modelling, or network analyses. Data were extracted to examine the frequency of SGBA and consistency of SGB term use. RESULTS: Twenty-five articles met the inclusion and exclusion criteria. Four articles (16%) conducted a statistical analysis using sex and/or gender as a factor. Twelve articles (48%) used terms consistently, 11 articles used terms inconsistently (44%), and two articles (8%) used no terms to describe sex and/or gender. When terms were inconsistent, common discrepancies included use of the term gender with male and female as groups (n=5) and use of the term sex with man and woman as groups (n=2). No articles (0%) described how sex or gender data were collected or included more than dichotomous groupings for sex and/or gender. CONCLUSIONS: Few articles considered sex or gender as a statistical factor and about half used terms consistently. Increased SGBA inclusion, more consistent term use, reporting how SGB data are obtained (e.g., self-report), and including more than two groupings (e.g., male, female, other) for SGB data can further understanding of SGB influences on standing balance for pwPD. REFERENCES: 1. Goetz et al. Mov Disord. 2008; 23(15). 2. Georgiev et al. Acta Neurol. Scand. 2017; 136(6). 3. Lee. BMB Reports. 2018; 51(4). 4. CIHR. https://cihr-irsc.gc.ca/e/50836.html. 2019. 5. Arora et al. J Spinal Cord Med. 2020; 43(1).

P2-S-110: ***Is altered gait a potential biomarker for drug resistance in juvenile myoclonic epilepsy?***

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Background and aim: Juvenile myoclonic epilepsy (JME) is the most common generalized epilepsy syndrome in adolescents and adults. Most JME patients respond well to medication, yet 15-30% of JME patients do not respond to medications. In JME patients, drug resistance is characterized by recurrent seizures that are not fully controlled with appropriate anti-seizure medications, in addition to cognitive and psychiatric disturbances, suggesting a diffuse brain dysfunction. Gait is a complex behavior that necessitates orchestrated coordination of various brain regions coalescing to motor-cognitive functional neural networks, which when disturbed, could lead to falls and injuries. Therefore, our aim was to examine gait alterations in patients with JME that respond to medications and patients with JME that are resistance to medication, when tested under cognitive load. Methods: We prospectively included patients fulfilling clinical criteria for JME: 11 responders and 8 resistant patients, from the epilepsy unit at Tel Aviv Medical Center. Clinical data including epilepsy duration, anti-seizure medication response and regimens were retrieved from patient charts. Patients underwent gait analysis while wearing five synchronized 3-axis body-fixed sensors on the lower back, bilateral wrists, and bilateral ankles. Participants walked for 1 minute under two conditions: (1) usual walking and (2) cognitively demanding dual-task

walking (serially subtracting 7 from a predefined 3-digit number while walking). Mean gait speed, mean stride time, stride time variability, arm swing acceleration, and arm swing amplitudes were calculated and compared between groups and walking tasks using mixed model analysis. Results: Resistant JME patients demonstrated altered gait pattern that included slower gait speed (p=0.042), longer stride time (p=0.034), smaller arm swing amplitude (p=0.011), and slower arm swing acceleration (p=0.018) compared to responders. No difference in gait variability was observed between the groups (p>0.153). In addition, both groups demonstrated worse gait pattern during dual task walking compared to usual walking. However, these differences did not include arm swing amplitude (responders: p=0.168, resistant patients: p=0.632). Epilepsy duration, anti-seizure medications regimen and total daily dose of Valproate, an anti-seizure medication that might alter gait, did not differ between groups (Disease duration: p=0.188, valproate dose: p=0.775). Conclusions: Drug-resistant JME patients perform poorer than responders in gait testing, irrespective of their medication composition. These alterations in gait suggest that drug resistance in this patient population reflect a diffuse dysfunction of motor-cognitive neural networks leading to poorer performance. Further studies are needed to investigate the predictive value of altered gait as a biomarker of drug resistance in JME and in other epilepsy syndromes. Acknowledgements and funding: This work was supported in part by a research grant from the Parasol foundation.

P2-S-111: ***Structural integrity of the cholinergic basal forebrain and pedunculopontine nucleus predicts gait decline in Parkinson's disease***

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BACKGROUND AND AIM: Gait impairment is a hallmark of Parkinson's disease (PD) and is normally refractory to dopaminergic medication. Degeneration of the cholinergic basal forebrain (cBF) and pedunculopontine nucleus (PPN), have been implicated in the deterioration of gait in PD. However, it is unknown whether the decline of gait can be predicted via the cBF and PPN using free-water content and diffusion tensor imaging (DTI). METHODS: 98 people with PD and 40 controls completed gait assessments via an instrumented walkway during 2 minutes of continuous walking. Assessments were taken at baseline, 18 months, 36-months, and 54-months, and spatiotemporal characteristics of gait were calculated for each assessment. Structural integrity of the cBF and PPN was measured via DTI and free-water content. The DTI metrics were corrected for free-water content to enhance the sensitivity of traditional DTI. Univariate analyses assessed baseline differences between controls and PD. Linear mixed models were used to assess whether baseline structural integrity of the cBF and PPN predicted decline in gait characteristics within the PD cohort. RESULTS: Baseline free-water content of the PPN was significantly higher in PD compared with controls. Longitudinal analyses demonstrated that higher free-water content

within the cBF at baseline predicted step length shortening and increasing step length variability and step time variability. In addition, free-water-corrected DTI metrics indicative of degeneration in the cBF predicted increasing step length variability. Lastly, free-water-corrected DTI metrics revealing degeneration in the PPN predicted shortening of step length and increasing step time variability. CONCLUSIONS: We have demonstrated that degeneration of the cholinergic nuclei, measured by free-water content and free-water-corrected DTI, can predict gait decline in people with PD. These measures could be used as biomarkers to identify individuals with a higher likelihood of developing gait impairments and allow appropriate treatments to be selected. Our results also provide scientific rationale for the use of cholinergic treatments for gait impairment in PD.

P2-S-112: ***White matter hyperintensity burden is associated with impaired gait in people with Parkinson's disease***

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Background and aim Gait impairments are cardinal symptoms of Parkinson's disease (PD) and lead to increased risk of falls and reduced quality of life. Current dopaminergic therapy does not alleviate all gait deficits, and in some instances can aggravate symptoms, consistent with additional underlying pathology. White Matter Hyper-intensities (WMH) are commonly used as a marker for brain vascular impairments and are associated with deposition of amyloid peptide (Aβ). In older adults (OA), WMH are associated with slower gait, but there is limited work exploring the role of WMH in gait deficits for people with PD. This work aimed to examine associations between whole brain WMH, as well as specifically periventricular WMH (PWMH) and deep WMH (DWMH), with measures of gait in PD and OA. Methods 69 PD and 40 OA were recruited from the Pacific Udall Centre (PUC) at the University of Washington and the VA Puget Sound Health Care System, Seattle, WA. WMH were derived from T2 FLAIR MRIs (TR/TI/TE = 5,000/1,600/294ms, resolution = 0.8 mm isotropic, matrix size = 208 × 240 × 256, and acquisition time = 8:01 minutes). WMH were segmented with a two-class fuzzy C-means clustering using the Flex program in MATLAB1. Gait characteristics representing domains of Pace/Turning, Rhythm and Variability were measured during a two-minute continuous walk task while wearing 6 inertial sensors (APDM, Portland, OR). ANCOVA's were used to determine differences between groups for WMH, DWMH and PWMH. Partial correlations were used to determine associations between WMH and gait. All analyses controlled for age, gender, and total intracranial volume. Additional analysis controlled for disease severity (H&Y) to determine the role of PD pathology. Results No differences between the PD and control groups were found in WMH ($p=.803$), DWMH ($p=.591$), or PWMH ($p=.743$). Greater whole brain WMH was associated with slower gait velocity ($p=0.009$), shorter stride length ($p=.001$) and reduced foot strike angle ($p=.009$) in the PD group. Greater DWMH and PWMH were also associated with slower gait velocity

(DWMH; p=.025, PWMH; p=.002), shorter stride length (DWMH; p=.004, PWMH; p=.003) and reduced foot strike angle (DWMH; p=.022, PWMH; p=.01) in the PD group. Slower turn velocity (p=.034) was associated with greater DWMH, and greater stride time variability (p=.002) was associated with greater PWMH. All correlations remained significant for PWMH, but not DWMH, when controlling for PD severity. In OA, greater PWMH was only associated with slower gait velocity (p=.019). Conclusions Greater WMH was mainly associated with pace measures of gait in PD, demonstrating that greater WMH is associated with poorer gait in PD more than in age-matched OA and contributes to the underlying pathology of gait deficits. For PWMH, associations remained when adjusting for PD disease severity, indicating different clinical correlates (i.e., cortical involvement) for control of gait for PWMH and not DWH. Gibson E, Gao F, Black SE, Lobaugh NJ. Automatic segmentation of white matter hyperintensities in the elderly using FLAIR images at 3T. J Magn Reson Imaging. 2010;31(6):1311-1322.

P2-S-113: ***The effect of the posterior parietal cortex on the cortical excitability of the tibialis anterior motor representation in Parkinson's disease and freezing of gait***

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BACKGROUND/AIM: Freezing of gait (FOG) is a prevalent motor symptom of Parkinson's disease characterized as the inability to step forward despite the intention to walk. The posterior parietal cortex (PPC) is a brain region associated with integration of sensorimotor information allowing to process and plan motor programs related to locomotion. Neuroimaging studies showed that in freezers, the PPC has considerable functional and structural alterations compared to healthy subjects. However, to our knowledge, this decrease in PPC excitability in FOG was only observed with brain imaging and it has not been evaluated in terms of its effect on cortical excitability of motor representations of the muscles involved in locomotion. Thus, the aim of this study was to quantify the effect of the PPC on the cortical excitability of the motor cortex representation of the tibialis anterior (TA) and to assess its day-to-day variability in freezers. METHODS: Fifteen adults with FOG were recruited. The study consisted of 3 sessions, all at the same time of the day with participants in the ON-medication state. The influence of the PPC on the cortical excitability of the TA motor representation was assessed using single and dual-pulse transcranial magnetic stimulation (TMS). Single-pulse TMS was applied over the TA hotspot at the MSO allowing to reach a 10-response average of 1mV. Dual-pulse TMS was applied over the PPC (x=-52, y=-49, z=47) at 90% of the resting motor threshold of the first dorsal interosseous muscle 4ms prior to the TA stimulation. Fifty pulses were delivered in each session, with half targeting the TA hotspot only and half targeting both PPC and TA hotspot. Each pulse was delivered in a random order and associated with a measurement of motor evoked potentials (MEPs) from the TA. Peak-to-peak amplitude of the MEPs was used to quantify the effect of the PPC on the TA by comparing single-pulse to dual-pulse TMS. Variability was assessed by comparing the effect of the PPC on the cortical excitation of the TA hotspot between the 3 sessions.

RESULTS: Preliminary data of 8 participants was acquired and analyzed. The effect of the PPC on the TA hotspot measured by change in MEPs was constant from day-to-day as no significant differences between sessions were found (P>.05). Activation of the PPC with TMS did not significantly affect cortical excitability of the motor representation of the TA (P>.05) as opposed to pilot data obtained in young, healthy adults. In this latter population, conditioning the PPC with dual-pulse TMS resulted in inhibition of the MEPs from the TA (P<.05). CONCLUSION: Preliminary results show no significant effect of the PPC on the excitability of the TA motor cortex nor in its day-to-day variability. This differs from data obtained in healthy adults where inhibition of the TA motor representation was seen, suggesting that the connectivity between the representation of the PPC and the TA is impaired or inexistant in FOG.

P2-S-114: ***Impact of pathological conditions on postural reflex latency and adaptability following unpredictable perturbations: A systematic review and meta-analysis***

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Background and aims: Pathological conditions such as Parkinson's disease and stroke have been associated with significantly increased risk of falls. However, the effect of these pathological conditions on postural reflexes, including the effect of exercise interventions is unclear. Therefore, we sought to determine the extent in which postural reflexes are impaired in people with pathological conditions and whether exercise interventions could shorten postural reflexes. Methods: MEDLINE, EMBASE, Scopus, SportDiscus and Web of Science were systematically searched for articles comparing postural reflexes measured as muscle activation onset latency in people with pathological conditions to healthy controls following unpredictable perturbations including the effect of exercise interventions (registration: CRD42020170861). Results: Fifty-three articles were included for systematic review. Significant delays in postural reflexes following perturbations were evident in people with multiple sclerosis (n=7, mean difference [MD]: 22ms, 95% confidence interval [CI]: 11, 33), stroke (n=10, MD: 34ms, 95% CI: 19, 49), diabetes (n=2, MD: 19ms, 95% CI: 10, 27), HIV (n=3, MD: 9ms, 95% CI: 4, 14), incomplete spinal cord injury (n=2, MD: 57ms, 95% CI: 33, 80) and back and knee pain (n=7, MD: 12ms, 95% CI: 6, 18), but not in people with Parkinson's disease (n=10) or cerebellar dysfunction (n=4). Following exercise interventions, the paretic limb of stroke survivors (n=3) displayed significantly faster muscle activation onset latency compared to pre-exercise (MD: -13ms, 95% CI: -24, -4), with no significant changes in Parkinson's disease (n=3). Conclusions: This systematic review demonstrated that postural reflexes are significantly delayed in people with multiple sclerosis, stroke, diabetes, HIV, incomplete spinal cord injury, back and knee pain; pathological conditions characterised by impaired sensation or neural function. In contrast, timing of postural reflexes was not impaired in people with Parkinson's disease and cerebellar dysfunction, confirming the limited involvement of supraspinal structures. Limited evidence was available for exercise in people with pathological conditions, with significantly shortened postural reflexes post-exercise found in stroke survivors, but not Parkinson's disease.

P2-S-115: ***Modulating the excitability of the posterior parietal cortex with rTMS in individuals with Parkinson's disease and freezing of gait***

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BACKGROUND AND AIM: Freezing of gait (FOG) is a common motor symptom of Parkinson's disease characterized by brief and sudden episodes of gait cessation despite the intention to walk. Extensive brain imaging evidence has shown that the posterior parietal cortex (PPC), a key brain area for visuospatial processing and locomotion, is involved in the neural correlates of FOG. However, no studies have attempted to modulate its excitability to improve FOG, most likely because of the nature of the neuroimaging modalities that does not allow to precisely determine the role of the PPC in real FOG episodes. Thus, the purpose of this study was to use repetitive transcranial magnetic stimulation (rTMS) to modulate PPC excitability in order to determine whether its activity contributes to FOG or compensates for dysfunctional neural networks to avoid FOG. METHODS: Fifteen individuals with Parkinson's disease and FOG were recruited. Testing occurred in the ON-medication state and consisted in 4 sessions separated by at least 72 hours. During the initial session, a clinical assessment was performed, and appropriate hotspots and motor thresholds were determined. There were three randomized experimental sessions: inhibitory rTMS on the PPC, excitatory rTMS on the PPC and a sham rTMS. The experimental measurements were acquired and compared before and after each stimulation protocol and included FOG severity outcomes (FOG-provoking test score, percent time frozen, time to complete the FOG-provoking test, time to turn, number of steps to turn), gait kinematics, cortical excitability measurements of the PPC and of the tibialis anterior motor cortex, UPDRSIII and the performance on the trail making test. RESULTS: Preliminary data was acquired and analyzed for 8 participants. Increasing PPC excitability resulted in a tendency to reduce the percent time frozen and the mean number of steps to turn compared to the two other protocols ($P=0.08$ and $P=0.09$, respectively). The UPDRSIII score was significantly reduced after increasing and decreasing PPC excitability ($P=0.0091$ and $P=0.0294$, respectively), but the change in UPDRS was not significantly different following the sham protocol. The time to complete the trail making test Part A tended to be reduced after decreasing PPC excitability ($P=0.058$), but the change in performance was not significantly different from the other protocols. Finally, no significant changes in the tibialis anterior motor cortex excitability, nor in the connection between the PPC and the leg motor cortex, were observed after either of the protocols. CONCLUSION: Preliminary data tend to show that increasing the excitability of the PPC results in less time spent in FOG, more efficient turning and less severe Parkinson's motor symptoms. This could suggest that facilitating the recruitment of the PPC with rTMS could enhance visuospatial processing and act as a compensatory mechanism for less FOG and more efficient walking.

P2-S-116: ***Experimentally induced freezing of gait in Parkinson's disease by modulating gait parameters and cognitive dual tasking***

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BACKGROUND AND AIM: Freezing of gait (FOG) is a movement disorder symptom characterized by a transient and involuntary interruption of walking. It is present in more than half of patients who suffer from Parkinson's disease (PD) five years post-onset and often increases the risk of falling. Evidence suggests less than half of PD patients with a history of FOG are clinically observed with it. This is mainly due to its unpredictable and episodic nature, but also to patients' sensitivity to a new environment and motivation, such as when they are in a hospital. This poses a significant challenge to treating and managing FOG. By clinically provoking FOG in a safe and standardized manner, we would gain needed insights into the mechanisms causing FOG and potentially set new directions for diagnostics and objectives for treatment options. METHODS: We conducted a pilot study employing conditions known to commonly provoke FOG in PD patients on a split-belt treadmill in virtual reality (VR). The four types of FOG-inducing conditions included increased walking speed, cognitive load with a dual task (e.g., arithmetic), step length asymmetry by reducing the speed of the least-affected limb (akin to turning), and visual loading (i.e., walking in a narrow 'rope bridge' scene). Our aim was to recruit 20 individuals with PD, half of whom typically experience overground FOG. Participants walked in both separate and combinations of the four conditions. The number and duration of FOG occurrences were recorded for analysis. RESULTS: We found that some individuals who often freeze overground could also freeze in FOG-inducing conditions presented on the treadmill. Moreover, we found that it was more likely for an individual to freeze when more stimuli were presented at once (e.g., speed change, split-belt, and dual tasking). We also detected an instance where a non-FOG individual showed FOG-like behavior on the treadmill. This was evident in the form of increased cadence while the trunk was shifted forward. CONCLUSIONS: Our preliminary findings suggest that it may be possible to induce gait behaviors consistent with FOG over a split-belt treadmill in VR. We found this to be possible in both PD individuals who often freeze overground and those who typically do not freeze. This finding supports the notion that the presence of FOG is not a dichotomy, but rather a phenomenon placed on one end of a continuum spanning from normal gait to akinesia. Future work will investigate the most efficacious modalities of freezing and contribute to a more consistent and standardized way to elicit freezing in individuals with PD.

P2-S-117: ***Quantification of differences in the gait in patients with different genes associated with hereditary spastic paraplegia (HSP)***

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BACKGROUND AND AIM: Hereditary spastic paraplegias (HSPs) are a group of heterogenous neurodegenerative disorders characterised by gait disturbance. At least 80 gene (SPG) loci have been described to associate with HSP, where SPG4 and SPG7 are commoner than others. Whilst SPG4 mutations often associate with a pure HSP phenotype, where the main feature is progressive lower limb spasticity, SPG7 mutations associate with a complicated phenotype characterised by cerebellar ataxia, eye movement failure, dysarthria, and proximal weakness. Clinical characterisation of gait in HSP patients attending regular clinics is often limited. At most participants perform a timed 10m walk, however, a detailed gait quantification is less well described. Here we investigated the value of quantitative assessment of gait as part of the clinical characterisation of HSP patients in a busy neurology clinic, and demonstrate gait outcomes can vary between two genetic cohorts even when matched by age and disease severity. METHODS: Two groups of 11 patients with SPG4 (age=47±13yrs, weight=85±19kg, height=166±7cm, 6 males) and 11 age-matched patients with SPG7 (age=51±8yrs, weight=85±15kg, height=179±6cm, 10 males) all able to walk 30m without walking aids, and with equivalent average clinical scores (SPRS, MAS, and SARA, Table 1) were selected from a larger cohort currently being longitudinally followed. Acceleration and angular velocity signals were recorded along vertical (V), medio-lateral (ML), and anteroposterior (AP) axes using one inertial measurement unit (McRoberts, NL) placed on the lower back using an adjustable velcro strap. Participants were asked to walk three times along a 10m walkway. Data was filtered and heel strikes were identified to calculate stride and step duration, cadence, and walking speed. Further, step and stride regularity, and asymmetry were computed. Differences in parameters were compared between the two groups with Wilcoxon signed-rank U-tests and non-parametric effect sizes (r) were established. RESULTS: Patients with SPG7 walked with significantly higher step and stride durations and a lower cadence compared to those with SPG4. They also had a significantly less regular gait (both at step and stride level) in the ML direction (Table 1). CONCLUSIONS: Despite presenting with similar disease severity, patients with SPG7 had a more prominent gait impairment than those with SPG4 HSP. Patients with SPG7 were less able to regulate repeating steps and strides in the medial lateral direction and control rhythmic displacements of the upper body during walking. This could be related to the additional ataxia and impaired proximal muscle strength in SPG7 patients. Research is underway to enlarge the sample size, however, based on the current results, gait metrics from inertial sensors show higher sensitivity than traditional clinical measures in patients with HSP.

P2-S-118: ***Evaluating Clinical Characteristics in Persistent Postural Perceptual Dizziness (PPPD): A Retrospective Review***

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Background And Aim: Prevalence of sustained chronic problems with balance affects 8 million Americans. Persistent postural perceptual dizziness (PPPD) is a chronic functional disorder of the nervous system depicted by symptoms of dizziness, unsteadiness, and hypersensitivity to self-motion or complex visual stimuli. Current diagnostic criteria classifies unsteadiness and non-spinning vertigo as the two dominant presenting symptoms reported by patients with PPPD. However, current research fails to examine the reported prevalence of these symptoms by patients with PPPD. In this study, we examine PPPD patients for reported symptoms and provocative factors by analyzing clinical notes and physician input to enhance diagnostic accuracy and assessment. Methods: A retrospective patient health record review of 111 patients diagnosed with PPPD across the University of Vermont Health Network was conducted. Reviewers evaluated chronology of symptoms, symptomatic reporting, history of head, neck, or spine trauma, and any clinical evaluations (vHIT, Audiograms, MRI, & X-rays) completed based on established diagnostic criteria of PPPD. Prevalence of persisting symptoms and gender-based correlations were determined. Results: The analysis showed that 62 (55.9%) of PPPD patients were diagnosed with a previous vestibular disorder, 108 (97.3%) had visual motion sickness, 60 (54%) had chronic headaches/migraines, 47 (42.3%) were diagnosed with anxiety/depression, and 14 (12.6%) of patients had a head, neck, or spine injury. Chi-Square test of independence and an odds ratio calculation reported that females were 3.3 times more likely to be diagnosed with migraines/chronic headaches as compared to males ($p=.002$), and males were 3.2 times more likely to have an audiogram conducted as compared to females ($p < .001$). Conclusions: Altogether, these findings aid in enhancing the future diagnostic decisions and testing procedures that physicians could use during initial assessments of future PPPD patients. Understanding the common symptoms reported within PPPD, could improve clinical decision-making, increase the diagnostic accuracy, as well as enhance possible treatment outcomes in PPPD.

T - Orthopedic diseases and injuries

P2-T-119: ***Gait variability to phenotype common neurologic and orthopedic gait impairments, a pilot study***

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BACKGROUND and AIM:Mobility impairment is a common symptom of age-related degenerative diseases. Gait features such as speed and cadence are sensitive for discriminating individuals with mobility disorders from healthy controls, yet to further phenotype different pathologies from gait data remains a challenge. In this secondary analysis, we aim to identify if gait parameters derived from inertial measurement units (IMU) during a 6-minute walk test (6MWT) would potentially phenotype mobility impairment from different pathologies (Lumbar spinal stenosis (LSS) - neurogenic claudication/neurologic mechanism, and knee osteoarthritis (KOA) - joint pain/orthopedic mechanism). We hypothesize that the manifestation of gait disturbance will differ based on the disease mechanisms. METHODS: Bilateral foot-mounted IMUs data during a 6MWT were collected for patients with LSS (n=10, Age:70.3 ± 9.4yrs) and KOA (n=10, Age:63.9 ± 8.1yrs). 11 gait parameters representing domains of pace, rhythm, asymmetry, and variability (coefficient of variation- CV) were derived for each minute of the 6MWT using validated algorithms in MATLAB[1]. Gait parameters that were not normally distributed were log-transformed. Group differences in gait parameters (by entire 6MWT and by each minute) were analyzed by the Student's t-test. Differences in gait parameters were further analyzed by two-way ANOVA (2 groups X 6 mins). RESULTS: In the analysis of the entire 6MWT, we found a marginally significant between-group difference (p=0.057) in the stride length variability (LSS: 4.7 ± 0.8; KOA: 4.0 ± 0.8), whereas no significant differences were found in other gait parameters. In the minute-by-minute analysis, the variability of stride length during the middle portion of the 6WMT was found as a significant marker for group difference (3rd min: LSS, 4.29 ± 0.94, KOA, 3.40 ± 0.45, p=0.009; 4th min: LSS, 3.94 ± 0.54, KOA, 3.47 ± 0.50, p=0.06). No minute-by-minute fluctuation in parameters during 6MWT was observed. CONCLUSIONS: These findings demonstrated the potential of gait variability measures (stride length variability) to phenotype mobility impairment from different pathologies. Increased gait variability indicates worsening gait consistency, a common feature of neurologic impairment in locomotor control[2]. This finding reflects the underlying mechanism for the gait impairment in LSS (neurogenic claudication/neurologic), thus serving as a potential biomarker to phenotype these two conditions. Future work is needed to determine if gait variability can be used to phenotype gait impairment from other orthopedic or neurological conditions. REFERENCES: [1]. Mariani, B., et al., 2013. Gait & posture, 37(2), pp.229-234.[2] Moon Y, et al. 2016. Hum Mov Sci.47:197-208.

P2-T-120: ***Impact of Prehabilitation on Functional Outcomes following Total Joint Arthroplasty for Osteoarthritis: A Systematic Review and Meta-analysis of Randomized Controlled Trials***

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BACKGROUND AND AIM: The importance of prehabilitation for people awaiting total joint arthroplasty (TJA), both hip and knee, due to osteoarthritis (OA) on postoperative functional outcomes remains controversial. This review aimed to summarize the impact of prehabilitation prior to TJA due to OA on self-reported and performance-based functional outcomes. METHODS: The databases Embase, MEDLINE, the Cochrane Register of Controlled Trials, CINAHL and Scopus (inception to June 2021) were searched for randomized controlled trials evaluating prehabilitation interventions in adults (18 years old or older) awaiting primary TJA due to OA. Trials were required to have at least one postoperative functional outcome measure. Self-reported outcomes were measures of function, health-related quality of life (HRQoL), and pain. Performance-based outcomes were measures of lower-body strength, balance, and range of motion. Narrative synthesis was performed to summarize trials, risk of bias and the reporting of the prehabilitation exercise interventions protocols. A random effects meta-analysis using standardized mean differences (SMD) and 95% confidence intervals (CI) was employed to generate overall effect estimates between the prehabilitation intervention and control groups at 6-weeks after TJA. Timepoint of interest coincides with routine surgical follow-up. RESULTS: Twenty-six studies capturing 2004 participants were included. High risk of bias was found in 24 trials. Lack of reporting of key methodology features of exercise interventions was evident across trials. No significant effect of prehabilitation was observed for self-reported measures of function (SMD 0.02 [95%CI: -0.17, 0.22]), HRQoL (SMD -0.02 [95%CI: -0.30, 0.27]) and pain (SMD -0.05 [95%CI: -0.40, 0.29]) at 6 weeks after total knee arthroplasty (TKA). No significant effect of prehabilitation was observed for performance-based measures of strength (SMD -0.06 [95%CI: -0.33, 0.20]), balance and mobility (SMD -0.16 [95%CI: -0.09, 0.40]) and range of motion (SMD -0.00 [95%CI: -0.20, 0.19]) at 6 weeks after TKA. There is limited research (n= 2) on the impact of prehabilitation on postoperative functional outcomes in people awaiting total hip arthroplasty (THA). We found improvements in function and increased ROM at 6 weeks in one study with people awaiting THA in comparison to the control group. CONCLUSION: This review demonstrates prehabilitation did not improve self-reported or performance-based outcome measures at 6 weeks after TKA surgery. Clinicians and policy makers should proceed with caution when making decisions on implementing a prehabilitation program for people awaiting TJA due to OA. The accompanying findings of a high risk of bias across trials does not support the implementation of prehabilitation programs for people awaiting TJA in current clinical practices.

P2-T-121: ***Factors Associated with Movement Reinvestment in People Before and After Total Knee Replacement Surgery***

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BACKGROUND AND AIM: Movement reinvestment is the predisposition of an individual to consciously control movements, and is known to be higher among individuals with compromised central gait control (e.g. stroke or parkinson's disease) or peripheral gait mechanics (i.e. knee osteoarthritis; OA). Previous work has demonstrated that older adults, 6-months following unilateral Total Knee Replacement (TKR), have higher movement reinvestment scores, as well as lower balance confidence and functional mobility than controls, but the relationship between movement reinvestment, pain and mobility characteristics before and after TKR are unknown. METHODS: Nineteen older adults (mean age 71.8±4.2 years, range 66-80]) were evaluated before TKR surgery and 4.5 month after. The Movement-Specific Reinvestment Scale (MSRS) was translated to Hebrew by two researchers (forward-backward translation) and used to evaluate movement-specific reinvestment. Gait parameters (speed, step length and time and double support duration) were assessed using the OptoGAIT Electronic Walkway during 1-minute walking at self-selected speed, knee pain and function were evaluated using the Western Ontario and McMaster Osteoarthritis Index (WOMAC), balance was evaluated using the mini-BESTest, balance confidence was evaluated using the Activities-specific Balance Confidence (ABC) Scale, cognitive function was evaluated using the Montreal Cognitive assessment (MoCA). Paired T-tests were used to compare pre- and post-surgery status. Spearman's correlations were used to evaluate the relationships between movement reinvestment, gait and balance

functions, pain and cognitive function. RESULTS: TKR surgery significantly improved knee pain and function (p=0.006) but did not alter movement reinvestment, gait or balance function or confidence. Prior to surgery, higher movement reinvestment was associated with slower gait, longer double-support and shorter steps bilaterally (r>0.52,p<0.02). In addition, higher movement reinvestment was associated with more knee pain (r=0.6,p=0.007), less balance confidence (r=-0.75,p<0.001), worse balance function (r=-0.52,p=0.019) and worse cognitive function (r=-0.51, p=0.02). After surgery, no significant relationships were identified between movement reinvestment and other factors, i.e. gait and balance function, knee pain, balance confidence or cognitive function. CONCLUSIONS: TKR surgery alters the relationship of movement reinvestment with measures of pain, gait, balance and cognitive function. Along with a significant drop in knee pain and improved function, conscious movement processing may play a less significant role in movement planning for gait control in older adults post-surgery. Additional work is needed to highlight factors underlying gait control post-TKR.

P2-T-122: ***Objective monitoring of daily-life gait in individuals scheduled for total knee replacement***

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BACKGROUND: End-stage osteoarthritis (OA) of the knee is characterized by pain and joint stiffness. When these symptoms substantially limit daily-life activities, total knee replacement (TKR) is considered. The decision towards TKR strongly hinges on subjective patient report of the extent of daily-life limitation, which may poorly reflect actual performance. To explore the clinical value of objective monitoring of daily-life functioning using inertial measurement units (IMUs), we 1) compared daily-life gait between individuals scheduled for TKR and healthy controls (HC), and 2) assessed the relation between daily-life gait and subjective reports of pain and function among individuals scheduled for TKR. METHODS: Individuals with unilateral knee OA scheduled for posterior cruciate retaining TKR (n=27) and 11 HC of similar age participated. Daily-life gait was measured for minimally 5 days using instrumented socks - with IMUs on the feet and ankle - and an IMU on the lower back. IMU data was processed using previously described algorithms [1]. The following outcomes were extracted: gait speed, stride length, stride time, and step time asymmetry. For each parameter, peak values were derived from the frequency distributions of all detected strides from each individual over all days. Between-group comparisons were made using mean differences and 95% confidence intervals (CI). Pain during activity and rest was measured using a numeric rating scale (NRS), and self-reported physical function was measured using the Knee Injury and Osteoarthritis Outcome Score - Physical Function Short Form (KOOS-PS). Pearson correlations between daily-life gait speed and NRS pain scores as well as KOOS-PS scores were determined. RESULTS: Gait speed during daily-life was 0.14 m/s (95% CI: -0.27 - -0.02) lower in individuals with knee OA compared to HC (Fig 1). This difference stemmed from a combination of (non-significant) lower stride lengths (mean diff: -0.10 m, 95% CI: -0.21 - 0.02) and slightly longer stride times (mean diff: 0.07 s, 95% CI: -0.01 - 0.14) in individuals with knee OA. There were no differences in step time asymmetry between groups (mean diff: 1.5 %, 95% CI: -1.0 - 3.9). A weak significant correlation was observed between daily-life gait speed and KOOS-PS scores (r = 0.43, p = 0.03). No correlations between daily-life gait speed and pain during rest (r = -0.15, p = 0.45) and activity were found (r= -0.13, p = 0.52) (Fig 1). CONCLUSIONS: On average, individuals with end-stage knee OA scheduled for TKR had an impaired daily-life walking performance, reflected by a lower gait speed compared to HC. The absence of an association between gait in daily-life and pain scores was striking. Taken together, these findings indicate that objective measures of daily-life gait may carry important additional information about a patient's actual functioning that seems relevant for clinical decision making. REFERENCES: [1] Shah V, et al. J Parkinsons Dis. 2020

P2-T-123: *Oxygen consumption and gait dynamics in transfemoral bone-anchored prosthesis users compared to socket-prosthesis users: a cross-sectional study*

Vera Kooiman[1], Lisanne Haket[2], Nico Verdonschot[1], Ruud Leijendekkers[1], Vivian Weerstesteyn[3]

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BACKGROUND AND AIM: A transfemoral bone-anchored prosthesis (BAP) is an alternative for the conventional socket-suspended prosthesis (SSP) in persons suffering from socket-related problems [1-4]. In these persons, it has been demonstrated to improve oxygen consumption during walking [5,6]. However, it remains uncertain whether the same improved findings are found compared to SSP users without any socket-related problems. Here we investigated whether oxygen consumption, centre of mass (CoM) and trunk dynamics during walking differ between satisfied transfemoral SSP and BAP users and able-bodied individuals (AB); and whether CoM and trunk dynamics and pistoning (i.e. vertical displacement of the stump within the socket) are potential determinants of oxygen consumption. METHODS: Highly-active transfemoral SSP and BAP users (K3-K4) without prosthetic problems were sampled. Oxygen consumption was measured while participants walked on a treadmill at preferred speed, 30% slower, and 30% faster. At preferred speed, we also evaluated CoM deviation, root-mean-square values (RMS) of mediolateral (ML) CoM and trunk excursions, and pistoning. In the prosthetic users, it was evaluated whether CoM and trunk dynamics, and pistoning were associated with oxygen consumption. RESULTS (Figure 1): We included BAP users (n=10), SSP users (n=10), and AB (n=10). SSP users demonstrated higher oxygen consumption, CoM and trunk RMS ML in comparison to AB during walking. BAP users showed intermediate results between SSP users and AB, however not significantly different from either group. In prosthetic users, greater CoM and trunk excursions were associated with higher oxygen consumption (CoM deviation: $r_s(19) = .756$; CoM RMS ML: $r_s(19) = .625$; Trunk RMS ML: $r_s(20) = .740$), in the SSP users a greater degree of pistoning, in turn, was found to associate with larger trunk RMS ML ($r_s(10) = .697$). CONCLUSIONS: The results indicate that satisfied SSP users have increased oxygen consumption compared to AB and use compensatory movements during walking. An evaluation of pistoning and CoM and trunk dynamics during walking may be considered for determining whether an individual SSP user may possibly benefit from a BAP, in addition to the currently used functional tests to evaluate eligibility. This might lead to a larger group of persons with a transfemoral SSP benefiting from this technology. References: [1] Aschoff et al. 2009, [2] Aschoff et al. 2011, [3] Brånemark et al. 2001, [4] Brånemark et al. 2005, [5] Van de Meent et al. 2013, [6] Hagberg et al. 2014 ACKNOWLEDGEMENTS AND FUNDING: The work was supported by ERC-H2020 Project "MyLeg" (n.780871).

V – Robotics

P2-V-124: ***Development of a Standing Balance Robot enabling Mediolateral Whole-body Motion***

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BACKGROUND AND AIM: Humans maintain standing balance by mostly generating torques via their lower leg muscles, resulting in small whole-body oscillations in both the anterioposterior (AP) and mediolateral (ML) directions. The AP kinematics of balance have been typically modeled as an inverted pendulum but the kinematics of ML balance depend on stance width. For example, the lower and upper body move in opposite directions for stance widths larger than pelvis widths, thus preventing its characterization as an inverted pendulum. Our first-iteration robotic balance device replicated exclusively in the AP kinematics of balance, with participants actuating the robot by generating ankle torques. Here, we developed a new robotic device that performs AP and ML motion and modified its control to decrease the actuation delays to below 20ms. METHODS: Our new robotic device featured two additional servomotors to accommodate ML movements. We modified the existing system AP motion code and implemented a kinematic model of ML balance that included motion at the shoulder (mid-deltoid) and pelvis (greater trochanter) to account for relative lower and upper body movements. To decrease system delay and increase responsiveness, we controlled the actuators with velocity inputs. The tuning of motor gain parameters coupled with PI control, where Kp2/4 = Ki, were crucial in maintaining system stability. We estimated system delay by calculating the relative phase between the target and actual position of the actuators in response to multisine trajectories with frequencies below 4Hz. RESULTS: We simulated the kinematics of ML balance motion with our novel robotic device. The system mimicked the changes in relative motion between the upper and lower body when simulating changes in stance widths. Controlling motion with velocity inputs allowed us to introduce a feedforward gain to further reduce system delays. When examining the relative phase between the target and actual position of the actuators across frequencies, the estimated delay was <10ms. The error between the target and actual position remained small, with the largest errors <0.1deg for oscillations faster (20deg/s) and larger (5deg) than typically expected for the unperturbed control of standing balance. CONCLUSIONS The updates to our balance robotic device incorporate the AP and ML control of standing balance. Using these new capabilities, we have developed a device that can manipulate the AP and ML control of standing balance while accounting for changes in

the ML kinematics of the body as participants change their stance width. The control of the motors with velocity inputs led to robust performance while keeping system delays under 10ms. Next, we will validate this new robotic balance device through experimentation involving human participants. We expect that this system will enable novel experiments characterizing how our brain adapts to the multiaxial interactions and requirements of balance. ACKNOWLEDGEMENTS AND FUNDING This research was funded by NSERC.

P2-V-125: ***Effect of trunk swinging behaviors on planar bipedal walking with hip joint stiffness***

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BACKGROUND AND AIM: Numerical walking simulation based on a simple model, especially a passive or an underactuated model such as passive dynamic walking, is one of effective methods to reveal the effect of a specific factor on its gait. In previous works, it is found that the direction of a trunk swinging behavior during one step affects a step time and a step length via numerical simulations based on a simple semi-passive dynamic walking model using only hip actuation between the stance-leg and the trunk. This fact indicates the possibility that the trunk swinging behaviors control the non-actuated swing-leg behavior and adjusts the gait based on its natural dynamics. This is an appropriate characteristic for the gait assist system because the system enables to promote the leg swinging using the healthy stance-leg and the trunk behavior if it is difficult for a person to swing one leg due to injury or illness. Therefore, in this study, numerical simulations were operated to study the effect of trunk swinging behaviors on the gait when the bipedal walking model has the hip joint stiffness and encumbers its leg with the stiffness. METHODS: 3-link planar bipedal model, consisted of two legs without knee joint and a trunk, walks down a gentle slope. This model has a hip joint stiffness between one leg (Leg A) and the trunk and no stiffness between another leg (Leg B) and the trunk. Therefore, the swinging behavior of Leg A is encumbered by the hip joint stiffness. This model has only the hip torque between the trunk and the stance-leg to enhance the effect of trunk swinging behaviors on the gait. The trunk is controlled based on three types of trunk swinging behaviors, forward swinging behavior (FS), no swinging behavior (NS), and backward swinging behavior (BS). The step length and the averaged step time were evaluated when the hip joint stiffness was varied. RESULTS: The gait based on FS had a long step length and a long step time, the gait based on BS had a short step length and a short step time, and the gait based on NS had the intermediate step length and step time were observed when the model has the same hip joint stiffness. Normalized results showed that the effect of the hip joint stiffness on the gait based on FS was the smallest and the effect of the hip joint stiffness on the gait based on BS was the largest. CONCLUSIONS: The direction of the trunk swinging during one step could control the step length and the step time even if the model has the hip joint stiffness. The gait based on FS was robust against the effect of a hip joint stiffness and the gait based on BS was susceptible to the effect of a hip joint stiffness. Therefore, the suitable trunk swinging behavior should be selected in consideration of the effect of a hip joint stiffness.

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W - Sensorimotor control

P2-W-126: ***Eccentric Viewing Shifts Subjective Visual Vertical Perception***

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BACKGROUND AND AIM: Verticality perception is crucial for space representation and body coordination, relying on the integration of visual, vestibular and somatosensory information, including prior knowledge about head (and body) orientation in space. In addition to vestibular signals providing head orientation information, the eye-in-orbit position serves as a reference for head orientation perception - thus also influencing whole-body postural control. Aging leads to vestibular deficits affecting mobility and contributing to increased visual dependence for perception and postural control. These age effects, combined with eccentric viewing, may help explain the higher fall risk and mobility issues of older adults with central visual field loss (e.g. due to age-related macular degeneration, AMD) who often adopt eccentric eye positions to exploit their intact peripheral retina. With the current preliminary study, we examined whether eccentric viewing alone alters one's subjective visual vertical (SVV) perception. With visual dependence in mind, we further questioned whether potential eccentricity effects on SVV persist with the influence of a misleading visual context. By assessing young adults first, we could address these questions without the added complexity of aging and visual impairment. METHODS: Twelve healthy young adults (6F) made orientation judgements on a briefly flashed rod (16°x0.6° visual angle -va-, flashed for 50ms) tilted clockwise or counterclockwise of the Earth vertical. The rod appeared with and without a constellation of dots moving across the screen (at a 20° angle CW or CCW off vertical at 10°va/s). Participants viewed stimuli through an optical tube on a 55' screen while seated at 60cm with the head restrained. The tasks were repeated while fixating a target displaced 10° horizontally to the right. 14 rod orientations were tested in conditions with a visual context and 10 in those without, with each orientation randomly presented 10 times. Eye-tracking goggles were worn to monitor fixation. The data were fit with a probit model and the point of subjective equality was estimated to assess bias in SVV. We examined the effect of eccentric viewing by comparing the difference in bias between central and eccentric fixation to zero via a one-sample t-test/Wilcoxon signed rank test. The same analysis method was used to examine the effect of visual context. Data acquisition is ongoing to explore potential interactions of eccentricity and visual context effects. RESULTS: A significant effect of eccentric viewing was found for orientation judgements with and without a visual context ($p<.0001$), with the bias shifting in the direction opposite fixation. The visual contexts also affected SVV significantly ($p<.001$), shifting the bias in the direction of visual motion. CONCLUSIONS: Our data suggest that eccentric viewing may affect one's SVV regardless of contextual visual information. The interaction of eye position and visual dependence will be important to consider further in the design of rehabilitation tools for individuals with AMD

who have eccentric fixation and may have increased visual dependence. ACKNOWLEDGEMENTS AND FUNDING: This study was supported by NIH research grant R00-EY-026994.

P2-W-127: ***The acute effects of aerobic exercise on sensorimotor adaptation in chronic stroke***

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Sensorimotor adaptation, or the capacity to adapt movement to changes in the moving body or environment, is a form of motor learning that is important for functional independence (e.g., regaining stability after slips or trips). Aerobic exercise can acutely improve many forms of motor learning in healthy adults. It is not known, however, whether acute aerobic exercise has similar positive effects on sensorimotor adaptation in stroke survivors as it does in healthy individuals. Purpose: The aim of this study was to determine whether acute aerobic exercise promotes sensorimotor adaptation in people post stroke. Methods: A single-blinded crossover study was completed. Twenty people with chronic stroke (>3months post stroke) participated in the study (aged 61 ± 13 years; 76% male). Participants attended two separate sessions at the university campus, completing an aerobic exercise intervention in one session and a resting control condition in the other session. Sensorimotor adaptation was assessed before and after each session via an upper limb task. Participants were asked to move a cursor to a target at one of three randomly presented positions under correct and perturbed feedback (rotation 30 deg) conditions. The aerobic exercise intervention was treadmill exercise at mod-high intensity (65% of HRR) for 30 minutes. Results: Results demonstrated that acute aerobic exercise in chronic stroke survivors significantly increased sensorimotor adaptation from pre to post treadmill intervention. Conclusion: These results indicate a potential role for aerobic exercise to promote the recovery of sensorimotor function in chronic stroke survivors.

P2-W-128: ***Does Levodopa Affect Gait and Balance in Older Adults?***

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BACKGROUND AND AIM: Cortical dopaminergic activity decreases in normal aging, with an exacerbated decrease observed in Parkinson's disease (PD). Levodopa (L-dopa), a dopamine replacement medication, is the prevailing therapy to treat PD. Although the pace of gait improves with L-dopa, postural sway may not improve or may worsen. Additionally, cortical sensorimotor inhibition (as measured by short-latency afferent inhibition [SAI]) is worse in people with PD when on L-dopa. The purpose of this investigation was to determine if L-dopa alters sensorimotor inhibition and mobility in older adults (OAs), as it does for

people with PD. We hypothesized that the effect of L-dopa on sensorimotor inhibition, gait and balance will mirror the L-dopa effect in people with PD. We also hypothesize that worse gait and postural sway would correlate with worse sensorimotor inhibition. METHODS: Fifteen healthy older adult males (Average age, 65.8 [6.5] years) participated. Sensorimotor inhibition was assessed using the transcranial magnetic stimulation technique, SAI. Gait measures were quantified during a 2-minute, 7-meter walk and balance measures were quantified during one minute of quiet stance, while wearing 6 body-worn, inertial sensors (APDM, Portland, OR). All participants were tested OFF and then ON a single 25/100 milligram dose of carbidopa/L-dopa. Paired samples t-tests were used to compare medication state differences in SAI, gait, and postural sway variables. Pearson's correlations assessed the relationships between SAI and mobility variables. Cohen's d effect sizes were calculated to characterize the magnitude of the medication effect with α set a priori to ≤ 0.05. RESULTS: Older adults showed no significant difference in SAI between the OFF (66.5% [17.3]) and ON (64.4% [16.3]) medication states ($t = 0.56$; $p = 0.59$; Cohen's $d = 0.14$). L-dopa also had no significant effects on gait or postural sway variables. However, arm swing excursion had a moderate effect size (Cohen's $d = 0.50$), with more arm swing excursion in the ON medication state compared to the OFF L-dopa state. Worse sensorimotor inhibition in the OFF L-dopa state was significantly related to increased percent time in double-limb support, jerkiness of sway, and sway area. Worse SAI in the ON L-dopa state significantly related to increased arm swing excursion and jerkiness of sway. CONCLUSION: A single dose of L-dopa does not affect cortical sensorimotor inhibition or mobility in OAs. However, sensorimotor inhibition of the cortex is related to postural control in both gait and quiet stance in OAs, and the relationships are affected by dopamine. Since dopamine replacement therapy in people with PD impairs sensorimotor inhibition and postural sway in stance, but improves gait speed, the heterogeneity of balance impairments in both OA and people with PD may stem from heterogeneous loss of dopamine with indirect effects on sensorimotor inhibition.

P2-W-129: ***Vestibular thresholds of the balance control system***

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BACKGROUND AND AIM: When balancing upright, the whole body is mechanically unstable. It exhibits small oscillations at low frequencies that the neural networks subserving the control of balance must detect. Detection thresholds of a system characterize its performance limits and physiological noise but are typically related to perceptual processes. Human perceptual thresholds for upright standing (Fitzpatrick & McCloskey, 1994), however, are distinct from the sensorimotor thresholds required to elicit responses from the neural networks governing the control of standing balance. The objective of this study was to quantify the vestibular thresholds of the balance system using electrical vestibular stimulation (EVS). METHODS: Participants stood upright on two force platforms with their eyes closed. They maintained their head forward and tilted their nose upward by ~18° to maximize vestibular-evoked balance responses along the frontal plane. We used the torque data to quantify the balance vestibular thresholds to EVS delivered in a binaural bipolar

configuration. We examined the frequency and amplitude dependence of balance vestibular thresholds by delivering the vestibular stimuli as sinewaves at amplitudes of 0.2, 0.4, and 0.6 mA, and frequencies of 0.1, 0.2, 0.5, and 1 Hz. We used signal detection theory to separate the signal from the noise required to generate balance responses. Here, the identified balance thresholds encompass noise associated with transduction of the electrical signals by the vestibular system, the neural integration processes, and the generation of motor commands. We calculated the discriminability index (d') to identify bidirectional balance thresholds to the vestibular stimuli in the frontal plane. RESULTS: Vestibular thresholds of the balance control system were independent of stimulus frequency. Participants, however, exhibited more variable balance responses as the amplitude of the vestibular stimuli increased. This larger variability in the balance responses led to larger estimates for the balance vestibular thresholds calculated using d'. CONCLUSIONS: Our results demonstrate that balance vestibular thresholds can be extracted independently of perceptual processes using methods from signal detection theory. The more variable responses and consequently larger vestibular balance thresholds estimated with larger vestibular stimuli may be attributed to participants detecting and reacting voluntarily to the stimuli.

P2-W-130: ***The role of gaze in deciding which path to walk***

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Background and aim People must often decide between two or more paths to walk. Acquiring relevant visual information, such as the characteristics of the terrain and presence of obstacles, is important for these decisions. Gaze behaviour serves to obtain visual information and may reflect the decision process (Dominguez-Zamora & Marigold, 2021). In this study, we had two aims: (1) to determine how gaze behaviour is involved in deciding between two paths to walk, and (2) to determine why people choose a certain path when given a choice. Methods We asked 6 participants to decide between one of two paths to walk while we recorded gaze behaviour with a mobile eye-tracker. Each walking trial, we randomly projected one of four environments on the ground, two of which simulated an urban environment (e.g., cracked sidewalk, asphalt) and two of which simulated a hiking environment (e.g., tree roots, dirt, mud). Each environment consisted of two paths, each with three patches of custom-made, realistic-looking images of terrain. We instructed participants to pretend the terrain were real and walk across the path they would likely take in the real world. Participants had two seconds between the appearance of the environment and a cue to start walking. We quantified gaze behaviour during the approach phase, from the appearance of the environment until participants began walking across one of the paths. After 20 trials, participants ranked (separately) the urban and hiking terrain based on how comfortable they were stepping on them (assuming the terrain was real). This allowed us to determine, for each environment, whether participants chose the path with the most comfortable terrain overall. Results Participants fixated the chosen path on 99.2% of trials and fixated the non-chosen path on 100% of trials, demonstrating that individuals use their gaze to explore the different options before making a choice. On average, participants made 6.3 fixations/trial, of which 3.6 fixations were made on the path they chose, and 2.7 fixations were on the path they did not choose. We also found the participants made 2.5 fixations in transition areas between terrain types. This behaviour allows the brain to covertly attend to both surfaces, maximizing information gain. Participants fixated more frequently at complex terrain compared to simpler terrain (mean of 2.2 and 1.3, respectively). We postulate this behaviour is because more complex terrain may be a richer source of information. These behaviours remained stable throughout all trials. Participants chose their perceived most comfortable path 75% of the time. Conclusion Our preliminary results show that when making decisions, people use gaze to seek information about their options. Also, people appear to choose a path based on their overall comfort level with the terrain present. This study is the first step in understanding how people use gaze to choose a path to walk. Funded by NSERC Canada.

P2-W-131: ***Continuous loading of the foot sole impairs sensitivity of cutaneous mechanoreceptors regardless of intact microvascular function***

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As we ambulate, glabrous foot sole skin provides vital sensory feedback about pressure, loading and slips, through the activation of mechanoreceptors. Loading the foot also generates localized ischemia within the skin microvasculature. Upon release, blood flow increases to offset the ischemic deficit; a mechanism known as post occlusive reactive hyperemia (PORH). In hairy skin, PORH is thought to be mediated by sensory nerves but remains unclear in the glabrous skin. Widespread ischemia to the entire limb using a cuff has been shown to impair vibration detection thresholds on the heel. Whether local ischemia isolated to the skin generate changes to skin sensitivity and whether those changes are dose and foot site specific is unknown. The current work aims to examine whether 1) there are decreases in sensitivity following skin ischemia of a healthy foot 2) there are correlations between PORH and sensitivity. Capillary flux was recorded using a custom-built-loading device with an in-line laser speckle contrast imager (FLPI-2, Moor Inc). The device applied load to the right foot at 2 magnitudes; 15 or 50% body weight for 2 durations; 2 or 10 minutes continuously. Each load was followed with a 2-minute PORH recording, repeated 3 times and block randomized. Peak PORH and slope was evaluated for skin over the third metatarsal (3MT), medial arch (MA) and heel. On a second test day, after loading, skin sensitivity was assessed using Semmes-Weinstein monofilaments (MF). Perceptual thresholds were determined for each site prior to loading and then applied repeatedly to a metronome for 2 minutes after the load released to define time to the first percept. Ten healthy participants (6 F; 25.6±3.7yrs) have been tested to date. A main effect was found for site ($p<.01$) such that all flux measures of the 3MT and Heel were influenced by loading, while the MA was not. Load magnitude was significant for peak PORH ($p<=.007$). Loading for either 2 or 10min at 50% generated greater PORH peak than 15% loads (2min, $p<0.03$; 10min, $p<0.01$). Duration of load was significant for slope ($p=.015$) such that flux returned slower in both 10min loading trials. MF revealed that heel sensitivity was most influenced by ischemia. Average time to first percept was 134.8 s after the 10min50% trial, which was significantly longer than 2min15% (1.66 s, $p<.001$) and 2min50% (33.9 s, $p<.001$). To date,

PORH and sensitivity correlation is only trending towards significance (p=.13). Findings from this work indicate that skin blood flow is essential for sensory feedback. The duration of ischemia impacts sensitivity regardless of greater PORH flux. PORH is blunted in diabetic populations, likely contributing to impaired sensory feedback. Together, this creates a higher risk for foot amputations. Our work provides insight into preliminary mechanisms that contribute to neuropathic ulcerations and highlights the critical need for operative sensory feedback to monitor loads and mitigate ulcer development.

P2-W-132: ***The effect of secondary tasks on the standing shortening reaction in people with Parkinson's disease***

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Background: Lower limb rigidity is associated with fall history in people with Parkinson's disease (PD). Rigidity, a cardinal sign of PD defined as increased resistance to passive motion, is assessed in a seated, relaxed state. Therefore, the mechanism by which rigidity may affect fall risk and balance control is unclear. When a rigid limb is passively manipulated, a shortening reaction (SR), e.g. a brief, paradoxical, contraction, occurs in the shortened muscle, at a longer latency than the stretch reflex response in the lengthened muscle. The SR creates an opposing torque to the agonist muscle about the joint, reducing its effectiveness in resisting the perturbation. Performing secondary task increases both rigidity and the SR during passive movement. In contrast, dopaminergic (DA) medication reduces the SR and has not been tested in combination with secondary tasks. Whether a similar phenomenon to the SR occurs in functional tasks in parkinsonian rigidity is not known. Here we defined the standing shortening reaction (SSR) to be the activation of the shortened muscles after the balance-correcting response in the agonist muscle. We hypothesized that a secondary task would increase SSR and DA would decrease it. Methods: We plan to test 20 people with PD during forward and backward support-surface translations. Participants are tested in the OFF and ON DA medication states on two separate days. Each day, participants are tested in four conditions; two secondary tasks, pulling a force transducer similarly to the Jendrassik maneuver (J) and tapping the index finger and thumb with arms crossed over the chest (T); and two controls, holding a force transducer (JC), and arms crossed over the chest (TC). Muscle activity is collected from tibialis anterior (TA), soleus (SOL), and medial gastrocnemius (MG) during assessment. Baseline activity is quantified as the average EMG activity -75 to 0ms before the onset of the support-surface translation. The SSR is quantified as the mean EMG response 75 to 225ms after platform onset in the muscle(s) shortened due to the perturbation. Linear mixed models are applied to each muscle measure using condition and medication state as discrete variables and subject as random effect. Results: Interim analyses (n=5) show that ON DA decreases baseline and the SSR in all muscles. Regardless of DA state, TA and MG baseline activity trend toward being increased in the presence of finger tapping; TA SSR response increases with finger tapping, whereas MG SSR response trends toward being increased in condition J. Conclusions: Dopamine

medication reduces baseline muscle activity during standing in people with PD. Activation maneuvers may affect baseline and shortening responses, but effects across muscles are variable. Surprisingly, secondary tasks may increase baseline muscle activity relatively more in the ON versus OFF DA state, suggesting that DA may not sufficiently mitigate the effects of secondary tasks on muscle activity. Acknowledgments and funding: Neuromechanics lab, Modeling PD R01 7240000027

P2-W-133: ***Markers of reactive control in stance***

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BACKGROUND AND AIM: Effective reactive balance control, recovering stability in the face of sensed instability, is of specific importance to preventing falls and ensuring stability control. Reactive control is often studied using external perturbations, however, there are often practical challenges to use in clinical settings. Alternatively, reactive control can be a significant contributor to the control of stationary standing. The potential use of naturally occurring postural sway measures as an index of reactive control is, however, challenged by the complexity of control. This study sought to disentangle the components associated with postural sway during standing to inform about the status of reactive control. Specifically, time-frequency decomposition is used to test for an association between task challenge and high frequency center of pressure (COP) components (1,2) believed to represent reactive control. The overarching hypothesis is that postural sway is composed, in part, by reactive control whose characteristics are dependent on task challenge (e.g. availability of sensory information). It is hypothesized that the availability of sensory information influences higher frequency (>0.4 Hz) COP components more than lower frequencies. METHODS: Young healthy participants (n=12) stood for 30 second trials in tandem stance. 3 sensory tasks were performed: Eyes closed, Eyes open (Vision), and Eyes closed with haptic touch (Haptic). Two force plates were used to measure COP, and for each trial the ML COP was decomposed to components of varying frequencies using Empirical Mode Decomposition (3). Signals were reconstructed from these components based on their frequency content: "High" frequency (≥ 0.4 Hz) and "Low" frequency (< 0.4 Hz) COP. RMS for the different components was used to compare tasks. RESULTS: Results revealed greater task related differences for High COP compared to Low COP. Overall, there was a 2.2 mm reduction in High frequency ML COP when Vision and a 1.4mm reduction when Haptic. Both approached statistical significance (p=0.08) There was no significant difference in Low frequency ML COP for either task comparison (Vision p=0.48, Haptic p=0.16). Significantly, the low COP component represented a greater proportion of the overall RMS. CONCLUSIONS: The results reveal a distinct role for high frequency components of COP specific to sensorimotor processing for postural control. Ongoing analysis will focus on comparison of periodic features rather than summary metrics. The lack of difference in low frequency components and strong relationship to overall RMS has implications to interpretation of the overall RMS as an index of reactive control even in challenging balance tasks. References: 1. Schinkel-Ivy, A., et al, (2016). Clin Neurophysiol, 127, 2463-2471. 2. Pauelsen, M., et al, (2020). PLOS

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P2-W-134: ***Cognitive-motor interference during locomotion: quantifying cross-domain interference effects during pedestrian collision avoidance.***

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BACKGROUND AND AIM: Cognitive-motor interference during locomotion is well documented in a range of research fields including those relating to ageing and cognitive impairments. However, little is known about the cross-domain interference effects between performance of tasks in the cognitive and physical domains. The first aim of this investigation is to quantify the relative contributions of cognitive tasks and simulated physical impairments to altered overground walking performance. The second aim of this investigation is to quantify the cross-domain interference effects of concurrent cognitive tasks on pedestrian collision avoidance. METHODS: Two experiments were conducted utilising a repetitive shuttle walking task recorded by motion capture. In the first experiment, twenty-one healthy young adults (M = 25.5; SD = 2.3 years), performed a working memory task whilst walking overground with a simulated physical impairment to investigate the cross-domain interference effects in cognitive domain and the physical domain. In the second experiment, twenty-two healthy young adults aged 20-29 years (M = 25.2; SD = 2.5 years) performed the shuttle walking task again with and without the concurrent working memory task. In both conditions, a pedestrian collision avoidance task was added to investigate the interference effects of a dynamic environmental challenge. RESULTS: The first experiment found that the working memory task and the simulated physical impairment both influenced physical domain performance, reducing walking velocity by 20% and 18% respectively. A condition where the working memory task and simulated physical impairment were combined resulted in a 32% reduction in velocity. Cognitive domain performance remained resilient to cross-domain interference. The second experiment found similarly reduced walking velocities but also found that collision avoidance behaviours were altered by the working memory task. On average, participants performed collision avoidance manoeuvres in 4.73 out of five trials in when walking without the concurrent working memory task and this was reduced to an average of 4.27 out of five trials with the working memory task. Performance on the working memory task was reduced by the pedestrian collision avoidance, with correct responses in the working memory task reduced from 96% to 86% due to collision avoidance with the oncoming pedestrian and an 8% reduction in response rate. CONCLUSIONS: This investigation finds that a working memory task and a simulated physical impairment had a similar impact upon walking performance and this effect was additive when conditions were combined. This investigation also finds the cognitive domain to be resilient to multitasking interference except during the pedestrian collision avoidance task where costs were also suffered in the cognitive domain.

P2-W-135: ***Deficits in standing balance control in people with mild traumatic brain injury and chronic balance complaints***

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BACKGROUND AND AIM: Complaints of imbalance are common following a mild Traumatic Brain Injury (mTBI). While most recover in 7-10 days, symptoms persist in about one quarter of subjects. Imbalance is often assumed to be associated with sensory deficits, and in particular vestibular disorders, but a broader view recognizes the potential contributions of both sensory and motor systems. We applied system identification methods, that we refer to as the Central SensoriMotor Integration (CSMI) test, to evaluate both sensory and motor contributions to balance in subjects with chronic mTBI in comparison to healthy controls (HCs). METHODS: The study included 52 subjects with chronic (> 3 months) unresolved mTBI symptoms and 58 HCs. Subjects performed a CSMI test that derived parameters of a feedback control model of the balance control system that accounted for experimentally measured anterior-posterior center-of-mass body sway evoked by repeated 20-s duration cycles of 2° (peak-to-peak) pseudorandom rotations of the stance surface and/or visual surround. Results are presented from surface-tilt stimuli applied during eyes-closed stance. The CSMI parameters included 1) a 'vestibular weight', 2) motor activation factors of normalized 'stiffness' and 'damping' that account for corrective ankle torque generation, and 3) system 'time delay'. RESULTS: Results showed essentially identical reliance on vestibular cues among mTBI and HC subjects (vestibular weight 0.48 ± 0.07SD for mTBI, N=49 (3 did not complete testing); 0.49 ± 0.08 for HC, N=58). However, motor activation parameters were significantly reduced (6.1% and 7.1% reductions in the mean normalized stiffness and damping factors, respectively) and time delays were significantly increased by 10.4% in the mTBI group compared to HCs. Across both groups stiffness and time delay measures were correlated with lower stiffness associated with longer time delays (r = -0.59). Using normative parameter ranges based on 10th%ile HC cutoffs for low stiffness and long time delays, 14 of 49 (29%) of mTBI subjects had both low stiffness and long time delays compared to 1 of 58 (2%) of HCs. CONCLUSIONS: Contrary to expectations, people with mTBI and chronic complaints of imbalance showed no deficit in their use of vestibular information for balance control. However, motor activation was reduced and time delays were longer in people with mTBI, with a notable subset having particularly reduced motor activation and long delays. Long time delay may be the primary mTBI abnormality with regard to balance control. Lengthened time delays in a feedback control system are detrimental to system stability. An effective compensation for lengthened time delay is to reduce motor activation. However, reduced motor activation has the deleterious consequence that the balance control system becomes excessively sensitive to external and internal balance disturbances. These finding have implications for rehabilitation therapy.

P2-W-136: ***Effects of a specific combined training on neuroplasticity underlying balance recovery in individuals with incomplete SCI: pilot study***

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Background: Individuals with incomplete spinal cord injury (iSCI) are at high risk of falling despite intensive rehabilitation. Postural reactions, which consist of specific muscle activation enabling balance recovery following a perturbation, are delayed and decreased post-iSCI. However, these deficits are not fully understood and are not routinely assessed clinically. Moreover, several therapeutic approaches have been studied but show varying degrees of efficiency among the SCI population. The degree of improvement might depend on the effect of these treatments on the nervous system reorganisation - the neuroplasticity. However, therapy-induced neuroplasticity is generally not assessed, which constitutes a pitfall in our appreciation of these novel paradigms. Aim: The objective of this pilot study was to determine the impact of a 4-week combined explosive strength and perturbation-based training on balance control and on neuroplasticity in iSCI individuals. Methods: Two individuals with chronic iSCI (ASIA D) were assessed 1 week prior, 1 week after and 1 month after explosive ankle strength and standing balance training (4 weeks; 3 times/week; 1h15/session). To obtain normative data, 5 healthy individuals were recruited. Postural reactions (EMG responses of tibialis anterior (TA) and soleus (SOL) and the 95% confidence area encompassing the excursion of the center of pressure) following backward and forward tilts were evaluated. Intracortical excitability was evaluated by paired pulse paradigm where TMS (1.1xMT) was preceded by a subthreshold conditioning stimulus (0.7xMT) at an ISI of 2ms (inhibition) and 12ms (facilitation). Sensory integration at cortical level was assessed using the short-latency afferent inhibition in SOL (tibial nerve: 1.5xmotor threshold (MT); Transcranial magnetic stimulation (TMS);1.1xMT; interstimulus interval (ISI):25-100ms). Results: Prior to training, the onset latency of TA and SOL activation were delayed, and the 95% confidence area was larger in iSCI participants compared to controls. Following training, the 95% confidence area decreased and the onset latency of both muscle activation following perturbation were closer to the control values. Improvement in postural reactions was paralleled by changes in neural excitability. Intracortical facilitation increased following training, leading to greater MEP amplitude. The short-latency afferent inhibition decreased after training leading to increased MEP amplitude. At 1-month post-training, the improvement observed in balance control were partially maintained but neuroplastic changes were no longer observed. Conclusions: These preliminary results suggest that combined explosive strength and perturbation-based training led to improved balance skills by enhancing cortical excitability and sensory integration. However, although behavioral improvements are still partially observed 1-month post-training, neuroplastic changes are not maintained in the pathways assessed.

P2-W-137: ***Effects of robotic assistance level and muscle stimulation intensity during overground walking assisted by an exoskeleton with functional electrical stimulation on muscle activation patterns and fatigue: a study protocol***

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BACKGROUND AND AIM: The latest advances about robotic rehabilitation technology allows the addition of multi-muscle functional electrical stimulation (mmFES) to overground powered exoskeleton systems. However, there is a lack of evidence on what the most efficient assistance and stimulation parameters to optimize muscle activations are. This study will therefore investigate the effects of different robotic assistance levels and mmFES intensities during overground walking on lower limb muscle activation patterns and fatigue in healthy young adults. METHODS: Twenty-five healthy adults, aged between 18 and 35 years old, with no self-reported musculoskeletal and/or neurological disorders nor contraindications to FES and exoskeleton use will be recruited for 2 laboratory sessions. Session #1 will consist in a fitting and familiarization session with the IndegoTM powered exoskeleton (Parker, USA) and mmFES (4 muscles/limb). During session #2, participants will complete 6 overground walking trials with the exoskeleton, in randomized order: 2 levels of robotic assistance (40% and 100%) each at 3 mmFES intensities set during sitting (no stimulation, minimum intensity inducing a visible muscle contraction, and strong but tolerable contraction). A total of 200 gait cycles will be completed per trial, along a long corridor. Electromyographic (EMG) activity of the stimulated muscles (tibialis anterior, gastrocnemius medialis, rectus femoris, semitendinosus) of the nondominant lower limb will be recorded using a Trigno Wireless EMG System (Delsys, USA). Muscle stimulation will be turned off in one cycle out of 10. EMG data collected during these non-stimulated strides will be analysed. Based on accelerometer signals from the Trigno sensors, data will be separated into individual gait cycles and time-normalized. Mean muscle activation amplitude, onset/offset timing and coactivation index with antagonists will be calculated. The median frequency of the power spectrum will also be calculated for each gait cycle. Two-way repeated measured ANOVA will identify differences in the outcome measures between trials. EXPECTED RESULTS: We hypothesize that higher robotic assistance and higher FES intensities will both decrease muscle activation amplitudes over time within a session, with little changes in timing or coactivation levels. Furthermore, it is expected that the effects of FES and robotic assistance will be additive, but that this effect might be hindered by muscle fatigue at high FES intensity. CONCLUSIONS: Results of this study will contribute to the identification of optimal parameters for overground powered exoskeleton gait training coupled with multi-muscle FES.

P2-W-138: ***Keeping in touch with our hidden side***

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BACKGROUND AND AIM: Previous studies have shown that the sensory modality used to identify the position of proprioceptive targets hidden from sight, but frequently viewed, influences the type of the body representation employed for reaching them with the finger. The question then arises as to whether this observation also applies to parts of the body which are hidden from sight, and rarely, if ever, viewed. METHODS: We used an established technique for pinpointing the type of body representation used for the spatial encoding of targets which consisted of assessing the effect of peripheral gaze fixation on the pointing accuracy. More precisely, an exteroceptive, visually dependent, body representation is thought to be used if gaze deviation induces a deviation of the pointing movement. Three light-emitting diodes (LEDs) were positioned at the participants' eye level at -25 deg, 0 deg and 25 deg with respect to the cyclopean eye. Without moving the head, the participant fixated the lit LED before the experimenter indicated one of the three target head positions: topmost point of the head (vertex) and two other points located at the front and back of the head. These targets were either verbal-cued or tactile-cued. The goal of the subjects (n=27) was to reach the target with their index finger. We analysed the accuracy of the movements directed to the topmost point of the head, which is a well-defined, yet out of view anatomical point (Fig. 1). Based on the possibility of the brain to create visual representations of the body areas that remain out of view, we hypothesized that the position of the vertex is encoded using an exteroceptive body representation, both when verbally or tactile-cued. RESULTS: The ANOVA and post-hoc analyses revealed that the pointing errors were significantly biased in the opposite direction of gaze fixation for both verbal-cued and tactile-cued targets ($p<0.05$), suggesting the use of a vision-dependent exteroceptive body representation. The enhancement of the visual body representations by sensorimotor processes was suggested by the greater pointing accuracy when the vertex was identified by tactile stimulation compared to verbal instruction. Moreover, we found in a control condition that participants were more accurate in indicating the position of their own vertex than the vertex of other people ($p<0.05$). This result supports the idea that sensorimotor experiences increase the spatial resolution of the exteroceptive body representation. CONCLUSIONS: Together, our results suggest that the position of rarely viewed body parts is spatially encoded by an exteroceptive body representation and that non-visual sensorimotor processes are involved in the construction of this representation.

P2-W-139: ***Exploring the role of vision on the center of pressure displacement during center of mass immobilization: A replication and expansion of Carpenter et al. (2010)***

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BACKGROUND AND AIM: In 2010, Carpenter et al., suggested that postural sway might represent an exploratory behavior; swaying may help collect sensorial information about the surrounding environment. They came to this conclusion after observing that the center of pressure (COP) displacement increased after artificially immobilizing the center of mass (COM), which should have removed the need for postural correction. Interestingly, they also showed that that there was no difference between an open and closed eyes condition; the increase in COP displacement, which they suggest indicates an exploratory behavior, was the same. This is surprising since removing vision is normally associated with changes in COP displacement due to a loss of sensorial information. That being said, their interpretation is only based on one trial per visual condition and on one measurement outcome (i.e. COP variability). To try to provide a better understanding of the role of vision during COM immobilization, the objective of the present study is to address Carpenter et al. (2010) findings using additional variables and trials. METHODS: Nineteen healthy young adults

(24.16 ± 1.57 years) were recruited. The experiment involved standing on a force platform (100 Hz) with feet at shoulder width while being firmly strapped to a wood board, itself link to a closed loop pulley system with brakes which allowed us to immobilize the participant (i.e. the COM) when needed. In that apparatus, participants underwent trials of approximately 150s. Each trial included a 60s unlocked phase followed by a 60s locked phase (i.e. immobilized by activating the brakes) used for data analysis. Trials were performed with eyes open and eyes closed, four times each. Like for Carpenter et al. (2010) study, COP variability was measured in the anterior-posterior (AP) direction. To get a better understanding of the COP behavior during the immobilization, we also added the COP sample entropy (SampEn), a non-linear measure of regularity, in AP and the COP mean velocity in AP. For each variable, a 2x2 (Vision X Phase) repeated measured ANOVA were performed. RESULTS: Statistical analysis revealed that the SampEn decreased, and the COP variability increased during the locked phase compared to the unlocked phase ($p<0.01$). Statistical analysis didn't reveal main effects of vision, nor interactions. CONCLUSIONS: Like Carpenter et al. (2010), we observed an increase in COP displacement during the COM immobilization which might indicate an exploratory behavior. Interestingly, the COP was also more regular during the locked phase, as suggested by the lower SampEn value. However, results suggest that vision did not play an important role in this experiment. Using other non-linear variables, like signal frequency, could provide additional information for understanding the role of vision during the COM immobilization. ACKNOWLEDGEMENTS AND FUNDING: Primary author has the NSERC Postgraduate Scholarship.

X - Tools and methods for posture and gait analysis

P2-X-140: ***Validation of a data-driven inertial-signal step detection method on elderly people***

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BACKGROUND AND AIM: Wearable devices hold potential for the assessment of gait and the calculation of falling risks. However, most falling risk indicators rely on the accurate detection of steps. A data-driven, inertial-signal based, step detection method, called Smartstep, previously assessed on young adults' and blind people's gait had shown promising results. The method processes acceleration and gyroscope signals with machine learning techniques. It is robust against sensor placements especially the hand, different populations, and different step modes (stairs-different walking grounds). In this study, we assess the ability of Smartstep to detect steps and calculate falling risk indicators in elderly's gait by applying it on two inertial measurement units (IMU) placed on two different body locations. METHODS: 21 elderly (4F and 17 M, 75 ± 5 y, 76 ± 21 Kg, 1.7 ± 0.1 m) performed a 6-minutes walking test while placing a smartphone at the waist in a sport running belt and placing an IMU on the wrist. The method was assessed against foot-mounted Gaitup IMUs.

First, the precision and recall of the step detection are given. Then, the Root mean square error (RMSE) and the Intraclass Correlation Coefficient (ICC) of instantaneous detected stride durations, and the limits of agreement of Standard deviation (SD) and Coefficient of Variance (Cov) of stride duration are calculated to evaluate the method. RESULTS: The step detection precision and recall were respectively 99.5% and 95.9% for waist position, and 99.4% and 95.7% for the wrist position. The ICC of stride duration was 0.91 for both the waist and the hand position. The RMSE of stride duration was 53 ms for the waist, 56 ms for the hand. The limits of agreement of Cov and SD of stride duration are respectively 2.15 %, 25 ms for the waist and 1.6 %, 16 ms for the hand. CONCLUSIONS: The ICC value is within the range found between different measurement devices. The result from RMSE shows that this method outperforms present ambulatory step-detection algorithms dedicated to calculating stride duration. Finally, the limits of agreement are less than the difference found between fallers and non-fallers, thus this method can be applicable for ambulatory fallers' classification studies. Robust against elderly's gait and different body locations, especially the wrist, this method can open doors toward ambulatory measurements of steps, and calculation of different step-related falling risk indicators.

P2-X-141: ***Predicting vertical ground reaction forces from 3D accelerometery using echo state networks leads to accurate gait event detection***

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BACKGROUND AND AIM: Accelerometers are low-cost measurement devices that can readily be used outside the lab to record large amounts of data. However, determining isolated gait events from accelerometer signals, especially foot-off events during running, can be a challenge and typically involves peak detection based and pre-selection of epochs of interest. We present a proof-of-concept two-step approach where machine learning serves to predict the shape of vertical ground reaction forces (vGRFs) from accelerometer signals, followed by force-based event detection. METHODS: Shank accelerometer data were obtained from five young adults (mean ± std, 24.2 ± 2.5 years) during comfortable walking and running on an instrumented treadmill to simultaneously record ground reaction forces. An echo state network was trained to predict vGRF waveforms based on shank accelerometer data along the direction of maximum variance (the leading principal component of the 3D accelerometer signals) and the derived velocity and position. We trained the network on segmented data and evaluated its predicted vGRF waveforms and subsequent event detection on continuous data for both walking and running. We verified the machine learner's capacity to predict separate trials using a leave-one-out cross-validation. RESULTS: The echo state network performed exceedingly well when predicting continuous vGRF waveforms after training on segmented data only (R^2 = 0.987 ± 0.002 and 0.978 ± 0.006 for walking and running, respectively) and similarly, the resulting event detection. Foot contact (foot off) was equally high with an accuracy (mean absolute error) of 7.6 ± 3.3 (9.7 ± 3.5 ms) and 6.5 ± 4.0 ms (14.0 ± 8.8 ms) for walking and running cf. Figure 1. The sampling frequency of the accelerometers was 2000/14 Hz and thus, the best possible performance has 7 ms (1 frame) accuracy. Results of the leave-one-out cross validation did not match

those of pooling the strides across participants, but it still performed very well (R^2 > 0.90 for both conditions). CONCLUSIONS: A single accelerometer placed on the shank combined with an echo state network proved to be highly accurate in predicting vGRF waveforms and step events during walking and running. By just training a small number of strides, the machine learner can accurately predict continuous data which is particularly beneficial for use outside the lab. ACKNOWLEDGEMENTS AND FUNDING: This project has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement no 715945 Learn2Walk) and from the Dutch Organisation for Scientific Research (NWO) VIDI grant (016.156.346 FirSTeps).

P2-X-142: ***Intrasession reliability and minimum detectable change of accelerometry-derived gait quality measures during dual-task walking in older adults***

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BACKGROUND AND AIM: Accelerometry-derived measures have emerged to assess gait quality under natural conditions without restricting mobility. These metrics can capture aspects of walking beyond gait speed, including adaptability, similarity, smoothness, etc. Interpreting gait quality measures remains limited, however, as their reliability and ability to detect differences have not been established or tested across conditions. Therefore, our aim was to quantify the intrasession reliability of accelerometry-derived gait quality metrics across different walking conditions. METHODS: Older adults (n=104, 74.5 ± 5.9 years, 60% female, community-dwelling, ambulate without assistance) completed four walking tasks with a tri-axial accelerometer (ActiGraph) secured on their lower back. Participants walked at a self-selected comfortable pace on even and uneven surfaces, with and without a cognitive dual task (reciting every other alphabet letter). Each task was performed over 15m and repeated 4 times; order randomized. Six gait metrics were computed from each trial: gait adaptability (standard deviation), regularity (entropy), rhythmicity (cadence), similarity (cross-correlation across axes), smoothness (harmonic ratio), and variability (stride time coefficient-of-variation). We computed the intraclass correlation coefficient (ICC, range 0-1, higher indicating better repeatability) as a measure of intrasession reliability (across 4 trials) and the standard error of measurement (SEM) and minimum detectable change (MDC) to quantify the influence of measurement variability. We normalized the SEM and MDC to the mean across participants to compare across metrics independent of their units. RESULTS: Intrasession repeatability was largely task invariant and consistent across metrics, except for gait variability (Fig 1). Excluding variability, gait metrics had good repeatability (ICC, mean±SD: 0.74±0.09) but high variation in errors (SEM, mean±SD: 14.9±5.4%) and could only detect a difference of approximately 40% of the mean value across participants (MDC, mean±SD: 41.2±15%). Gait variability was inconsistent across trials (ICC, range: 0.28-0.62), with large variance (SEM, mean±SD: 80.0±5.4%) and was unable to detect differences (MDC, mean±SD: 222±15%), particularly during even walking. CONCLUSIONS: Most gait quality metrics were reliable across intrasession trials, but additional study is needed to use these measures to monitor change or interpret differences in short walking bouts. In our

analysis, stride-time variation differed across repeated short distances of walking and could not be reliably determined. In future work, it will be important to examine intersession reliability as well as differentiate variability due to measurement error from individual performance variability to better interpret these measures. ACKNOWLEDGEMENTS: Pittsburgh Pepper Center (P30AG024827), NIH grants K01AG053431, R01AG057671, U01AG061393.

P2-X-143: ***The impact of acceleration phases on gait speed and dual-task cost outcomes of clinical gait assessment***

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BACKGROUND AND AIM: Gait assessment typically focuses on steady state walking over relatively short distances and excludes measurement of positive and negative acceleration phases with steps taken before and after the measurement length. Older adults and patient cohorts can require more steps to attain steady state gait speed [1], assuming steady state is achieved in these populations. A singular focus on steady state walking during clinical assessment limits our understanding of patients' gait performance. For instance, most daily walking occurs in shorter bouts [2], emphasizing the need to understand the interaction between steady state and acceleration phases. An approach that can reveal both acceleration and steady state phases of walking would provide important advantages to both clinical and free-living gait analysis. The objective of this study was to examine the implications of including acceleration phases during clinical walking tasks. METHODS: Data were collected as part of a longitudinal study in neurodegenerative disease and dementia [3]. A convenience sample (n=29) with and without cognitive impairment wore bilateral ankle accelerometers during 6-meter walking tasks (preferred pace, dual-task, and fast). A GAITRite mat (GR) was used for validation purposes. For each trial (bout of walking), accelerometer data was processed to determine speed and dual task gait cost (DTC). Steady state walking was estimated for each bout in 3 ways: 1) only steps matching GR data (MATCH), 2) 2 steps removed from start and end (SS), and 3) full bout including all acceleration phases (FULL). Correlational and error analyses were conducted to compare accelerometer and GR outcomes. RESULTS: Participants had a mean age of 67.5±7.1 years (24.1% female). Averaged preferred gait speed was 1.2±0.2 m/s as measured by GR. For gait speed, the correlation between MATCH and GR was very strong across all tasks ($r(27)$ 0.94 to 0.98, p's<.001) and had a 14% average percent error. Associations between MATCH, SS and FULL were lower ($r(28)$=.65 to .8). The average percent error was 3.7% and 5.7% comparing between MATCH and SS, and MATCH and FULL, respectively. Importantly, SS and FULL methods led to an increase in DTC which resulted in 25% (7 of 29) participants exceeding a 20% threshold (Fig 1) [4]. CONCLUSIONS: How the acceleration phases are addressed in clinical gait analysis has impact on gait characteristics and DTC. There is need, in analyzing gait bouts, to be able to identify acceleration versus steady state gait phases to provide a more accurate profile of patients' gait performance. Accounting for the interaction between steady state and acceleration phases will avoid compounding error related to the

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P2-X-144: *Automatic gait assessment of people with Parkinson's disease and freezing of gait with motion capture and deep learning*

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BACKGROUND AND AIM: Freezing of gait (FOG) and its associated temporal gait disturbances are commonly assessed during complex experimental protocols that involve turning with or without a cognitive dual-task in people with Parkinson's disease (PwPD) [1]. Current assessment implies that the gait cycle phases, e.g. stance and swing, and the FOG episodes are annotated manually based on the 3D marker trajectories of a motion capture system (MoCap), and standard camera footage [2]. These time-consuming tasks motivate the search for algorithms to automatically delineate gait cycle phases and FOG episodes. This study proposes a deep learning framework to automate gait assessment of PwPD and FOG. METHODS: The dataset includes seven PwPD with FOG [1]. Experimental conditions consisted of straight-ahead, and 180 and 360 degree turns, with or without a cognitive dual-task. MoCap was performed at a sampling frequency of 100 Hz with a ten-camera optical motion capture system. The FOG episodes and gait cycle events were manually annotated by a clinical expert. The proposed framework uses a deep learning backbone, entitled multi-stage graph convolutional neural network (MS-GCN) [3]. This network architecture features dilated convolutions to extract long-term temporal patterns, graph convolutions to exploit the spatial characteristics within MoCap data, and refinements to reduce over-segmentation errors (e.g. splitting a single FOG episode into multiple shorter FOG episodes). From the automatic and manual annotations, five clinically relevant outcomes were computed. Specifically, the percentage of time spent in double support I and II (TDS1 and TDS2), single support (TSS), swing (TS), and frozen (TF). The reliability of the automatically derived outcomes with respect to the outcomes derived from the manual annotations were assessed with the concordance correlation coefficient (CCC). Only the trials with FOG were considered, as trials without FOG would inflate the reliability scores. All results were derived by following a leave one subject out evaluation protocol. RESULTS: CCC [95% confidence interval] values showed excellent agreement (CCC = 0.92 [0.85, 0.96] and 0.90 [0.82, 0.95]) for TF and TSS, good agreement (CCC = 0.87 [0.77, 0.93] and 0.82 [0.67, 0.90]) for TSW and TDS1, and moderate agreement (CCC = 0.71 [0.50, 0.84]) for TDS2. CONCLUSIONS: The proposed framework enables valid and automated gait assessment of PwPD and FOG. However, further validation is required on a verification cohort. ACKNOWLEDGEMENTS AND FUNDING: [1] Spildooren J., Vercruysse S., Desloovere K., Vandenberghe W, Kerckhofs E., and Nieuwboer A.. 2010. Movement Disorders: Official Journal of the Movement Disorder Society 25 (15): 2563-70. [2] Nieuwboer, A., R. Dom, W. De Weerdt, K. Desloovere, S. Fieuws, and E. Broens-Kaucsik. 2001. Movement Disorders: Official Journal of the Movement Disorder Society 16 (6): 1066-75. [3] Filtjens B., Ginis P., Nieuwboer A., Slaets P., and Vanrumste B.. 2021. arXiv [cs.CV]. arXiv. http://arxiv.org/abs/2103.15449.

P2-X-145: ***Accuracy and Precision of a Custom Photogate Setup to Measure Foot Clearance on Stairs***

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BACKGROUND AND AIM: Insufficient foot clearance is one of the primary mechanisms for tripping/falling on stairs. Foot clearance on stairs is typically measured using optoelectronic systems (e.g. Vicon), though these are often constrained to the laboratory environment, due to their complex setups, specialist software and cost. Use of other motion capture alternatives (such as 2D video capture [1] or inertial measurement units [2]) are limited for foot clearance measurements due to factors such as the measurement error or the securing of instrumentation to the participant that may be obtrusive. This study tested a prototype standalone photogate setup that measures foot clearance on stairs and compared this to the optoelectronic system approach. METHODS: Twenty-two laser diodes and phototransistors were arranged vertically on blocks to create a series of photogates spaced at ~0.6cm intervals operated through a Raspberry Pi computer. The photogate setup was first validated by comparing the Vicon measured height of a single marker (attached to a rigid object) passed over a step edge, to the marker height measured by the photogates over 150 trials. Next, twelve participants (age 22 ± 3 years) completed 25 stair ascent trials each on a seven-step staircase. Foot clearance over one step edge was measured using Vicon and the photogate setup. For the photogate setup, the height of the lowest photogate broken was used as the measure of single marker height and foot clearance. In Vicon, the vertical distance of the single marker and foot (virtual toe tip landmark) away from the step edge was used as the single marker height and foot clearance respectively. All measures were calculated at the point of step edge crossing. A limits of agreement analysis and Pearson's Correlation Coefficient compared the accuracy, precision, and relationship between both systems. RESULTS: For the single marker height measurements, a mean difference of -0.14 cm (accuracy) was found between the two measurement systems (Photogates: 7.27 ± 3.38 cm, Vicon: 7.13 ± 3.42 cm) with an upper and lower limit (precision) of 0.35 cm and -0.64 cm respectively. A very strong positive correlation was found between the measurement systems ($r = .99$, $n = 150$, $p<.0001$). For foot clearance, a mean difference of -0.15 cm was found between the two measurement systems (Photogates: 5.26 ± 1.22 cm, Vicon: 5.11 ± 1.27 cm), with upper and lower limits of 1.27cm and -1.58cm, respectively. A very strong positive correlation was found ($r = .83$, $n = 294$, $p <.0001$) between the two systems. CONCLUSIONS: The small mean differences and strong correlations suggest the photogates could be a potential alternative solution for measuring foot clearance on stairs. This may be a useful setup for stairs outside a laboratory where optoelectronic systems are not routinely used. Improvements to design factors such as vertical spacing between the gates may help to increase the measurement precision of the photogates. REFERENCES: [1] Zult (2019) SCI REP-UK. [2] Benoussaad (2016) Sensors.

P2-X-146: ***Centre of mass sway estimation with an inertial measurement unit***

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BACKGROUND AND AIM: The growing availability of low-cost wearable sensors has allowed for the study of balance outside of the laboratory setting. By doing so, we can improve the ecological validity of our research and better understand how humans stand in a variety of natural contexts. While many authors have correlated summary statistics of body centre of mass (CoM) estimated using optical motion tracking and wearable sensors, these correlations often involve different metrics related to the CoM, e.g., CoM displacement and acceleration. Others have successfully estimated CoM sway during standing balance using wearable sensors, but their approaches involved multiple sensors or were validated only for short durations (≤30s) that do not fully capture the low-frequency components of standing balance sway. Standing balance is often modelled as an inverted pendulum in the anteroposterior (AP) direction, so a simple approach to estimate CoM displacement involves using the angle of the inverted pendulum. Thus, the purpose of this study was to estimate the AP CoM displacement time series using a single wearable sensor with the assumption the body sways in AP as an inverted pendulum. METHODS: Twenty healthy young adults (10 F; mean age=22.3) stood quietly on a solid surface with eyes open and arms at the side for nine 120s trials. Three infrared markers (Optotrak Certus) and an inertial measurement unit (IMU; MPU6050) were attached to a rigid body positioned on the fifth spinous process of the lumbar spine. First, the orientation of the IMU was determined using a simple complementary filter algorithm and was correlated with the orientation of the rigid body derived from the motion capture markers. The sensor orientation was then used to estimate the CoM displacement. CoM linear acceleration was also estimated from the IMU. The estimated results from the IMU were correlated with the average displacement and acceleration calculated from the three rigid body markers for each trial. RESULTS: AP tilt orientation derived from the IMU and the motion capture data were highly correlated ($r=0.99\pm0.02$ SD). AP CoM linear acceleration estimates from the IMU and motion capture were also highly correlated ($r=0.90\pm0.04$ SD) but correlations were lower for CoM linear displacement estimates ($r=0.53\pm0.32$ SD). Partially contributing to these poor correlations, we observed transient shifts in the IMU CoM linear displacement estimate that were more common in trials exhibiting correlation < 0.8 (2.1 ± 1.9 vs 0.4 ± 0.7 shifts). CONCLUSION: Despite good orientation estimates from the IMU, a simple inverted pendulum model was not adequate to estimate the CoM displacement possibly due to local movements of the lumbar region. Therefore, additional IMUs or optimal estimation techniques (e.g., Kalman filters) may be required to improve the CoM displacement estimate. Successful estimation of the CoM displacement with a single IMU will allow for simple and reliable balance assessments outside of the research laboratory. ACKNOWLEDGEMENTS AND FUNDING: Funded by NSERC.

P2-X-147: ***Evaluating the Spatial Measurement Properties of the Lean-and-Release Test for Individuals with Incomplete Spinal Cord Injuries***

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BACKGROUND AND AIM: Individuals with incomplete spinal cord injury (iSCI) are more likely to take multiple reactive steps to regain their balance compared to able-bodied individuals. Additionally, individuals with iSCI take reactive steps that are more variable in length and width than their able-bodied counterparts. A standardized approach to evaluate reactive stepping ability is the Lean-and-Release test, which simulates a forward fall from standing. A growing number of studies have used the Lean-and-Release test to evaluate reactive stepping and recently it has been used to assess the effectiveness of balance interventions for individuals with iSCI. Therefore, it is important to understand the reliability and validity of the Lean-and-Release test. In the iSCI population, the behavioural and temporal parameters of the Lean-and-Release test have been examined, but the spatial parameters have not. The aim of this study was to evaluate the test-retest reliability and convergent validity of the Lean-and-Release test's spatial parameters (i.e. step length, step width, step length variability, step width variability) for individuals with iSCI. METHODS: Ten individuals with chronic iSCI (2 males, 52.3±16.0 years old) were included in the study. To elicit reactive stepping, a horizontal cable attached at waist height was unexpectedly released once 8-12% of a participant's body weight was supported in a forward lean position (i.e. Lean-and-Release test). Each participant underwent two sessions spaced two weeks apart involving up to 10 Lean-and-Release trials in a single session. Kinematic (i.e. 3D motion capture) and kinetic (i.e. 4-cell force plate) data were recorded. Step length and width were calculated for the first reactive step of each trial. Standard deviation between trials was calculated to represent the variability in step length and width within a participant. Test-retest reliability was assessed using intraclass correlation coefficients (ICC) and convergent validity was assessed by examining the correlation with related clinical measures: gait parameters collected on an instrumented walkway, mini-Balance Evaluation Systems Test (mini-BESTest), Activities-specific Balance Confidence Scale, and lower limb strength as assessed with manual muscle testing RESULTS: Mean step length and mean step width had clinically useful test-retest reliability (ICC=0.90 and 0.76, respectively), but step length variability and step width variability did not (ICC=0.04 and 0.07 respectively). The convergent validity of mean step length only was supported by significant correlations with measures of gait (stride width: 0.80, P<0.01), balance (Mini-BESTest reactive sub-scale: -0.65, P<0.05), and leg strength (total score: -0.66, P<0.05, hip flexion: -0.89, P<0.01, knee flexion: -0.70, P<0.02). CONCLUSIONS: These findings suggest that mean step length may be a psychometrically sound measure to include in future assessments involving the Lean-and-Release test for the iSCI population.

P2-X-148: ***Improved accuracy in estimating the position of the Center of Mass through optimal merging of kinematic and forceplate measurements***

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BACKGROUND AND AIM: Stability analyses of standing and walking rely on accurate measurements of the position of the center of mass (CoM). Unfortunately, this cannot be directly measured, and is typically estimated using kinematic markers placed on the body. Various kinematic models of the CoM have been proposed, ranging from very simple (a single marker on the sacrum) to very detailed (38 markers). The accuracy of these models is however unknown. A different approach has been to estimate the CoM position through double integration of forceplate measurements. This approach is however very susceptible to drift, and usually relies on high-pass filtering the force signal with an arbitrary cutoff frequency. The aim of this study is twofold: first, to evaluate the accuracy of state-of-the-art kinematic models of the CoM; and second, to improve this accuracy by combining kinematic and forceplate measurements. METHODS: Data from a publicly available database were analyzed [3]. Two subjects performed treadmill running for one minute at 3 m/s and 4 m/s. Marker positions were smoothened to obtain smooth marker accelerations. These were then used to calculate the CoM position according to three kinematic models: 1. the state-of-the-art model, requiring 38 markers, 2. a simplified version requiring 13 markers, 3. the hip mid-poin. The CoM position was differentiated twice to obtain acceleration. Only the flight phases of running were analyzed. A Kalman filter structure was adapted to optimally combine noisy measurements of CoM position (from kinematics) and noisy measurements of CoM acceleration (from forceplates). RESULTS: During the flight phase of running, the acceleration of the CoM is equal to gravity, i.e. null in the horizontal plane and downwards of amplitude 9.81 m/s2. However, the mean acceleration calculated from all three kinematic models had a bias both in the vertical direction and in the horizontal plane. Altogether the mean error in acceleration was largest for the hip markers (4.8 m/s2), followed by the simplified model (3.7 m/s2) and the full model (2.4 m/s2). Forceplates have a much higher accuracy in measuring CoM acceleration (0.02 m/s2). Nevertheless, they tend to have small, low-frequency drift, which is drastically amplified when calculating the CoM position from double integration of acceleration. The proposed Kalman filter merges high-frequency forceplate information and low-frequency kinematic information. The cutoff frequency is automatically determined from the ratio of kinematic noise to force noise. CONCLUSIONS: State-of-the-art kinematic models of the CoM were found to have very low accuracy. On the other hand, estimating the position of the CoM from forceplates alone requires high-pass filtering the forceplate signal at an arbitrary frequency. I propose an adapted Kalman filter which optimally combines kinematic and forceplate information to improve the accuracy of CoM measurements. The code for calculating the CoM position from kinematics alone and from combining kinematic and forceplate measurements will be made available online.

P2-X-149: ***Shear wave tensiometry of the Achilles tendon to estimate muscle force and coactivation during balance perturbations***

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BACKGROUND AND AIM: Agonist-antagonist muscle coactivation is common during standing, and increases during challenging balance conditions. Increased coactivation is also associated with aging, movement disorders, and impaired balance. Quantifying muscle-tendon forces during coactivation is important to the understanding of the sensorimotor and biomechanical processes underlying balance control. However, standard inverse dynamics cannot account for muscle forces during coactivation that do not contribute to movement dynamics. Shear wave tensiometry (Martin et al. 2018) can estimate tendon force by non-invasively tracking the propagation speed of the shear waves within the tendon; squared wave speed is proportional to tendon force. Our objective was to test whether shear wave tensiometry can identify increased Achilles tendon force during muscle coactivation in reactive balance when net joint torque does not change. METHODS: Backward support-surface perturbations (displ. 12cm, vel. 24cm/s, acc. 1.6cm/s2) were delivered to 13 participants. Participants were instructed to either 'relax' or 'coactivate' lower leg muscles (while maintaining joint angles) during quiet standing. For coactivated trials, participants used visual electromyographic activity biofeedback to increase soleus muscle activation level (250% of relaxed standing). Shear wave propagation was measured in the right Achilles tendon (100Hz) produced by a tapping device driven by 50Hz square wave. Whole-body kinematics and ground reaction forces were simultaneously recorded (100Hz). For each trial Pearson correlation coefficients were evaluated between the squared wave speed time and ankle moment (estimated in Opensim) trajectories. Derived wave speed metrics (mean speed during quiet standing and maximum peak after the perturbation) during relaxed and coactivated trials were compared using paired t-tests. RESULTS: Squared wave speed closely tracked ankle moment during reactive balance recovery in 'relaxed' trials ($r=0.84\pm0.19$; Fig.1A). In 'coactivated' trials, the correlation between squared wave speed and ankle moment ($r=0.74\pm0.29$) was lower than in relaxed trials ($p=0.06$). Baseline square wave speed was greater in coactivation (1545±620m2/s2) vs relaxed (727±353m2/s2) conditions ($p=0.08$, Fig.1B), whereas ankle moments were not different across conditions ($p=0.51$). Interestingly, peak square wave speed during balance recovery was not different across conditions ($p=0.52$; Fig.1C), indicating that muscle-tendon forces were greater during coactivation prior to, but not during support-surface perturbations. CONCLUSIONS: Shear wave tensiometry can help characterize increased muscle coactivation during both standing and reactive balance response to postural perturbations. While wave speed metrics could distinguish coactivated from relaxed conditions, participant-specific calibration may be needed to assess absolute muscle-tendon force and complement inverse dynamics. This study was supported by NIH grant R01 HD90642.

P2-X-150: ***A passive sway referencing system for standing balance in the anteroposterior direction***

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BACKGROUND AND AIM: Standing balance involves the integration of multisensory cues but somatosensory cues below the ankles are sufficient to balance a body-like load in the anteroposterior direction. To alter somatosensory contributions to the anteroposterior control of balance, fundamental and clinical scientists have used sway-referencing methods that minimize ankle movements as the whole-body sways forward and back. Sway referencing about the ankles can be performed with mechatronic devices that precisely control the orientation of the support surface, resulting in minimal ankle movements despite the whole-body movements. A passive sway referencing approach involves balancing on a foam pad placed on the ground, but such methods do not precisely minimize ankle movements and lead to deformations of the support surface that make estimating the contact forces difficult. In the present study, we designed a passive sway referencing system that is low-cost and provides precise control of the relative ankle motion with respect to whole-body motion. METHODS: Our system relies on the known load stiffness properties of anteroposterior biomechanics of standing balance when assuming an inverted pendulum. The system consists of two main parts: a top part that rolls on the bottom part to sway reference ankle motion in the sagittal plane. Given that both parts are rigid, we mounted a force plate and inertial motion unit on the top part to quantify 1- the force and moments applied by the participants to the ground and 2- the orientation and angular velocity of the support surface to correct for the gravito-inertial loads acting on the force plate. To match the passive load stiffness of standing balance in the anteroposterior direction, 36 tension springs can be attached to eyebolts mounted at specific locations (25cm, 20cm, 15cm, 10cm from the axis of rotation) on the top and bottom parts to pull both parts toward each other. RESULTS: We can adjust the number and position of the springs based on the participant's mass, their center of mass height, and gravity to match their body characteristics and minimize ankle motion. Another advantage of the system is that the relative ankle rotation in space can be scaled by regulating the number of springs or their stiffness. Ideally, rigid springs mimic the normal standing balance, and a matched passive load stiffness results in a sway referenced motion. Note that the system could tolerate load stiffnesses up to 2000 Nm/rad (with a safety factor of 3.5). CONCLUSIONS: Here, we have developed a low-cost passive sway referencing system that can minimize ankle movements under a controlled condition and thus change somatosensory contributions to the anteroposterior control of standing balance. In future experiments, we will characterize the performance of the system by comparing the whole-body and ankle angle in human participants. ACKNOWLEDGEMENTS AND FUNDING: Funded by NSERC.

P2-X-151: ***Reliability of Inertial Sensors for Assessing Lower Limb Segment Angles During Gait***

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Background and Aim: Inertial measurement unit sensors (IS) are small, portable, and relatively affordable sensors that integrate accelerometers, gyroscopes, and magnetometers to capture human kinematics. Optical motion capture (MOCAP) systems are considered the 'gold standard' for recording human movement, although they require extensive set-up, cost, and time to obtain outcomes of interest (e.g., joint angles, gait speed) compared to the immediate output of IS system. Previous research has found moderate to high agreement between a commercial wireless IS system (Xsens) and MOCAP during gait, slipping and tripping, and stair climbing. Bluetooth IS have been used to evaluate gait and would allow for gait monitoring outside of the clinic and home where wireless networks are unavailable. However, there is limited knowledge regarding the validity of commercial Bluetooth IS with 'gold standard' systems. Therefore, the aim of this analysis was to examine the reliability of a customized, cost-effective Bluetooth IS system measuring lower limb segment angles during gait. Methods: Eleven young adults (27.2(3.5) y; Mean(SD)) walked at a self-selected speed on a seven meter overground walkway. We developed a custom IS system using Bluetooth IS (Wit-Motion) connected to an Android tablet. IS were placed bilaterally on the thigh and shank. Full-body kinematics were collected from MOCAP (Qualisys Motion Capture). Segment angles of the thigh and shank were calculated as the angle of the segment relative to the vertical plane for both IS and MOCAP. For MOCAP data, the thigh and shank segments were based on hip and knee markers, and knee and ankle markers, respectively. Segment angles were calculated for the right lower limb at right touchdown (RTD) and subsequent left lift off (LLO); totally 4 variables were compared between these two systems. Mean differences in segment angles between systems, correlation coefficient (R), and intra-class correlation (ICC) were used to assess agreement between IS and MOCAP. Results: All IS joint segment angles significantly correlated with MOCAP joint segment angles ($p<0.01$). R values ranged from 0.50-0.88 for all the variables; ICC values ranged from 0.57-0.92 for all the variables ($p<0.01$ for all). Mean differences between IS and MOCAP segment angles ranged from -7.29-1.52° (Table 1). Conclusions: Results indicate moderate to good reliability of our customized Bluetooth IS system when measuring segment angles during gait. IS provide a more in-depth, mechanistic analysis of gait than functional measures such as the Berg Balance Scale and Timed Up-and-Go test. Thus, IS are a promising tool for clinicians to rapidly analyze gait kinematics, which can indicate functional impairments and fall risk. Bluetooth IS could additionally be used outside of the home and clinic to assess gait kinematics during activities of daily living and community ambulation for a broader scope of monitoring and gait analysis.

P2-X-152: ***A multilevel model analysis of dynamic balance during and following a training intervention with attentional focus cues***

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Background and aim: Falls in older adults have been deemed a public health concern due to the high rate of falls. To enhance current balance training programs, we infused attentional focus (AF) cues into 12-week balance training program with older adult fallers, and followed them for 8-weeks after the training to measure retention. Our previous work showed that external focus (EF) cues led to better performance during the training and stronger retention relative to internal focus (IF) cues. However, many of the tests in our study used subjective clinical assessments or objective assessments that were not clinician friendly. To address this challenge, we also included a custom Android app that measured temporal and spatial

characteristics during a dynamic balance test (i.e., stepping-in-place). The app was designed to be an objective, portable, and cost-effective way to measure balance in field-based settings. It was hypothesized that participants in the EF group would exhibit greater improvements in temporal and spatial characteristics as measured with the app relative to the IF group. Methods: Twenty-eight adults who had fallen at least once in the past year participated, with 15 in the EF group (79.4±6.07) and 13 in the IF group (79.77±6.93). The training consisted of balancing of a wobble board for 20-minutes twice per week for 12 weeks. The EF group was told to focus on keeping the wobble board parallel to the floor and the IF group to focus on keeping their feet parallel to the floor. The smartphone app protocol consisted of a 70s stepping-in-place task in three conditions: (1) eyes open (EO), (2) eyes closed (EC), and (3) headshake (HS). Each condition was completed three times, with the average of the three trials taken as their performance. Temporal (mean stride time) and spatial (mean and SD of peak thigh flexion) were measured via the phone's sensors. Participants were assessed three times: (1) baseline, (2) after completion of training (week 12), and (3) eight weeks after training (week 20). A piecewise linear growth model was estimated using multilevel modeling to assess treatment effects on the temporal and spatial variables during the intervention (weeks 0-12) and retention periods (weeks 12-20). Results: The groups were coded IF=0, EF=1. For EC condition, there was an interaction effect of group by time for training for SD of peak flexion (β= -0.66, p= 0.045). For HS condition, there was an interaction effect of group by time for retention for SD stride time (β = -0.031, p=0.026), and approached significance for mean stride time (β = -0.062, p= 0.061). Discussion: External focus of attention reduced variability of a spatial metric during EC, as well as a temporal metric during HS. Our data show that EF training can have a positive effect on balance during training that is also retained after training. No differences were observed in EO condition, but for a community-dwelling adult population, the EO condition was likely not challenging enough to differentiate the groups.

P2-X-153: ***Nonlinear analysis of the effects of vision and postural threat on upright stance***

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BACKGROUND AND AIM: The ability to control and maintain an upright standing posture is crucial for humans interacting with their environment. Many factors, such as a fear of falling as observed when exposed to a postural threat [1], can cause changes in postural stability. The ability to quantify changes in postural stability is critical to understand psychological (and physiological) effects on balance. Therefore, the goal of the study is to use linear and nonlinear analyses to identify the effects of vision and postural threat on upright stance. METHODS: This study involves re-examining the dataset previously reported [2]. This secondary analysis was conducted as the initial analysis did not examine the sway temporal dynamics. Twenty young healthy adults stood on a force plate mounted to a hydraulic lift at two height conditions, 0.8m (LOW) and 3.2m (HIGH). Both height conditions were performed with both eyes open (EO) and closed (EC). Participants stood quietly for 60 seconds on a force plate, and centre of pressure (COP) was calculated from ground reaction forces and

moments. For the linear analyses, anterior-posterior COP root mean square (RMS) and mean power frequency (MPF) were calculated. For the nonlinear analysis, recurrence plots were generated from the COP data. These plots provided a visualization of the timepoints in which the trajectory returns to a location it has visited before. A recurrence quantification analysis (RQA) was then used to quantify the number and duration of recurrences. RQA measures included recurrence rate, determinism, entropy, and average diagonal line length. RESULTS: For the linear analyses, COP RMS showed no effect of vision or of a vision-height interaction; however, a main effect of height was observed, with sway amplitude decreasing in the HIGH compared to LOW condition. For COP MPF, main effects were found for both height and vision, with frequency increasing in the HIGH compared to LOW condition, as well as increasing in EC compared to EO. For the nonlinear analysis, main effects were found for both height and vision, with all RQA measures decreasing in the HIGH compared to LOW condition, and decreasing in EC compared to EO. CONCLUSIONS: Both linear and nonlinear analyses revealed differences across height and visual conditions. When standing at height, a decrease in amplitude and increase in frequency were observed, thought to resemble a stiffening strategy [1]. The decreases in RQA measures across height and visual conditions may provide additional evidence for a change in postural strategy. These changes across conditions might be suggestive of the participant trying to deliberately minimize their sway magnitude, but end up resulting in higher frequency and less predictable sway patterns. Given the nonlinear analysis identifies changes in visual (and height) conditions, this study shows a need to go beyond traditional linear measures when assessing balance. Nonlinear measures can enhance our understanding of postural stability and should be used in future analyses with the potential to identify changes that linear measures may not detect. ACKNOWLEDGEMENTS AND FUNDING: Funded by VISTA and NSERC. REFERENCES: [1] Carpenter et al, Exp Brain Res, 2001; [2] Cleworth & Carpenter, Neurosci Lett, 2016.

P2-X-154: ***Instrumented up-on-the-toes test: use of IMUs as a valid alternative to using a force platform***

Sarah Zahid[1], John Buckley[1], Yunus Celik[2], Alan Godfrey[2]

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BACKGROUND AND AIM: The mechanical output at the ankle provides a key contribution to everyday activities, particularly step and stair ascent and descent. Older adults experience age-related decline in ankle functioning, lead to an increased risk of falls on steps and stairs. The rising up-on-the-toes (UTT) 30 sec test can assess ankle muscle strength/function and endurance; with no. of UTT movements completed being main outcome. This study describes how inertial measurement units (IMUs) can be used to assess the UTT 30 sec test by determining whether they provide metrics that are comparable to those gained from a force platform (FP). A secondary aim was to describe how IMUs can be used to assess the movement dynamics and postural stability when performing a single UTT movement which is held for 5 seconds. METHODS: From standing position on FP, twenty adults (26.2 ± 7.7 years) completed UTT 30 sec test, at a comfortable speed until indicated to stop (after 30 sec). For the single UTT, participants rose UTT as fast as possible and attempted to hold position for 5 sec. Data from both the FP and IMUs were collected at 100Hz for the entire

UTT protocol. Parameters extracted manually from FP data include number of UTT movements, mean and SD in peak CoPyVel, peak CoPyVel, peak CoPyAccel and Fz impulse. Parameters (including plantarflexion angular velocity) were extracted from the IMUs using a MATLAB based automatic segmentation and analysis algorithm, excluding peaks (noise) above a visually-set threshold of 150°/s. RESULTS: We found that IMUs assessment detected the same number of attempted UTT movements (average 23.7) within 30 sec as that observed by the researcher (23.6) and determined by FP (23.6) (R = 0.99), and provided an objective means to discount any of the attempted UTT movements that were not completed 'fully' (average 19.9 for both IMUs and FP): this was something the observer was unable to do. There was a moderate correlation between peak plantarflexion angular velocity and CoPy velocity during the rise to toes (R=0.46). For the single UTT test, there were strong correlations between participants' plantarflexion angular velocity and peak CoPy velocity (R = 0.74), and plantarflexion angular velocity and Fz impulse (R = 0.80); a strong correlation between the SD in L5 acceleration and the SD in CoPy velocity was (R = 0.72, and a moderate correlation between peak L5 upward acceleration and peak CoPy acceleration (R = 0.60). CONCLUSIONS: Findings highlight that use of IMUs can provide robust and objective assessment of the UTT tests by yielding parameters that are comparable to those determined using a FP. Hence, IMUs can be a valid alternative to the 'gold-standard' approach of using a FP.

Y - Vestibular function and disorders

P2-Y-155: ***Does dizziness predict falls in older adults? A longditudinal study using data from the English Longitudinal Study of Ageing (ELSA)***

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BACKGROUND AND AIM: Falls represent a significant social and economic problem, and 1/3 of people over 65-years old fall every year. Dizziness affects approximately 1/3 of older adults and is linked with increased falls risk. However, previous studies have not considered other known falls risk factors, particularly a history of previous falls when making these assertations. The current study aimed to ascertain if dizziness is an independent risk factor for falling. METHOD: Data was analysed from ELSA over a 10-year period (2004/5-2014/5) to determine if the severity of dizziness reported by participants was associated with increased falls risk over this period. Participants were asked at baseline "how often do you experience dizziness when walking on a level surface?". They were followed up biennially to ascertain falls reported. Falls were classified as any fall, recurrent fall (>1 fall in 2 years), injurious fall (requiring medical assistance) or new fall (fall following no previous reports of falling). RESULTS: A logistic regression model showed that, when accounting for known risk factors for falling (Participant's age, sex, medical history, frailty level (using the Fried phenotype), physical activity level and previous falls history), those reporting dizziness were significantly more likely to report recurrent falls in the following 2 (OR 1.398, p=0.014), 4 (OR 9.734, p=0.009) and 6 years (OR 9.486, p=0.024) than those never reporting dizziness. However, no

association was observed at any stage with other categories of falls: new falls, injurious falls, or all falls. CONCLUSIONS: Dizziness is independently predictive of recurrent falls over a 6-year period. Recurrent falls are more likely to result in significant morbidity and mortality and associated personal and economic consequences. Clinicians should routinely ask older adults how often they experience dizziness to enable earlier intervention of falls prevention measures. ACKNOWLEDGMENTS AND FUNDING: Hannah Barbour's PhD is funded by the Brunel Partners Academic Centre for Health Sciences

P2-Y-156: ***Exploring the usefulness of auditory cues in maintaining heading direction during dynamic postural task***

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Background. Visual, vestibular, and somatosensory cues and more recently auditory cues have been shown to influence postural control. These sensory cues are combined and used to control body orientation and motion in space. Providing auditory cues to hearing and vestibular impaired subjects can help reduce sway in a static postural task. However, the effect of auditory cues during a dynamic postural task is not as well understood. Here, we measured the influence of a spatially fixed sound source on heading direction in healthy subjects with induced vestibular asymmetry using DC galvanic vestibular stimulation (GVS). We also evaluated the influence of prior awareness of the sound source on the use of auditory cues during a dynamic postural control task. Methods. Twenty young healthy subjects were divided evenly in two groups (instruction 1 and 2) and tested while initially facing a stationary click-train sound source that was turned on or off on individual trials. The first group performed a stepping-in-place task (50-steps, arms at the sides), blindfolded with the head tilted forward to produce a GVS-evoked yaw rotation signal with instructions to maintain the starting position/orientation (no specific information about the sound source).The second group performed the same task except they were additionally informed that the sound source source was not moving. The task was repeated under two auditory conditions [with sound or without sound (earplugs+no auditory stimulation)] and three vestibular conditions [no GVS; GVS anode right ear; GVS anode left ear]. Each condition was assessed three times and presentation of conditions was randomized within each block. Angular deviation at head level in the traverse plane relative to the sound source was measured during each trial using a motion capture system (Optotrack). Difference between with and without auditory input was calculated for GVS anode left and GVS anode right conditions using median of all three trials. Positive differences indicated reduced angle of deviation with auditory cues. Results. Repeated-measure ANOVA 2 groups (instructions 1 and 2) as a between factor with 2 GVS conditions (Anode: left and right) as a within factor revealed significantly larger influence of auditory input on head rotation when anode was on left mastoid as opposed to the right [$p=0.027$]. However, no significant group effect was observed [$p=0.179$]. Finally, a one-sample t-test revealed that difference induced by auditory cues was significant (different from zero) only for the anode left condition [$p=0.039$].

Conclusion. The results showed a significant influence of auditory input only for the anode left GVS condition and did not show evidence that angular deviation was influenced by prior awareness that the sound source was stationary.The results from this exploratory study opens interesting questions about the mechanisms regulating the use of auditory cues during dynamic postural control tasks.

Z - Visual function and disorders

P2-Z-157: ***The role of feedback and feedforward visuomotor control during locomotor learning***

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BACKGROUND AND AIM: Vision plays a vital role in executing precision walking, such as hiking on irregular terrain, where step location matters. During precision walking, gaze fixations on the walking surface are used to make corrective actions to the current step and to plan future limb trajectories and step locations (Patla 2003). How and when these feedback and feedforward visuomotor control strategies are used depends on the task and the skill of the individual. Skilled individuals emphasize feedforward visuomotor control more than their novice counterparts (Sailer et al. 2005). However, how this difference arises is unknown. Here, we examined how reliance on these two visuomotor control strategies adapt during a locomotor learning task. We hypothesized that people would increase reliance on feedforward visuomotor control strategies with training. METHODS: Participants (N=7) completed a treadmill-based target stepping task in which they were asked to accurately step on small moving targets projected onto the treadmill surface. Stepping accuracy and gaze fixation were measured across three visual conditions: 1) full vision, 2) feedback-only: targets only visible within 1.5 steps of the participant, and 3) feedforward-only: targets only visible greater than 1.5 steps ahead of the participant. We compared stepping accuracy during the two limited vision conditions to the full vision condition to determine a participant's reliance upon each visuomotor strategy. Additionally, participants' fixation distance was used to determine which visuomotor strategy their gaze behavior suggested. RESULTS: During the full vision conditions, we found that with training, participants decreased their step error (22% more accurate, $p<0.05$) and increased their fixation distance (36% farther ahead, $p<0.05$) post-training compared to pre-training (Figure 1). Together, these results suggest that step accuracy benefits from an increased emphasis on feedforward visuomotor control. However, when we compared the change in reliance (as determined by step accuracy during two limited vision conditions), we found that participant reliance on feedback visuomotor control increased (16%) while reliance on feedforward visuomotor control slightly decreased (-3%) with training. Therefore, based on step accuracy, participants relied upon feedback visuomotor control more to perform the task, even after training. CONCLUSIONS: The conflicting results presented here suggest different roles for feedback and feedforward visuomotor control strategies. Feedback visuomotor control is necessary to perform a target stepping task, even after training. While feedforward visuomotor control strategies are necessary for improving at the task. Future research should further investigate the balance between feedback and feedforward visuomotor control strategies, and how to utilize these in training and rehabilitation. ACKNOWLEDGEMENTS AND FUNDING: Funding was provided by the Northwestern Nicholson Fellowship and ACSM Foundation Doctoral Student Research Grant.

P2-Z-158: ***Visual Motion Detection during Walking and Standing***

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Background and Aims: Vision plays an important role in balance control for standing and walking by providing information about movement relative to the environment via optical flow. Visual acuity tests show positive correlations with fall risk and balance outcomes, indicating better visual acuity is associated with better balance control. Visual acuity tests include measurements of contrast sensitivity, depth perception, visual field recognition of light stimuli, and motion detection thresholds. A visual motion detection threshold is an estimate of the smallest movement of the visual field detectable by the participant, typically estimated while sitting in a stable position with minimal head movement. During standing and walking, the head moves to a considerable degree. It is currently unknown how these head movements affect visual motion detection thresholds. In this study we aim to: 1) test whether a visual motion detection threshold can be reliably measured during standing and walking; and 2) investigate whether visual motion detection thresholds differ during standing and walking. Methods: A pilot cohort of seven subjects stood on and walked along a self-paced, instrumented treadmill inside a virtual environment displayed on a large dome. Each participant performed two walking and two standing tests, in alternating order with counter-balanced starting condition. Each test consisted of 100 trials for a total of 400 trials. The visual scene included a tunnel of randomly spaced white cubes on a dark background which occupy the participants full range of view. Movement stimuli consisted of the complete scene rotating around the anterior-posterior axis of the treadmill. Participants performed a 2-alternative forced choice experiment in which they verbally responded "left" or "right" depending on if they perceived the virtual scene rotate to the left or right. A 6 down 1 up adaptive staircase algorithm was used to change the amplitude of the rotation: decreasing amplitude after answering 6 correct in a row and increasing amplitude after answering one incorrect. A psychometric fit to the participants' binary responses provided an estimate for the detection threshold. Results: Preliminary analysis of the pilot cohort show a moderate correlation between thresholds obtained between walking trials and a weak correlation between thresholds found between standing trials. Thresholds obtained during walking are on average higher than those obtained from standing indicating that movement is better detected during standing versus walking. Conclusion: Visual motion detection thresholds can be obtained during both walking and standing. These results indicate that the reliability of visual information for balance control may be different between standing and walking. An individual's threshold of motion detection may be an indicator of how much their balance control system is influenced by visual perturbations and could be of use as a clinical assessment tool.

P2-Z-159: ***Phone reading whilst walking: image stabilisation strategies and their relationship with visual performance***

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BACKGROUND AND AIM: Pedestrians commonly reduce their walking speed when a handheld phone is concurrently viewed. Due to being in motion, the visual constraints related to the task of identifying what is presented on the screen may explain the slowing of walking. This study determines how walking-induced phone motion affects the ability to read on-screen information. METHODS: Phone-reading performance (PRP) was assessed during treadmill gait at Slow, Customary and Fast walking speeds. The fastest speed was repeated, wearing an elbow brace (Braced) or with the phone mounted stationary (Fixed). An audible cue ('beep') indicated participants had 2s to lift/view the phone and read aloud a series of digits. PRP was the number of digits read correctly. Each condition was repeated 5 times. A 3D motion-tracking system recorded phone and head motion. A subject-calibration procedure recorded the offset angles between the head-orientation and a calibration marker placed 1.5m in front of the participant, vertically and horizontally aligned with the eyes' midpoint. Subsequent tracking of the phone screen in the head's reference frame allowed determination of the assumed gaze angles in the up-down (UDGAZE) and right-left (RLGAZE) directions (Fig. 1A). The acceleration variability of changes in assumed gaze angles and in the assumed gaze distance (DGAZE) were analysed for each of the reading periods and compared across conditions. RESULTS (Fig. 1 B-E): Walking condition affected the phone's relative motion ($p < 0.001$); post-hoc analysis indicated that acceleration variability for the Fast, Fixed and Braced conditions were increased compared to that for the Slow and Customary conditions ($p \leq 0.05$). PRP was found to decrease with walking speed, particularly for the Braced and Fixed conditions ($p = 0.022$). There was an inverse association between phone acceleration variability and PRP ($p = 0.02$). CONCLUSIONS: At slower speeds, the relative phone motion was smoother/more regular, i.e., it was better coupled with motion of the head. Good coupling makes fewer demands on the oculomotor system by ensuring that the retinal image is stable enough to allow legibility of the information presented on the screen. These findings help explain why walking speed slows when viewing a hand-held phone. ACKNOWLEDGEMENTS AND FUNDING: This study was funded by UK College of Optometrists PhD studentship.

P2-Z-160: ***Links Between Central Visual Field Loss and Movement Processing During Locomotion***

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BACKGROUND & AIM: Age related macular degeneration (AMD) affects nearly 200 million people worldwide (Wong et al. 2014) and is the leading cause of central visual field loss (CFL). While much is known about the visual limitations associated with this condition, one of its more dangerous and less studied outcomes is the increase in the risk of falls, which can be debilitating and even deadly in older adults. Recent studies suggest that older adults deemed to be at an increased risk of falls may alter how they think about and process their movements during walking (Wong et al. 2008). Specifically, heightened conscious movement processing and non-walking related ruminations are observed; both of which are linked to increased fall-related anxiety and increased movement errors when walking (Ellmers et al. 2019). These behaviors are also linked with maladaptive visual search strategies (i.e., reducing previewing of an intended walking path) during locomotion that may further increase the risk of trips, slips and falls. The current study sought to evaluate if similar conscious movement processes emerge in individuals with CFL and if these changes are related to the extent of visual deficit. METHODS: To assess changes in movement processing we used three Gait-Specific Attentional Profile (G-SAP, Young et al. 2020) sub-scales: conscious movement processing (CMP), anxiety, and rumination. The total score for each category was calculated separately for each participant and correlated with measures of binocular contrast sensitivity (MARS letter test), Snellen visual acuity (logMAR) of the better eye, and the ratio of visual acuity between the eyes. A total of 29 individuals with CFL (18 F, age: 76.6 ± 18.1) and 29 healthy-sighted age-matched controls (22 F, age: 75.1 ± 16.2) were surveyed for the study. RESULTS: We found that while there was no significant increase in CFL G-SAP scores compared to controls (ANCOVA, $p>0.2$), binocular contrast sensitivity was a significant predictor of increases in gait-specific anxiety ($p=0.02$) and CMP ($p = 0.01$) during locomotion in individuals with CFL. which is likely to affect gait behaviors (both gait and oculomotor). CONCLUSIONS: Increases in walking-related anxiety and CMP are likely to affect gait behaviors, which can be further compounded by oculomotor deficits in those with CFL. These findings suggest that further research is needed to identify changes in gaze and posture strategies and whether they are adaptive or, more likely, maladaptive and how they contribute to fall risk in those with CFL.

Poster Session 3

A - Activity monitoring

P3-A-1: ***Changes in the sleep patterns of preschool aged children: The Guelph Family Health Study***

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BACKGROUND AND AIM: Childhood obesity is proliferating globally at an alarming rate (Kopp et al., 2019) and has been largely attributed to changes in movement patterns. Sleep, physical activity and sedentary behaviour comprise the 24-hour movement-nonmovement continuum (Tremblay et al., 2016). Understanding how movements behaviours evolve during development is imperative if we wish to identify disadvantageous health behaviours in young children. Our primary aim was to conduct a sub-sample analysis for sleep patterns of preschool children enrolled in the Guelph Family Health study (GFHS) at baseline (BL) and 6-months (6M) to determine if they met World Health Organization (WHO) sleep guidelines. Data was also examined to elucidate whether differences between the sexes and health intervention groups were present. METHODS: The GFHS is a longitudinal study that aims to evaluate the effectiveness of a family-based health intervention (bi-weekly emails and 4 home visits from a health educator). At both BL and 6M, children wore an Actigraph wGT3X-BT (100 Hz) accelerometer on their right hip, 7 days, 24 hours/day. Data was analyzed using Actigraph software; Sadeh et al (1994) algorithm was used to perform sleep scoring and the Tudor-Locke (2014) algorithm was applied to calculate sleep metrics. This included total sleep time (TST), sleep efficiency, wake after sleep onset, sleep onset and wake-up times. Children were classified as meeting the WHO guidelines if they slept >10 hours a night. A 3-way mixed-model ANOVA was performed to assess the effect of time-point (BL, FFU), sex (female, male) and intervention (control, intervention). RESULTS:Forty-three typically developing preschool children (mean age=4.41±0.37yrs; 23M; 28 control) were included. It was found that within this subsample, 15 of the children (6 males) met the WHO guidelines at BL; 9 children met guidelines at 6M (2 males) and only 7 children (2 males) met guidelines at both time points. The ANOVA revealed a significant main effect of time-point for TST [F(1, 39)=4.217 (p=0.047)] and wake-up time [F(1, 39)=10.394 (p=0.003)]. The pairwise comparison revealed that compared to BL, TST was significantly reduced at 6M and wake-up times were significantly earlier. Furthermore, a significant main effect of sex for TST [F(1, 39)=6.176 (p=0.017)] and wake-up time [F(1, 39)=5.382 (p=0.026)] was found. Additionally, females had significantly increased TST and wakeup times were significantly later when compared to males. No main effect of intervention or interaction effects were observed. CONCLUSIONS: According to this analysis, preschool children's sleep decreases and wake-up times become earlier as they age; these findings are consistent with previous research (Kaar et al., 2020). Future research will investigate whether these trends persist during development and possible links to physical activity and adiposity metrics. FUNDING: Canada Foundation for Innovation; Canadian Institutes of Health Research.

P3-A-2: ***How older adults walk in daily life - The Trondheim 70+ study***

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BACKGROUND AND AIM: Gait assessment can provide valuable information about people's physical function. Traditionally, this consisted largely of snap-shot performances in controlled laboratory settings. Recent developments in wearable sensor technology allow for continuous gait monitoring in daily life over multiple days, but current knowledge about how humans walk is still limited to studies with small sample size and little variation in age and function [1]. The Trondheim 70+ study recruited a large sample of older adults across the entire spectrum of the population, irrespective of living situation and health status. The aim of the current study is to present the first results on gait, focusing on walking bouts and cadence in daily life, and gait speed as measured in the lab. METHODS: In total 1745 older people were recruited, ranging from fittest-to-frailest. Participants either came to a field station for testing or received a (care) home visit from trained personnel. The assessment protocol included SPPB, MoCA, questionnaires and clinical tests. Daily life activity was monitored for one week in a subset of 1330 participants, using two Axivity AX3 sensors attached to the lower back and thigh. From the raw acceleration signals, walking bouts were identified and their duration and cadence calculated [2]. Further analyses will focus on locomotion characteristics such as total locomotion time and daily-life performance-related metrics, as well as the relationship between 'in lab' assessment of gait speed (i.e., capacity), and 'real-life' walking behavior (i.e., performance) [3]. RESULTS: Valid activity data from 1306 participants (715 women, 54.7%) were included in the analyses. Participants varied widely in age (mean 77.5 yrs, range 70 - 105), health and physical function, with gait speed in the lab varying from 0.14 m/s to 1.85 m/s (mean 0.98, SD 0.28 m/s). Real world activity data showed that the number of walking bouts during a day varied greatly, from 5 to 6588 (mean 1864, SD 987). Walking bouts had a mean duration of 3 to 56 seconds (mean 13.3, SD 5.2), while maximum cadence ranged from 95 to 176 steps/min (mean 134, SD 11). CONCLUSIONS: The current study provides a unique picture of how older adults actually walk in daily life, opening up possibilities for future research to investigate associations with other health-related aspects. [1] Orendurff et al., J Rehabilitation Research & Development 2008, 45(7):1077-1090. [2] Paraschiv-Ionescu et al. J Neuroengineering and Rehabilitation 2019, 16(1): 24. [3] Paraschiv-Ionescu et al. Gerontology 2018, 64(6): 603-611.

P3-A-3: ***Smart Belt Recognition of Serious Hip Impacting Fall Motions***

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Serious injuries resulting from a fall are a growing problem in the older adult population. Efforts to mitigate fall injuries have been focused on fall risk mitigation strategies embedded into national and worldwide efforts. Though interdisciplinary management of the factors that contribute to fall risk have been shown to reduce falls, the rate of serious injuries from falls in the vulnerable population of those most at risk has not been reduced with the current strategies. Advancement in technology has enabled development of wearable sensors for real time application of injury avoidance. The Tango Belt utilizes 3D sensors to continuously monitor the motion wearers perform in order to identify serious hip-impacting fall motion for action. With the recognition of motion in-action that would likely result in a serious, hip-impacting fall the Smart Belt will deploy an airbag anatomically designed to surround both hips before the individual strikes the ground. Wear time of the sensor has educated the algorithm in discerning fall motions that would most likely result in a serious injury to the hip for activation of the airbag at the appropriate time needed. Motions which result in a hip fracture specifically identified and very recently verified in research, are required to trigger airbag deployment. Information regarding the acceleration at which the individual is moving in the fall motion further offers decision to the wearable system as to whether airbag deployment is indicated. Finally, the inability to control the movement within the fall is analyzed by the sensors to complete the in-dwelling automatic deployment of the airbag from the Tango Belt. Laboratory testing of the sensor system followed by collective real-user wear time of > 70,000 hours in multiple settings has further strengthened the serious hip-impacting fall sensing algorithm in the wearable. The poster will share the algorithm development as well as outcomes of fall motions produced in laboratory and real-world falls.

P3-A-4: ***Classification of daily physical behavior using raw accelerometry in older adults: a validation study***

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BACKGROUND AND AIM: Older adults over 70 years are a heterogeneous group regarding physical function, health, and level of daily physical activity. Due to this, accurately identifying categories of physical behavior from activity measurements may be more challenging in older adults compared to younger adults. Raw accelerometry measurements combined with machine learning (ML) models may contribute to detailed knowledge of daily physical behavior that can be useful to study in relation to different health outcomes in older adults. However, most of the existing approaches for objective measurement of physical behavior are developed and validated on datasets collected from younger adults. It is an open question whether such models accurately identify the daily living activities walking, standing, sitting, and lying in a heterogenous (fit-to-frail) sample of older adults. Hence, this study aims to evaluate the performance of an activity type recognition ML model for classification of daily physical behavior in older adults. METHODS: A convenience sample of 18 older adults aged between 70 and 95 years (79.6 ± 7.6 years; 50% female) with a wide range of physical function (5 participants used walking aids) were included. Participants were equipped with two Axivity AX3 accelerometers (thigh and lower back) and a chest-mounted GoPro Hero 8 camera pointing downwards filming only abdomen and lower limbs. Participants performed a semi-structured free-living validation protocol including several repetitions of the daily living activities walking, standing, sitting, and lying both inside and outside nearby the participants'

own homes. Video recordings were labelled frame by frame (25 frames per second) according to pre-defined activity definitions. The video analysis was used as the gold standard for the classification of the physical behavior identified with an ML model, previously developed on training data from young- and middle-aged adults. RESULTS: Agreement between the gold standard labelled accelerometer data and output from the ML model for classification of daily physical behavior will be analyzed by generating confusion matrices. Overall accuracy, and activity type specific sensitivity, specificity, and positive predictive value will be calculated. Results will be presented at the conference. CONCLUSIONS: From this study we will be able to evaluate the performance of an activity type recognition ML model for classification of daily physical behavior in older adults. If the results reveal a need for age-specific ML models for accurate monitoring of physical behavior in older adults, this study offers a unique dataset for further development of the ML model. A validated ML model for fit-to-frail older adults may contribute to accurate and detailed knowledge of daily physical behavior from activity measurements that is essential for future research.

B - Adaptation, learning, plasticity and compensation

P3-B-5: *VR Walk - A Virtual Reality-based Exergame for Rehabilitation Purposes*

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Background and aim: Exergames are playing a greater role in rehabilitation settings. Previously, commercial games have dominated, but increasingly, bespoke games for specific rehabilitation contexts are emerging. The virtual reality-based exergame VR Walk is being developed with the aim of improving balance and mobility for different clinical groups through engaging and motivational motor-cognitive training. Methods: The exergame VR Walk is developed in an interprofessional team including health (scientists and clinicians) and computer science, following a loop-based iterative design approach including prototyping, minimal viable product, validating, evaluation and design/development phase. The first validating phase is performed as a cross-sectional repeated-measure design, with healthy adults being tested on one occasion under different tasks and environmental constraints. Gait patterns were measured using accelerometer, and simulator sickness was evaluated using the Simulator Sickness Questionnaire. Further projects, where the exergame is validated for clinical groups, are planned. Results: The current version of VR Walk is a head mounted display-based exergame for use on a treadmill. The virtual environment is set to resemble a Mediterranean area and the main objective is to walk on a virtual path while avoiding obstacles and performing tasks of perceptual, cognitive, and motor characteristics. Six tasks with difficulty adjustments are developed; Path width, Glass bridge, Coin collection, Balance ball, Footsteps and Memorize. In the first validating phase, testing 29 healthy adults, we found that gait patterns were impacted by solving motor tasks, and by environmental constraints, suggesting increased need for balance control among healthy individuals. No

increase in Simulator Sickness symptoms occurred. As for further validating of the exergame for clinical groups, the exergame is included in an ongoing project investigating the impact of VR-based balance training among elderly with hearing loss, and in a planned project investigating the impact of VR-based gait rehabilitation on motor-, cognitive- and social skills among prematurely born youth. Conclusions: The development and investigation of a VR-based exergame for rehabilitation purposes is ongoing, and current findings show positive effects of interprofessional collaboration and the use of iterative design approach for development of technological advancements in rehabilitation.

P3-B-6: ***Adaptation effects of continuous and discrete visual feedback training on static postural control: a preliminary study***

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BACKGROUND AND AIM: Augmented visual biofeedback (VF) training is well-known as an effective rehabilitation method to improve postural control. Whereas several studies have shown that the VF training induces the tendency for visual input to hold priority in perception, as called visual dominance, and prevent the motor adaptation, the discrete VF training showed the adaptation effects on bimanual movements. Recently, we showed the adaptation effects of dynamic postural control, that is, a spatial accuracy on voluntarily body sway relative to a moving target was improved using the discrete VF training, but not using the continuous VF training. However, it is unknown whether the similar adaptation effects of static postural control using the discrete VF training would emerge. Therefore, this study aimed to compare the adaptation effects using continuous VF training to that using discrete VF training to improve static postural control. METHODS: We used a randomized, single-blinded, cross-over design, in 8 healthy young adults. Participants were asked to stand still on a firm surface with continuous and discrete VF in the training session, with an 8-week washout period. The real displacements of the center of pressure (COP), measured by a force plate, were displayed on a monitor as a yellow point during both VF training. However, during the discrete VF training, participants received this feedback only when the COP displacement exceeded 60% confidence ellipse area of the COP sway. During the standing tests with eyes open, participants gazed at a gray monitor without any VF information. In the test session before and after the training session, the 95% confidence ellipse area of the COP sway was measured both on firm and foam surfaces with eyes open and closed. In addition, the Romberg ratio (RR) was calculated as the formula: sway area with eyes closed was divided by that with eyes open on both firm and foam surfaces. We used a linear mixed-model that included fixed effects (kind of feedback, order, and period) and random effects (participants) for the statistical analysis. RESULTS: The COP sway area both on the firm and foam surfaces with eyes closed significantly reduced after the discrete VF training, but not the continuous VF training, compared to before the VF training ($p=0.01$ and $p<0.01$, respectively). On the other hand, the sway area with eyes open and RR both on the firm and foam surfaces after both VF training did not change compared to before the VF training. CONCLUSIONS: Our findings suggest that the adaptive effect of static postural control is

improved by discrete VF training, but not by continuous VF training in the short term. It may be explained that discrete VF training reduces the impact of visual dominance and strengthen the linkage between VF and vestibular and/or proprioceptive sensory information.

P3-B-7: ***Rhythmic auditory stimulation enhances adaptation and retention effects by reducing common neural drives to lower limb muscles during gait adaptation***

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BACKGROUND AND AIM: Gait adaptation is a motor learning process with practice dependent alteration in response to a novel perturbation during gait. Rhythmic auditory stimulation (RAS) improves gait speed and symmetry in neurological patients with asymmetric gait patterns; however, its effect on enhancement of gait adaptation remains unclear. We investigated the effects of RAS during gait adaptation on enhancement of adaptation and retention. In addition, to investigate cortical involvement during gait adaptation with RAS, we used coherence analyses of paired surface electromyographic (EMG) recordings. METHODS: Twenty healthy young adults were subjected to consecutive treadmill gait measurements: baseline gait for 5 min, gait with the perturbation of resisting forward movement of the right leg during the swing phase (adaptation period) with or without RAS (RAS or no-RAS condition) for 5 or 10 min (short or long condition), gait without the perturbation for 5 min (de-adaptation period), gait with the perturbation for another 5 min (re-adaptation period), and post-adaptation gait without the perturbation for 5 min. Subjects randomly experienced four conditions on four different days. Gait symmetries of swing phase durations and step lengths were calculated during late baseline (LB), adaptation (LA), de-adaptation, and re-adaptation; and early adaptation (EA), de-adaptation (ED), re-adaptation (ER), and post-adaptation. EMG-EMG coherence was calculated from the proximal and distal parts of the rectus femoris muscle (RF-RF) and the semitendinosus and biceps femoris muscles (ST-BF). The areas under the coherence curve were calculated in the beta band (15-35 Hz) during the LB, EA, and LA periods in each condition. All paired EMG-EMG coherence areas in the EA and LA periods were calculated as the ratio of the EA and LA values divided by the LB value. RESULTS: Swing phase and step length symmetry was significantly greater in the RAS conditions than in the no-RAS conditions in the EA and LA periods. After- and retention effects on gait symmetry were significantly greater in the RAS conditions than in the no-RAS conditions in the ED and ER periods, respectively. In the ER period, while the long condition had significantly greater retention effects than those in the short condition in the no-RAS condition, there were no significant differences in retention effects between the short and long RAS conditions. RF-RF coherence in the beta band during the swing phase on the perturbed side was significantly lower in the RAS conditions than in the no-RAS conditions in the EA and LA periods. CONCLUSIONS: RAS improved gait symmetry during the adaptation periods, which accelerated the increased after- and retention effects. RAS may enhance learning efficiency by reducing cortical involvement during gait adaptation, which may explain our result of the same retention effects on gait symmetry during short and long RAS conditions. ACKNOWLEDGEMENTS AND FUNDING:

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P3-B-8: ***Compensatory movement strategies when adapting to walking with an anterior or posterior elastic perturbation at the wrist***

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Background and Aim: People rapidly adapt to unilateral lower limb resistance perturbations during the swing phase of locomotion, and show brief movement aftereffects after the perturbation is removed, implicating combined feedforward and feedback control of the legs during walking. The purpose of this study was to determine whether similar control mechanisms affect upper limb adaptation to unilateral resistance, as well as to determine if these adaptations differ between anterior and posterior-directed perturbations. Methods: Thirteen healthy young adults walked on a treadmill during two laboratory sessions, each involving a perturbation in either the anterior or posterior direction. Perturbations were applied to the right wrist using elastic tubing attached to an external frame. Participants were asked to "resist the force to swing their arms normally" throughout the perturbation. Each session consisted of walking on a treadmill for three continuous conditions: baseline walking (2 min), perturbed walking adaptation (10 min), and baseline walking readaptation (5 min). Full-body kinematic data were used to determine: 1) Arm anterior-posterior excursion; 2) Peak anterior and posterior displacements of the arms; and 3) Temporal coordination of limb pairs by identifying phase shifts between the fundamental harmonics of the limb trajectories. Variables were compared across five windows: final 10 strides of baseline walking (Walk), initial 10 strides of adaptation (early adaptation: E-AD), final 10 strides of adaptation (late adaptation: L-AD), initial 10 strides of readaptation (early readaptation: E-RE), and the final 10 strides of readaptation (late readaptation: L-RE). Results: Magnitude of the perturbed right arm excursion did not change for either perturbation direction. However, there were anterior and posterior shifts of the right arm trajectory during E-AD and L-AD with anterior and posterior perturbations, respectively. Magnitude of the non-perturbed left arm excursion was greater in E-AD and L-AD for both perturbation directions, which was driven by the left arm peak position swinging further backward in both perturbation conditions. Elastic perturbations also produced a phase lead of the right arm with respect to the left leg during L-AD, and a phase lead of the left arm with respect to the right leg during E-RE for both anterior and posterior perturbation directions. Conclusions: In contrast with studies on the lower limb, elastic force perturbations led to minimal changes in the perturbed limb and the relatively large compensations of the non-perturbed limb, with increased phase leads in the left arm suggesting altered feedforward control. These differences are likely due to differing task constraints between upper and lower limbs during locomotion. Adaptations were similar for the anterior and posterior-directed perturbations, highlighting the robust compensatory actions of the non-perturbed upper limb to maintain a stable walking pattern.

C – Aging

P3-C-9: ***Older adults standing balance is not compromised by their greater head rotation when tracking a horizontally moving visual target***

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BACKGROUND AND AIM: Fixating at a stationary visual target reduces standing postural sway. Smooth pursuit eye movements on the other hand, destabilize standing balance but to a similar extent in young and older adults [1] . We assumed that the absence of an age effect is due to the immobilisation of the head during the smooth pursuit task. The present study examined the effects of gaze pursuit of a horizontally moving visual target without restricting the head movement, on the standing balance of young and older adults. We predicted that standing balance is compromised to a greater extent in older than young adults by the gaze pursuit task due to their greater head contribution to the tracking of the moving target. METHODS: Twenty-two older (72.07+8.32 years, 12M/10F) and 24 young adults (24.6 + 4.19 years, 12M/11F) stood (normal bipedal stance) on a force platform (Bertec Balance Plate) in front of a 60-inch monitor (distance from monitor = 1.95m), in two visual conditions: fixation and gaze pursuit. During fixation, participants fixated a stationary target for 30´´whereas during gaze pursuit participants visually tracked a target moving horizontally at constant velocity (15.96o/s) and amplitude (31.9°) for 60´´(Fig 1a). In addition to standing balance, head and shoulder rotations were recorded with the Vicon motion analysis system while gaze was captured by the Pupil Labs Invisible mobile visual tracking system. RESULTS: Postural sway increased during gaze pursuit compared to fixation (CoP velocity ML: $F(1,43)=18.556$, $p<.001$, $h2=.301$; CoP path: $F(1,43)=23.53$, $p<.001$, $h2=.354$) while the induced destabilizing effect was greater in older compared to young adults (CoP path : $t(21) = 4.558$, $p<.001$). Moreover, older adults pursued the moving target employing greater head yaw rotation compared to young participants ($t(43)=2.852$, $p=.007$; Fig 1b)). When the groups were sub-divided using the group median to those employing the head to pursue the target (head-free group) and those keeping the head relatively stable (head-fixed group) during gaze tracking, no significant between group differences were noted in the postural sway measures ($p>.05$). No differences in the visuo-motor accuracy of gaze tracking were found between age groups ($p>.05$). CONCLUSIONS : When the head is free to move during gaze pursuit of a moving target, older adults engage in greater head rotation to accurately track the moving target possibly to compensate for their age-related deficits in smooth pursuit eye movement [2]. However, this strategy does not seem to have a negative impact on standing balance increasing thus the risk of falling in older adults. [1] N.M. Thomas et al Eye movements affect postural control in young and older females, Front. Aging Neurosci. 8 (2016) 1-11. [2] Moschner, Baloh, Age-related changes in visual tracking, (1994), Gerontol ;49(5):M235-8 Fig1:a) experimental Setup b)head yaw rotation for young (top) and older (bottom) participants

P3-C-10: ***The link between sleep and gait through the aging process***

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Background: Older adults with sleep complaints are at a four-fold risk of falls compared with those without sleep complaints. Recent studies demonstrate comorbidity between gait and sleep, both are essential, modifiable, and age-sensitive functions. Deficiencies in each are considered hallmarks of the aging process and are associated with significant and common deterioration in health and functional outcomes, including an increased risk of falls. However, most studies were conducted on older adults, whereas studies on middle-aged adults when fall prevention programs can be implemented are lacking. Objective: To explore the link between sleep quality and gait among community-dwelling middle-aged adults. Method: One hundred and three adults (mean age 59.3, SD=7) were recruited from six Kibbutzim in Israel. Gait was evaluated based on the dual-task (DT) paradigm with subtraction by 7 as a cognitive task. Gait parameters (speed and variability) were assessed with the APDM mobility lab. Sleep quality was evaluated objectively using a one-week actigraphy and subjectively by the Pittsburg Sleep Quality Index (PSQI). Results: Increasing age was significantly associated with earlier bedtime ($p=0.007$), lower sleep efficiency ($p<0.01$) and increased wake after sleep onset ($p<0.01$). After controlling for age and gender a significant main effect was found for actigraphy-based sleep duration (short / intermediate / long) on gait speed, such that gait speed was slower in long compared to short and intermediate sleepers under DT only ($p<0.01$). Conclusion: Our findings demonstrate a negative association between sleep duration and gait speed under DT. These findings are consistent with previous studies showing adverse health outcomes for long vs. short and intermediate sleepers. Gait with DT can serve as a marker for sleep deterioration.

P3-C-11: ***The link between non-communicable disease risk factors and gait speed among middle-aged adults***

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Background and aim: Non Communicable Disease (NCD) risk factors such as glycaemia and inflammation may be considered underlying mechanisms of a variety of age-related health outcomes. Yet the link between major NCD risk factors and gait speed, a central marker of aging, is yet to be fully investigated. Due to its incipient and gradual onset, it is becoming clear that the aging process must be evaluated during mid-life, before early manifestations of aging become apparent. Thus, here we aimed to evaluate the link between NCD risk factors and gait speed among middle-aged adults from the Muslim Arab minority in Israel who suffer from high level of cardio-metabolic diseases. Method: Three hundred and seventy-nine participants (mean age 45 years old, SD - 7.9) participated. Gait speed and variability were evaluated using the dual-task paradigm for one minute and during a six-minute walking test using One-step application. NCD risk factors included lipid profile (HDL, LDL, Cholesterol), inflammation markers (CRP and fibrinogen), and glycemic markers (fasting glucose, Hemoglobin A1C and Insulin) collected from blood samples. Insulin resistance (HOMA-IR) was calculated. Demographic, body composition and cognition were assessed. Linear regression models were used to evaluate associations between NCD risk factors and gait speed. Results: Gait speed assessed during the six-minute walking test, was negatively associated with fibrinogen level (β=-0.199, p=0.016) and insulin resistance (β=-0.153, p=0.010) in the fully adjusted model. No significant associations were found between NCD risk factors and gait during a one-minute walk under the DT paradigm. Conclusions: In middle-aged adults, higher systemic inflammatory activity and insulin resistance are linked with gait speed, beyond current cardio-metabolic status and cognition. Thus, in middle-aged adults, longer walking time is needed to identify individuals at risk for gait decline due to NCDs' risk factors. These markers are sensitive and tend to precede NCD symptoms.

P3-C-12: ***Associations between measurements of physical and cognitive functioning in older adults in a memory clinic***

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[1]Western Norway University of Applied Science, [2]Oslo University Hospital, [3]Norwegian National Advisory Unit on Ageing and Health

Background and aim: Dementia is predicted to be one of the most substantial health burdens in the decades to come. Although traditionally and primarily seen as a brain- and thinking disorder, cognitive impairment has wide-reaching consequences also for physical functioning, such as walking function, fine motor skills and muscle strength. Therefore, it is important to have measurement instruments that can reflect the burden of functional decline that is due to cognitive impairment. By investigating associations between cognitive and physical functioning, it is possible to make inferences about which measurements of physical functioning that are most informative about cognitive functioning. The aim of this study is therefore to investigate correlations between cognitive functioning and well-known measurement instruments of physical functioning. Method: Data was collected from men and women attending a memory clinic at a university hospital. Cognitive functioning was measured using the Mini-Mental State Examination (MMSE). Physical functioning was measured as fast gait speed, dominant hand grip strength, dominant hand Grooved Peg Board and the 5-times Sit-to-Stand-test. Associations were determined using linear regression, with adjustment for age and sex. Results The analyses are based on 124 memory clinic patients (mean age 68.7 (7.7), 57% men). 12.9% had subjective cognitive impairment, 25.8% had mild cognitive impairment and 61.3% had dementia. The median (IQR) MMSE was 27 (9-30). The average grip strength was 36.6 kg (SD11.5). The women had an average grip strength of 26.3 (SD 6.3), while the men had an average grip strength of 44.3 (SD 7.8). The median Grooved Peg Board time was 103.5 seconds (IQR 63), the average fastest gait speed was 1.02 meters/second (SD 0.2) and the average 5-times Sit-to-Stand was 10.5 seconds (SD 2.9). Linear regression with MMSE as dependent variable and physical functioning as independent variables were: Handgrip strength (B=0.08 (95%CI -0.05 - 0,20, p=0.23), Grooved Pegboard (B=-0.17 (95%CI -0.03 - 0.002), p=0.02), fast gait speed (B=-1.10 (95%CI -1.92 - -0.29, p=0.01) and the 5-times Sit-to-Stand (B=-0.28 (95%CI -0.57 - 0.005), p=0.054). Conclusion and discussion The most strength-intensive measurement instruments (handgrip strength and the 5-times Sit-to-Stand) were not associated with cognitive functioning, while fine (Grooved pegboard) and gross (fast walking speed) motor skills were. Although the analyses do not allow for inferences about causality, we can speculate that tests of physical function that involve coordination of the whole body (walking) or that are complex (Grooved Pegboard) are more affected by cognitive impairment than strength tests that are relatively easy to perform. The results also suggest that hand grip strength, although found to be an important indicator of health and functioning in older adults, is not the end-all measurement instrument in geriatric practice. It should also be noted that fast gait speed was low in this sample, while grip strength was high, casting some doubt on the representativeness of our sample. Another limitation is that we used the MMSE as the measure of cognitive function, while this test has known ceiling effects and modest diagnostic accuracy

P3-C-13: ***Effect of aging on cognitive and brain inter-network integration patterns underlying usual and dual-task gait performance in aging***

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Background: Gait is a complex behavior that involves the integration of motor, sensory and cognitive functions. Aging impacts the interplay between cognition and gait performance. Neuroimaging studies reported associations between gait performance and structural brain measures; however, functional imaging techniques might be more sensitive for depicting the ongoing dynamic mechanisms taking place aimed at maintaining optimal performance under various conditions. Objectives: To explore the impact of age on divergent cognitive and inter-network functional connectivity (FC) patterns underlying gait performance during usual (UW) and dual-task (DT) walking. Methods: N=115 community-dwelling, healthy participants ≥ 20 years (mean±SD: 60.45±13.75, N=64 females) were enrolled. All participants underwent comprehensive cognitive and gait assessments and completed MRI scans acquiring structural and resting state functional MRI datasets. Z-transformed correlation matrices were generated among time-series data corresponding to 264 regions of interest, and inter-network FC from the cerebellum and somatomotor hand networks to 6 primary cognitive networks was estimated. Finally, a set of step-wise regression models tested the relationships among usual and dual-task gait parameters, inter-network FC, neuropsychological performance scores, and demographic variables. A significance threshold of $p<0.05$ was adopted for all statistical analyses. Results: UW was associated with FC levels between motor and sustained attention brain networks, while DT gait performance was associated with inter-network FC levels between motor and divided attention, as well as processing speed in the overall group. In the age group < 65, UW was associated with FC between motor and sustained attention networks. DT performance was associated with cognitive performance, and FC between motor and divided attention networks. While similar connectivity patterns were observed in the age group > 65, this group relied on additional resources including FC between motor and dorsal and ventral attention networks for UW performance. Conclusions: The results indicate that while UW relies on inter-network connectivity between motor and sustained attention brain networks, DT gait performance

relies on additional cognitive capacities and increased FC between motor and executive control brain networks. With age, additional neural and cognitive resources are implicated to maintain an optimal gait.

P3-C-14: *Improved walking through an aperture in a virtual environment transfers to a real environment*

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Introduction Virtual reality (VR) could be used to set up a training protocol to improve one's collision-avoidance behavior; there is no physical contact with obstacles under VR, so participants are free from collision-induced issues, such as tripping or falling. Kondo et al. (2021) developed a VR system for training older individuals to walk through an aperture in both safe (i.e., no collision) and efficient (i.e., no exaggerated behavior to ensure collision avoidance) manners. Their results showed that, although the training led older individuals to modify their behavior to move efficiently during real walking, collision rates tended to be greater, suggesting the necessity of modifying the system. The present study revisited the study of Kondo et al. (2021) with three modifications (the addition of vibratory stimulation for virtual collisions, positive feedback for successful trials, and gradual increase of task difficulty during training). Methods Nineteen older adults (12 females, 74.4 ± 5.3 years) and twenty-one younger adults (3 females, 25.1 ± 5.0 years) participated. They were randomly assigned to one of two training groups: the intervention group (older: n = 10; younger: n = 10) or the control group (older: n = 11; younger: n = 9). The experiment consisted of pre- and post-tests in the real environment and training in a VR environment. For the training in the intervention group, participants stood 1.5 m in front of a large screen and stepped in place as if a VR image on the screen (an image of forward self-motion at 1.00 m/sec) was moving in response to their stepping. Participants held a 91 cm horizontal bar while stepping and tried to pass the aperture without collision while minimizing the spatial margin created between the bar and the doors. The critical values of the spatial margin within which the stepping-over performance was regarded as successful became gradually smaller to gradually increase the difficulty of the task. In pre- and post-test performances conducted in a real environment, participants tried to pass through the aperture without collision while minimizing the spatial margin. Results and conclusion A comparison between pre- and post-test performances showed that, for both older and younger adults in the intervention group, spatial margins became significantly smaller, while the successful rate remained unchanged. For those in the control group, neither the spatial margin nor success rate was improved. These results suggest that the three modifications made for the VR system contributed to improvement of the system and helped participants to transfer the learned behavior from the VR environment to real walking.

P3-C-15: *The development and preliminary effects of network-based transcranial direct current stimulation (tDCS) designed to reduce gait variability in unsteady older adults*

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Background and Aim: Elevated gait variability sensitively predicts falls and cognitive decline in older adults. In this population, gait variability has been linked to the functional connectivity between two large-scale brain networks underlying sustained attention: the dorsal attention network (DAN) and the default network (DN). These two networks typically function in a reciprocal relationship; i.e., when the DAN is activated, the DN is suppressed. Transcranial direct current stimulation (tDCS) enables selective modulation of brain excitability. The purposes of this study were to 1) develop a tDCS montage designed to target both networks, and 2) examine its effects on gait variability and sustained attention in older adults with elevated gait variability. Methods: We created a tDCS montage (electrode placement and current parameters) to simultaneously increase DAN excitability and decrease DN excitability. Optimization modeling assigned target electric fields of +0.5 V/m, -0.5 V/m, and 0 V/m, to the DAN, DN, and the rest of the cortex, respectively (Figure 1). We also created a sham montage that used similar electrode placement and non-zero current flow to create cutaneous sensation (similar to tDCS) yet minimal direct effect on the cortex. We recruited 25 older adults (81±10 y/o, 19F) with elevated gait variability; i.e., stride time coefficient of variation (CoV) ≥2.5% when walking at preferred speed. Gait and sustained attention were assessed during two separate visits, both before and after 20-minutes of tDCS or sham stimulation. The stimulation order was blinded and randomized across visits. Primary outcomes were gait variability (CoV) and sustained attention measured by the gradual-onset Continuous Performance Task (d-prime). Results: Participants were successfully blinded to tDCS condition: the proportion of guesses for each type of stimulation was not different from that expected by chance (p=0.20) and after the first visit, there were no differences in guess confidence by type (tDCS: p=0.88, Sham: p=0.24). Gait variability was not significantly changed by tDCS (pre: 3.2±1.0%; post: 2.9±0.9%) or sham stimulation (pre: 3.4±1.1%; post: 3.3±1.0%, ns). Intriguingly, tDCS as compared to sham appeared to worsen sustained attention (tDCS: pre: 2.3±0.9; post: 2.0±1.0; Sham: pre: 2.1±0.8; post: 2.3±0.8, p=0.03). Conclusions: We developed a novel tDCS montage concurrently targeting two brain networks and a related sham paradigm that enabled successfully masking. Our results suggest that a single exposure to this novel form of tDCS may not alter gait variability and may even disrupt sustained attention when tested just after stimulation. Future work is needed to investigate the effects of this form of network-based stimulation on functional brain connectivity and its relation to cognitive-motor outcomes in larger numbers of older adults, particularly in comparison to other forms of tDCS with demonstrated positive effects on locomotor control. Acknowledgments and Funding: We appreciate the following funding resources: NIA T32 and Harvard Catalyst KL2 Awards.

P3-C-16: *Age and uneven surfaces decrease smoothness of walking*

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BACKGROUND AND AIM: Higher gait variability is seen in aging individuals, particularly when they suffer from mobility impairments. But what happens to the smoothness of movement? A movement that is less smooth is more interrupted and intermittent, which manifests in some neurological conditions (e.g. Parkinson's Disease). Reduced smoothness could also contribute the high prevalence of age-related mobility loss in non-neurological conditions. We sought to determine the effect of terrain unevenness and age on smoothness of walking by analyzing the jerk (time derivative of acceleration) of the approximate centre of mass. We hypothesized that an increase in unevenness of the walking surface would yield increased jerk. Additionally, we hypothesized that the jerk would be greater with aging and with mobility function decline, after accounting for baseline differences in walking speed. METHODS: We recruited 16 young and 35 older adults. Older adults were separated into high-mobility function (n=22) and low-mobility function (n=13) groups based on their mobility-related physical performance from a standardized battery. Subjects walked over four uneven terrain surfaces on a treadmill (flat, low, medium, and high unevenness) with an inertial measurement unit placed over the sacrum. Walking speed varied between subjects (based on functional ability) but was constant across surfaces for each subject. For each condition, we calculated the peak-to-peak value of the resultant jerk stride-by-stride and then averaged across all strides. Because the data were not normally distributed, we performed Quade's analysis of covariance on Group (3 subject groups) and Condition (4 surfaces) with speed as a covariate. We used Scheffé's post-hoc Test. RESULTS: We found a main effect of Condition ($F=23.43$, $p<.01$, $\eta p2=.27$). The flat surface yielded lower peak-to-peak jerk values than the other surfaces ($p<.01$), while the other conditions were not significantly different from each other. There was a main effect of Group ($F=6.83$, $p<.01$, $\eta p2=.07$). After adjusting for speed, younger adults had lower jerk values than high-mobility ($p<.01$) and low-mobility ($p<.05$) older adults. We did not find a significant difference between the older adult groups. CONCLUSIONS: The surface unevenness influenced walking smoothness. The uneven surfaces had higher jerk values compared to flat walking, but increasing unevenness had no additional impact on jerk values. There was an effect of age on the smoothness of walking as the older subjects had higher jerk values using speed as a covariate. We did not find a significant difference between the high- and low-mobility older adults. Results suggest that jerk values of a sacrum inertial measurement unit are sensitive to differences in terrain unevenness and aging, but not necessarily mobility function. They may provide important feedback about locomotor behavior in real-world settings. ACKNOWLEDGEMENTS AND FUNDING: This work was supported by the National Institutes of Health (U01AG061389).

P3-C-17: ***Characteristics of reactive stepping with and without a cognitive task in elderly women with mild cognitive impairment***

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Background and aim: Stepping responses to external perturbations are affected with aging. Although aging is associated with declining cognitive function, little is known about the balance responses to external perturbation in older adults with cognitive dysfunction. Therefore, the aims of this study were (1) to determine the characteristics of reactive stepping to external perturbations in elderly adults with mild cognitive impairment (MCI), and (2) to investigate the influence of a cognitive task on reactive stepping in elderly adults with MCI. Methods: Eight healthy young women (age, 22.3±2.0 years), seven healthy elderly women (age, 79.6±6.9 years), and nine elderly women with MCI (age, 79.1±5.8 years) participated in this study. The Montreal Cognitive Assessment was used to classify the elderly women with MCI based on a cutoff score of 26. The subjects were suspended in a forward-leaning position by a lean control cable with a load of 12% of body weight and instructed to regain balance upon release by taking a single step forward. The reactive step was induced while carrying out two conditions: (1) simple front fixed gaze (control condition), (2) color word reading as a word is displayed in a color that does not match the name of the color (Stroop task condition). Electromyography data for determining the muscle activation onset latency was obtained from the gastrocnemius muscle on the stepping leg. In addition, time of unloading onset, foot-off, and foot contact were recorded from vertical ground reaction force. Results: Delays in muscle activation onset and unloading onset and foot off time and shorter foot contact time were found in elderly women with MCI compared with young women. A delay in unloading onset time in the Stroop task condition was found in healthy young women compared with the control condition; however, this outcome did not apply to the healthy elderly women or elderly women with MCI. Conclusions: Elderly women with MCI demonstrated remarkably delayed automatic postural response and reactive stepping to recover balance upon perturbation compared to healthy younger individuals. A delay in stepping responses to perturbation may represent a contributing factor to falls among elderly adults with MCI. However, in contrast with our hypothesis, healthy elderly women and elderly women with MCI were not affected by a cognitive task during reactive stepping; regardless, younger adults were affected.

P3-C-18: ***Older adults not resilient to balance perturbations have less complexity than middle-aged and older adult that are resilient***

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BACKGROUND AND AIM: Resilience is defined here as the ability to recover from an external perturbation, which is an integral aspect of functional adaptability and healthy behavior. As people age, they tend to lose adaptive capacity and resiliency. It has been hypothesized that there is a general loss of complexity associated with increasing age past young adulthood. Yet, most studies observe differences between younger and older adults, with little attention on middle aged adults. This study aimed to determine the difference in resilience to standing balance perturbations between middle aged and older adults. METHODS: 34 middle aged (54.4±7.3 yrs) and 30 older adults (70.7±4.2 yrs) stood on a force platform which could move quickly in the anteroposterior direction. During five, 60-sec trials, the platform moved posteriorly at 20 cm/s for a randomized distance of 2.54, 5.08, 7.62, 10.16, or 12.7 cm. Timing of the perturbation occurred between seconds 17-21 and was different for each distance. Detrended Fluctuation Analysis (DFA) was calculated on anteroposterior center of pressure with moving windows of five seconds (500 data points). Higher alpha values (arbitrary units) were interpreted as a more desirable behavior. Baseline DFA alpha (BA) was obtained by averaging windows before the perturbation. Directly after the perturbation, windows were analyzed continually until either; a) the participant's DFA alpha value returned within two standard deviations of BA, called Return Alpha (RA), or b) the trial ended. If DFA didn't return to BA, DFA of the last window was taken as the RA. Subjects' trials were then labeled as Returns or Non-Returns based on whether or not BA returned. To test group differences in BA and RA, 2x2 repeated-measure ANOVAs (age x Return) were used. RESULTS: ANOVA revealed a significant main effect of age on BA (F=15.65, p<.001). Middle age adults had significantly higher BA (mean=1.80) than older adults (mean=1.78). A significant main effect of age (F=5.97, p=.016) and Return (F=10.14, p=0.002) on RA was found. Middle aged adults had a significantly higher RA (mean = 1.78) than older adults (mean = 1.75). Returners had a significantly higher RA (mean=1.79) than Non-Returners (mean=1.75). Moderate evidence was found for an interaction between age and Return (p=0.058) (Figure 1). CONCLUSION: Those who did not return to baseline exhibited less complex sway patterns as evidenced by decreases in RA. This decrease in RA is mainly attributable to the older adult Non-Returners, as there was no difference between middle age and older adults who returned. The ability to return is a desirable trait as this indicates resilience to the perturbation. Older adult Non-Returners demonstrating decreased complexity is indicative of decreased adaptive capacity and resiliency. Future studies should investigate individual factors that contribute to non-return (e.g. executive function), which could be a mediator of resiliency. FUNDING: NU SEM grant

D – Biomechanics

P3-D-19: ***Neuromuscular responses of protective arm reactions are modulated with fall velocity prior to impact***

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Background and aim: Hip fracture and brain injury are a common result of falls. Studies of falls from standing height have demonstrated a wide range of fall characteristics, velocity, direction, etc. and evoked protective reactions. Protective arm reactions can be modulated with fall height and velocity; however, it is not well understood if they are modulated when fall conditions are unpredictable. The aim of this study was to gain insight into the control mechanisms of protective arm reactions in response to a forward fall with an unpredictable fall velocity. Method: Forward falls were evoked via sudden release of a standing pendulum support frame with adjustable counterweight to control fall acceleration from an initial lean angle of 37 degrees from vertical. Participants fell at unpredictable times twice with a small (S), medium (M), medium-large (ML), and large (L) counterweight. The counterweight load, 7, 12, 18, and 29 %BW, was randomly selected for each pair of trials. Thirteen younger adults (1 female) participated in this research study. Repeated measures ANOVAs were

used to test the effects of counterweight load on characteristics of protective arm reactions (elbow angle at impact, pre-impact EMG activation timing of the triceps, average triceps amplitude prior to impact, and co-activation index of the biceps and triceps). Additional variables characterized the fall characteristics (angular velocity at impact, drop duration, and maximum vertical ground reaction force). Results: Counterweight load explained more than 89% of the variation of fall angular velocity prior to impact. Angular velocity decreased ($p<0.001$), drop duration increased (598, M: 648, ML: 701, L: 836 ms, $p<0.001$), and the maximum vertical ground reaction force decreased (S: 64, M: 56, ML: 53, L: 45%BW, $p<0.001$) with increasing counterweight. Elbow angle at impact (129 degrees extension), triceps pre-impact time (120 ms), and co-activation (57%) were not significantly affected by counterweight load (p-values >0.08). Average EMG amplitude decreased with increasing counterweight (S: 0.25, M: 0.26, ML: 0.24, L: 0.19 V/V, $p=0.005$). Discussion: Protective arm reactions were modulated with fall velocity by reducing or abbreviating EMG amplitude prior to impact. This suggests protective arm reactions are deployed based on fall condition upon deployment. If ongoing balance recovery efforts reduce the fall velocity, the CNS adjusts the muscle activation of the arm to presumably modulate the stiffness of the elbows. This demonstrates a neuromotor control strategy for managing the time constraint problem of deploying protective arm reactions when faced with an unpredictable fall velocity. Future work is needed to further understand how the CNS deals with additional perturbation unpredictability (e.g. direction, extent, magnitude) in deploying protective arm reactions.

P3-D-20: *Does relative timing between pole and heel strike influence lower limb loading among young and older naïve pole walkers?*

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BACKGROUND AND AIM: Proponents of pole walking (PW) suggest the use of walking poles facilitates a more effective form of physical activity, while also being less demanding, in terms of loading, on the lower limbs, compared to regular walking (RW). However, research has revealed contradictory findings on the utility of walking poles for reducing lower limb loading; it has been suggested that the use of walking poles may increase [1], decrease [2], or have no effect [3] on lower limb loading. These contradictory findings may be related to the relative timing between pole and foot ground contact which could influence any contribution made by the pole to reduce lower limb loading. This study quantified the relative time difference between heel and pole strike during pole walking and investigated the effect on lower limb loading among naïve pole walkers. METHODS: Fourteen young (4F; 25.3±5.4yo) and 8 older adults (4F; 68.5±3.2yo) performed 15 PW and 15 RW trials along a force-plate (AMTI, USA) embedded walkway at two different visits. PW instruction was provided during visit one. The time difference between pole and foot contact during both the onset of ground contact and at peak force application was calculated. The following measures were calculated from the vertical ground reaction forces (vGRFs) at the foot: peak vGRF of heel strike (HS), HS impulse, HS rate of loading (ROL), foot impulse, peak foot push-off vGRF; and walking poles: peak vGRF of pole strike (PS), PS impulse, PS ROL, pole impulse. Analysis of covariance, with step time as the covariate, was performed to compare between gait conditions, age groups, and visits. Spearman partial correlations assessed the relationship between relative timing, pole, and foot loading metrics. RESULTS: A significant decrease (% difference; p-value) in peak vGRF of HS (-3.4%; <0.01), HS ROL (-5.2%; 0.02), foot impulse (-2%; <0.01), and peak foot push-off vGRF (-2.1%; 0.01) was found during PW, when compared to RW. No difference in pole loading was found between age groups and visits. No significant correlations were found between the relative timing and foot-related measures. Significant negative correlations were found between peak vGRF of HS and peak vGRF of PS (-0.44), peak vGRF of HS and PS impulse (-0.57), peak foot push-off vGRF and PS impulse (-0.49), peak vGRF of HS and pole impulse (-0.51), and between peak foot push-off vGRF and pole impulse (-0.58). CONCLUSIONS: The use of walking poles reduced vGRFs at the foot, among naïve pole walkers. Several significant low-to-moderate negative correlations suggested that as pole force magnitude or duration of force application increased, foot loading forces may decrease. These findings add to the knowledge base regarding the use of walking poles and support previous claims that the use of walking poles may reduce lower limb loading. REFERENCES: [1] Stief F, et al. J Appl Biomech 2008;24(4):351-9 [2] Willson J, et al. Med Sci Sports Exerc 33,2001,p.142-47 [3] Hansen L, et al. Scand J Med Sci Sports 2008;18(4):436-41

P3-D-21: ***A measure of walking balance based on a compass gait model***

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BACKGROUND AND AIM: Fall accidents of elderly people are one of the major health concerns. The assessment of walking balance is important to improve the individual walking balance of elderly people and people with walking impairments. We propose a new balance assessment framework termed as balance map analysis which is based on a prediction of fall using a simple biomechanical model (a compass gait model). In this study, we aimed to validate the balance map analysis from actual human gait kinematics data during steady state walking and walking with stumbling. METHODS: Seven healthy young participants participated this experiment. We measured steady state walking and stumbled walking during a treadmill by an optical motion capture system. A stumbling perturbation was induced by pulling a rope that was connected to the ankle position of the subject. The horizontal position of the center of mass (COM) of the swing leg (swing position) and the COM of the upper body and the stance leg (stance position) was calculated from the kinematics data. The stance position/velocity and swing position/velocity were used as a state variable of the compass gait model. The regions of the forward balance loss and backward balance loss are defined in the state space of the stance position and velocity (balance map). The state in the forward (backward) balance loss regions implies that the compass gait model from the state is going to fall in the forward (backward) direction without joint torque. A margin from the balance loss was quantified by the Euclid distance between the current state and the nearest point on the boundary of the balance loss region. RESULTS: Most of the trajectories during steady state walking did not locate in either forward or backward balance loss region. During the perturbed steps, the trajectories approached to and went into the forward balance loss region. During recovery steps, the trajectories converged toward the pattern in the steady state walking. The margin from the forward balance loss in the stumble steps was significantly smaller than the step before stumbling and the steps after recovery. CONCLUSIONS: Our results revealed that the balance map analysis can detect forward balance loss in human walking. The evaluation of walking of elderly people and people with neurological diseases by the balance map is one of the future works. ACKNOWLEDGEMENTS AND FUNDING: This work was supported in part by JKA and its promotion funds from KEIRIN RACE and in part by the Japan Society for the Promotion of Science (JSPS) KAKENHI under Grant 18K12173.

P3-D-22: ***The instrumented walking and turning test to evaluate space suited gait dynamics and performance in extravehicular activity training environments***

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BACKGROUND AND AIM: The Neutral Buoyancy Lab (NBL) simulates lunar gravity (1/6G) by adding weight to underwater subjects to alter buoyancy, whereas the Active Response Gravity Offload System (ARGOS) uses a computer controlled overhead suspension system to offload a percentage of a subject's weight to simulate 1/6G. Performance of turning maneuvers may be affected differently in different extravehicular activity (EVA) training facilities that simulate partial gravity. The degree to which dynamic movements such as turning are comparable across these EVA training facilities has not yet been evaluated. The instrumented gait test helps NASA scientists and engineers evaluate gait dynamics and performance in suited conditions and understand the unique characteristics and limitations of EVA training facilities. We developed an instrumented walking and turning test using inertial measurement units (IMUs) and conducted the test at NASA's EVA training facilities. Results were used to compare suited walking and turning characteristics in the ARGOS and the NBL. METHODS: Subjects donned the Mark III space suit during offloading with the ARGOS spreader bar gimbal and donned the Z2.5 space suit while underwater in the NBL with weights and floatation added. The test team securely attached three Opal wireless IMUs (APDM, OR, USA) on the space suit (one for the hard upper torso and two for both ankle bearings) for each test run. During the NBL tests, the IMUs were encased in a waterproof housing (GoPro). At both testing facilities, 6.3 m x 1.0 m (LxW) walking lines were marked, and a cone for turning was located at the end of the walking path with another line indicating the stopping point after walking around the cone. Under simulated 1/6G, subjects began by standing at the marked line with their arms folded across the chest, they then walked at a preferred speed along the straight walking path, turned 180 degrees around the cone, and finally stopped at the marked stopping point. All recorded IMU signals were processed using custom MATLAB (Mathworks, MA, USA) codes to generate gait parameters during both the walking and turning components of the task. These parameters included time (s), speed (m/s for walking and rad/s for turning), step number (n) and walk:turn time ratio (% time spent straight walking versus turning). RESULTS: Less time, faster gait, fewer steps, and higher walk:turn ratio during both walking and turning components were exhibited during tests performed at the ARGOS versus those performed at the NBL. During the NBL tests, the slower walking speed continued at the same rate throughout a U-shape turn. During the

ARGOS tests, the subjects performed shorter and tighter turns at 4 times the speed of the NBL turns because they walked 30% faster and the vertical offloading system gave them more support. CONCLUSIONS: Our data show that the differences in walking and turning parameters during the NBL tests may be due to the high viscosity in the water environment where the motion of the lower limbs was slow and did not reach full flexion and extension. These tests improve the current knowledge of testing environments in preparation for EVAs on the lunar surface.

P3-D-23: ***The Current State of the Margin of Stability***

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BACKGROUND AND AIM: Owing to its simplicity and wide applicability, the 'extrapolated center of mass' (XcoM) concept has enjoyed tremendous popularity since it was first introduced by At L. Hof in 2005 (1). The concept extends the classic inverted pendulum model for static stability in which the center of mass (CoM) must remain within the base of support (BoS) to maintain stability. In dynamic situations, such as walking, this simple model does not hold as the CoM velocity needs to be accounted for. Here, stability can be quantified as the distance of the velocity-adjusted position of the COM times a constant related to posture and the edge of an individual's BoS at any given instant in time (margin of stability). In order to achieve steady-state gait, bipeds place their feet at a certain distance behind and outward of the XcoM, thereby redirecting the movement of the CoM. The minimum distance between the effective BoS - XcoM describes the mechanically most unstable point (bmin). Here, we discuss do's and don'ts related to adaptations made to the original calculation of the margin of stability. METHODS: We review the development of the XcoM concept and the original papers describing it. Subsequently, we identify and discuss several adaptations to the original calculation of the margin of stability. Furthermore, we will discuss common pitfalls in the definition of the (effective) boundary of the base of support (umax), and the instance/timing of minimal stability during the gait cycle. RESULTS: A number of common formulations and applications of the margin of stability are not well grounded in the inverted pendulum model and thereby lack construct validity. Various choices related to XcoM calculation and the (lack of) accounting for treadmill speed in the calculation, and graphical representations thereof in the literature may compound the issues. Experimental data on walking at 1 m/s is presented in Fig. 1 to visually contrast differences in parameter selection using kinematic and force plate data. For instance, selecting a distal phalanx I marker for the AP BoS could result in positive AP margin of stability values at contralateral initial contact. CONCLUSIONS: We observe a number of concerning deviations in the literature concerning the application and reporting of the margin of stability concept. By discussing and demonstrating these issues, we hope to draw researchers' attention to these and propose recommendations to avoid them in the future. REFERENCES: 1) Hof et al. (2005) J. Biomech. 38(1):1-8.

P3-D-24: ***Effects of foot orthoses on the biomechanics of the lower extremities in adults with and without musculoskeletal disorders during functional tasks: a systematic review***

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BACKGROUND AND AIM Foot orthoses (FOs) are among the most commonly used external supports to treat musculoskeletal disorders. It remains unclear how they change the biomechanics of the lower extremities during functional tasks. This systematic review aimed to determine the effects of FOs on primary outcomes (i.e., kinematics, kinetics and electromyography of the lower extremities) in adults with and without musculoskeletal disorders during functional tasks. METHODS A literature search was conducted for articles published from inception to June 2021 in Medline, CINAHL, SPORTDiscus, Cochrane libraries and PEDro electronic databases. Two investigators independently assessed the titles and abstracts of retrieved articles based on the inclusion criteria. Of the 5 578 citations, 24 studies were included in the qualitative synthesis as they reported the effects of FOs on the primary outcomes. Risk of bias of included studies was determined using the modified Downs and Black Quality Index. RESULTS During low impact tasks (e.g., step and stair ambulation), FOs decrease ankle inversion and increase midfoot plantar forces and pressure. During higher impact tasks (e.g., landing from a jump), FOs had little effects on electromyography and kinematics of the lower extremities but decreased ankle inversion moments. CONCLUSION Even though the effects of FOs on the biomechanics of the lower extremities seem task-dependent, FOs mainly affected the biomechanics of the distal segments during most tasks. However, few studies determined their effects on the biomechanics of the foot. It remains unclear to what extent FOs features induce different biomechanical effects and if FOs effects change for different populations.
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P3-D-25: ***Biofeedback Gait Training in Cerebral Stroke Patients with Stance Phase as Target Parameter***

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Biofeedback technology (BFB) is currently considered effective and promising for training walking function. The data on the use of highly selective walking parameters for BFB training are very limited. The aim of our study was to investigate the feasibility of using BFB training targeting one of the basic parameters of gait symmetry stance phase duration in cerebral stroke (CS) patients. The study included 20 hemiparetic patients in the early recovery period after the first hemispheric ischemic CS. The control group included 20 healthy subjects. The

BFB training and biomechanical analysis of walking (before and after all BFB sessions) were done using an inertial system. The mean average number of BFB sessions was nine (from 8 to 11) during the three weeks in clinic. There was not a single negative response to BFB training among the study patients, either during the sessions or later. The spatiotemporal parameters of walking showed the whole syndrome complex of slow walking and typical asymmetry of temporal walking parameters, and did not change significantly as a result of the study therapy. The changes were more significant for the kinematics of hip and knee joints. The contralateral hip amplitude returned to the normal range. For the knee joint, the amplitude of the first flexion increased and the value of the amplitude of hyperextension decreased in the middle of the stance phase. Muscle function, the observed significant decrease in the function of m. hamstring on the paretic side remained without change at the end of the treatment course. The presence of objective feedback on the dynamics of changes in the trained parameter allowed us to assume that it is possible to focus on the patient's individual response to training. In addition, the very individual reactions of the patient with respect to biomechanical parameters of walking during training require a separate study. We obtained positive dynamics of the biomechanical parameters of walking in patients after the BFB training course. The feasibility and efficacy of their use for targeted correction need further research. The study was funded by FMBA Reg. No. AAAA-A19-119042590030-2.

P3-D-26: ***Test of kinematics reaction to arbitrary and fast walking to assess the functional state of the knee joint***

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The function of the knee joint (KJ) during the recovery period after injuries and surgeries is not well understood. It is well known how the joint kinematics reacts to an increase in the normal pace of walking. We used the gait functional test (FT) usual and fast walking to determine the joint response. The aim of the study is to determine the capabilities of this FT for assessing the state of the joint relatively normal reaction. The study enrolled 51 patients after different traumas of KJ as before as well as after surgery in recovery period. The FT was assessed by using an inertial gait analysis system. Biomechanical parameters of walking were recorded at the usual pace and at a fast pace. According to the results of the study, three groups of patients with a compensatory response to FT (41 man) decompensation (6 human) and an undifferentiated (4 patients) were identified by expert estimation. In the groups of compensation and decompensation, with an increase in walking speed, the time of the walking cycle, stance and double support phases are significantly reduced. The value of the period of single support and the coefficient of rhythm increases for the compensation group. In both groups, the amplitude in the hip joints increases. In the compensation group, this amplitude increases symmetrically and its value is the same, both for the affected side and for the healthy one. And in the deocompensation group for a high pace, an asymmetry of the amplitudes appears and its value on the side of the lesion is significantly lower. All

types of the listed reactions, with the exception of asymmetries, are physiological and characteristic of changes in the pace of walking in normal conditions. For the decompensation group, a constant amplitude of the first flexion, an increase in joint extension during the single support phase and a decrease in flexion during the swing phase were found. The joint is not yet able to adapt its work. More demonstrative is the decrease, in comparison with the voluntary tempo, in the amplitude of the swinging flexion. This is a symptom that a high stride pace cannot be supported by an adequate swing amplitude and the latter is decreasing. Its decrease is asymmetric. The amplitude of extension in the single support phase remains the only one that demonstrates a physiological response to a change in the pace of a walking. In the group with undifferentiated symptoms, there are contradictory changes with a wide range of reactions between patients. This prevents the FT response from being differentiated. Study of EMG muscle activity showed a common response of increasing amplitude to FT in both groups. However, there are slight asymmetries of the function, which increase with an increase in the pace of the step. Thus, FT can be used to determine the direct response of the KJ to an increase in functional load. The use of FT will make it possible to more accurately dose the load on the KJ when walking. The study was funded by FNKC FMBA Reg. No. 20.001.19.800

P3-D-27: ***Dynamics of biomechanical and clinical symptoms before and 6 months after valgus osteotomy of chirurgical correction of genu varum deformity***

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Varus deformity of the knee joint (KJ) is one of the most common in clinical practice. The aim of this study was to investigate the mid-term functional and clinical results in patients who underwent surgical correction of the limb axis. Mid-term clinical and functional outcomes after valgus osteotomy have not been adequately studied yet. The study included 25 patients with medial osteoarthritis of the KJ 2-3 degrees and varus deformity of more than 3°. High tibial osteotomy was performed as described in [Saragaglia D, 2010]. The control group included 20 healthy subjects. The biomechanical analysis of walking (before and after 6-month surgical correction) were done using an inertial system. Clinical and biomechanical assessments were done twice: immediately prior to and 6 months after the surgical treatment First of all, it concerns a significant 2.5-fold reduction in the pain syndrome assessed using the VAS scale, as well as a 1.5-fold knee function improvement based on the KOOS score compared to preoperative data, even as early as 6 months after surgery. A significant increase in the amplitude of extension KJ was found. As early as 6 months after a valgus osteotomy, we already observed improved biomechanics of the joint motions compared to pre-operative data. By that time, the swing flexion amplitude of the affected knee had increased - although not very much (by 3-4°) - and become symmetrical, which had not been the case before surgery. We observed a total of three changes in the KJ kinematics after surgery: increased swing flexion amplitudes in both KJs, a decreased extension amplitude in the affected KJ, and increased first flexion amplitudes in both KJs.

Increase in the swing flexion amplitude is what is necessary for normal walking. Six months after surgery, the amplitudes of both KJ flexions (at stance and swing phases) increased. So, the typical knee pathomechanics was reversed, which could only be the result of the valgus osteotomy. Although the range amplitude at KJ certainly did not reach normal values, the differences from the control group in the bending amplitude significantly reduced. According to our study, the midterm outcomes after a valgus osteotomy showed clinical improvements based on the VAS and KOOS scores, which were however less pronounced than in similar studies with a longer assessment term after surgery. We also found a significant increase in the amplitude of joint extension, but only in females. As the function of the operated joint is concerned, valgus osteotomy restored the kinematics of walking movements to a nearly normal gait with increased first and second flexion amplitudes. The very important thing is that the function becomes symmetric though the intact side, of course, underperforms. But the left-right side symmetry is a more physiological compensatory mechanism. Thus, the healthy and functionally more capable side is copying the movement pattern of the affected side. Hence, the intact leg is functioning less efficiently than it is required by the walking pace. The study was funded by FNKC FMBA Reg. No. 20.001.19.800

E - Brain imaging/activation during posture and gait

P3-E-30: *Cortical gamma activity is evoked during reactive balance control and increases with perturbation difficulty*

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BACKGROUND AND AIM: We currently lack a mechanistic understanding of how and/or when cortical resources become engaged during balance control, hindering our ability to improve fall risk assessments and rehabilitation interventions. During a destabilizing event, an automatic, brainstem-mediated balance correcting muscle response is evoked, followed by longer latency muscle activity that may be cortically mediated. The time scale of this muscle activity makes direct measures of cortical engagement during balance control challenging to quantify. We recently demonstrated that sensorimotor cortical β activity (13-30Hz oscillatory neural activity) evoked during reactive balance recovery reflects sensorimotor processing, as it increased with perturbation magnitude and in individuals with lower balance ability. Here we expand upon this study to investigate perturbation evoked γ activity (30-50Hz). γ may provide additional information regarding the cortical processing involved in balance control as γ has been associated with movement preparation, sensorimotor integration, and motor output, but has not been investigated after balance perturbations with respect to balance ability. We hypothesize that perturbation-evoked γ activity will increase with perturbation magnitude and be higher in individuals with lower balance ability. METHODS: Eighteen healthy young adults (Age: 19-38, 10F) underwent a series of backward support-surface perturbations delivered at unpredictable timing and magnitude while recording electroencephalography. γ was quantified as the peak power 0-

500ms post perturbation at the central midline electrode (Cz). Balance ability was quantified via a BEAM score, or the distance traversed on a difficult beam walking task. An ANOVA was used to test the effect of perturbation magnitude on γ. To determine the relationship between γ and balance ability, a correlation between participant's BEAM score and perturbation evoked γ was performed. RESULTS: Perturbation evoked γ power increased with perturbation magnitude ($p<0.01$ for all comparisons). There was no association between evoked γ power and balance ability ($R^2=0.07$, $p=0.26$). CONCLUSION: The increase in perturbation-evoked γ power suggests cortical engagement in standing balance increases in more difficult reactive balance conditions. The lack of association between evoked γ and balance ability differs from what was previously found in β, suggesting that γ reflects different aspects of cortical engagement than β. Additional work investigating how γ power is altered by an individual's balance ability is warranted as we currently only examined healthy young adults, who may rely on cortical resources less than older adults and those with balance impairments. Identifying measures of cortical engagement during balance control is a key step in identifying declines in balance health prior to noticeable balance impairments.

P3-E-31: ***Disease severity and prefrontal cortex activation during obstacle negotiation among patients with Parkinson's disease: Is it all as expected?***

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Background and aim: Previous reports show that patients with Parkinson's disease (PD) activate the prefrontal cortex (PFC) during complex activities such as obstacle negotiation, to compensate for impaired motor function. However, the influence of disease severity on PFC activation has not been systematically evaluated. In this study, we aimed to examine the effects of disease severity on PFC activation during obstacle negotiation. Methods: 80 patients with PD (mean age 68.2±7.35 yrs; 62.5% men) were divided into three groups based on Hoehn and Yahr stages. All patients walked along an obstacle course while negotiating anticipated and unanticipated obstacles (long/short available response time, ART) at heights of 50 mm and 100 mm. PFC activation was measured using functional near-infrared spectroscopy (fNIRS) and was compared between groups and tasks using mixed model analyses. Results: PFC activation was greater among patients with more severe disease during the negotiation of anticipated obstacles, both low and high obstacles. Participants with more advanced PD (i.e., Hoehn and Yahr 3) had higher PFC activation levels when negotiating anticipated obstacles, compared to participants with milder PD (i.e., Hoehn and Yahr 1, 2) ($p<.001$). In contrast, during the negotiation of unanticipated obstacles, disease severity did not affect prefrontal activation levels. Conclusions: The present study showed significantly higher prefrontal activation levels in later stages of the disease (i.e., Hoehn and Yahr 3), compared to more mild disease stages (i.e., Hoehn and Yahr 1 and 2) however, we found that the preparation time played an important role. In contrast, during the unanticipated condition, prefrontal activation levels were not associated with disease severity. This work provides new insights on potential mechanisms that are recruited in an attempt to overcome impairments in high level motor behavior. This knowledge should be taken into an account in future plans to develop effective interventions to improve obstacle negotiation in PD patients.

P3-E-32: ***Subthalamic local field potential recordings during gait in patients with Parkinson's disease: first experiences with the Percept® neurostimulator***

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BACKGROUND AND AIM: Freezing of gait and falls are the main motor disabilities in patients with advanced Parkinson's disease (PD). These signs worsened with time and are not fully improved by the antiparkinsonian treatment or deep brain stimulation of the subthalamic nucleus (STN-DBS), leading to severe disability and increased morbidity. Our objective is to understand the link between STN neuronal activity and these episodic axial motor signs by using the Percept® neurostimulator (Medtronic, Ind. USA). METHODS: We recorded STN local field potentials (LFP) in 3 patients (2F/1M, mean age: 68.6 yrs, mean disease duration: 17.7 yrs, mean delay from STN-DBS surgery: 5.3 yrs) synchronized with gait recordings using a force plate and the Vicon system. These patients had residual On-dopa freezing of gait and/or falls. Patients were assessed both Off and On-dopa after intake of a suprathreshold dosage of levodopa both before STN-DBS, 6 months after STN-DBS and at 5 years after STN-DBS at the time of the Percept neurostimulator implantation. RESULTS: Recordings showed that 6 months after surgery, gait improved in all patients with increased step length and velocity with STN-DBS relative to before surgery Off-dopa. Conversely, 5 years after surgery, gait parameters were aggravated with no significant effect of STN-DBS, and an additional aggravation with levodopa treatment in two patients. Five years after surgery, peak power increases in the alpha and high beta bands during gait initiation Off-dopa, concomitantly with a low-beta band power decreased. The beta band power decreased On-dopa. Moreover, we found changes in the low beta band frequency related to gait events, with alternating increased and decreased peaks power relative to foot-off vs foot-contact events. Off-dopa, we found a decrease in the low-beta band power at the time of the lift-off of the contralateral foot during straightforward gait and a high-beta band power increase during foot-contact. On-dopa, the alpha-beta powers decrease and the gamma band power increases with no clinical improvement in motor disability or gait performances. One patient had freezing of gait On-dopa with concomitant increases in the low and high-beta band powers during FOG episodes that reversed at the time of the end of the FOG episode. CONCLUSIONS: These preliminary results indicate that the use of the Percept® system is feasible for recording STN-LFP recordings in PD patients, and can be combined with behavioral tasks such as gait. Further studies are needed to be able to specifically and individually correlate STN-LFP neuronal activity and motor or non-motor symptoms with the aim of developing closed-loop system with individualized paradigm for these patients.
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P3-E-33: ***Cortical Control of Cognition, Balance, and Gait in Huntington's Disease***

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Background and Aim: Huntington's disease (HD) is a neurodegenerative disease characterized by significant cognitive and motor deficits which increase fall risk and negatively impact quality of life. The ability to successfully multitask allows individuals to communicate with others and safely respond to environmental stimuli while navigating through their environment. However, as motor and cognitive impairments worsen, individuals with HD exhibit difficulty holding, shifting, and dividing attention between multiple tasks. Although previous studies investigated the negative relationship between impaired cognition and balance and gait in HD, our understanding of the neural mechanisms underlying these relationships is minimal. Furthermore, due to the constraints of fMRI, imaging the brain during dynamic and ecologically valid gait and postural conditions is not possible. However, advancements in portable functional near-infrared spectroscopy (fNIRS) have provided a noninvasive means to functionally image the brain under a variety of conditions. Based on the concept of neurovascular coupling, fNIRS monitors cortical activity in real-time by measuring alterations in oxygenated (HbO2) hemoglobin in the cortex. The objective of this study is to examine the cortical control of cognition, balance, and gait in HD under single-task (ST) and dual-task (DT) conditions compared to healthy controls. Methods: Nine participants with HD and 7 healthy controls completed ST and DT balance and gait testing wearing inertial sensors and an fNIRS cap to collect spatiotemporal gait and postural sway variables while concurrently measuring hemodynamic alterations in the prefrontal cortex (PFC). Additionally, a neuropsychological test battery measuring several cognitive domains was administered with concurrent fNIRS testing. Results: Trends in our preliminary data suggest that individuals with HD have greater activation of the PFC during ST gait ($p = 0.02$) conditions compared to healthy controls. However, a decrease in PFC activation is observed in HD under DT gait ($p = 0.1$) and balance ($p = 0.1$) compared to ST conditions. HD participants also had increased PFC activation compared to controls during performance of executive function tasks (digit span, $p = 0.002$; COWAT, $p = 0.001$). We anticipate the significance of these comparisons to continue to strengthen as our group numbers increase. Conclusion: Due to a decrease in motor automaticity, individuals with HD require greater attentional resources than healthy controls to safely maintain postural control and ambulate under ST conditions. However, the increase in PFC activation is not sustained with the addition of a cognitive DT due to limited maximal cortical recruitment. To our knowledge, this is the first fNIRS study performed in HD and we aim to use this technology to understand the neural underpinnings of the impact of cognition on balance and gait dysfunction in HD and to use this information to inform future rehabilitation and preventive therapies in HD. In future studies, we will also employ voxel-based morphometry of brain MRIs to determine structure-function relationships between cortical activation patterns, motor impairments, and neurodegeneration.

P3-E-34: ***Brain Activity Response to Cueing for Walking Impairment in Parkinson's disease: a Mobile EEG Study***

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Background: Walking deficit is common in Parkinson's disease (PD) and can lead to falls. Walking deficits include smaller steps, slower speed and freezing (a brief loss of walking). Cues can improve walking in PD, such as internal (thinking about bigger steps) or external prompts (visual, auditory or tactile), but the mechanisms involved in response remain unclear. Understanding how internal or external cues influence brain activity involved in cued walking may help determine mechanisms of response and future development of therapeutics. This study aimed to examine brain activity when walking with and without internal and external cues in PD. Methods: Mobile EEG (SAGA, TMSi, Netherlands) recorded brain activity when walking without and with cues (internal, visual, auditory, tactile) in 11 participants with PD (Age: 66.5±7.5 years, MDS-UPDRS III: 24.1±13.3, On Medication). Internal (thinking about bigger steps), visual (lines on the floor to step over), auditory (metronome beats to step in time with) and tactile (vibrations to step in time with) cues were used. Synchronized inertial sensors measured gait. EEGLAB software (Delorme and Makeig, 2004) derived brain activity, specifically source localized independent component (IC) clusters and their power spectral densities; Delta (δ:1-4Hz), Theta (q:4-8Hz), Alpha (α:8-13Hz), Beta (β:13-30Hz) and Gamma (γ:30-50Hz). We identified 32 ICs in total and formed three clusters (32/11 = 3) with source locations in the right parietal cortex (RPC), as well as the left (LSC) and right somatosensory cortices (RSC). Permutation statistical analysis using repeated measure ANOVAs were performed in EEGLAB. Results: Preliminary results showed significant differences for cueing strategies in several power spectral density outcomes, particularly in α, β and γ bandwidths. Parietal Cortex: there was reduced α and β power in the RPC when walking with visual cues (both $p<0.05$), and increased γ power when walking with auditory cues ($p<0.05$) compared to walking without cues or with other cueing strategies. Somatosensory Cortices: there was a reduction in α and β power in the LSC when walking with visual, tactile or internal cues compared to without cues ($p<0.05$), and increased γ power in the LSC when walking with auditory or internal cues compared to walking without cues or with other strategies ($p<0.05$). Similarly, in the RSC there was a reduction in α power when walking with auditory and tactile cues ($p<0.05$), and increased β and γ power with internal and visual cues compared to walking without cues ($p<0.05$). Conclusions: Preliminary EEG findings indicate that the parietal and somatosensory cortices responded to different cueing strategies. Particularly, cueing-related changes observed in the parietal cortex may indicate greater attentional as well as greater sensorimotor processing with visual and auditory cues. Responses observed in the somatosensory cortex may indicate greater sensory processing with all cueing strategies tested. The described responses may be part of the neural mechanisms underlying gait improvement with cues in PD. Acknowledgements and Funding: This study was funded by the Parkinson's Foundation (PF-FBS-1898, PF-CRA-2073) (PI: Stuart).

P3-E-148: ***The contribution of ascending arousal system to anxiety-induced freezing of gait***

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Background: Anxiety is a crucial contributor to freezing of gait in Parkinson's disease. Despite a growing body of evidence that suggests anxiety may be at the core of freezing of gait, no research study to date has investigated the neural underpinnings of anxiety-induced freezing of gait. There is evidence that the sympathetic arousal system increases in activity prior to a freezing episode, which highlights a potential neural mechanism to underpin the relationship between anxiety and freezing of gait manifestation. Aim: Here, we aimed to investigate how anxiety might 'set the stage' for freezing gait, through the ascending arousal system, by examining an anxiety-inducing virtual reality gait paradigm inside a functional MRI. Method: We used a virtual reality gait paradigm that has been validated to elicit anxiety by having participants navigate a narrow virtual plank compared to normal walking (no plank), whilst simultaneously collecting task-based functional MRI data from 26 individuals with PD with confirmed freezing of gait. We estimated time-varying dynamic functional connectivity and used graph theoretical approaches, to investigate system level features of brain network. To estimate ascending arousal modulation, pupils were also examined during the VR gait paradigm. Results: As expected, the plank condition (i.e., navigating across a narrow plank above a deep pit) provoked more freezing episodes when compared to the normal walking condition (i.e., navigating overground; $p = 1.86x10-4$). By utilizing a dynamic connectivity analysis, patterns of increased 'cross-talk' within and between motor, limbic and cognitive networks were identified during the threatening conditions compared to normal walking. Findings further showed that the threatening condition was associated with heightened network integration. Finally, increased pupil dilation ($p<0.026$) was observed during the anxiety-inducing condition of the virtual reality gait paradigm in a secondary experiment. When taken together, this study provides evidence of an increased ascending arousal response throughout the brain during the anxiety-inducing condition. Conclusion: In conclusion, our findings provide novel evidence for a neurobiological mechanistic pathway through which heightened sympathetic arousal related to anxiety could foster increased 'cross-talk' between distributed cortical networks that ultimately manifest as paroxysmal episodes of freezing of gait.

G - Cognitive, attentional, and emotional influences

P3-G-35: ***Dual-task conditions induce maladaptive turning behaviors and increased stepping errors during adaptive gait in older adults***

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BACKGROUND AND AIM: Falls are a prominent cause of disability and injury in older adults, yet the investigation of the contributing factors is a complex and multifaceted undertaking. One suggested contributor to falls is a maladaptive bodily reorientation strategy known as 'cross-stepping' (or 'spin' turns), whereby weight is shifted during a pivot around the stance limb, leading to the feet crossing over. Despite the implications of this stepping behavior, the causes of this possibly dangerous strategy have yet to be studied. One potential explanation for this behavior is impaired movement planning caused by issues with attentional allocation while walking. To test this suggestion, this study aimed to investigate whether the presence of a dual-task would increase the number of 'cross-steps' during locomotion. METHODS: Fifty-one older adults (M age = 74.63, SD = 7.39) free from neurological, musculoskeletal, and major cognitive impairment participated in the study. The walking task completed was modified from the multiple target stepping task implemented by Yamada et al. (2011). Participants traversed a 6-metre GAITRite walkway containing 24 (10cm x 10cm) stepping targets arranged into eight rows of three. A yellow, blue, and red target were presented in each row in a randomized order. When walking, participants were asked to step only on targets of a designated color and avoid other targets. This task was completed under single-task (normal walking) and dual-task (verbally serially subtracting in sevens) conditions. The average number of cross-steps, defined as when the stepping foot was planted with the heel over the midpoint of the stance foot, and stepping errors per trial were assessed via video footage by two independent raters (97.6% inter-observer reliability). Gait velocity (cm/s) alongside single- and double-limb support (% of gait cycle) were collected from the GAITRite. The number of correct calculations for the cognitive dual-task was also collected. RESULTS: When compared with single-task walking, the presence of a dual-task resulted in significantly more cross-steps ($Z = -3.46$, $p = .001$) and stepping errors ($Z = -4.09$, $p < .001$). Dual-task conditions also resulted in significant reductions in gait velocity ($Z = -5.79$, $p < .001$) and single-limb support ($t(51) = 4.10$, $p < .001$), as well as significant increases in double-limb support ($Z = -4.67$, $p < .001$) compared to single-task. In addition, cognitive performance significantly decreased when completing the dual-task ($Z = -5.64$, $p < .001$), with fewer correct answers produced. CONCLUSIONS: The increased incidents of cross-steps under dual-task conditions potentially indicates that this behavior is the result of attentional inefficiencies, and possibly poor movement planning. The effects of how attentional allocation could contribute to this behavior should be further investigated to confirm this interpretation.

P3-G-36: ***Evaluating the Influence of Sensory Feedback in Virtual Reality During Walking with Postural Threat***

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BACKGROUND: Given that humans have a lifetime of experience perceiving our bodies when we look down, it is not surprising that research has shown that visual exproprioception (i.e., the visual relation of the body to the environment) plays a crucial role in on-line control of lower limb trajectory during adaptive locomotion. Additionally, evidence suggests that young adults increase their attention towards their movement control during postural threat, which can be exacerbated in highly trait anxious individuals. However, it remains unclear how the absence of visual feedback about body movement in virtual environments might impact gait behaviour when faced with postural threat. AIM: Hence, the primary objective of the current study was to determine the influence of ex-proprioceptive visual feedback on gait behaviour during postural threat. The secondary objective of this study was to explore whether the influence of visual feedback was attenuated based on individuals' characteristic trait anxiety. METHODS: Ten young adults completed 24 walking trials in virtual reality, which varied the height (i.e. ground versus elevated) and width (wide vs narrow) of the walkway to manipulate threat. Visual feedback about the body was altered using an avatar which was only visible on half of the trials. Self-reported anxiety levels and spatiotemporal gait parameters were recorded for each trial. RESULTS: A significant interaction between height, width, and visual feedback was found for self-reported anxiety ($F(1, 7) = 5.73$, $p = 0.048$), which showed that participants had significantly greater anxiety ratings during elevated, narrow conditions compared to all other conditions. A main effect of visual feedback was found for step length ($F(1,7)=6.68$, $p=0.036$) such that step length decreased significantly (in all conditions) when visual feedback was present (compared to absent). Additionally, a significant interaction between walkway width and visual feedback was found for both step length variability ($F(1,7)=7.66$, $p=0.028$) and stride width ($F(1,7)=6.25$, $p=0.041$), such that in narrow conditions both parameters increased when visual feedback was present (compared to absent). Finally, a significant interaction between height, visual feedback, and group was found for step length variability CV ($F(1,7)=5.8$, $p=0.047$) which revealed that in elevated conditions, highly trait anxious participants decreased step length variability when visual feedback was available, whereas low trait anxious participants increased their step length variability when visual feedback was available. CONCLUSIONS: The findings from this study suggest that the presence of exproprioception while navigating a virtual height-induced threat appears to increase online control of gait behaviour in young adults. Additionally, our preliminary findings highlight that trait anxiety may influence the utilization of visual feedback when walking in threatening situations, however due to our small sample size, further work is needed. Future studies examining postural threat in virtual environments should consider the implications of disembodiment during gait which may limit the generalisability of findings to real-world behaviours. ACKNOWLEDGMENTS AND FUNDING: This study was funded by NSERC.

P3-G-37: ***Comparing the Effect of Two Different Secondary Cognitive Tasks on Cognitive-Motor Interference during Dual-Task Gait in Healthy Young Adults***

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Background and Aim: Cognitive-motor dual-task (DT), such as walking while talking or thinking, simultaneously challenges both dynamic balance and executive function. Different cognitive tasks challenge different cognitive domains, and may have different interference effects with gait. We aimed to compare the secondary tasks of verbal-fluency(VF), an internal processing task with verbal responses, and story memory(SM), an external auditory processing task, on cognitive-motor interference(CMI) during DT gait in healthy young

adults. Methods: Subjects were 32 young, healthy adults (78% female, mean age=25). Subjects wore sensors in knee sleeves that wirelessly sent kinematic data to a mobile iOS device. Subjects performed 3 trials of the ST conditions:10-meter walk test (TMWT), SM and VF. SM involved recall of 12 story elements, and VF involved listing as many words as possible of a particular category. They also performed two DTconditions (TMWT+SM (DT-SM) and TMWT+VF (DT-VF)). Gait speed(m/sec), stride time(sec), stride time variability(%CoV), cadence(steps/sec), number of correct words for VF, and number of recalled elements for SM were measured. CMI was calculated: DTcost (DTC)= ((DT-ST)/ST) X100, with negative values indicating poorer performance under DT condition. 1X3 repeated ANOVA compared gait variables across conditions, Paired t-test compared cognitive performance of ST and DT conditions, and One-sample t-test examined the null hypothesis of DTC=0. Statistical significance was set at $p<0.05$. Results: For most gait measures, there was statistically significant difference between ST and both DT conditions. For most gait measures, there was statistically significant difference between (DT-SM) and (DT-VF), with greater gait decrements under VF. There was significant DTC on gait for most gait variables, and DTC on all gait variables was higher under VF than SM. For gait speed, DTC for SM=-12% and VF=-15%, for stride time, DTC for SM=-6% and VF=-9%, for cadence for SM=-5% and VF=-8%, and for stride variability DTC for SM=-86% and VF=-102%. For cognitive performance, there was statistically significant difference and significant DTC between ST and DT conditions for number of story items recalled but not for correct response rate in VF. For SM performance (DTC-11%, p=0.00) for VF (DTC=-2%,p=0.55). Conclusions: Young adults showed gait performance decrements under both DT conditions, but the internally-driven demand of VF caused slower speed, slower cadence, and increased stride time compared to the SM, an externally-driven task. Under DT, subjects recalled less story elements but showed no change in VF performance compared to ST. Results suggest gait decrements under DT-VF is a result of prioritizing VF performance, thus showing cognitive-related motor interference pattern, while mutual-interference pattern appeared when SM was the secondary task. The findings support that the type of the secondary task during DT activity mediates CMI pattern.

P3-G-38: ***Association Between Turning Mobility and Cognitive Function in Chronic Poststroke***

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Background and Aim: Turning difficulties are common in patients with stroke. The detrimental effects of dual tasks on turning indicate a correlation between turning and cognition. Cognitive impairment is prevalent after stroke, and stroke combined with cognitive decline may have a greater effect on turning performance than stroke itself. Therefore, we investigated the association between turning mobility and cognitive function in patients with chronic poststroke. Methods: This cross-sectional observational study was conducted from

October 2019 to January 2021 at four hospital in Taiwan. The inclusion criteria were (1) age 20 to 99 years, (2) survivors of a single unilateral stroke with hemiparesis for at least 6 months before recruitment to the study, (3) ability to walk >10 m independently. Angular velocity (°/s) was assessed using APDM Opal wireless sensors and Mobility Lab software during 180° walking turns and 360° turning on the spot at a self-selected pace from both sides. Global cognition and distinct cognitive domains were assessed using the Mini-Mental State Examination. Results: A total of 90 patients with chronic stroke were recruited. Their turning mobility was significantly associated with global cognitive function and distinct cognitive domains, such as visuospatial ability and language. Individual items, including immediate memory, sentence reading, sentence writing, and sentence construction, significantly correlated with turning mobility. Conclusions: The association of turning mobility with cognition highlights the complexity of the turning movement and dynamic motor and cognitive coordination necessary to safely complete a turn. The turning parameter could be developed as a motor biomarker of cognitive impairment after stroke. Future interventional studies may incorporate cognitive training into the turning exercise for improving turning performance. However, our findings should be regarded as preliminary, and a thorough neuropsychological assessment to provide a valid description of distinct cognitive domains is required.

P3-G-39: ***Sensory Experience in VR Drives Balance-Related Anxiety***

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BACKGROUND AND AIM: Balance-related anxiety is a concern for individuals with a history of falling and vestibular disease. Balance-related anxiety has primarily been studied in the context of real postural threats. Yet there is widespread availability of inexpensive virtual reality (VR) systems, and VR has become an interesting alternative to traditional exposure therapy for individuals with anxiety. Exposure to high heights alters postural control and elevates autonomic arousal. How the sensory context of a virtual high-height postural threat in the absence of a real threat modulates autonomic arousal is unknown. We hypothesized that the context of sensory experience will mediate autonomic arousal responses associated with balance-related anxiety. METHODS: Five healthy young adults (mean age 20, 1 SD) participated in five standing balance conditions: two baseline conditions and three VR experimental conditions. The baseline conditions included standing with eyes open outside VR not wearing the head mounted display (HMD) and standing with eyes open wearing the HMD while turned off. The experimental conditions presented in random order included: being at a low height (ground level), being at a high height (seven meters above the ground), and arriving at a high height after an elevator ride. We measured electrodermal activity (EDA), electrocardiogram (ECG), respiration, electromyography (EMG), body sway, and subjective self-reports (anxiety, fear, stability, reality, emerging) during 40-second trials. Condition effects were analyzed using repeated measures ANOVA for the root mean square difference of heart rate variability (HRV) and the average tonic EDA. Pearson Correlations were calculated between HRV and tonic EDA with subjective reports. RESULTS: There was a significant main effect of condition effect for average tonic EDA ($F(4,16) = 5.48$, $p = 0.0056$).

Post-hoc t-tests revealed that the elevator ride experience had a significantly higher average tonic EDA (3.33 ± 0.82, $p = 0.009$) compared to wearing the HMD while turned off. There were no significant condition effects for HRV. EDA was negatively correlated with the perception that the VR was both real ($r = -0.35$, $p = 0.002$) and immersive ($r = -0.32$, $p = 0.006$). HRV was positively correlated with perception that the VR was both real ($r = 0.30$, $p = 0.01$) and immersive ($r = 0.29$, $p = 0.013$). Perceived stability was negatively correlated with both self-reported fear ($r = -0.29$, $p = 0.01$) and anxious ($r = - 0.28$, $p = 0.01$). CONCLUSIONS: These preliminary results suggest that autonomic arousal was influenced by the VR sensory contextual experience. These results may have important implications for VR exposure training to reduce balance-related anxiety or at home/clinical exergaming for individuals with balance-related anxiety. ACKNOWLEDGEMENTS AND FUNDING: NIH

P3-G-40: ***How does instructional set impact auditory Stroop and locomotor dual-task performance in young adults?***

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BACKGROUND AND AIM: The auditory Stroop task (Knight & Heinrich, Front Psychol, 2017) is a useful tool in dual-task research as it provides a facilitative or inhibitory cognitive challenge to participants without structural visual interference. We know the cognitive system is flexible and adaptable (Koch et al., Psychol Bull, 2018). However, we were curious to determine if the typical blocked presentation of Stroop cues used in most experimental paradigms resulted in reduced facilitative and/or inhibitory effects of the Stroop (Kalanthroff & Henik, Conscious Cogn, 2013). To our knowledge, the impact of randomly presenting neutral cues (which are neither facilitative nor inhibitory) and task presentation order have not yet been explored when an auditory Stroop test is administered during gait. We expect cognitive task response time (RT) to increase when auditory Stroop and neutral tasks are presented randomly, due to greater central processing demands. METHODS: Data collections are ongoing. To date, 10 young adults (aged 18-30; 6 female) were fitted with kinematic markers (Optitrack, 120 Hz) and completed 64 self-paced walking trials. During the trials, participants responded to a single auditory cue, either an auditory Stroop task (identify the pitch of a recorded voice saying, "high" or "low"), which was either congruent or incongruent with the word spoken (congruent, incongruent Stroop) or a neutral auditory task in a moderate pitch (repeat the words "Hello," "Lab," "Lemon," or "Home"). Trials were completed in two blocks; participants either received instruction on the type of cognitive task they would hear ("known" condition) or did not receive instruction (i.e., cognitive tasks randomly presented, "unknown" condition). Participants were randomly assigned to either group A ($n = 5$) who completed "known" trials first, or group B ($n = 5$) who completed "unknown" trials first. For each trial verbal response times (RT) to the cognitive task were collected via a custom-built microphone (1.2kHz), and center of mass velocity (CoMv) of the trunk and pelvis was estimated. Three-way repeated measures analyses explored the effects of participant group (group A, group B) by cognitive task (incongruent, congruent Stroop, neutral task) and instructional set ("known" vs. "unknown") on both RT and CoMv. Bonferroni post-hoc analyses were performed when appropriate. RESULTS: While no interaction effects were observed in RT, results revealed a main effect of cognitive task (incongruent Stroop > congruent Stroop > neutral task; $p < 0.05$) as well as Instructional set (Unknown > Known; $p < 0.05$). There were no interaction or main effects observed for CoMv. CONCLUSIONS: Preliminary results revealed that including a neutral task within a block of auditory Stroop trials increases the processing time required to respond to all cognitive tasks. This suggests that inclusion of a neutral task may increase central demands of an auditory Stroop during a locomotor protocol. ACKNOWLEDGEMENTS AND FUNDING: This project was supported by funding awarded to Dr. Lori Ann Vallis from the Natural Sciences and Engineering Research Council (NSERC) of Canada, and the Canadian Foundation for Innovation (CFI).

H - Coordination of posture and gait

P3-H-41: ***Surface topographic evaluation of 3D vertebral body position while standing: presentation of normative reference data***

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BACKGROUND AND AIM: Using surface topography (ST) it is possible to estimate individual vertebral body positions in an upright standing position with high precision. The technique is reliable and currently used in particular for monitoring the intraindividual progress of scoliotic patients. For the evaluation of an one-time posture analysis, a reference data set of a subject group defined as "healthy" is important. Up to now in scientific literature this is only available for global spinal parameters, like thoracic kyphosis and lumbar lordosis. Detailed 3D data for individual spinal segments are missing so far. Our study was set up to close the gap and gain these for the thoracic and lumbar vertebral bodies. METHODS: The present analysis is based on data from a comprehensive postural and movement analysis asymptomatic participants with DIERS Formetric III 4D? system (DICAM v3.7.1.7; DIERS International GmbH, Schlangenbad, Germany). This study was registered with WHO (INT: DRKS00010834) and approved by the responsible ethics committee at the Rhineland-Palatinate Medical Association (837.194.16). In order to analyze a cohort that is as „healthy" as possible, strong inclusion/exclusion criteria were defined. 100 women, aged 20-64 years, in habitual standing positions have been analyzed. Two-sample t-tests were used for age comparisons. To test deviations from symmetrical zero positions of VP-L4, one-sample t-tests were used. RESULTS: Coronal plane: on average, the vertebral bodies were tilted to the right between the VP and T4 (maximum: T2 − 1.8° ± 3.2), while between T6 and T11 they were tilted to the left (maximum: T7 1.1° ± 1.9). T5 and L2 were in a neutral position, overall we see a mean right-sided lateral flexion from T2 to T7 (apex at T5). Sagittal plane: the kyphotic apex located at T8 with − 0.5° ± 3.6 and the lumbar lordotic apex at L3 with − 2.1° ± 7.4. Transverse plane: participants had a mean vertebral body rotation to the right ranging from T6 to L4 (maximum: T11 − 2.2° ± 3.5) (see Figure). Age-specific differences were seen in the sagittal plane and had little effect on overall posture. CONCLUSIONS: Unexpected in habitual standing of healthy women, we found systematically tilted vertebral bodies in all three planes. In addition to well-known inclination in the sagittal plane, we determined a systematic vertebral rotation and lateral flexion to the right in vertebral segments T2-T7. Only little age-specific differences have be seen. These results should be taken into account in the rating of postural analysis and could influence the definition of therapy goals in the future. Data analysis for additional subjects is currently running, so that the results can be extended for male participants and the differences to females.

P3-H-42: ***Arm Swing during Pregnancy and its Impact on Balance and Momentum***

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Background and Aim: Arm swing has been shown to improve dynamic stability (Angelini 2018) and form reliable coordination patterns with other body segments during walking (Dedieu 2012; Meyns 2013). Studies of pregnancy have focused on the lower extremities and trunk. However, arm swing may also impact gait stability and efficiency. Examining arm swing may shed light on energy expenditure and fall risk during pregnancy. The purpose of this study is to examine the impact arm swing has on maintaining balance and momentum during pregnancy. Methods: Twenty-three pregnant women (28 ±4 y) were tested in four-week intervals (±2 weeks) at 18-, 22-, 26-, 30- and 34-weeks' gestation. Anthropometry and kinematic data were measured as they walked at self-selected speed. We calculated kinematics (stride, joint angles, joint velocity), balance (COM motion), coordination (modified vector coding), and whole-body momentum variables at each visit. Linear mixed model analyses were used to examine change over time and regression analyses were used to determine correlations between kinematics, balance and momentum. Results: Arm range of motion significantly increased ($p=0.006$) over gestation time. Arm flexion and extension velocities ($p=0.012$ and $p=0.004$) and leg flexion and extension velocities ($p=0.022$ and $p=0.015$) significantly increased over gestation time. Thorax and pelvis rotational velocities did not significantly change over time. Sagittal arm coordinations with sagittal leg ($p=0.042$), transverse thorax (Figure 1; $p=0.033$), and transverse pelvis ($p<0.001$) motions all significantly changed to be arm-dominant throughout pregnancy. All balance ($p<0.060$) and momentum ($p<0.014$) variables significantly increased over time, except single support time which decreased ($p=0.005$). 27% of the change in momentum over the course of gestation is explained by changes in arm coupling coordination's ($r=0.521$): leg-arm ($\beta=4.772$, $p=0.001$), thorax-arm ($\beta=0.550$, $p=0.001$), and pelvis-arm ($\beta=-0.529$, $p=0.006$). Changes in thorax-arm coupling explains 15.2% of the changes in single support time ($r=0.390$, $\beta=0.079$, $p<0.001$) and 10.6% of the change in center of gravity movement to edge of base of support ($r=0.326$, $\beta=0.193$, $p=0.001$). Changes in pelvis-leg coupling was only correlated with balance measures [mediolateral COM velocity ($r=0.205$, $\beta=1.249$, $p=0.035$)]. Conclusion: Arm swing increases over the course of gestation, but not thorax or pelvic rotations. Wu et al. (2004) also found no significant intra-individual trunk rotation differences by gestation week, but they did not examine arm motion changes. Our study shows that the coordination patterns the arms form with the rest of the body may have important implications for maintaining momentum during pregnancy. If arm motion is interrupted by constrained arm swing during a push, pull, or carry task, there may be greater energy required of the lower extremities, causing fatigue and increased fall risk.

P3-H-43: ***Adaptability of locomotor patterns during walking and turning in people with Parkinson's disease***

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BACKGROUND: Healthy walking is characterized by a high degree of flexibility in interlimb coordination, but neurological diseases like Parkinson's disease (PD) impair this complex interlimb coordination. Changes in walking direction are particularly challenging, requiring appropriate adaptions to the interlimb coordination patterns within the gait cycle. The aim of the study was to determine the effect of walking speed and medication state on interlimb coordination in people with PD and healthy individuals during straight walking and turning. METHODS: A total of 26 participants with idiopathic PD and 10 neurologically healthy older adults performed preplanned turns to the left and right, at different turn angles (45, 90, 135, and 180°) while walking at preferred and fast speeds. Participants with PD were tested twice, in their practical OFF state (at least 12 hours after their last intake of antiparkinsonian medications) and subsequently in the ON state (1 hour after a L-dopa challenge dose that was approximately 1.25-fold of their regular L-dopa dose). 9 degree of freedom wireless inertial sensor (Opals V1, APDM Inc.) data of the head, sternum, lumbar, feet, shanks and wrists were collected at 128 Hz. We extracted the 3 steps around the turn apex and applied cross-recurrence quantification analysis (cRQA) techniques to quantify the interlimb coordination for the right and left legs as well as arms. Four primary outcome variables were extracted: percent determinism, mean diagonal line length, maximal diagonal line length, and entropy of diagonal lines. Linear mixed effects models for repeated measures were applied. RESULTS: Figure 1 shows that people with PD have less deterministic coupling of the arms, couple for shorter periods of time (mean and max diagonal line length) and have less predictable coupling lengths of time (entropy) than their healthy peers. This appears true for all turn angles except for the most extreme 180-degree angles. Controls modulated arm-arm coupling based on turn angle, however people with PD did not. Yet, leg-leg coupling was modulated similarly between controls and people with PD across turn angles. However, people with PD show adaptation in coupling of the legs with turn angle that is very similar to controls. In the ON state, people with PD show a higher level of coupling in the arms than in their OFF state, but again no adaptation to turn angle. Turning and walking at fast speed further increased coupling of the arms. Yet, medication state did not change the coupling of the legs, while speed had minimal effect. CONCLUSIONS: During turning, the coupling of the legs is constrained by the requirements of the complex task; the arms, in contrast, can move freely. Reduced or asymmetric arm swing are well known clinical features of PD. Levodopa and fast speeds may play a role in restoring the disrupted interlimb coordination of the arms in those with PD. FUNDING: Medical Research Foundation of Oregon and NIH P20 GM109090.

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P3-H-44: ***Energy consumption during treadmill walking in adults with cerebral palsy as compared to neurologically intact adults***

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BACKGROUND AND AIM: Adults with cerebral palsy (CP) have reduced central motor control and peripheral soft tissue changes due to their central motor lesion. We hypothesize that these neuromuscular impairments affect postural control and movement energy efficiency of daily activities such as gait, and that reduced energy efficiency could be a factor in the high prevalence of fatigue in adults with CP. We therefore aimed to measure energy consumption during gait in adults with CP and how it is affected by the neuromuscular changes following the central motor lesion. METHODS: Twenty adults with CP and twenty age- and sex matched neurologically intact (NI) adults was recruited to undergo measurements of oxygen consumption, electromyography of the lower leg muscles, and gait kinematics obtained by Qualisys movement tracking during treadmill walking at their self-selected pace. We calculated an energy efficiency index from the oxygen consumption and gait speed and compared this to the step-to-step variation and postural symmetry. Additionally, ultrasound- and stiffness measurements of the plantar flexors was performed to assess the effect of muscle composition on gait pattern and the everyday experience of fatigue was assessed by the Multidimensional Fatigue Inventory questionnaire. In this way, we analyzed how specific movement patterns associated with efficiency of energy. NI adults walked at both 50% and 25% of their self-selected gait speed to see how energy efficiency was affected by gait speed. Maximal oxygen uptake was measured from an incremental VO2-max test on a stationary exercise bike. Maximal oxygen uptake was used to calculate the relative metabolic load that everyday activities, such as gait, require when living with CP. Electromyography was used to test whether the muscles of the lower limb exhibit fatigue during the gait test and how the fatigue affects gait posture. RESULTS: We found reduced energy efficiency during toe gait and during slower walking speeds. Many adults with CP walk on toes, at a slower pace than NI adults and with asymmetric and variable gait patterns, leading to a higher energy expenditure during everyday gait. NI adults did not show fatigue-related changes in muscle activity during walking, but CP adults fatigue faster due to their different muscle composition, further decreasing energy efficiency. CONCLUSIONS: Our study provides indications about how neuromuscular impairments in adults with CP affects energy efficiency during everyday movement and how this might be an important factor for the daily experience of fatigue. ACKNOWLEDGEMENTS AND FUNDING: The study was funded by a personal grant from the Elsass Foundation to Professor Jens Bo Nielsen. Grant number 19-3-1081

P3-H-45: ***How feedback model parameters in standing relate to performance during perturbed treadmill walking***

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BACKGROUND AND AIM: The human postural control system underlies both walking and bipedal standing. Many mechanisms are likely shared between tasks, but some may differ due to distinct biomechanical constraints. In walking, the base of support is changing with each step and the center of mass (COM) is moving in and out of the support; while in bipedal standing, COM motion is smaller and remains within the stationary support. In standing, external perturbations and parameterized feedback control models have been very helpful in quantifying the scaling of sensory-to-motor transformations and sensory reliance. Therefore, we used a feedback model in standing and a perturbed walking paradigm to better understand the relation between standing and walking reactive balance. METHODS: Seven healthy young adults (25.3±1.8SD) participated in both perturbed walking and standing trials. In walking, subjects were on a treadmill that was mounted to a moving platform. Reflective markers were placed on 25 bony landmarks. The platform translated continuously according to a sum of sine waves that appeared random and evoked balance responses in the frontal plane for 50 seconds. Metrics of performance included trunk sway, pelvis velocity, step width, step length, and joint angles. In standing, subjects stood with eyes open on a tilting platform that moved according to a pseudorandom sequence for 4 minutes evoking either frontal or sagittal plane responses. COM body sway was analyzed via root mean square, frequency response functions, and a feedback model. The feedback model parameters were normalized to body size and included: sensory weights (proprioception and vision+ vestibular), scaling of sensory-to-motor transformations (stiffness, damping, and integral gains), and neural time delay. Correlations between performance in gait and standing balance parameters were explored. RESULTS: In walking, the perturbations increased trunk sway, decreased step length, increased step width, and decreased joint range of motion. A high majority of metrics of perturbed walking and model parameters in standing were not correlated. However, shorter neural time delays (relative to body size) in standing were correlated with smaller frontal plane trunk sway in perturbed walking (R=0.83), lower variability in step width (R=0.81), and more knee range of motion (R=-0.88). Shorter time delays imply rapid corrections to deviations in trunk sway, which may limit the need for large adjustments in one's step width, and allow for more normal motion in lower extremities. We also found higher stiffness gains in standing were correlated with less frontal plane trunk sway in walking (R=-0.70) and more knee range of motion (R=0.86). Finally, higher visual+ vestibular reliance in standing was correlated with lower frontal plane COM velocity in walking (R=-0.71). CONCLUSIONS: Preliminary data suggests healthy young subjects with shorter neural time delays, higher stiffness, and more reliance on visual+ vestibular feedback relative to body size have improved metrics of performance during perturbed walking. Research is on-going to expand the range of subjects' ages, performance, and control parameters. FUNDING: DoD grant W81XWH-19-1-0870 (PI:Goodworth)

P3-H-46: ***Changes of dynamic balance in real life turning movements are sensitive for cerebellar ataxia***

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BACKGROUND AND AIM: The analysis of real-life walking movements adds ecologically validity to natural history and intervention studies. Turning movements represent a highly relevant component of everyday walking behaviour, since 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 aging focused on the assessment of general turning parameters like turn angle, mean velocity, duration or the number of steps within the turn. However, these measures do not reflect specific dysfunctional mechanisms like 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 $\delta=0.68$), with LVC also differentiating preataxic against healthy subjects ($\delta=0.53$). LVC was highly correlated with clinical ataxia severity (SARA score, effect size $\rho=0.79$) and patient-reported balance confidence (ABC score, $\rho=0.66$). 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 preataxic stage.

P3-H-47: ***Orthopedic footwear improves spatiotemporal gait characteristics and gait adaptability in individuals with hereditary motor and sensory neuropathy***

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BACKGROUND AND AIM Individuals with hereditary motor and sensory neuropathy (HMSN) typically suffer from lower-limb muscle weakness, sensory impairments and secondary ankle-foot deformities impacting their walking capacity. Orthopedic footwear is commonly prescribed to improve walking capacity in people with HMSN. However, supporting evidence for the efficacy of orthopedic footwear in people with HMSN is scarce. Furthermore, the effect of orthopedic footwear on more complex aspects of their gait capacity, related to the ability to adjust the walking pattern to changing environmental demands, have never been investigated. Therefore, the aim of this study was to investigate the effect of orthopedic footwear on spatiotemporal gait characteristics and gait adaptability in individuals with HMSN. METHODS Fifteen individuals with HMSN performed a two-minute walking test (2MWT) and a precision stepping task on an instrumented treadmill projecting visual stepping targets. They performed these tasks with custom-made orthopedic footwear and with standardized footwear (i.e. minimally supportive, flexible sneakers) in a random order. Primary outcome measures were gait speed (2MWT) and the average absolute distance between the middle of the visual targets and the middle of the foot placements (i.e. constant stepping error) during precision stepping. Secondary outcome measures included other spatiotemporal gait parameters from the 2MWT (step length, step time, step width) and the standard deviation of the constant stepping error (i.e. variable stepping error) during precision stepping. Differences between the footwear conditions were analyzed with a paired t-test (α=0.05). RESULTS Participants walked significantly faster with orthopedic footwear (1.27 m/s ± 0.27) compared to standardized footwear (1.05 m/s ± 0.34) (t(14)=3.8, p=.002). On average, orthopedic footwear resulted in a 9 cm larger step length (t(14)=3.8, p=.002), 30 ms shorter step time ((14)=-3.3, p=.005), and 3 cm smaller step width (t(14)=-3.3, p=.005) compared to standardized footwear. During precision stepping, the constant stepping error was significantly smaller for orthopedic footwear (5.2 cm ± 2.5) compared to standardized footwear (6.5 cm ± 3.0) (t(14)=-2.9 p=.037). Also the variable stepping error was significantly smaller with orthopedic footwear (2.5 cm ± 0.8) than with standardized footwear (3.3 cm ± 1.3) (t(14)=-3.2, p=.011). CONCLUSIONS The use of custom made orthopedic footwear appears to substantially improve the spatiotemporal gait characteristics and gait adaptability in individuals with HMSN, compared to using minimally supportive, flexible footwear. Further research should focus on the critical determinants of orthopedic footwear in relation to specific patient characteristics.

P3-H-48: ***Pelvic stability evolution during the Ultra-Trail® of Mont Blanc®***

Mellie Lavenant[1], Olivier Garcin[1]

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Mellie Lavenant[1,2], Olivier Garcin[2] 1- 3 route de Torfou, 91730 Chamarande, France 2- Podox'ygene, sports podiatrist BACKGROUND AND AIM Pelvic instability and its consequences are a common reason for consultations in podiatric practice. Pelvic instability is caused by a weakness of hip muscles stabilisator and related to injuries of the lower extremity area. (Barwick and al,2012). The aim of this study is to determine if the race induces a decrease of the time of the unipodal stance and a pelvic drop. METHODS 14 runners : 11 men and 3 women without pelvic instability at the beginning of the race (average age 41). 11 Finishers and 3 forfeiters at Courmayeur are evaluated during the ultra-trail of the Mont Blanc® (UTMB) 2019. Race of 172 kilometers and 10 000 meters of positif incline. Measurements points : Start / P2 (Courmayeur km80) / P3 (Champex km126) / Finish line. 3 tests were performed : all the tests were recorded with running shoes and both legs were tested - Unipodal test of pelvic stability - Single leg stance test (SLS) - Pain scale (VAS)

RESULTS - SLS was higher for the Finishers at P2. (P<0.05) - The unipodal test of pelvic stability increases at the finish line in comparaison with P2. (P<0.001) - VAS for the finishers increases between start and P2 and between P2 and the finish line. (P<0.05) - VAS for the forfeiters increases between the beginning of the race and P2. (P<0.01) CONCLUSIONS For the 2 populations the running fatigue seems to induce; - Drop of the SLS - Increase of the unipodal test of pelvic stability - Increase of VAS But not at the same time... At P2 the finishers are better than the forfeiters. After a rest at P2 the finishers seem to be more reactive on the SLS at P3. However with a raise of the pelvic instability. VAS increases more at P2 for the forfeiters (reason of the stop for some runners). It drops at the finish line for the finishers (Euphoria ?). ACKNOWLEDGEMENTS AND FUNDING Thank you to the medical committee of the ultra sport science and the UTMB organization to let us achieve this study. Thank you to Podox'ygene for the funding.

P3-H-49: ***The effect of balance control on dynamic visual acuity task in cheerleaders***

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BACKGROUND: Postural control in young adults is attentionally demanding. Additionally, as the demand for stability increases, there is an accompanying increase in the attentional resources that are utilized by the postural control system. Previous findings suggest that balance control in athletes with a recent sport-related concussion (SRC) may not be fully recovered upon return to play. However, it is unknown whether balance control is affected in athletes with a previous SRC while performing a secondary task or when balance is challenged. The purpose of this current study was to determine the effects of previous concussion on cheerleader's balance control during a dynamic visual acuity (DVA) task. The hypothesis is that cheerleaders with a previous SRC will demonstrate poorer balance control during a DVA task compared to non-concussed cheerleaders. METHODS: To date, 6 female varsity cheerleaders (~20.3 yrs) who reported previous SRC (CONCUSSED; mean time from injury = 28.7 days) and 8 (~20.4 yrs) with no recent history of SRC (CONTROL) have participated in the study. The participants stood on a Bertec force plate (sampled at 100Hz) standing quietly for 45s and while performing a continuous DVA task in four stance conditions: wide, narrow, single leg (left and right foot) on both a firm and a foam surface. Balance was assessed using root mean square (RMS) displacement of CoP in anterior-posterior (A/P) and medial-lateral (M/L) directions. The DVA task displayed an optotype character "E" that moved in a random motion condition across a 55" LED monitor. Participants were asked to maintain their focus on the moving letter and press an arrow on a keypad that identifies its orientation (i.e., up/down/left/right) as quickly and accurately as possible. As participants correctly identified the letter's orientation, the following letters became increasingly smaller until their orientation was not correctly identified on three trials. DVA scores (i.e., smallest letter identified) were assessed using LogMAR scores. RESULTS: Preliminary results revealed no significant differences in balance control between CONCUSSED and CONTROL groups during any of the stance conditions while standing quietly or while additionally performing a DVA task. Additionally, both groups maintained a consistent DVA score throughout each trial. See table 1. CONCLUSIONS: Unlike previous

findings, this group of athletes with excellent balance control did not demonstrate changes to a secondary visual attention task while balance control was challenged. Additionally, the group with a previous SRC, who recovered and returned to full activity, demonstrate that there are no residual effects from their previous concussions impacting their balance control abilities when challenged with a secondary task. This paradigm is challenging and may be more useful in determining readiness to return to sport following a SRC in the early stages of recovery.

P3-H-50: *Immediate effects of wearing a passive exoskeleton on spatiotemporal gait parameters.*

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BACKGROUND AND AIM: In the last decade, there has been a significant interest in the use of passive exoskeleton in the workplace. These technologies are identified as a promising ergonomic intervention to reduce the risk of work-related musculoskeletal disorders. Indeed, passive exoskeletons aim to reduce the workload associated with certain specific tasks such as repetitive lifting or moving loads. However, there is a lack of field-based evidence on the effects of using an exoskeleton on motor control during daily activities. The aim of this study was to examine whether wearing a passive exoskeleton for the upper or lower limbs affects spatiotemporal parameters during gait. METHODS: The study was completed by 18 healthy adults (mean age 22.9 [SD 1.1] years; 1.74 [SD 0.10] m; 68.9 [SD 0.1] kg; 9 males, 9 females). Each participant performed walking at a natural pace under 4 conditions: 1) without an exoskeleton (No), 2) with an upper limb exoskeleton (Exoup), 2) with a non-activated lower limb exoskeleton (ExoLo-), and 4) with an activated lower limb exoskeleton (ExoLo+). For each condition, data from 6 walking trials were collected and included for analysis. Each condition was realized in a random order. A GAITRite analysis system recorded spatiotemporal parameters of gait : 1) velocity (cm.s-1), 2) cadence (step.min-1), 3) step length (cm), and 4) double stance phase period (% cycle). For each parameter, we performed a Friedmann test to identify significant difference between the conditions. Depending on the results, we used post hoc analyses (Wilcoxon signed rank test) RESULTS: No significant difference was observed between conditions for gait speed and step frequency ($p = 0.09$ and $p = 0.625$, respectively). On the other hand, the step length was impacted by the experimental conditions ($p = 0.0009$). Post hoc tests revealed highly significant differences between No vs Exoup ($p = 0.001$), No vs ExoLo- ($p = 0.0005$) and No vs ExoLo+ ($p = 0.0004$). No significant difference was observed between the different exoskeleton conditions. We also observed a significant increase when wearing the exoskeleton in double stance period compared to the No condition ($p < 0.01$). CONCLUSIONS: Wearing a passive exoskeleton does not affect spontaneous gait speed. However, step length is reduced and double stance phase period is prolonged. Surprisingly, the changes in gait pattern are similar regardless of the type of exoskeleton (ExoLo or Exoup) and whether the assistance is activated or not (ExoLo+ vs ExoLo-),. When wearing an exoskeleton reduces step length, participants keep the same rhythmic organization of gait.

Further research is needed to determine the discomfort or resistance effects of exoskeleton wearing on gait and how to explain these effects in terms of biomechanical load, cognitive or psychosocial components. The effects of prolonged wearing on spatiotemporal gait parameters should also be investigated. FUNDING:This study was supported by the European Regional Development Fund (Interreg FWVI NOMADe)

P3-H-51: ***Theta burst stimulation of the posterior parietal cortex in healthy young adults, does it affect upper limbs and lower limbs differently? A sham-controlled study.***

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BACKGROUND AND AIM: The posterior parietal cortex (PPC) is a cortical area involved in planning and executing of visually guided locomotion. Several studies have demonstrated that the PPC is functionally and anatomically connected to the primary motor cortex (M1), which has different anatomical representations for the upper and the lower limbs. Previous studies have applied repetitive transcranial magnetic stimulation (rTMS) on the PPC to modulate the cortical excitability of upper limb, however there is a paucity of studies targeting lower limb. Therefore, the purpose of this study is to determine if the excitability of the upper and the lower limbs differs when targeting the PPC with rTMS. METHODS: Ten healthy young adults (aged 26±4) were recruited. The study consisted of 4 sessions conducted at least 72 hours apart. During the initial session, hotspots location for the first dorsal interosseous (FDI) and tibialis anterior (TA) were determined, as well as motor thresholds. On the three experimental sessions they received either inhibitory rTMS, excitatory rTMS or sham rTMS over the PPC. To quantify the effects of rTMS on the PPC, the PPC-M1 excitability was assessed using a dual-coil protocol, with an interstimulus interval of 4ms, a conditioning stimulus of 90% resting motor threshold (RMT) of the FDI and a test stimulus that evoked 1 mV on the target muscle, in both hand and leg representations. The measurements were acquired immediately before, and at three timepoints (0,20 and 40 minutes) after rTMS. RESULTS: Preliminary data of 10 participants was acquired and analyzed. In all participants we were able to measure the RMT of FDI and TA. But only in 5 participants it was feasible to reach a response of 1mV on the TA. Mean FDI RMT was of 44 ± 9.0% of maximal stimulator output (MSO), and mean TA RMT was 51 ± 14%MSO. There was no significant difference in the interindividual variability between FDI RMT and TA RMT (P=0.387). Additionally, there was no significant changes on the cortical excitability of FDI and TA when preconditioned by PPC, before and after the experimental protocols. CONCLUSIONS: Preliminary results showed that in 50% of the participants it was not feasible to reach 1mV responses on the TA. This suggests that not everyone will be a candidate for lower limb stimulation, due to the unfeasibility to modulate cortical excitability. PPC did not induce changes in the cortical excitability of the FDI and TA, before and after the experimental protocols, suggesting that functional connection between PPC-M1 cannot be modulated by stimulation of the PPC.

P3-H-52: ***Effect of temporal asymmetry on muscle synergy during walking with rhythmic auditory cueing in post-subacute stroke patients***

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Background and aim Temporal asymmetry characteristic of walking disorders post-stroke, caused by neurological disorders, is associated with impaired muscle activity patterns during walking. Although muscle activity during walking is patterned by muscle synergy, the association between temporal asymmetry and impaired muscle synergy is unclear. We examined the association between temporal asymmetry and muscle synergy during walking using rhythmic auditory cueing (RAC) in post-subacute stroke patients. Additionally, we examined factors affecting the changes in muscle synergy during walking with RAC. Methods Forty post-subacute stroke patients were assessed in a random block design under two conditions: comfortable walking speed (CWS) and walking with RAC. RAC was used as a condition to experimentally control the temporal symmetry during walking. The single-leg support time, lower-limb and knee joint angles, and electromyograms were measured. Factors affecting the complexity of muscle synergy (variance accounted for; VAF1) between walking conditions were examined using hierarchical multiple regression analysis. In the hierarchical multiple regression analysis, all variables were entered as the amount of change between walking conditions. Results The lower-limb flexion and knee flexion angles, single-leg support time on the paretic side, and the symmetry index of single-leg support time were evaluated in RAC compared to the CWS condition. VAF1 was decreased in the RAC condition (73.9 ± 0.15) compared to the CWS condition (76.9 ± 0.13, $p = 0.002$). A hierarchical multiple regression model was performed, with the change in VAF1 between walking conditions as the dependent variable; variables were manually added at each step to separate the effects of kinematic and temporal factors of walking. In Step 1, to confirm the effect of kinematics, Δlower-limb flexion angle ($p = 0.456$), Δlower-limb extension angle ($p = 0.527$), and Δknee flexion angle ($p = 0.790$) were entered; however, the model was not significant (R2 = 0.04, $p = 0.738$). To further examine the effect of the temporal factor, when Δsingle-leg support time was included in Step 2, the explanatory rate of the model increased to 38.8% from Step 1 (R2 = 0.43, $p = 0.002$). Conclusions RAC combined with walking immediately extended single-leg support time on the paretic side and improved temporal asymmetry. Moreover, the RAC condition demonstrated a more complex representation of muscle synergy than the CWS condition, and the change in single-leg support time on the paretic side affected changes in muscle synergy more than changes in kinematic variables on the paretic side. Our findings revealed that temporal asymmetry affect deficits in muscle synergy caused by neurological phenomena in post-subacute stroke patients. Acknowledgments We would like to thank the staff at Kio University Graduate School, Takarazuka Rehabilitation Hospital of Medical Corporation SYOWAKAI, and Nakazuyagi Hospital of Medical Corporation HIMAWARIKAI for their advice and help. Conflicts of interest statement The authors declare that there is no conflict of interest.

P3-H-53: ***Evaluation ofmuscle functions that contribute to pelvic stability during walking with lower limb length discrepancy***

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BACKGROUND: Lower Limb discrepancy can be related to shortening of bone structure (SLLD), such as osteoarthritis of the lower limb, before and after arthroplasty, or it can be caused by functional changes in the lower limb. In general, leg length differences of 3 cm or more result in changes such as increased floor reaction forces and increased lower limb kinetic energy. However, few studies have described the relationship between pelvic and lower limb joint motion and muscle activity of trunk and peri-hip muscles, and the mechanism of gait with SLLD is still unknown. Therefore, the aim of this study was to elucidate the muscles that contribute to pelvic stability by clarifying the kinematic and electromyographic changes during walking with SLLD in a population of healthy adults. METHODS: The subjects were 12 healthy adults without orthopedic diseases. The subjects walked on the treadmill at an optimal speed, and the muscle activities of the right and left erector spinae (ES), gluteus medius (GMed), and tensor fasciae latae (TFL) muscles were measured at a total of six locations. The subjects walked barefoot and wore shoes with a thickness of 4 cm on the dominant foot. 10 cycles of walking were measured at 8 time points (0/1/2/3/4/5/10/15min). The integrated values of pelvic and thoracic anterior forehead angles and muscle activities during stance and swing phases at each time point of each walking condition were used for analysis. For statistical analysis, the maximum pelvic tilt angle and muscle activity were classified into two groups: 0-5 min and 5-15 min of supplementary gait, and multiple comparisons by Tukey method ($p<0.05$) were performed within the groups including barefoot gait. RESULTS: The thoracic frontal plane movements in barefoot and walking with SLLD showed similar movements in both stance and swing phases. The maximum tilt angle of the pelvis was significantly tilted upward toward the swing leg in the stance leg phase compared with the barefoot phase($p<0.001$). In addition, the muscle activity of the left and right ES increased significantly up to 1 minute of supplementary stilt walking($p<0.05$). On the other hand, there was no significant difference in muscle activity of stance side GMed. CONCLUSIONS: These results suggest that during the stance phase on the non-compensatory side, the upper trunk was maintained in the median position, and pelvic elevation was performed by increasing the amount of right and left ES activity to secure the clearance between the complementary foot and the floor. On the other hand, there was no change in the amount of muscle activity in the stance leg side GMed, which is thought to contribute to the horizontal pelvic floor holding, suggesting that it is not related to the pelvic elevation movement on the swing leg side. These results suggest that dorsal trunk muscles, such as ES, are related to pelvic elevation movements during walking and contribute to pelvic stability in the frontal plane.

P3-H-54: ***Influence of postural body inertia on the use of postural balance mechanisms***

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BACKGROUND AND AIM: Standing upright remains difficult for humans because they must continuously stabilize their whole-body center of mass (CoM) high above a small base of support (BoS). To do so, humans can use two complementary mechanisms (Hof, 2007): 1) moving the center of pressure (CoP) within the BoS, i.e. oscillating around the ankles, and 2) mobilizing body segments' inertia, by rotating them around the CoM to create horizontal shear forces. This second mechanism has rarely been characterized but its contribution should increase when the contribution of the first mechanism is limited by the size of the BoS. Our objective was to determine whether postures modifying inertia around the anteroposterior axis crossing the ankles (IA) and/or the CoM (ICoM) would increase the use of the second mechanism when humans have to stand with a reduced BoS. METHODS: 24 healthy young adults (14 women, 26 ±6 years old) maintained four different unipedal upright postures on a forceplate, with eyes open and for 45s each: a reference posture, with arms alongside the body and small additional masses (2% of their body mass) attached to each shoulder, and three Vrikshasana postures without any additional mass: 1) arms grouped on the chest (IA -9% and ICoM -45%), 2) arms extended laterally at shoulder level (IA +0% and ICoM +0%) and 3) arms extended above the head (IA +11% and ICoM +7%). The contribution of the first mechanism was estimated by the percentage of the CoM mediolateral acceleration computed with Newton's second law that was correctly predicted by an inverted linearized inverted pendulum model (Hof, 2007). RESULTS: The contribution of the first mechanism in the reference posture (77%) was significantly superior to the three Vrikshasana postures (67%, 65%, and 63%, respectively for postures 1, 2, and 3, all $p<0.01$). CONCLUSIONS: The smaller the percentages indicate the more the second mechanism contributes to global postural balance control. Our results show that the second mechanism contributes from 20 to almost 40% of global postural balance control while maintaining unipedal standing postures, with eyes open. Although not changing inertia characteristics, the second mechanism contributed more to the second Vrikshasana posture than the reference posture, suggesting the nervous system relies more on this mechanism when a leg is elevated and positioned on the other leg. Similarly, despite no significant differences between postures, elevating the CoM (from Vrikshasana postures 1 to 3) seems to increase the contribution of the second mechanism to global postural control. Together, these results support that changing inertial parameters can help the central nervous system to maintain postural balance when the size of the BoS is reduced.

P3-H-55: ***The effect of age on intersegmental coordination during gait: a scoping review***

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BACKGROUND AND AIM: Aging impacts many aspects of neuromuscular control, e.g., rate of force production, but the effects on spatiotemporal patterning, i.e., motor coordination, and related functional implications are less clear. Impairments in bimanual motor coordination with age are often extrapolated to explain increased fall risk in older adult. However, as most falls occur during gait, measures of locomotor coordination may be more appropriate to mechanistically link coordination and falls. We performed a scoping review to answer the following questions regarding intersegmental coordination of the lower limbs during gait: 1) Is it worse in older adults than younger adults? 2) Are age-related changes associated with mobility and falls? 3) Do targeted interventions exist? METHODS: A comprehensive search was conducted in 6 databases using terms related to aging and kinematics/coordination. Studies needed to include: 1) older adults (mean age ≥65); 2) a measure of intersegmental coordination derived from lower limb kinematics; 3) normal walking. Studies were excluded if they considered: 1) interlimb coordination; 2) coordination of the head/thorax/pelvis, or foot segments; 3) turns or sit-to-stand only; 4) perturbations causing significant gait deviations. Included studies were reviewed in two stages by two blinded reviewers; discrepancies were resolved by a third reviewer. RESULTS: Twenty-four articles were included, which employed: uncontrolled manifold (UCM) analysis or covariation analysis (n=8), continuous relative phase or vector coding (CRP/VC) (n=7), principal coordinate analysis (n=8), other (n=1). Sixty-one percent of studies reported a significant effect of age ($p<0.05$ for at least one statistical test). Five studies considered the effects of falls history or the ability to predict falls: one-of-three employing UCM analysis reported a significant effect; two utilizing CRP/VC. reported effects. Two studies that collected clinical measures of mobility reported correlations with single leg stance and Dynamic Gait Index. Collectively, seven studies support an association between the ability to increase walking speed and coordination. One study reported coordination was unrelated to falls self-efficacy. One intervention study suggested coordination (per UCM analysis), can be improved through unstable resistance training. CONCLUSIONS: There is an apparent inconsistent effect of aging on coordination in community-dwelling older adults. Healthy older adults may develop strategies to ensure coordination and counter age-related neuromuscular change. Conversely, aging effects reported in 61% of studies may reflect older adults having difficulty in adapting gait patterns or intentionally relying on a smaller repertoire of solutions to maintain balance, particularly when gait is challenged. Future work should aim at to separate these conflicting explanations to better elucidate the functional implications of coordination in aging.

P3-H-56: ***Gait variability measures allow to capture longitudinal change in real life walking within one year in degenerative cerebellar ataxia***

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BACKGROUND AND AIM: Measures of step variability and body sway during gait have shown sensitivity to ataxia severity mostly in cross-sectional studies by correlating gait measures from laboratory-based assessments with clinical ataxia scores. However, to serve as ecologically valid biomarkers in upcoming intervention studies for degenerative cerebellar ataxia (DCA), gait measures have to prove (i) their sensitivity to individual short-term longitudinal change and (ii) their capability to quantify ataxia-induced impairments in laboratory-based assessments as well as in real life walking behavior. This longitudinal study aimed to unravel quantitative motor biomarkers in degenerative ataxias in real-life gait behaviour which are sensitive for longitudinally change in DCA. METHOD: Longitudinal (one-year and two-years interval) study in subjects with degenerative cerebellar (N=50) disease including pre-ataxic mutation carriers (N=16). Gait movements were assessed by three body-worn inertial sensors (Opal, APDM) attached to the feet and the lower back) in (1) instructed laboratory assessment, and (2) unsupervised real-life movements at patients' homes (4-8 hours per subject, including inside and outside walks). Out of the real-life data stream we extracted straight walking periods with bout lengths with-in the range of 20 to 50 strides. We focused on the analysis of spatio-temporal step variability and measures quantifying body sway in gait. RESULTS: Laboratory-based gait assessment showed first significant changes in gait measures after one year (stride duration variability: p=0.02, effect size rprb =0.38) and after two years (e.g. stride duration variability: p=0.01, rprb=0.58; lateral step deviation: p=0.054, rprb =0.44). Furthermore, longitudinal analysis of the reallife assessment (N=26) revealed significant changes in gait measures between baseline and one-year follow-up, (stride duration variability: p=0.04, rprb =0.47; lateral step deviation: p=0.03, rprb =0.51; lateral sway variability: p=0.03,rprb =0.58). Two-years follow-up analyses in real-life (N=14), showed confirming results with higher effect sizes (e.g. lateral step deviation: p=0.02, rprb=0.77; lateral sway variability: p=0.001, rprb =0.95). We found significant correlations between lab-based assessment and real-life gait measures (e.g. lateral step deviation: R=0.61, p<0.001), as well as between gaitmeasures and subjective confidence in real-life balance control (ABC-score)(e.g. lateral sway variability: R=-0.81, p<0.001). CONCLUSIONS: Despite the generally increased gait variability in everyday life movements, measures of gait variability capture ataxic-specific changes in real life walking with high sensitivity to longitudinal change, even within one year. Effect sizes in real life gait are increased compared to laboratory-based gait assessment. They thus present promising ecologically valid biomarkers for upcoming intervention studies.

P3-H-57: ***Advanced 3D vector space analysis to determine posture and gait dynamics***

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BACKGROUND AND AIM: In functional locomotion, stability and mobility must be maintained despite small kinematic disturbances or control errors. Many complex, non-linear dynamical systems approaches have been used to quantify gait stability and disturbance. We propose a novel approach based on vector space analysis (VSA) to illustrate stability of the body's center of mass (CoM) and coordination of body segments and joint angles using 3D phase diagrams, which can distinguish the gait performance between healthy subjects and persons with chronic stroke. METHODS: Participants with chronic stroke and age-matched healthy controls walked at their preferred, comfortable speed on a servo-controlled and self-paced treadmill while viewing a 3D-animated virtual reality scene that was coupled to the instantaneous speed. They were instructed to maintain a comfortable, preferred speed (self-paced). Body motions were captured with a 6-camera VICON MX system and analyzed based on a 41-marker, Plug-in Gait model. The body's CoM and lower limb joint angles were computed and normalized in time to the stride cycles of the individual paretic limb (for stroke participants) or the equivalent right/left limb (for healthy controls). Velocity data were obtained by differentiating position/angles in time and smoothed with a low-pass filter of 10 Hz. The VSA involves plotting 3D velocity vectors along with 3D mean trajectory points to construct a 3D phase diagram that embeds the 6D data set. This output is essentially a 3D plot of the velocity-position coordination of CoM or joint angles. The 3D velocity vector projections in each axis across the gait cycle were then squared and averaged. The mean sums of squares were then calculated for each direction and summed to represent the mean total kinetic energy related to the unit mass. The combined specific positional and kinetic energy can be evaluated using the mean Sobolev norm. RESULTS: The proposed VSA show distinct between-group differences in phase diagrams and Sobolev norms. The CoM velocity vectors are markedly increased in the mediolateral direction in the stroke participants compared to healthy controls, indicating a compromise in mediolateral stability. Stroke participants show lower Sobolev norms, particularly in the paretic limbs of low functioning participants walking at slow speeds. CONCLUSIONS: VSA in 3D can reveal the dynamics of limb coordination and stability control during gait, as well as any disturbance such as coordination impairments or mediolateral instability in people with chronic stroke.

P3-H-58: *Postural instability affects coordination of arm movement and postural adjustments during whole-body reaching in healthy adults*

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BACKGROUND AND AIM: Appropriate organization of kinematic degrees of freedom enables the system to accomplish multiple task goals with different combinations of joint rotations. Reaching from standing represents a dual-task in which two task components have to be adjusted: the endpoint (EP) trajectory and postural stability. The increased demand for postural adjustments may interfere with the stability of reaching. The objective of this study was to investigate the effect of postural instability on the use of kinematic redundancy to stabilize the EP and center-of-mass (COM) trajectories during reaching from standing in healthy adults. METHODS: Eleven healthy young adults performed standing reaching movements with and without postural instability induced by small base-of-support. The 3D positions of 48 markers were recorded at 100Hz. The uncontrolled manifold (UCM) analysis was performed separately with the finger and center-of-mass positions being the performance variable, and joint angles being the elemental variables. The Delta V, which was the proportion of variance that stabilizes (VUCM) and destabilizes (VORT) the performance variables respectively, was calculated separately for finger (Delta VEP) and center-of-mass (Delta VCOM) positions, and was compared between stable and unstable base-of-support. RESULTS: Delta VEP decreased after movement onset and reached the minimum value at around 50% normalized movement time, and increased until movement offset, while Delta VCOM remained stable. In 60%-100% normalized movement time, Delta VEP was significantly reduced in the unstable base-of-support, compared to the stable base-of-support condition. Delta VCOM remained similar between the two conditions. At movement

offset, Delta VEP at movement offset was significantly reduced in the unstable base-of-support, compared to the stable base-of-support condition, and was associated with an increase in VORT. VUCM remained similar between conditions. CONCLUSIONS: Postural instability might reduce the ability to use kinematic redundancy to stabilize the reaching movement. The central nervous system may prioritize the maintenance of postural stability over focal movement when postural stability is challenged. ACKNOWLEDGEMENTS AND FUNDING: We thank Ryuichi Kabasawa and Hikaru Koyama for support on data collection. The study was funded by the Gunma Foundation for Medicine and Health Science.

P3-H-59: ***Sagittal-plane motions accompany recovery from frontal-plane pelvis perturbations during staggered stance***

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Background and aim A staggered stance posture can be adopted in many scenarios during daily life. For example, during very slow walking a relatively long part of the gait cycle is spent in double support [1]. While standing in staggered stance, the recovery options in the frontal-plane without stepping are limited. This is due to the narrow base of support (BoS) compared to the larger BoS in the sagittal-plane. However, walking simulations showed that sagittal-plane ankle torques can also support in frontal-plane recovery [2]. We aimed to identify how healthy subjects make use of sagittal-plane motions when balance is perturbed in the frontal-plane while standing in staggered stance. Methods Ten healthy subjects stood in staggered stance, with the right foot leading, the left foot trailing and the centre of mass (CoM) in the middle. They received pelvis perturbations in medial (leftward) and lateral (rightward) directions (figure 1), with a magnitude of 9% of the subject's body weight and a duration of 150 ms. Data was recorded with a Qualisys motion capture system, Delsys EMG sensors and two Motekforce Link force plates. Body kinematics and dynamics were acquired via OpenSim [3]. The analysed outcome variables were the centre of pressure (CoP), CoM, extrapolated CoM (XCoM), muscle activities and joint torques. Results Initially, the mediolateral (ML) perturbations predominantly induced ML motion of the CoM with an accompanying weight shift in the direction of the perturbation. However, also motions in the sagittal-plane were involved in the recovery, figure 1. After medial perturbations, plantarflexion of both ankles was seen, shifting the CoP to the front. However, the CoM was also brought forward due to extension of both knees and a forward lean of the torso. This reduced the load on the trailing leg, which had initially increased due to the medial perturbation. An opposite strategy was seen after the lateral perturbations. Dorsiflexion of the ankles resulted in a backward shift of the CoP, while the CoM was brought backward due to flexion of the knees. This reduced the load on the leading leg, which was initially increased due to the lateral perturbation. These responses contribute in returning to the original weight distribution between the left and right leg, without directly opposing the perturbation direction in order to return to the initial condition. Figure 1: Top-down view of the BoS and trajectories of the CoM (solid), CoP (dashed) and XCoM (dotted) in AP and ML directions after medial (blue) and lateral (red) perturbations. The triangles mark the start (filled) and

end (open) of the perturbations. The line stops 1.5 s after the start of the perturbation (bar). Conclusions Strategies in the sagittal-plane accompany balance recovery after perturbations in the frontal-plane. These contributions could be explained by the strong plantar-dorsiflexion muscles and their large ability to modulate the CoP in the AP direction and restore weight bearing. References 1. Wu A.R. et al., Mechanics of very slow human walking. Sci. Rep, 2019 2. Kim M., Collins, S.H., Once-per-step control of ankle push-off work improves balance in a three-dimensional simulation of bipedal walking, IEEE Trans. on robotics, 2017 3. Delp S.L. et al., 2007

I - COVID-19

P3-I-60: ***Electromyographic abnormalities and balance in patients recovering from moderate to severe COVID-19.***

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AIM: To assess the influence of electromyographic abnormalities and functional capacity (6 min walk test) on the functional balance (Balance Berg Scale and Timed Up and Go test) of patients recovering from moderate to severe COVID-19 (after hospital discharge), with adequate performance on both cognitive test (Mini-mental State Examination ≥24) and activities of daily living (Barthel index ≥95). METHODS: Forty-three patients (25 men and 18 women) accepted to participate (mean age 51.4 ±9.3 years; Body Mass Index 28.5 ±4.57), 20%, with a history of diabetes and 30% of high blood pressure. After clinical assessment including muscle strength, evaluations were performed within 2 days, including the functional test and electromyography. RESULTS: Normal electromyography recordings were obtained just in 14 patients (32%), the abnormalities included: polyneuropathy (n=9), peroneal mononeuropathy (n=8), median mononeuropathy (n=7), multiple mononeuropathies (n=4), tibial mononeuropathy (n=1), and generalized myopathy (n=1). The distance on the 6 min walk test was 78.9% of the predicted, with oxygen saturation decrease to <90%. Multivariate analysis of covariance showed that the total score on the Berg Scale was related to abnormal electromyography, the dominant hand strength, and the performance on the 6 min walk test ($R=0.74$, $R2= 0.55$, $p<0.001$); the time to perform the Up and Go test was related to abnormal electromyography, the dominant hand strength, the time of hospital stay and the gender (i.e it was longer in women than in men) with a borderline result for the performance on the 6 min walk test ($R=0.75$, $R2=0.57$, $p<0.001$). CONCLUSIONS: The study shows the relevance of functional testing, including neuro-motor performance after hospital discharge of patients with moderate to severe COVID-19.

J - Development of posture and gait

P3-J-61: ***Daily living measures of Sit-to-stand transitions and mobility Across disease stages of Parkinson's disease***

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Background and aim: Gait and mobility impairments are considered a cardinal sign in Parkinson's disease (PD), gradually deteriorating as the disease progresses and severely impacting independence and quality of life. However, mobility assessment is usually done in a controlled clinical environment and little is known on the patterns of movement in everyday life and their progression with disease. Previous work has examined micro and macro measures of gait. The aim of this study was to explore sit-to-stand and mobility measures collected in daily-living conditions in different stages of PD. Methods: The study used a cross-sectional design to compare healthy controls (HC) and patients with PD who were divided into three groups based on their Hoehn and Yahr (H&Y) stage. Mobility data was collected using a tri-axial accelerometer (AX3, Axivity) worn by patients on the lower back for 7 days. Two wavelet-based algorithms were used to detect Sit-to-Stand (StS) transitions and activity segments in the signal. StS measures extracted included the number of transitions-per-day, transition duration, jerk, vertical velocity, and acceleration range. Physical activity and mobility measures included step count, number of walking bouts (NoB), percent-of-activity (PoA) during the day, and mean SVM (a measure of activity). Mobility data was supplemented by a thorough neurological assessment. Age, gender, and disease severity were included as co-variates in non-parametric ANCOVA to determine group differences. Results: 141 HC (mean age 53.0±10.2yrs), 63 early stage (ES)-PD (60.9±10.7yrs; H&Y: 1.1±0.2), 136 mild-PD (66.3 ± 9.2; H&Y: 2.0±0.1) and 44 moderate-PD (79.3 ± 6.9; H&Y: 2.87 ± 0.2) were compared. Step count, NoB, PoA, and mean SVM did not show differences between HC and early stage PD but showed a significant gradual decline between the PD groups. Similarly, the number of daily transitions declined with disease severity. However, transition "quality" measures such as jerk, vertical velocity and range only differed between HC and early-stage PD and between mild-stage and moderate-PD, but not between early-stage and mild-PD groups (Table 1). Conclusion: Postural transitions may be a sensitive indicator of PD in early disease stage, more than activity and general activity measures. With disease progression, changes in activity become more sensitive and pronounced, while in later stages, both postural transitions and activity measures markedly change.

P3-J-62: ***Development of the relationships among dynamic balance control, inter-limb coordination, and torso coordination during gait in children aged 3-10 years***

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BACKGROUND AND AIM: Knowledge about the developmental process of dynamic balance control comprised of arms and legs coordination and torso coordination is important to advance balance assessment for abnormal development. This study examined the development of dynamic postural stability, upper arm and upper leg coordination, and trunk and pelvic twist coordination (trunk/pelvis coordination) during gait. METHODS: This study included 77 healthy children aged 3-10 years and 15 young adults. The child cohort was divided into four groups by age: 3-4, 5-6, 7-8, and 9-10 years. Participants walked barefoot at a self-selected walking speed along an 8 m walkway. A three-dimensional motion capture system was used for calculating the extrapolated center of mass (XCOM), the spatial margin of stability (MoS), and phase coupling movements of the upper arms, upper legs, trunk, and pelvic segments. MoS along the mediolateral axis is defined as the minimum distance from the XCOM to the mediolateral position of the ankle marker in the stance leg. One-way analysis of variance was used to analyze the parameters among the groups. Then, the Tukey-Kramer post hoc analysis was performed. In addition, Pearson's correlation coefficient was used to examine the relationships between XCOM along the mediolateral axis and each inter-limb coordination and torso coordination. Finally, Pearson's correlation coefficient was also used to examine the relationships between contralateral combination (ipsilateral upper arm and contralateral upper leg combination) and trunk/pelvis coordination in each group to assess balance control strategies of the age groups. RESULTS: MoS in the mediolateral axis was significantly higher in the young adults than in all children groups. Contralateral coordination gradually changed to an in-phase pattern with increasing age until 9-10 years of age. Significant correlations of XCOM with contralateral coordination and with trunk/pelvis coordination were found ($r = 0.26$, $p < 0.01$; $r = -0.30$, $p < 0.01$, respectively). Significant correlations between the contralateral coordination and the trunk/pelvis coordination were observed only in the 5-6 years and at 7-8 years groups ($r = -0.59$, $p < 0.01$; $r = -0.52$, $p < 0.05$, respectively). CONCLUSIONS: Dynamic postural stability during gait was not fully mature at age 10. XCOM control is associated with the development of contralateral coordination and trunk/pelvis coordination. The closer to in-phase pattern of contralateral upper limb coordination improved the XCOM fluctuations. Conversely, the out-of-phase pattern of the trunk/pelvis coordination increased the XCOM fluctuation. Additionally, a different control strategy was used among children 5-8 years of age and individuals over 9 years of age, which suggests that limb swing depended on trunk/pelvis coordination in children 5-8 years of age. ACKNOWLEDGEMENTS AND FUNDING: This work was supported in part by a Japanese Grant-in-Aid for Scientific Research (19K19901).

K - Developmental disorders

P3-K-63: *Increased Proprioceptive Weighting During Postural Control in Young Adults with Autism Spectrum Disorder (ASD).*

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Background and Aim: Postural control deficits in Autism Spectrum Disorder (ASD) are well established, yet their aetiology remains unclear. Postural control involves integration of information from proprioceptive, visual and vestibular channels, with proprioception typically contributing more information compared with the other two channels. When a sensory perturbation occurs, for example when we step from a hard surface to grass or sand, proprioceptive information is down-weighted and visual and vestibular information are up-weighted to maintain balance using an adaptive sensory re-weighting process. Evidence suggests that the postural control deficits observed in people with ASD may be due to an over-reliance in proprioception. However, due to a lack of research in this area, it is unclear how NT and ASD adults differ in their ability to re-weight sensory information during the time immediately following perturbation. The aim of this study was to investigate a bias for using proprioceptive over visual information for postural control in adults with autism. We compared how NT and ASD adults adapt to visual and proprioceptive perturbations. Methods: 16 young adults with ASD (age range: 16-40) with IQ>80 and 20 NT age, gender and IQ matched controls participated. Non-postural measures included an IQ test, sensory profile and ADOS-2 (for the ASD group only). Participants stood unshod on a balance platform and sway was measured using motion capture (Fig 1A) in response to three sensory conditions: visual perturbation (surround sway-referencing, Fig. 1B, top), proprioceptive perturbation (platform sway-referencing, Fig. 1B, middle) and combined visual and proprioceptive perturbation (Fig. 1B, bottom). Each trial comprised 2 minutes of standing on a fixed surface with eyes open (baseline), 3 minutes of perturbation and again 2 minutes on a fixed surface with eyes open (reintegration). Results: Postural sway path length between groups did not differ at baseline. In response to the start (the first 30s) of the visual perturbation, NT, but not ASD adults, showed a greater increase in sway compared with baseline. Conversely, in response to the start of the proprioceptive perturbation, ASD, but not NT adults increased their sway from baseline. Both groups showed the greatest increase in sway in response to the start of the combined visual and proprioceptive perturbation, although there was no group difference in this condition. Finally, across the 3-minute adaptation phase, the ASD group showed consistently higher sway levels compared to the NT group, regardless of sensory condition. Conclusions: Our results show an increased reliance on proprioceptive and decreased reliance on visual information for postural control in adults with ASD. The lack of group differences in sway from baseline to perturbation-start in the combined condition suggests that these sensory-channel-specific group differences may be offset by one another. Our results support the presence of balance deficits in adults with ASD and suggest that these deficits are likely to be due to an over-reliance on proprioception and an inability to re-weight proprioceptive information.

P3-K-64: ***Texting while walking performance among adolescents with and without ADHD under different texting task requirements***

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BACKGROUND AND AIM: Texting while walking is becoming increasingly common especially in younger ages and is developing into a significant health risk. Children and adolescents with ADHD show deficits in executive function, as well as difficulties in gross and fine motor skills and gait stability that make them at higher risk when dual tasking. It was shown that texting while walking results in dual-task cost (DTC) reflected mainly in lower gait speed. However, studies that examined texting while walking as well as the effect of various attentional loads (difficulty of the secondary cognitive tasks) in adolescents are scarce, and specifically in adolescents with ADHD. The aim of this study was to evaluate the performance of adolescents with ADHD when texting while walking, in two levels of texting task (differ in motor and cognitive demands) and in two environments (inside and outside), compared with that of controls. METHODS: Nineteen adolescents with ADHD (mean±SD age 13.7 ± 2.2 years; 63.2% female) and 30 healthy adolescents (12.8 ± 1.9 years; 56.7% female) walked for one minute across an indoors corridor and an outdoor sidewalk, with and without texting on a mobile phone. The texting tasks included (1) copying simple three words sentences and (2) a verbal fluency task, i.e., texting as many words as possible starting in a predefined letter. Walking and texting performance were measured using inertial measurement units and a custom-made mobile app, respectively. In addition, participants were administered with the trail making tests to assess executive function. RESULTS: Gait speed was significantly lower (inside- $F(1,45)=31.95$, $p<.0001$;outside- $F(1,47)=36.25$, $p<.0001$), and DTC of gait speed was significantly higher (inside-$Z=-5.04$, $p<.0001$;outside- $Z=-5.08$, $p<.0001$) in the fluency texting task in both groups, with no significant between-groups differences. No significant differences (between tasks and groups) were found in gait variability. In addition, no between-groups differences were found in typing speed in both tasks and number of items in the verbal fluency task performed as single or dual tasks. No significant correlations were found between DTCs and trail making tests. CONCLUSIONS: Adolescents with ADHD did not demonstrate deficits in dual-task performance of a texting and walking task, regardless of the difficulty of the task or the environment. DTC of gait was higher during the more challenging task in both groups inside and outside, showing that despite the lower motor demand in the verbal fluency, the additional attentional load had a significant adverse effect on walking.

P3-K-65: ***A sensorimotor representation impairment in dyslexic adults: a specific profile of comorbidy***

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BACKGROUND AND AIM: Sensorimotor disorders have been frequently reported in children and adults with dyslexia over the past 30 years. As reading is a complex ability that requires perfect coordination between neural systems (vision, audition, language and motricity), this may explain why the phonological impairment is frequently associated with other disorders in dyslexia. The strength of the perception-action coupling between this various system is therefore central. This functional coupling, as underpinned by the mirror neuron system, is established early in infancy and is the basis for the development of cognitive, social and sensorimotor representations. Indeed, according to the theory of internal models, sensorimotor representations are needed to anticipate and act on one's environment. The present study aims specifically to explore the sensorimotor abilities and representations in young dyslexic adults. METHODS: Using 52 dyslexic participants and 58 normo-readers, we investigated whether the underlying phonological deficit, which is reported in the literature, was associated with a general impairment of sensorimotor representations of articulatory and bodily actions. As motor imagery is a relevant paradigm to explore internal representations, we used motor imagery tasks, consisting of measuring and comparing the durations of performed and imagined actions chosen from their current repertoire of daily life activities. To detect sensorimotor deficits, all participants completed the extended version of the M-ABC 2, as a reference test. RESULTS: We found sensorimotor impairments in 27% of the young dyslexics adult, then considered as sensorimotor comorbid, as opposed to much less in the normo-reader group (5%). Motor slowdown, reflecting motor difficulty, was present in all dyslexic adults. In contrast with slowness, specifically the sensorimotor comorbid subgroup showed an increased variability in execution durations. Motor imagery, as a process of exploration of sensorimotor representations, was impacted only in this specific dyslexic subgroup with sensorimotor impairments. CONCLUSIONS: The present study aimed to determine the impact of sensorimotor comorbidity risks in dyslexia by investigating the functional links between phonological and sensorimotor representations in young dyslexic adults. It highlights the relevance of studying sensorimotor profiles beyond the typical consensus phonological deficits and provides new arguments supporting the perspective of multiple deficit approaches in dyslexia. Furthermore, it highlights the importance of the quality of the perception-action coupling for establishing the functional link between language and sensorimotor representations, which is essential for reading. ACKNOWLEDGEMENTS AND FUNDING: We gratefully acknowledge all the participants of this study. This work was supported by a grant from the Fédération 3C, Aix Marseille Univ, CNRS, in Marseille, France.

P3-K-66: ***Articulatory and gait rhythmic performances in dyslexic adults : domain-specific or general impairments?***

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BACKGROUND AND AIM: Impairment of rhythm perception and reproduction has been previously reported in developmental dyslexia (DD). However, rhythm production has been little explored in this population. It is questionable why the link between spontaneous gait and articulation rhythmicity, which has been studied many times in healthy and pathological populations, has not crossed the boundary of DD despite the strong sensorimotor comorbidities and the importance of rhythm in reading. Thus, the present study aimed to examine the rhythmic skills as domain-specific or general by investigating the possible relationship between articulatory and gait rhythmic performances in young dyslexic adults with or without sensorimotor (SM) disorders. METHODS: We explored the articulatory and gait rhythmic skills in 52 young dyslexic participants (with and without SM comorbidity) and 58 skilled readers (SR). We investigated whether such skills were related to the SM

disorders/reading profile. To detect SM deficits, all participants completed the M-ABC 2. Articulatory rhythmic skills were explored with an oral diadochokinetic task, i.e., a syllable alternating motion rate, consisting of repeating the pseudoword /pataka/ as fast as possible for 30s. This protocol allowed a direct measurement of orofacial motor control, independently of other speech dimensions. Gait rhythmic skills were tested using a natural gait task and a complex gait task (tandem gait) with a strong balance constraint. RESULTS: Articulatory rhythmic skills correlated with reading fluency performance and were specifically impaired in the pre-defined dyslexic group with SM impairment comorbidity. In contrast, gait rhythmic skills (without or with balance constraint) were not affected in any dyslexic group. Moreover, an expected correlation between articulatory and gait rhythms was reported in SR and dyslexics without SM disorders. However, this correlation was not found in the group of subjects with SM comorbidity. CONCLUSION: The originality of this study was to explore gait and articulatory rhythmic skills with the objective of distinguishing single and generalized impairment in DD as a function of the subject' SM comorbidity. The lack of correlation between spontaneous gait and orofacial rhythm in these subjects indicates a desynchronization of the spontaneous rhythmicity of the body as a whole. However, a domain-specific rhythmic impairment (i.e., articulatory) was reported in dyslexic subjects with SM comorbidity. Moreover, the correlation between articulatory rhythmicity and reading performances in all subjects highlights the importance of exploring possible articulatory rhythm disorders in dyslexic populations and is in line with recent theories postulating that poor sampling and temporal coding of events in DD affects their processing of information in reading. ACKNOWLEDGEMENTS AND FUNDING: This work was supported by a grant from the Fédération 3C, Aix Marseille Univ, CNRS, Marseille, France.

L - Devices to improve posture and gait

P3-L-67: ***Virtual Reality in Physical Therapy - Differences Between Clinicians and Students in Intention to use VR in Clinical Practice***

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BACKGROUND AND AIM: Physical Therapy (PT) aims to address motor deficits (including of gait and posture) and improve quality of life following aging, injury or disease. Research supports virtual reality (VR) as an intervention to improve motor outcomes. The unique features of VR allow for the creation of safe, customizable, engaging, and interactive interventions that may be difficult or impossible to create through traditional interventions in the physical world. Despite evidence supporting the utility of VR as a rehabilitation tool, in a previous survey of Physical Therapists (PTs) and Physical Therapist Assistants (PTAs), only 31% of respondents reported using VR in their current PT practice. The reasons behind this low adoption are unclear. Additionally, the difference between intention to use VR in clinical practice by current clinicians and future clinicians is unknown. Thus, the purpose of this study was to investigate the degree to which licensed clinicians (PTs and PTAs) and future

clinicians (PT and PTA students) intended to use VR in clinical practice. The Assessing Determinants of Prospective Take-up of Virtual Reality Survey version 2 (ADOPT-VR2), presented via an electronic survey, was used to assess behavioral intention to use VR by both licensed and student clinicians. METHODS: PTs (n=528), PTAs (n=98), PT students (n=58) and PTA students (n=33) were recruited to participate in the electronic survey. Recruitment was via e-mail contact through state licensing boards, specialty practice areas, accredited PT or PTA programs, as well as by convenience and snowball sampling through social media and other digital outlets. The survey consisted of demographic questions followed by the ADOPT-VR2 survey. The ADOPT-VR2 responses are on a Likert scale (1 to 9). Three questions on the ADOPT-VR2 address behavioral intention to use VR in clinical practice. The mean of these responses was used to quantify overall behavioral intention to use VR in clinical practice for each group. To investigate the differences between clinician and student groups on behavioral intention, a two-tailed independent t-test was used. RESULTS: As expected, a small percentage (7.2%) of licensed clinicians reported using VR in clinical practice. Students (M=4.95, SD=1.91) had significantly higher behavioral intention to use VR than clinicians (M= 3.28, SD=2.13), t(125.119)=7.641, p=<.001). CONCLUSIONS: To our knowledge, this survey is the only survey of this nature and scale investigating the use of VR by rehabilitation professionals, that incorporates PTAs, PT and PTA students. The views of both clinicians and students provide important insight into the current and future usage of VR in clinical practice. The lower behavioral intention of clinicians may help to explain why current clinical VR adoption is low. However, significantly higher behavioral intention by students is a promising finding for the future of VR use in PT as these students become practicing clinicians.

P3-L-68: ***Effects of wearing textured versus smooth shoe insoles for 12-weeks on gait, foot sensation, and patient-reported outcomes, in people with Multiple Sclerosis: a randomised controlled trial***

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BACKGROUND AND AIM: Innovative shoe insoles, designed to enhance sensory information on the plantar surface of the feet, could help to improve walking in people with Multiple Sclerosis. Textured insoles appear to be of greatest benefit in populations where sensory and motor deficits coexist, such as Multiple Sclerosis, and are therefore gaining impetus as an attractive intervention within neurorehabilitation. The aim of this study was to compare the effects of wearing textured insoles versus smooth insoles, on measures of gait, foot sensory function, and patient-reported outcomes, in people with Multiple Sclerosis. METHODS: A prospective, randomised controlled trial was conducted with concealed allocation, assessor blinding and intention-to-treat analysis. Thirty ambulant men and women with Multiple Sclerosis (Disease Steps Rating 1-4) were randomly allocated to wear textured insoles or smooth insoles for 12-weeks. Self-reported insole wear and falls diaries were completed over

the intervention period. Laboratory assessments of spatiotemporal gait patterns (12 metre walkways with even and uneven surfaces), foot sensation (light-touch pressure sense, vibration sense, two-point discrimination) and proprioception (ankle joint position sense), and patient-reported outcomes (walking ability, Multiple Sclerosis symptoms, falls, and quality of life), were performed at Week 0 (Baseline 1), Week 4 (Baseline 2) and Week 16 (Post-intervention). The primary outcome was the size of the mediolateral base of support (stride/step width) when walking over even and uneven surfaces. Independent t-tests were performed on change from baseline (average of Baseline measures) to post-intervention. RESULTS: There were no differences in stride width between-groups, when walking over the even or uneven surfaces (P ≥0.06) at post-intervention. There were no between-group differences for any of the secondary outcomes including gait (all P values >0.23), foot sensory function (all P values ≥0.08), and patient-reported outcomes (all P values ≥0.23). Data from the insole wear diaries indicated that a proportion of participants in the control (N=7, 47%) and intervention (N=9, 60%) groups, experienced changes in foot sensation, but this was not significantly different (P=0.72). CONCLUSIONS: Wearing textured insoles for 12-weeks did not appear to alter walking patterns or foot sensation in people with Multiple Sclerosis who have limited foot sensory loss. However, textured insoles may be an effective gait rehabilitation strategy for people with Multiple Sclerosis who have significant loss of foot sensation: this area is yet to be explored. It remains unclear if wearing textured insoles for an extended period leads a user to habituate to the sensory stimuli, and thus any immediate or short-term improvements in gait become redundant over time. Further investigation is needed to investigate the effect of textured insoles in people with neuropathy, and to explore optimal insole design features, by way of larger studies. ACKNOWLEDGEMENTS AND FUNDING: This work was supported by a Multiple Sclerosis Research Australia Project Grant (Grant ID: 13-006).

P3-L-69: ***Immediate effects of wearing textured versus smooth insoles on standing balance and spatiotemporal gait patterns when walking over even and uneven surfaces in people with Multiple Sclerosis***

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BACKGROUND AND AIM: Textured shoe insoles, comprising raised nodules designed to stimulate plantar mechanoreceptors, are gaining impetus as a possible intervention to improve balance and gait in clinical populations. Existing evidence in people with Multiple Sclerosis focuses on the effects of wearing textured insoles for the first time on measures of unperturbed standing and level-ground walking, however, these protocols fail to simulate more challenging conditions encountered in everyday life such as changing terrain (e.g. uneven ground; pavements) and the sensory environment (e.g. compliant surfaces; carpet), which can disrupt upright stability. The aim of this study was to determine whether wearing textured insoles for the first time improves measures of standing balance and gait, under challenging sensory conditions, in people with Multiple Sclerosis. METHODS: A cross-sectional study was conducted with 41 ambulant men and women with Multiple Sclerosis (Disease Steps Rating 1-4). Assessments of balance whilst standing for 30 seconds on a firm and foam surface and with eyes open and closed (AMTI force platform), and walking ability when negotiating even and uneven surfaces (12 metre walkways) at a self-selected speed, were performed wearing textured insoles, smooth insoles, shoes only, and barefoot (randomised). Outcome measures were centre of pressure movement during standing (elliptical area, sway path velocity) and spatiotemporal gait patterns (stride/step width, stride time, double-limb support time, stride length, velocity). For each measure, symmetric percentage differences from the 'shoes only' condition was reported, and a global P value (testing for within-subject differences between the insole conditions) was calculated. The alpha was set to 0.05. RESULTS: Wearing textured insoles led to reductions in centre of pressure velocity measures when standing on a compliant foam surface with eyes open and closed, compared to smooth insoles and barefoot (P values ≤0.023). Textured insoles did not appear to be superior to smooth insoles or shoes only for improving spatiotemporal gait patterns. However, walking barefoot led to poorer gait performance for both the even and uneven surface tasks, relative to the insole/shoe conditions (P values ≤0.041). CONCLUSIONS: Wearing textured shoe insoles for the first time can lead to immediate improvements in balance when standing on compliant surfaces. For people with Multiple Sclerosis, stimulating the foot sole with 'texture' appears to provide enhanced sensory input with the capacity to reduce centre of pressure velocity during standing, indicative of a more controlled movement pattern. It remains unclear whether wearing textured insoles for the first time can alter walking patterns. Further research is needed to identify which individuals may benefit most from wearing textured insoles, with consideration to the severity of baseline foot sensory loss and gait impairment in people with Multiple Sclerosis. ACKNOWLEDGEMENTS AND FUNDING: This work was supported by a Multiple Sclerosis Research Australia Project Grant (Grant ID: 13-006).

P3-L-70: ***Assessing the Effects of a Lower Limb Exoskeleton During Postural Perturbations on Center of Pressure***

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Background: Falls result in significant medical, social and economic costs for the elderly as well as a variety of patient populations. Robotic exoskeletons are being used more frequently with clinical populations to facilitate rehabilitation, though little work exists examining the effects of exoskeletons themselves on postural control. The aim of this project is to examine an individual's brain waves to identify an impending fall and use that information to apply corrective torques with an exoskeleton to prevent falls. Prior to realizing this aim, a greater understanding of how wearing an exoskeleton impacts postural control in response to perturbations is necessary. Methods: Seven healthy, young adults received 30 backward postural perturbations with and without wearing an exoskeleton. Center of pressure (COP), lower limb electromyography (EMG) and electroencephalography (EEG) data were collected. Data were separated into three epochs: baseline (200 to 0 ms prior to the perturbation), response (1 to 350 ms after the perturbation), and recovery (351-950 ms after the perturbation). Data were time synchronized during collection. The sagittal plane COP waveform were normalized such that each waveform began at 0 cm. This report concerns only the COP data analyses. Peak values and root mean square measures (RMS) of COP and COP velocity were calculated for each epoch. COP pathlength (PL) within the response and recovery epoch were also calculated. Statistical parametric mapping (SPM) was used to assess potential differences in the COP waveforms with and without the exoskeleton (Robinson, Vanrenterghem, & Pataky, 2015). SPM computes the conventional univariate t-statistic between two waveforms as calculated at each sample. Statistical differences between waveforms at specific segments can then be identified. Results: All participants displayed very similar COP response waveforms with peak excursion occurring approximately 350 ms after the perturbation. Peak COP in the exoskeleton condition was less than in the no exoskeleton condition ($p = 0.036$). There were no significant differences in any of the RMS measures. PL was significantly different between the no exoskeleton and exoskeleton conditions during the response and recovery epochs. SPM analyses revealed that the COP was significantly different between the two exoskeleton conditions for 72% of the response epoch and 63% of the recovery epoch. Conclusions: SPM analyses revealed significant differences between COP waveforms that were not detected using RMS measures. The results indicate that employing a number of analysis techniques can provide a more complete profile of the effects of a lower limb exoskeleton on COP profiles during backward postural perturbations. These findings highlight the importance of assessing how kinematic response patterns may be modified with the wearing of exoskeletons when developing brain-activated exoskeletons to most successfully prevent falls. This project was sponsored by the NSF IUCRC Building Reliable Advances and Innovation in Neurotechnology (BRAIN) Center Award (NSF Award 1650536)

P3-L-71: ***Assessing the Effects of a Lower Limb Exoskeleton During Postural Perturbations on Lower Limb Neuromuscular Activation***

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Background: Though there is little previous research on the effects of exoskeletons on postural control, they are increasingly being used in rehabilitation programs for a variety of patient populations. Exoskeletons are generally used to promote individual mobility and lessen the impact of, or entirely prevent, falls. As new robotic exoskeletons are developed, it is important to consider how these devices impact postural control. The overall aim of this project is to identify brain waves associated with impending falls and use that information to activate a robotic exoskeleton in order to prevent falling. However, to realize this goal a greater understanding of how wearing an exoskeleton impacts postural control in response to perturbations is necessary. Methods: Seven healthy participants between the ages of 18

and 35 received a series of 30 backward postural perturbations with and without wearing an exoskeleton. Lower limb electromyography (EMG), center of pressure (COP), and electroencephalography (EEG) data were synchronously collected. For each perturbation, data were separated into three epochs: baseline (200 to 0 ms prior to the perturbation), response (1 to 350 ms after the perturbation), and recovery (351-950 ms after the perturbation). This report concerns only EMG data analyses. EMG data from the medial (MG) and lateral gastrocnemius (LG), tibialis anterior (TA) and soleus (SO) muscles were filtered and rectified. Root mean square values (RMS) were calculated within each epoch, for each muscle. Peak amplitude values were also obtained. Statistical parametric mapping (SPM) was used to assess potential differences between EMG waveforms with and without the exoskeleton (Robinson, Vanrenterghem, & Pataky, 2015). SPM computes the conventional univariate t-statistic between two waveforms as calculated at each sample. Statistical differences between waveform samples can then be identified. Results: EMG analyses revealed that peak MG amplitude was significantly less when wearing the exoskeleton while the SO RMS was less during the recovery epoch compared to baseline. MG RMS during the response epoch approached significance ($p=0.06$) with the exoskeleton condition being less than without. SPM analyses indicated that only a single sample of the MG and TA waveforms reached significance. These differences occurred approximately 30 ms after peak COP was reached. No other differences between EMG waveforms were identified. Conclusions: These results indicate that there are minimal neuromuscular activation changes associated with the wearing of an exoskeleton, when responding to backward perturbations. This suggests that the exoskeleton itself does not significantly impact neuromuscular components of postural control. However, more research is needed to identify additional parameters that may impact postural stability when wearing robotic exoskeletons. This project was sponsored by the NSF IUCRC Building Reliable Advances and Innovation in Neurotechnology (BRAIN) Center Award (NSF Award 1650536)

N – Ergonomics

P3-N-72: ***Sitting vs. standing: historical evolution, incidence, and related consequences on task performance and health***

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Background and aim: various activities/body configurations are performed everyday (performing physical activities, walking, standing, siting). Fundamental mechanisms of posture and gait are relevant questions but investigators also need to know how much time individuals spend in performing these activities/body configurations. Here, we focus on standing vs. sitting at a worldwide level. Our ancestors were mostly nomadic and today (especially since Word War II), individuals spend a lot of time in passive nonambulatory behaviors (e.g. sitting in a chair or on a sofa). Method 1: Our first analysis will test the prevalence of sitting vs. standing positions in recent history, also in considering the effect of the coronavirus disease 2019 pandemic. Result 1: In our review, objective measures of

sitting (using accelerometers and/or inclinometers) performed in many high-income countries will show that healthy adults (aged 18-65 years) sit more than 8 h/d. Method 2: The question will become whether the passive time spent sited is not excessive? Result 2: Our review will show that excessive sitting is associated with a very large amount of so-called non-communicable diseases (e.g. premature mortality; diseases such as type 2 diabetes, cancers; physiological problems such as sleep disorders; immune and endocrine impairments; impairments in executive function, cognitive performance, self-control; psychological aspects such as anxiety, demotivation, depression). Method 3: The next question will be asked what are the recommended thresholds of time not to cross to avoid these non-communicable diseases. Result 3: Recent publications in the World Health Organization still do not recommend any threshold. However, my colleague and I will emphasize that regularly sitting more than 8 h/d is dangerous for health. Overall, it is hard to understand why our societies have counterproductively and counterintuitively constrained individuals to sit so much. Conclusions: In conclusion, we will recommend spending more time in active nonambulatory behaviors (e.g. sitting on a Pilates ball) than individuals do today. The fact of maintaining balance seems to be important to stay healthy, as shown by researches investigating nonambulatory behaviors of hunter-gatherers living nowadays. Second, we will recommend spending more time in the standing position in regularly alternating sitting vs. standing. One way to succeed is to use sit/stand desks at work and even at home. In the ISPGR, we are all wondering mechanisms to be efficient in posture and gait. Here, my colleague and I are wondering the posture to be adopted to be efficient in long-lasting activities, i.e. in work productivity. Clearly, it seems better to maintain balance more actively to avoid non-communicable diseases and related breaks in work productivity.

O - Exercise and physical activity

P3-O-73: ***High sedentary behavior negatively impacts postural balance but not gait***

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Background and aim: Evidence exists that older adults who self-report high physical activity (PA) levels have a reduction in postural sway in the absence of visual input as well as decreased gait variability. However, these studies fail to account for sedentary behavior (SB). While significant evidence exists on the physical and mental health benefits of PA, additional evidence exists that high SB may nullify the positive health benefits of PA. While we are unaware of literature examining these phenomena in balance and gait, based on the negative consequences of high SB we may hypothesize differences in balance and gait for individuals who self-report high SB levels. Therefore, this exploratory study sought to evaluate balance and gait parameters in healthy young adults based on SB and meeting PA guidelines. Methods: In a cross-sectional design, 134 healthy adults (18-36yrs), with no neurological disorders and no visual, somatosensory, balance or gait problems were recruited and screened. Qualified participants were fitted with APDM mobility monitors and completed a 2-minute walk test around a 6m track and the modified Clinical Test of Sensory Interaction on

Balance. Participants then completed the International Physical Activity Questionnaire to self-report PA and SB. Using ACSM PA guidelines, participants were split into Met (M)/Did Not Meet (DNM) PA guidelines (M>150min/wk, DNM<150min/wk), and SB (high [H]>6h/day and low [L]<6h/day). The four groups were H-M, H-DNM, L-M, L-DNM. Using a combination of T-tests and ANOVAs we analyzed differences in M and DNM for H and also for L. Results: There were no significant differences between the four groups for age, sex, height and weight (p>.05). When comparing the L groups, we found no significant differences (p>.05) in any of the balance and gait parameters between the M and DNM groups. However, significant differences exist in H groups between M and DNM for balance parameters. Postural jerk (p=.036), velocity (p=.034) and RMS sway (p=.046) during the eyes open (EO) firm surface (FS) condition showed significant differences between the H-M (0.75+0.84m2/s5) and H-DNM (3.41+8.67m2/s5) groups, with H-M showing a lesser postural jerk. In the eyes closed (EC) FS, H-M had less RMS sway (0.61+0.02m/s2) compared to H-DNM (0.75+0.03m/s2). There were no significant differences in gait parameters between H-M and H-DNM groups. Conclusion: Young adults with SB>6h who do not meet PA guidelines report significantly greater postural sway in both EO and EC condition on a FS however, not on foam surface. PA may modify the balance impairment in individuals who report high SB however, these effects are not seen in low SB individuals. These findings indicate that health practitioners should educate the general populace to avoid living a sedentary lifestyle. Future studies should examine the interaction between PA and SB levels in older adults who may have significantly amplified effects of SB on balance and gait.

P3-O-74: ***Can a Turning-Focused Rehabilitation Program Improve Turning during Daily Life in People with Parkinson Disease?***

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BACKGROUND AND AIM: Falls are a common and serious problem in people with Parkinson's disease (PD) and often occur while a person is turning during daily-life activities. The majority of people with PD have difficulty turning, even early in the disease. As a result, people with PD fall five times more than age-matched elderly people. We recently found that turning quality measured in daily life with inertial sensors is particularly impaired in people with PD compared to age-matched control subjects even more than straight-ahead gait. We currently lack interventions aimed specifically at improving turning in PD. Therefore, we developed a Turning Rehabilitation program, to target the underlying constraints that impair turning. We hypothesize that rehabilitation focused on the underlying constraints that impair turning will improve quality of turning in daily life sufficiently to justify a larger clinical trial. We outline here the protocol for our Turning rehabilitation study. METHODS/DESIGN: We will recruit 60 people with PD (age range 55-85 years), Hoehn & Yahr score of II-IV, levodopa responsive, and have experienced one or more falls in past 12 months. Participants will be randomized into either the Turning Rehabilitation or Control groups. Participants in treatment group will attend supervised, 1-hour classes, 3 times per week for 6 weeks, one-on-one with an exercise trainer, overseen by a physical therapist. Participants spend 10-15 minutes at each exercise station focusing on particular constraints of turning ability including aerobic priming, axial rotation, weight-shifting, and functional turning of various angles. Stations will be progressed across levels to be more challenging, including the addition of dual-tasking. A body-weight support harness will be used as needed to allow participants to practice challenging exercises safely. The control group will have no intervention. All participants will be tested at baseline and again after six weeks. To measure turning at home, participants will wear inertial sensors on feet and lumbar level (APDM Wearable Technologies) for seven days. The primary outcome measure will be the change in turn angle amplitude during daily-life, a measure known to be impaired in people with PD. Secondary outcomes will include other daily-life measures, such as the change in number of steps to complete a turn, change in turn peak velocity, change in turn duration, and variability of double-support time. We will also track fall rate over following 12 months. Registered in clinicaltrials.gov (#NCT04897256). RESULTS: We are presenting the protocol for our Turning Rehabilitation program, so there are no results to include now but we anticipate an interim analysis by the time of the conference. CONCLUSIONS: We anticipate that the intervention group will improve turning ability, leading to reduced falls in the subsequent year, and that the results of this pilot intervention study will justify a larger clinical trial. Our novel measurements of turning and gait over seven days of daily life with body-worn, inertial sensors could provide powerful, functional outcomes for clinical trials and clinical practice focused on mobility disability. ACKNOWLEDGEMENTS: Grant support NIH grants R01 HD100383 and UL1TR002369.

P3-O-75: ***Exergame-based voluntary step training does not improve reactive stepping***

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BACKGROUND AND AIM: Deficits in reactive stepping capacity are common in neurological and elderly populations, likely contributing to falls in daily life. Perturbation-based training improves reactive stepping but is not widely available due to the use of advanced equipment. Exergames involving voluntary stepping are a promising and more accessible alternative since these allow training of step characteristics that are also important in reactive stepping (i.e. step velocity and step length). In this proof-of-concept study, we investigated the effect of home-based exergame training on voluntary and reactive stepping in healthy young individuals. METHODS: Healthy young participants were allocated to an exergame (n=10) and control group (no training, n=10). The exergame group was instructed to use the "Clock Yourself" app for 2 weeks, with the aim to practice fast and large voluntary steps in multiple directions. Voluntary and reactive stepping parameters were evaluated using motion capture in a single measurement session (post-training for the exergame group). Reactive stepping was evaluated using a movable platform, exposing participants to 20 large (4.5m/s^2) backward translational perturbations. At first stepping foot contact, we determined the angle of the leg with the vertical, as a compound measure of reactive step quality [1]. Leg angles were computed for each of the first 5 trials, as well as an average value for the last 5 trials (steady state). Voluntary stepping performance was evaluated using a custom-made choice

reaction time stepping task; outcome measures included step onset, step duration, total time (step onset + step duration), step velocity and step length. Leg angles were compared between groups using a repeated measures ANOVA, with GROUP and TRIAL as independent variables. Voluntary step parameters were compared across groups using independent t-tests. RESULTS: The leg angles of reactive steps did not improve in response to training, as indicated by non-significant GROUP or GROUP*TRIAL interaction effects ($F(1,18)=0.05$, $p=0.83$; $F(2.6, 46.1)=1.73$, $p=0.18$). Yet, post-intervention voluntary step characteristics differed between the groups. Total time was longer in the exergame group compared to controls (0.94±0.18 vs 0.79±0.11s), mainly due to a longer step duration (0.37±0.07 vs 0.28±0.06s). Participants in the exergame group took larger steps compared to controls (0.55±0.10 vs 0.44±0.09m). The other step characteristics were not different across groups ($p>0.05$). Conclusions: Exergame home-based step training led to changes in voluntary step characteristics in healthy young individuals. Yet, training effects apparently did not carry over to a challenging reactive stepping task, likely due to lack of task-specificity. Future studies may focus on the development and evaluation of more task-specific home-based exercise interventions to improve reactive stepping in clinical populations. 1. Weerdesteyn 2012. Gait & Posture

P3-O-76: ***Minimum exercise dose of a fall prevention program to improve balance and mobility among older adults who fall***

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BACKGROUND AND AIM: Impaired balance and mobility contribute to falls and can be improved through exercise. The Otago Exercise Program (OEP) is an established fall prevention strategy and it constitutes 3 sessions of balance and strength retraining exercises per week. The minimum dose of the OEP to improve balance and mobility is not established. Elucidating the minimum dose of exercise necessary to provoke improvements in balance and mobility will contribute to more precise recommendations for fall risk reduction. Therefore, the aim of this secondary analysis was to determine the minimum dose of the OEP to improve the Short Physical Performance Battery (SPPB) relative to usual care alone in older adults with a history of falls that resulted in medical attention. METHODS: This is a secondary analysis of a 12-month randomized controlled trial [NCT01029171; NCT00323596] in which 344 adults aged 70 years and older were randomized to: 1) usual care (CON); or 2) OEP plus usual care. In this complete case analysis, we included 258 of the 344 participants that were randomized (CON; n=132/172; Age: 81.7 ± 5.8 years; 72.0% Female; OEP; n=126/172; Age: 81.1 ± 6.2 years; 62.5% Female). Usual care consisted of a comprehensive geriatrician assessment based on the American Geriatrics Society Falls Prevention Guidelines. The OEP included physical therapist-prescribed strength and balance exercises for 30 minutes, 3x/week, for 12 months. We tracked adherence via monthly calendars and calculated a percent score [(frequency of strength and balance training sessions per week/3 strength and balance training sessions per week) * 100]. We

investigated the minimum dose required to demonstrate between-group differences in 12-month SPPB score. Thresholds used were > 1, 1.5, 2, and 2.5 sessions per week. In these models, baseline SPPB, age, sex (male/female), baseline Montreal Cognitive Assessment, baseline Lawton Instrumented Activities of Daily Living, and group were covariates. RESULTS: An adherence of ≥2x/week was necessary to detect improved 1-year SPPB between OEP vs. CON (R^2=0.49, RMSE=1.71; OEP baseline SPPB=8.2, 1-year SPPB=8.4; CON baseline SPPB=8.0, 1-year SPPB=7.8; Estimated Mean Difference: 0.4 points on the SPPB). CONCLUSIONS: Performing 30 minutes of balance and strengthening exercises at least 2x/week for 12 months (~67 % OEP adherence; ≥~55 hours of exercise) is necessary to improve the SPPB score among older adults who fall. These findings enable more precise recommendations to promote balance and mobility outcomes in older adults with a history of falls. ACKNOWLEDGEMENTS AND FUNDING: This study was funded by the Canadian Institutes for Health Research (MOP-110954 and MAT-92025) to TLA. TLA is a Canada Research Chair (Tier 2). DAJ was funded through the Michael Smith Foundation for Health Research (MSFHR). JCD is a MSFHR career scholar. KM is funded through the Allan M. McGavin Foundation and Vancouver Coastal Health Research Institute.

P3-O-77: ***Autonomic dysfunction alters heart rate responses during non-contact boxing in Parkinson's disease***

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Non-contact boxing training (NCBT) is a feasible and effective exercise intervention in people with Parkinson's disease (PD). However, little is known about heart rate (HR) responses and level of exercise intensity attained during NCBT, which is a complex form of high-intensity interval training (HIIT). NCBT is particularly challenging for people with PD who present with an impaired HR response or more severely, chronotropic incompetence (CI), which is a feature of autonomic dysfunction. A greater understanding of HR responses in people with PD is required to optimize exercise protocols and the clinical management of NCBT. Objective This cross-sectional study examines HR responses during NCBT in people with PD with (PD-CI) and without CI (PD non-CI), and in age-matched controls (Control). Participants This study aims to include 20 people clinically diagnosed with PD (H&Y I-III), aged 50-70 years old and 20 age-matched controls, with interim results from n=32 presented here. Method All participants underwent a cardiopulmonary exercise test (CPET) on a stationary bike to exhaustion. Maximum HR (HRmax), and HR at ventilatory thresholds during CPET were used to determine individualized training zones. Data from CPET was also used to classify the presence or absence of CI. Following CPET, two NCBT sessions were performed on different days with each session including 4 rounds of 4 min bouts, interspersed by 2 min of passive recovery. HR was measured throughout the session to investigate HR responses. Main outcome measures HRmax, %HRmax, total time spent at high-intensity zone, and HR recovery. Results To date, 32 participants completed CPET with 23 completing one or two boxing sessions, resulting in 39 NCBT sessions. Preliminary data shows that HRmax and mean HR at each boxing round was significantly lower ($p \leq 0.001$) in the PD-CI group (n=5) compared with PD non-CI (n=8) and controls (n=10). However, when expressed as a

%HRmax attained during CPET, there was no significant difference between groups, indicating that a high-intensity training zone was achieved during each round. HR recovery between rounds was significantly lower in PD-CI compared with PD non- CI ($p \leq 0.05$) and controls ($p \leq 0.001$). HR recovery was also significantly lower between PD non-CI and controls ($p \leq 0.05$). Reasons for not performing or not completing the boxing sessions were related to HR response, risk of falling, or painful finger joints. Conclusion PD participants with CI present with lower HRmax and mean HR during NCBT, which may underestimate the potential for people with CI to attain a high level of intensity during NCBT. HR recovery is reduced in both PD groups during HIIT, suggesting more recovery time may be necessary for PD compared with healthy controls. Acknowledgements and funding Neurology Special Interest Group (NSIG) of Physiotherapy New Zealand Award. Parkinson's New Zealand (PNZ).

P - Falls and fall prevention

P3-P-78: ***Turning in people with Parkinson's disease: Classifying the fall and the faller***

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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). A reduced quality of turning (slower, less variable, more cautious turning strategy) has been observed older adults who fall[1] and people with Parkinson's disease (PD)[2]. Understanding which outcomes are sensitive to faller status (faller v non-faller) is important for selecting features for fall risk and prediction models. Understanding falls typology is critical for developing robust classification methods for stratifying fallers (i.e. fall frequency v pre-fall event) and streamlining intervention. To explore the utility of turning performance to discern PD fallers from PD non-fallers by contrasting two fall classification methods (stratifying fallers by fall frequency vs. pre-fall event). METHODS: 49 PD recruited to a longitudinal cohort study were included (ICICLE-Gait 54 month follow up)[3]. Participants were categorised as fallers (PD-F) or non-fallers (PD-NF; n=16) using monthly fall diaries[4]. Fallers were selected and stratified by: fall frequency (if they had fallen at least once; PD-FAll, n=33) or pre-fall event (if they fell specifically during ambulation; PD-FAmb, n=20)[5]. Three 180 degree turns were extracted from four 10-m intermittent walks during a laboratory gait assessment. 99 turning features were extracted from an inertial measurement unit on the lower back (Opal 120Hz) using a validated algorithm[6]. PD-NF were compared to PD-FAll and PD-FAmb in separate analyses to determine which outcomes were able to differentiate between PD-NF and PD-F (Area under the curve; AUC). RESULTS: Movement smoothness during the start of the turn (Jerk RMS in the mediolateral direction) ranked #1

when discriminating PD-NF and PD-F for both classification methods. An AUC of 75% was found for PD-NF vs. PD-FAll (Sensitivity/Specificity: 79/71%), compared to an AUC of 85% for PD-NF vs. PD-FAmb (Sensitivity/Specificity: 86/84%). 16 outcomes were found to discriminate PD-NF vs. PD-FAll with an AUC>70% compared to 37 outcomes that discriminated PD-NF vs. PD-FAmb with an AUC>70%. A summary of significant outcomes with AUC>70% stratified by feature type, signal direction and turn phase is provided in Figure 1. CONCLUSIONS: Turning outcomes across all movement planes were equally important to fall typology with an emphasis on the start phase of the turn. Signal-based features (accelerometer and gyroscope) were also influential. Important turning features have been identified and may be used for feature reduction. This work will contribute to the ongoing challenge of identifying and managing the complexity of falls and future analysis will utilise turning features in the prospective evaluation of fall risk. ACKNOWLEDGEMENTS AND FUNDING NIHR Newcastle Biomedical Research Unit and NIHR Newcastle CRF Infrastructure funding supported ICICLE-GAIT REFERENCES: [1] Mancini 2016 J Gerontol Series A [2] Mancini 2015 Neurorehab [3] Lord 2017 J Neurol [4] Hunter 2017 Disability & Rehabilitation [5] Mactier 2015 Park Rel Dis [6] Rehman 2020 Sensors

P3-P-79: ***Changes in physical activity and falls pre-post the COVID-19 pandemic in people with Parkinson's disease: Results from a nationwide online survey***

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BACKGROUND AND AIM: Falls are common in people with Parkinson's disease (PwPD)[1] who have a higher risk of falls per steps taken compared to other faller groups[2]. The COVID-19 pandemic has placed unprecedented restrictions on habitual physical activity. In Spain, an online survey (May-July 2020, n=568) revealed that more than half of PwPD felt their symptoms had worsened during lockdown[3]. In Germany, during semi-structured telephone interviews (April 2020, n=99) almost a third (31%) of PwPD reported a decrease in mobility mainly due to worsening PD symptoms[4]. In the USA, an online survey (April-May 2020, n=5429) revealed that many PwPD reported disruptions in their medical care (64%), exercise (21%), social activities (57%) and worsened motor (43%) and non-motor (52%) symptoms[5]. To evaluate changes in physical activity and falls pre-post the COVID-19 pandemic in PwPD in England using an online survey. METHODS: An online survey was developed to evaluate falls pre-post the COVID pandemic 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; fall history, physical activity levels, and contextual information about falls occurring 1 year pre and 1 year post COVID-19 restrictions began in England (March 2020). RESULTS: The group had a median age of 72y (range 60-86y) and 51% were male. The majority were retired (90%) and the remainder were either working part-time/full-time or volunteering. When asked to rate their health; 25% (n=29) rated "good", 49% (n=57) rated "average", 27% (n=31) rated "poor". The vast majority (86%) had received a medication review in the last 12 months. 57% of PwPD felt their physical activity levels had changed due to COVID (n=67). The majority (82%) felt their physical activity levels had reduced, with many reporting COVID/lockdown restrictions (n=28/55) were the cause. In the last 2 years, 68% PwPD (n=79/117) had fallen. Of those that had fallen; 17% reported no difference in the number of falls pre-post lockdown, 37% reported falling more pre-lockdown, and 47% reported falling more post-lockdown. Falls occurred in a variety of environments (44% indoor, 11% outdoor, 44% combination of indoor and outdoor). Falls often occurred during ambulatory tasks with turning (71%), walking (48%), moving too quickly (47%), transferring (34%) and negotiating steps/stairs (27%) ranked as the five most common pre-fall activities (Figure 1). CONCLUSIONS: The sample of PwPD in England that completed this survey were less physically active during the COVID-19 lockdown in agreement within findings from studies in Spain, Germany and the USA. Reduced physical activity had a differential effect on falls (more/less) post COVID-19 restrictions. Reinvigorating social and communal opportunities that promote physical activity, in addition to developing interventions to improve safety during turning manoeuvres are important. ACKNOWLEDGEMENTS AND FUNDING: The authors would like to thank Parkinson's UK for their support. REFERENCES: [1] Lord 2017 J Neurology [2] Del Din 2020 J Gerontol Med Sci [3] Santos-Garcia 2020 Mov Dis [4] Zipprich 2020 J Clinical Med [5] Brown 2020 J Park Dis

P3-P-80: ***Cost-effectiveness of the StandingTall exercise programme for fall prevention in older people***

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Background: Globally, falls and fall-related injuries are the leading cause of injury-related morbidity and mortality in older people. In our ageing society healthcare costs are increasing, therefore programmes that reduce falls and are considered value for money are needed, given scarce healthcare resources. Objective: To assess the cost-effectiveness of an e-Health balance exercise programme that reduced falls and injurious falls in community-living older people compared to usual care from a health and community-care funder perspective. Design: A within-trial economic evaluation of an assessor-blinded randomised controlled trial with two-years of follow-up. Setting: The StandingTall balance exercise programme delivered via tablet-computer at home to older community-living people in Sydney, Australia. Participants: 503 individuals aged 70 years or over who were independent in activities of daily living, without cognitive impairment, progressive neurological disease or any other unstable or acute medical condition precluding exercise. Main outcome measures: Cost-effectiveness was measured as the incremental cost per fall and per injurious fall prevented. Main results: The total average cost per patient for programme delivery and care resource cost was $8,321 (standard deviation [SD] 18,958) to intervention participants and $6,829 (SD 15,019) to control participants. The incremental cost per fall prevented was $4,785 and per injurious fall prevented was $6,585. Conclusion: The StandingTall balance exercise, an e-Health programme, is considered good value for money compared to more traditional face-to-face delivery of fall prevention programmes in terms of incremental cost per fall prevented.

P3-P-81: ***Fear of falling increases the occurrence of falls, but its influence is not constant according to fall history: One-year follow-up observational study***

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Background and Aim: Both multiple fall experiences and fear of falling (FoF) would affect another fall, however, the associations are unknown. In the present study, we investigated the association of fall occurrence with fall history and FoF, including the interaction between these two factors in statistical models. We hypothesized that FoF increases the fall occurrence, but that its influence is not consistent with fall history. The study aimed to clarify this association, hinting at the development of assessment tools and a new clinical approach for preventing falls. Methods: This study adopted a longitudinal observational design. We visited 20 community centers to recruit 1,025 older adults (aged 65 years or older), and 801 met our inclusion and exclusion criteria. At the baseline, demographic characteristics of participants were collected using a self-administered questionnaire. The questionnaire items included age, sex, height, weight, neurological disease (stroke and Parkinson's disease), number of drugs taken per day, number of falls in the past year, and FoF. A fall was defined as "an event that resulted in the participant unintentionally coming to the ground or another lower level". The participants were classified into three fall history groups (0: non-faller, 1: single faller, 2 or more: multiple faller). FoF was assessed through the question "Are you afraid of falling (yes/no)?" At the one-year follow-up, the number of falls during the year was considered as the main outcome. Poisson regression models clarified the influence of FoF on fall occurrence during the one-year follow-up, according to the participants' fall history. Results: The final sample comprised 530 individuals (follow-up rate: 530/801, 66.4%). Fall history group; FoF; and interaction between multiple fallers and FoF were significant (RR [95% CI]: single fallers = 2.61 [0.98, 5.83], multiple fallers = 15.10 [8.90, 25.40], FoF = 3.34 [2.27, 5.07], multiple fallers*FoF = 0.36 [0.20, 0.66]). These parameters remained significant after adjusting for confounders (RR [95% CI]: single fallers = 2.81 [1.06, 6.30], multiple fallers = 13.60 [8.00, 23.04]; FoF = 3.70 [2.48, 5.67]; multiple fallers*FoF = 0.37 [0.20, 0.68]). On the other hand the interaction between single fallers and FoF was not significant in all statistical models. Conclusions: FoF affects the occurrence of falls among community-dwelling older adults, and its influence was not consistent with fall history at baseline. Compared to non-fallers, FoF has a lower influence on the occurrence of falls in multiple fallers, while it does influence fall occurrence in single fallers. Our results have implications for clinical staff members to interpret the influence of FoF on fall occurrence.

P3-P-82: ***Effects of In-Place Perturbation Training on Falls in People with Parkinson's disease and Postural Dysfunction***

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BACKGROUND AND AIM: The ability to execute a protective step after a loss of balance is critical for fall prevention; however, people with Parkinson's disease (PwPD) elicit protective steps that are slower and smaller than neurotypical adults. While recent research suggests perturbation training may improve protective stepping in PwPD, whether PwPD and postural dysfunction (a group with particularly high fall risk) reduce falls through training is poorly understood. Thus the aim of this study is to determine if in-place perturbation training can reduce fall rate in PwPD and postural dysfunction. METHODS: Data from 21 PwPD (Age: 70.5 ± 6.55, motor UPDRS: 22.7 ± 8.50) were included in this preliminary analysis. Number of falls were tracked prospectively for 2 months prior to and 2 months after a 2-week (6-session) protective step training protocol. Participants recorded their falls via a physical falls calendar as well as an online survey every two weeks. During training visits, participants completed 32 reactive steps (8 each forward, backward, left and right) via a split-belt instrumented treadmill that administered quick translations of the support surface. The acceleration was increased or decreased at 0.2m/s2 increments based on the participants performance. The Falls Self-Efficacy Scale (FES-I) was also collected before and after training to track the participants' confidence throughout the study. A Wilcoxon signed-rank test was used to compare the means of both outcomes before and after training. RESULTS: These results represent a preliminary analysis of the current dataset. After training, 10 participants experienced fewer falls, 3 experienced more falls, and 8 experienced no change in fall rate. However, there was not a statistically significant reduction in the number of falls in the 2 months after training compared to pre-training (pre: 2.10 ± 2.86; post: 1.76 ± 3.59; p=0.12). Similarly, falls self-efficacy was not statistically significantly impacted by training (pre: 16.76 ± 5.34; post: 16.71 ± 6.46; p=0.648). CONCLUSIONS: In this preliminary analysis, although 47.6% of participants reduced falls after training, the number of falls and FES-I scores were not statistically significantly impacted by perturbation training in PwPD and postural dysfunction. This is inconsistent with previous fall reduction training that showed people with PD (motor UPDRS score ≤ 26) had a 69% reduction in falls after an intervention, and improved FES-I scores. This may represent either the shorter training and fall-observation period in the current study, the more severe nature of the current PD cohort, or preliminary nature of the current dataset. Subsequent analyses will investigate the type and severity of falls pre and post training, and follow-up studies will conduct longer-term fall observation periods to understand the effects of balance training in reactive stepping in this population. ACKNOWLEDGEMENTS AND FUNDING: We would like to acknowledge the Michael J Fox Foundation for funding this project.

P3-P-83: ***Postpartum Fall Recall Accuracy and Fall Efficacy during Pregnancy***

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Background and Aim: According to the most widely cited study on the subject, a quarter of pregnant women experience at least one fall during pregnancy, peaking in month seven (Dunning 10). However, Dunning et al. used postpartum survey data to determine fall rates during pregnancy. The shortcoming of that study is the amount of time to recall and salience of these falls may affect agreement with actual/true fall events. Researchers have since relied on Dunning et al. to justify studies of fall risk factors to focus on changes that likewise peak in the 3rd trimester. This study seeks to understand the accuracy of postpartum recall of falls. Near falls were included with falls to be called "fall events" because they are emblematic of an initial loss of balance that may lead to a fall. Additionally, fall efficacy was studied to assess a possible reason for the salience of fall events. Methods: 14 volunteers participated in this study. At enrollment (~13 weeks gestation) participants were given instructions on what constitutes a fall and a near-fall. Weekly during pregnancy, participants were asked via text or email if they experienced a fall or near-fall that week and the circumstances that caused it. For this study, the responses of fall events during pregnancy are classified as "true" fall events. A postpartum survey (to mimic Dunning et al.) was also done to determine the recall accuracy of fall events. To understand salience, fall efficacy scores were assessed through a modified FES-I questionnaire every six weeks during pregnancy. Paired t-tests were used to assess differences in true vs postpartum fall events at each month. Linear mixed models were used to assess fall efficacy changes. Results: The most significant difference between true and postpartum events were in months five ($P = 0.055$, $d = 1.102$) and seven ($P = 0.078$, $d = 1.817$) (Figure 1). Though the results do not cross the 95% CI, the effect sizes from months four through nine were very large, ranging from $d = 1.773$ at month four to $d = 2.312$ at month nine. The same trends held even with falls and near-falls separately analyzed. With additional data from ongoing participants, we expect to see significant differences. Average efficacy scores show an increasing trend throughout pregnancy, with mean scores increasing from 16.6 (out of 100) at 13 weeks gestation to 25.2 (out of 100) at 37 weeks gestation ($P = 0.046$). Conclusions: These results suggest there is a mismatch between true fall events and postpartum recall of fall events, with a postpartum overestimation of quantity and a shift in time from 2nd trimester to 3rd trimester. Additionally, there was a clear trend in fall efficacy throughout pregnancy. Researchers have used Dunning et al. to justify focusing on the 3rd trimester as being the most dangerous, however, our data show a preponderance of fall events occur in the 2nd trimester. The data also suggest there are 2nd trimester changes that are primary risk factors for falls.

P3-P-84: ***Stair descent behavior in young adults: Females less likely to use handrails and more likely to engage in in-person conversations***

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BACKGROUND AND AIM: Stairs are one of the most serious hazards encountered during community mobility. Stair-related injuries occur across the lifespan, with a peak in young adults in their 20s and the majority of stair-related injuries experienced by females [1]. It is unknown why females sustain more stair-related injuries. Field observation can be used to quantify behavior on stairs that may increase the risk of falls, such as handrail use and distracted attention. Our aim was to determine if young adult females demonstrate riskier behavior than males during stair descent in the field. Short and long staircases were included as both are typically encountered in the community. METHODS: Two staircases in

campus buildings were videotaped: short (2 steps) and long (17 steps) staircases (Fig. 1). Young adults (N=2,400; 61% male) captured on video included: 1,013 pedestrians (48% male) on the short staircase, and 1,387 pedestrians (71% male) on the long staircase. Six trained coders analyzed the video. Coded behaviors included: handrail use, electronic device use, holding item in hand(s) (e.g., coffee cup), in-person conversation, hands in pocket, skipping steps, etc. Cohen's Kappa statistics were calculated to quantify reliability between coders (average 97% agreement; κ's=0.82-1.0, $p<0.001$). Gender differences were evaluated using odds ratio (OR). RESULTS: No pedestrians used the handrail on the short staircase. On the long staircase, females used the handrails less than males (31 vs 37%, $p=0.03$). On both staircases, females were more likely to be walking with someone (20 vs 13%, $p\leq0.05$) and had more in-person conversations (18 vs 13%, $p\leq0.05$). Females and males used electronic devices at similar rates on both staircases (14 vs 14%, $p>0.3$); however, females used their hands more to hold items on both staircases (70 vs 46%, $p<0.01$). Finally, males put their hands in pockets more on both staircases (19 vs 9%, $p<0.01$) and were more likely to skip steps (4 vs 1%, $p<0.01$). CONCLUSION: Higher stair-related injuries in young adult females [1] may result, at least in part, from females being less likely to use the handrails and being more distracted on stairs. Lower handrail use in females may have occurred because 70% of them were carrying items in their hands. Since females were more likely to be walking with someone, they were more likely to be talking in-person; conversation imposes cognitive demands that may impair attention and increase fall risk [2,3]. Males also exhibited risky behaviors: having hands in pockets reduces opportunity to use the handrail and to use the upper limbs to reduce fall impact. Males were also more likely to skip steps, which could lead to a fall. These sex-specific behaviors on stairs can be used to inform fall prevention strategies. REFERENCES: [1] Blazewick et al., 2017. Am J Emerg Med, 36(4), 608-614. [2] Cho et al., 2021. PLoS one, 16(4), p.e0250360. [3] Raffegeau et al., 2018. Gait Posture, 64, pp.59-62.

P3-P-85: ***The frequency and circumstances of falls in young adults: the effect of sex, physical activity, and prescription medications***

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BACKGROUND AND AIM: It is well-known that older females sustain more fall-related injuries than older males. However, less well-known is the fact that females sustain higher fall-related injuries at age 20 [CDC]. Falls in young adults are not uncommon, but are rarely studied [1-3]. Quantifying behaviors and factors that are associated with falls will help determine why young adults, particularly females, experience falls. The aim was to determine how the frequency and circumstances of falls are associated with sex, physical activity level, and the number of prescription medications in young adults. METHODS: College student participants (N=325, 19.9 ±1.1 years, 89 males) reported the number of prescription medications and physical activity level with the Leisure-Time Exercise Questionnaire (LTEQ). A fall survey was emailed daily for four months to determine fall frequency and their circumstances [1]. A zero-inflated Poisson model was used to quantify the relationship between the frequency of falls and sex, LTEQ, and number of medications. Odds ratio (OR)

was used to compare males versus females. RESULTS: Forty-eight percent of participants fell at least once during the four months (Fig 1). The frequency of falls was positively associated with being male ($p<0.01$), higher numbers of prescription medications ($p<0.01$), and higher level of physical activity ($p=0.03$). The main causes of falls for both sexes were slip (38%), trip (29%), and hit/bump (11%). The main activities at the time of fall for males were sports (49%) and walking (37%), and for females, walking (44%) and sports (33%). For circumstances of falls, females were more likely to be talking to a friend at the time of the fall than males (OR 2.95; CI 1.31-6.65). Females were more likely to report injuries than males (16% vs 10%). CONCLUSION: The association between medications and falls is a largely unrecognized relationship in young adults that should be explored further. Although males had a higher frequency of falling, females sustained more injuries, consistent with higher fall-related injuries in medical reports [CDC, 2,3]. The following observations support the possibility that females have impaired balance/gait relative to males: 1) females were more likely fall during lower-risk activity (walking) whereas males were more likely to fall during higher-risk activity (sports), 2) females were more likely to be talking (i.e. distracted) at the time of the fall, and 3) only females sustained injuries from falls that occurred while walking. These differences could result from lower muscle strength, slower reaction time, and greater focus on social cues in females [4]. REFERENCES: [1] Heijnen & Rietdyk. Hum Mov Sci, 46, 86-95, 2016. [2] Timsina et al. Plos One, 12(5), p.e0176561, 2017. [3] Court-Brown et al. Injury, 48, 819-824, 2017. [4] Tom & Granie. Accid Anal Prev. 43: 1794-1801, 2011.

P3-P-86: ***Is the Cost-Effectiveness of the Otago Exercise Programme Among Older Women and Men Similar or Different? A Secondary Analysis of a Randomized Controlled Trial***

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Background and aim: The costs of falls incurred by older adults are well documented internationally. Emerging evidence suggests that costs sustained by older adults vary between women and men. Fall rates and risk of fall-related injury also differ between men and women. The Otago Exercise Programme (OEP)is a cost-effective primary and secondary falls prevention strategy. However, whether the OEP is cost effective for both women and men is unknown. Using stratified analyses, we examined the cost-effectiveness of the OEP, from a health care system perspective, among women and men who have previously fallen. Methods: This study was a secondary stratified analysis (by women and men), of a 12-month prospective economic evaluation of a randomized clinical trial (OEP compared with usual care). Three hundred and forty four community-dwelling older adults (≥70 years; n=172 OEP (n=110 women; n=62 men), n=172 usual care (n=119 women; n=53 men)) who sustained a fall in the past 12 months and received a baseline assessment at the Vancouver Falls Prevention Clinic, Canada (www.fallsclinic.ca) were included. A gender by OEP/usual care interaction was examined for the falls incidence rate ratio (IRR). Outcome measures stratified

by gender included: falls IRR, incremental cost-per fall prevented (ICER), incremental cost per quality adjusted life year (QALY, ICUR) gained, and mean total health care resource utilization costs. Results: Men were frailer than women at baseline. Our gender-stratified analyses indicate the mean total healthcare costs were greater for men (exercise: $5690 CAD (SD: $6754); usual care: $6794 CAD (SD: $11906)) compared with women (exercise: $3691 CAD (SD: $3353); usual care: $3665 CAD (SD: $5026)) regardless of whether participants were randomized to the exercise group or the usual care group There was no significant gender by OEP/usual care interaction on falls IRR. The efficacy of the OEP did not vary by gender. The adjusted IRR for the OEP group demonstrated a 39% (IRR: 0.61, CI: 0.40, 0.93) significant reduction in falls among men but not women (32% reduction (IRR: 0.69, CI: 0.47, 1.02)). The ICER showed the OEP, compared with usual care, was effective in preventing falls and less costly for men, while it was costlier for women by $42 CAD. The ICUR showed the OEP, compared with usual care, did not impact quality of life. Conclusion: Our study indicates that among older men who have had a fall, the OEP is a cost-saving secondary prevention strategy. Future studies should explore gender factors (i.e., health seeking behaviours, gender related frailty) that may explain observed variation in the cost-effectiveness of the OEP as a secondary falls prevention strategy.

P3-P-87: ***Predictors of fall resistance during treadmill induced perturbations among people post-stroke.***

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BACKGROUND AND AIM: Balance is critical in stroke rehabilitation, both for improving mobility and for reducing fall risk. People will encounter perturbations if they are mobile and fall resistance is the ability to avoid falling in the face of these perturbations. Fall risk is estimated through clinical measures, but fall resistance does not have established measures. Our protocol of scaled and progressive treadmill perturbations was able to quantify pre to post intervention improvements in fall resistance parameters, including fall vs. recovery outcomes to specific perturbations and a maximum recoverable perturbation value. Some characteristics of individuals that are theorized to be related to fall risk or balance ability include clinical balance measures, gait speed, and self-perceived stability. Clinical balance via the Mini-Balance Evaluation Systems Test (MiniBEST), gait speed, and a self-rating measure of stability, the Rate of Perceived Stability (RPS-adj) were assessed pre to post intervention as well. The purpose of this study was to identify relationships between these characteristics of individuals and the individuals' fall resistance. METHODS: Twelve adults post stroke completed pre and post intervention progressive treadmill perturbation testing. Falls/recoveries, maximum recoverable perturbation (MRP), Mini-BEST, maximum and normal gait speed (MWS, NWS), and RPS-adj were all assessed pre-and post. Paired t-tests were used to examine pre to post differences and regression analyses to examine relationships among variables. RESULTS: Post intervention vs. pre, the MRP was higher ($p = .005$), there were fewer falls ($p = 0.015$) and more recoveries ($p = 0.001$), RPS-adj scores were lower ($p=0.0005$), and NWS ($p = 0.003$) and MWS ($p = 0.01$) were higher; MINI-Best scores were not different. Overall, RPS-adj scores were not related to NWS, MWS, or

MiniBest scores. Falls and recoveries were related to RPS-adj but not other participant characteristics. The MRP was related to MiniBest and NWS ($p < 0.001$) but not RPS-adj. CONCLUSIONS: RPS-adj explained fall vs. recovery outcomes to discrete perturbations. At post testing, participants rated perturbations of objectively higher magnitude as less challenging; the fact that they were able to respond more effectively to the more challenging perturbations indicates that RPS-adj appropriately reflected the challenge of the task to the person. MRP is the highest magnitude perturbation an individual was able to resist. It was unrelated to RPS-adj, though it was strongly related to MiniBest and NWS. These latter two may be more effective measures of balance capability than strict fall risk measures. Since real world perturbations are of variable and unpredictable type and intensity, being able to respond to larger perturbations is a worthwhile therapeutic goal. FUNDING: American Heart Association (18IPA34170316)

P3-P-88: ***What comes before a fall? A study of daily accelerometry data associated with falls events.***

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BACKGROUND AND AIMS: Attributing specific causes to falls events that occur in the home or community can be challenging. Falls in older adults are typically intermittent events, often unwitnessed, and memory recall may be unreliable. Understanding underlying dynamic bio physiological changes, or interactions between clinical and non-clinical biomarkers, may therefore inform novel predictor models and falls prevention. It has not been established as to whether activity monitoring or daily gait patterns in a time period prior to a fall can provide important information regarding a deterioration in mobility and stability, signifying an underlying condition. Development of methods for monitoring daily mobility patterns and trends may be beneficial in predicting impending increased falls risk. Wearable sensors provide useful daily information but have to be actively worn particularly leading up to the time of a fall. This study explores mobility data from the implanted Medtronic Reveal LINQTM Insertable Cardiac Monitor (ICM) device primarily used for remote cardiac monitoring purposes. The ICM device contains an embedded tri-axial accelerometer. METHODS: Subjects, having previously had one or more unexplained falls and referred for ICM insertion by the Falls and Syncope Unit, St. James's Hospital, were recruited to the study (n=30). Following detailed clinical baseline assessment including quantitative gait analysis (GAITRite, CIR Systems), subjects were asked to perform a routine daily walk of sixty seconds duration, during which time tri-axial accelerometer data was recorded and retrieved for analysis. Daily activity counts were also recorded. Gait metrics pertaining to walk quality, step count, harmonic ratio, stride time and stride time variability were extracted for further analysis. In addition, subjects attended in-clinic for follow up assessment at three monthly intervals. Subjects provided daily data for twelve months duration, during which time circumstances of any falls events were investigated and recorded. RESULTS: Data metrics were collated on activity levels, and on the presence and quality of the daily walk, including derived spatiotemporal gait parameters and harmonic ratio analysis. A methodology was developed to present summary metrics and trends, suitable for inclusion in a continual assessment of

falls risk. Case studies are presented showing data trends prior to and subsequent to an unexplained fall. CONCLUSIONS: Falls events are frequently multifactorial in nature. Falls management benefits from a holistic approach to include both transient (e.g. cardiac arrhythmias), and chronic risk factors e.g. deterioration in gait and balance, potential effects of medication, increased nocturnal activity. The availability of a charted daily gait analysis assessment and activity profile provides additional important information for the falls assessment team to optimise management of at risk older adults in community settings. ACKNOWLEDGEMENTS AND FUNDING: The authors wish to acknowledge the invaluable contribution of the Medtronics advanced sensors and data analytics teams. This study is funded as part of an EIT Health - Innovation by Design grant.

P3-P-89: ***The influence of home environment and COVID-19 pandemic on falls in older adults***

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BACKGROUND AND AIM: One third (149,450 out of 489,000) of fall related hospital admissions in England between 2019-20 occurred because of a slip/trip/stumble on level surfaces, steps, and stairs, with 74% of admissions in adults aged ≥60 years[1]. Falls in older adults have severe consequences; they are more likely to be admitted to hospital and care homes, with significant public health costs. The ability to move safely in the home environment is critical for retaining independence and quality of life as we age. Reports show that serious falls occur in the home environment[1,2]. Unaddressed home fall hazards are estimated to cost the NHS in England £435m annually[3]. Identifying fall hazards in older people's homes is thus essential for solutions to be developed and reduce the financial, psychological, and societal consequences of falls. The danger of falls in the home environment has been worsened by the ongoing COVID-19 pandemic. People have been living in home-confinement for long periods, with reduced social interaction and activity levels because of restrictions[4]. We devised a survey to: (1) explore the influence of the home environment on falls; and (2) determine whether the COVID-19 pandemic increased falls, in adults aged ≥60 years. METHODS: An England-wide online survey was conducted with older adults (≥60 years) between March and July 2021. The survey captured fall history, including activities and features of the home influencing the fall, during the 1 year pre and 1 year post March 2020, when COVID-19 restrictions began in England. RESULTS: 193 participants completed the survey, with 33% (N=64) of participants (median age 69y, range 61-94y) experiencing 155 falls. Most fallers experienced a fall indoors (47%, N=30) compared to outdoors (27%, N=17) or a combination (27%, N=17). Most common activities at the time of falling in the home were walking (52%), walking up or down stairs (34%), moving too quickly (27%) and turning (20%). Most falls occurred when negotiating steps/stairs (50%, N=32), crossing over objects on the floor (23%, N=15), or crossing over door frames (20%, N=13). There was minimal difference between those who fell more prior to or after COVID-19 restrictions began in England (pre-COVID-19: 33%, N=21; post-COVID-19 restrictions: 36%, N=23; no change: 31%, N=20), with 83% of fallers stating they were

physically active. CONCLUSIONS: Negotiating raised surfaces, steps and stairs in the home environment led to a greater number of falls for participants completing this survey. Further investigation should determine the interaction between the faller and their environment to develop appropriate home-based interventions. COVID-19 restrictions did not affect the number of yearly falls occurring in the home environment. Most fallers reported they were physically active, had increased activities including walking/gardening during COVID-19 restrictions, and were from areas of low deprivation (Index of Multiple Deprivation, 69% in the 6th decile or above). These factors may have offset the possible effects of home-confinement and sedentarism. REFERENCES:[1] NHS Digital (2020) tinyurl.com/37adykzw. [2] Turner (2011) Cochrane Database Syst. Rev. [3] Nicol (2016) tinyurl.com/2p8kfrhd. [4] Narici (2020) Eur J Sport Sci

P3-P-90: ***Age-associated effect of pre-step interlimb weight shifting on rapid sidestepping is related to fall history and hip strength***

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BACKGROUND AND AIM: Rapid sidestepping is a crucial protective action against falls where timing delays are risk factors for falls among older adults. As sidestepping requires support-limb loading and step-limb unloading, rapid interlimb weight transfer is important for effective protective stepping. Hip abductor-adductor (AB-AD) muscle function is linked with weight transfer ability. Therefore, age-associated delays in lateral step timing may involve deficits in reactive response and/or limited AB-AD muscle capacity. This study investigated the temporal characteristics of rapid sidestepping under different pre-step limb loading conditions in younger and older adults in relation to fall history and hip AB-AD muscle strength. METHODS: Fourteen healthy younger and 28 older adults (14 fallers) performed two-choice LED-cued reaction time (CRT) sidestepping under two conditions: weight evenly distributed before the go cue (no-prep: NP), and while continuously alternating weightbearing distribution between the limbs (prep: P, Fig. 1). Due to the transient weight shifting in the P condition, the sidestepping task was preceded by a two-choice (left and right) hand CRT task during NP and P conditions as a surrogate estimate of RT. Ground reaction forces and motion capture data were recorded. Group differences in RT, weight transfer time, and step lift-off time were assessed. Older adults were divided into two groups based on either fall experience (non-fallers vs. fallers) or isometric hip AB/AD strength (High vs. Low). RT was the time interval between the go cue and hand response. Weight transfer time was estimated by subtracting RT from step lift-off time, the time interval from the go signal to first step lift-off. RESULTS: RT was longer in older fallers by 15% than non-fallers in the P condition ($p \leq .014$), but similar between hip AB/AD strength groups. Weight transfer time was not different based on fall experience or hip AB strength. However, the AD Low group had a longer weight transfer time by 47% than the AD High group when a step was initiated during step-limb loading phase in the P condition ($p \leq .031$). Older fallers and AD Low group respectively demonstrated 15 and 20% longer step lift-off time than non-fallers ($p \leq .089$) and AD High ($p \leq .015$) when a step was initiated during step-limb loading phase in the

P condition. CONCLUSIONS: Older adults with greater fall risk or lower hip adductor strength demonstrated a longer step lift-off time when initiated during the step-limb loading phase. Slower step lift-off was attributable to a longer reaction time for older fallers and a longer weight transfer time for those with lower hip adductor strength. Targeting enhancement of reaction time and hip adductor strength may promote faster protective stepping and reduce fall risk. ACKNOWLEDGEMENTS AND FUNDING: This work was supported by JSPS KAKENHI Grant Number JP18H03162.

P3-P-91: ***Biomechanical Determinants of Lateral Step Initiation Speed Immediately After Ground Support Perturbation in Healthy Adults***

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Background and Aim Falls are a major public health problem and are common in many clinical populations as well as older adults. Deficits in lateral stability regulation ability have been associated with falls and fall-related injuries among older individuals. When encountering a sudden balance disturbance, an effective strategy to avoid a fall is to modify the base of support by taking a rapid protective step. Such movement could be challenging because it may require the stepping limb to generate push-off force to unload the bodyweight along with the forces produced from the stance limb to regulate lateral stability and support the body. To date, the major biomechanical factors that determine how fast an individual could perform lateral step initiation following perturbation remain unclear. From a biomechanical standpoint, hip abductor torque contributes to lateral stability regulation as well as vertical force generation. In addition, ankle plantarflexor torque is a key factor for body weight support. Accordingly, this study aims to determine the relationships between these biomechanical variables and lateral step initiation speed following standing surface perturbation in healthy adults. Methods Preliminary data were collected from 5 healthy adults (3 young and 2 old). Participants stood with their natural standing posture with one foot on each moveable platform that can drop vertically by 7.4 cm to induce body lateral tilting and limb loading towards the lowered side. Participants were instructed to take a lateral step as fast as they could immediately after ground contact following the perturbation. Data from the 1st trial for each participant were analyzed. Ground contact duration, determined as the duration from initial ground contact to stepping foot lift-off, was used to characterize step initiation speed. Bilateral peak vertical ground reaction forces (VGRF), hip abduction and ankle plantarflexion torques were calculated during the ground contact phase. Pearson's correlation analysis was used to determine the relationships between each variable and ground contact duration. Results Amongst the variables tested, ground contact duration was negatively associated with stance limb hip abduction torque (r=0.85) and peak VGRF (r=0.69); and positively associated with stepping limb peak VGRF (r=0.6). No other relationships were detected. Conclusions Our initial results indicated that lateral stepping speed following perturbation might depend on stance limb hip abductor strength and vertical support force generation. In addition, delayed lateral step initiation may require more vertical force generated from the stepping limb to unload the body weight. These findings highlight the importance of stance limb hip abductor muscles during lateral balance recovery. With

more participants tested, we expect that significant relationships will be revealed. Ongoing and future work includes investigating neuromuscular determinants of lateral step initiation speed and comparing stepping characteristics between younger versus older adults. Acknowledgments We thank our funding source: University of Texas at Austin College of Education Small Grant Award

P3-P-92: ***Neuromuscular and biomechanical determinants of lateral balance recovery stepping in younger and older adults.***

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BACKGROUND AND AIM: Aging leads to significant neuromuscular deficits that can affect balance and protective stepping performance. Furthermore, balance stability among older adults is particularly vulnerable in the frontal plane, where the hip abductor-adductor (AB-AD) musculature is fundamental in controlling center of mass' (CoM) motion. During medio-lateral (ML) balance perturbations, younger individuals more frequently use a single lateral sidestep (SLS) to recover their balance. In contrast, older adults with limitations in hip AB capacity predominantly rely on alternative stepping strategies that lead to multiple recovery steps (MRS) and increased fall risk (e.g. cross-over or successive ML steps). Hence, this study investigated the neuromuscular and biomechanical determinants underlying ML balance recovery with SLS compared with MRS, in younger and older adults. METHODS: 15 younger (29.1±1.1 yrs) and 15 older adults (71.3±0.9 yrs) underwent a motorized, position-controlled lateral waist-pull balance perturbation protocol. Participants were instructed to recover their balance only using a SLS. Kinetic (two AMTI force platforms), kinematic (VICON) and surface electromyography (gluteus medius [Gmed] and tensor fascia latae [TFL]) data were collected. A linear mixed-effects model was used to perform within and between-group comparisons, with significance set at $p<0.05$. RESULTS: Participants were not always successful at recovering balance with a SLS (93% and 73% of trials, younger and older adults respectively). Significant main effects for stepping response were observed for: hip AB rate of torque development (RTD) (37% lower during MRS than SLS); hip AB peak concentric power (PCP) (73% lower during MRS than SLS); Gluteus Medius (Gmed) rate of activation (RActv) (27% lower during MRS than SLS); Gmed activation onset (29% earlier during MRS than SLS); and TFL activation onset (26% earlier during MRS than SLS). Additionally, there were main effects for group ($p<0.05$) for: hip AB peak torque (46% lower for younger than older adults); TFL RActv (20% greater for younger than older adults); and Gmed activation onset (21% earlier for younger than older adults). CONCLUSIONS: When younger and older adults were unable (and able) to recover ML balance with a SLS, they showed similar hip AB rapid force generation. However, it was greater during SLS compared with MRS responses. Furthermore, older adults showed generally greater hip AB peak torque than younger individuals, possibly to compensate for the delay in activation of Gmed and slower TFL RActv. These results may guide the development of a rapid force generation threshold assessment protocol to identify future fall risk with aging among younger adults. ACKNOWLEDGEMENTS AND FUNDING: We thank the Claude D. Pepper Older American

Independence Center, University of Maryland, Baltimore and acknowledge funding from the National Institute on Aging at the National Institutes of Health (R01AG033607).

P3-P-93: ***Effect of environmental factors on the risk for falls during sit-to-stand transfers by older adults living in long-term care***

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Background and Aim: The ability to rise from sitting to standing is fundamental to mobility and quality of life. However, sit-to-stand (STS) transfers are challenging for frail older adults, and 12% of falls by long-term care (LTC) residents occur during STS (Yang, 2015). Yet these same residents often transfer without falling. Improved knowledge of the biomechanical factors that affect fall risk during STS should inform improvements in fall prevention. We analyzed video footage of real-life movement patterns in LTC, to test the hypothesis that upper limb support strategies separate falls from successful STS transfers. Methods: We recorded videos of 42 real-life falls during STS transfers, experienced by 32 LTC residents (15 female; 17 male; mean (SD) age: 85.8 (7.8) years). All falls were in common areas (e.g., dining rooms). We also recorded videos of successful STS transfers (performed without falling) by the same residents during the period 7 days before their fall (n=79; 1-2 successful STS transfers per fall). Transfers were most often from wheelchairs (n=49) and dining chairs (n=41). We used a structured questionnaire to characterize the features of each transfer, and Generalized Estimating Equations to test for differences between falls and successful STS in grasping and movement of environmental objects during STS (e.g., armrests or tables). Results: Most transfers, regardless of outcome, involved the use of upper limb supports (114/121 transfers; 94.2%). Armrest use was observed in 86% of transfers (104/121) and did not associate with fall risk (odds ratio = 0.77; 95% confidence interval = 0.32-1.84). Residents contacted their hands on weight-bearing supports external to their seat in 67% of transfers (81/121), which reduced their fall risk by 2.5-fold (0.39; 0.19-0.83). The most common external supports were tables/counters (n=52), external chairs (wheelchairs, dining chairs and lounge chairs; n=12), and walkers (n=12). Falls were 6.7-fold less likely when residents held tables/counters compared to external chairs (0.15; 0.05-0.42), as external chairs sometimes tipped or translated (n=6; all resulted in falls). Movement of the seat occurred in 50% of transfers (60/121), and was judged to be deliberate in 38% of cases (e.g., a resident moving a chair closer to a table before rising), and involuntary in 62% (e.g., a wheelchair rolling backward). Deliberate seat movement reduced fall risk compared to no seat movement (0.06; 0.01-0.46); involuntary seat movement increased fall risk (6.58; 2.92-14.86). Conclusions: We show the importance of upper limb support strategies and seat movement as factors that separate successful and unsuccessful STS transfers in LTC. LTC homes should provide stable handheld supports to assist older adults in safe STS. Efforts are needed to reduce the likelihood for involuntary seat movement during transferring (e.g., via wheelchair locking systems), while facilitating deliberate repositioning of the seat for successful STS.

P3-P-94: ***Can initial compensatory step predict inability to recover from unexpected balance loss in older adults.***

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Background and aims: If balance is lost unexpectedly, i.e., postural perturbation, a compensatory step response is very common reactions to loss of balance in daily life in older adults. The question of what went wrong in the kinematics of the compensatory stepping responses in the unsuccessful balance recovery events (i.e., falls). In a laboratory-based study, we aimed to compare the kinematics of the initial compensatory recovery step in the unsuccessful and the successful balance recovery trials. This may help to improve our understanding on the mechanism of balance recovery. In the present analysis we study compensatory stepping in standing i.e. "static stance', since a sizable proportion of falls occur during quasi-static engagements and activities. Also, loss of balance during standing share a number of fundamental control subtasks with loss of balance during gait (e.g, appropriate placement of the swing foot, stabilization of the center of mass (CoM) during swing, etc'). Methods: We investigate 84 community-dwelling older adults that were exposed to unexpected balance loss to a lateral destabilization. They were instructed to stand on a perturbation device that provided multi-directional surface translations and to "react naturally" to random time of onset and direction (right or left) surface translations that systematically increased from low to high magnitudes. The presence of a successful balance recovery response or failure response were observed at each perturbation trial. Fall event was defined as: 1) the subject grasped the research assistant; 2) the participant caught by the research assistant; 3) when the safety harness stretched and the participant fell into the harness. During the falling trials three-dimensional (3D) kinematic data were acquired. The following kinematic parameters (1) first recovery step initiation duration (ms); (2) first recovery step duration (ms); (3) first step length (cm); (4) CoM path displacement (cm), defined as the distance in cm of the CoM traveled from the initial point prior stepping to the point that the participants fell. Results: Of 2180 balance recovery trials, we observed 18 fall events. The kinematics of these fall events were compared with 18 successful perturbation trials at the same perturbation magnitudes of the same participants. The first recovery step initiation (i.e. foot lift-off the ground) were similar, however, CoM displacement, swing phase duration, step duration, and step length of the first recovery step where significantly different (see table 1). Conclusion: Larger CoM displacement during the first recovery step of fall events suggests that participants were unable to decelerate the moving CoM over the base of support provided by the feet, causing larger (and still unsuccessful) first step length, longer swing phase time, thus step duration. This suggest that training should improve the ability to faster recruit motor units i.e., muscle power, to reduce the CoM displacement after a loss of balance.

P3-P-95: ***The effect of short-term versus long-term Perturbation Balance Based Training (PBBT) on balance function***

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BACKGROUND AND AIM:Falls among older adults are a known problem contributing to the rise in morbidity and mortality rates all over the world, with significant economic costs. Studies showed that older adults can reduce the risk of falls after participation in perturbation-based balance training (PBBT). PBBT provides a greater threat to balance, which creates a greater stimulus for active learning processes and even in short periods of training provide satisfactory results.PBBT intervention periods have been investigated individually to show that the duration of each training is beneficial and can be generalized to everyday balance requirements. The importance of determining the minimum effective PBBT dose for fall reduction is indescribable, as those results have a major impact on financial resources that are required for incorporating perturbation training in clinical settings. The goal of this study was to examine the effects of short-term (1-month) versus long-term (3-month) PBBT among older adults on balance parameters. We hypothesize that older adults who participated in the 3-month PBBT would show more beneficial effects on balance reactive and proactive function than older adults who participated in a 1-month PBBT. METHODS:We examined our goal by supplementing an analysis of two RCTs that were conducted by our research team. In the first RCT, 53 community dwelling older adults were recruited and randomly allocated to an intervention group (n =27) or a control group (n = 26). The intervention group received 24 training sessions over three months that included unannounced perturbation balance exercises during treadmill walking. The control group performed treadmill walking with no perturbations. The second RCT included a convenience sample of 20 community-dwelling older adults who received eight training sessions over 1-month that included unannounced perturbation balance exercises during treadmill walking i.e., random PBBT and block PBBT. Since 1-month random PBBT and 1-month block PBBT did not differ significantly, we grouped these two PBBT groups together and compared them with the 20 participants in the earlier study 3-months PBBT. Thus, in this analysis, we measured reactive and proactive balance control during standing and walking conditions, and compared the 1-month versus the 3-month PBBT training programs. RESULTS:Balance reactive capacity (i.e.,highest perturbations achieved) was improved in both PBBT's (1-month and 3-month), with no superiority of one training period over the other (70% improvement vs 65% improvement post training, respectively,$p=0.736$)). However, 3-months of PBBT can be transferred to other tasks, i.e., improve the ability to voluntarily step rapidly with a significant improvement in foot off time and foot contact time ($p = 0.007$,[ES]= 0.78 and $p = 0.003$[ES] = 0.91, respectively) and control standing balance with a significant improvement in M-L sway ($p = 0.007$,[ES]= 0.26). CONCLUSIONS:Our results shows that while 1-month of PBBT can improve specifically balance reactive abilities, it cannot be generalized to other tasks such as proactive balance task and balance control in standing. Adding two months of PBBT resulted in transfer and generalizability of the PBBT training approach to other tasks.

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P3-P-96: ***Preventing falls with exergaming: results from a 12-month randomised controlled trial of smart±step cognitive-motor training in community-dwelling older people.***

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BACKGROUND AND AIM: Exergames show great promise for fall prevention by integrating the training of both cognitive and motor functions that are known fall risk factors. This study aimed to examine the effects of the smart±step home-based exergame training system, delivered either as cognitive-only training (seated computer training) or cognitive-motor training (standing and stepping on a wireless mat), on preventing falls in community-dwelling older people. METHODS: The protocol was pre-registered (ACTRN12616001325493) and statistical analysis plan published prior to data analysis (https://osf.io/av2mq/). 769 community dwelling older people aged 65+ years were randomised to one of three groups (cognitive-only training, cognitive-motor training or control). Intervention participants were asked to undertake two hours of smart±step exergame training per week for 12 months. All participants reported falls monthly for 12 months. 300 participants attended a 6-month follow up assessment of physical and cognitive performance secondary outcomes. Analyses were conducted with an intention-to-treat approach. RESULTS: Participants in the motor-cognitive training group reported significantly fewer falls compared to control (IRR=0.74, 95%CI=0.56-0.98) while falls in the cognitive training group was not significantly different to control (IRR=0.86, 95%CI=0.65-1.12). The motor-cognitive training had significantly improved choice stepping reaction times, compared to the control group, while other physical and cognitive outcomes were not different between groups. CONCLUSIONS: Home-based exergaming involving step training can provide a safe and efficacious method of preventing falls in older people living in the community. The mechanism of this effect appears to be via improved stepping reaction time. ACKNOWLEDGEMENTS AND FUNDING: We acknowledge the time and effort of our research participants and the large research team that worked on this study, which was funded by the National Health and Medical Research Council of Australia.

P3-P-97: ***Impact of foot-floor friction on falls in the elderly: a computational simulation using neuromusculoskeletal model***

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BACKGROUND AND AIM: In recent years, the barrier-free construction of buildings has been making great progress, resulting in fewer steps in buildings. However, fall incidents due to trips in the elderly do not decrease. We hypothesized that one of the reasons can be high friction between the sole and the floor. That is, when walking with short step length and low foot clearance that are often seen in the elderly, high friction between the sole and the floor may cause a large horizontal force in such walking causing tripping. Therefore, the current

study aimed to investigate the effect of foot-floor friction on the risk of trip-induced falls during young and elderly gaits, in a computational simulation study. We used a computational model with neural rhythm generators and neuromusculoskeletal systems by which gait emerges in a self-organized manner. METHODS: Neuromusculoskeletal model developed by Taga [1] was used to simulate gait for young (young adult gait) and elderly adults (elderly gait). By changing the positive constant for torque generation at each joint, time constants of the inner state and the adaptation effect of the neurons, and an external input in differential equation of a neural oscillator, an elderly gait was simulated, which resulted in a reduction of step length, walking speed, and foot clearance (0.46 m, 0.74 m/s, and 0.10 m, respectively, in the elderly gait compared with 0.61 m, 1.13 m/s, and 0.19 m, respectively, in the young adult gait). Note that these changes in gait as well as the model's reactive balance were automatically generated in a self-organized manner. To alter the foot-floor friction, we changed the ratio of the spring coefficient of the floor in the horizontal (kgx) and vertical (kgy) directions (kgx/kgy). A fall was identified based on the height of the body's center of mass. RESULTS: In the simulated young adult gait, slip-induced falls were identified under low-friction conditions (kgx/kgy < 0.319). Moreover, there were no trip-induced falls at high foot-floor friction in young adult gait. However, in the elderly gait, slip-induced falls occurred under low-friction conditions (kgx/kgy < 0.549), whereas trip-induced falls occurred under high-friction conditions (kgx/kgy > 1.451). These results indicate that a trip-induced fall is unlikely to occur in young adult gait but is likely to occur in elderly gait across a high-friction floor. CONCLUSIONS: We demonstrated that the simulated elderly gait is more sensitive to foot-floor friction compared to the young adult gait. Our results provide new insight into the footwear and floor design for the elderly, who tend to walk with short step length and low foot clearance. There must be an optimal range for a friction coefficient between foot and floor contact in order to reduce the risk of trip- and slip-induced falls for the elderly. Further experimental research is needed to identify the optimal range for a friction coefficient. ACKNOWLEDGEMENT: This work was supported by JSPS KAKENHI Grant Number 20H04558. REFERENCES: [1] Gentaro Taga, A model of the neuro-musculo-skeletal system for human locomotion, Biol. Cybern. 73, (1995) 97-111.

Q - Habilitation & rehabilitation

P3-Q-98: ***Communicating standing and walking data after spinal cord injury: a patient-engaged, qualitative study***

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BACKGROUND AND AIM: Standing and walking ability are commonly affected after a spinal cord injury (SCI). During inpatient SCI rehabilitation in Canada, physical therapists use the Standing and Walking Assessment Tool (SWAT) as a guide for assessing standing and walking ability. Currently, there is no formalized approach to sharing SWAT-related outcomes with patients. Thus, the study aims were to understand 1) how information about standing and walking ability is currently shared with inpatients during rehabilitation, and 2) if and how individuals with SCI would like to receive information about their standing and walking ability during inpatient rehabilitation. METHODS: Sixteen adults with SCI, recruited as inpatients at the Lyndhurst Centre-Toronto Rehabilitation Institute, consented to participate. At three months post discharge, participants were interviewed over the phone by two researchers. Each interview lasted 45-60 minutes. A semi-structured interview guide was used to query patient experiences and preferences for receiving feedback on standing and walking ability. Interviews were audio-recorded and transcribed verbatim. An inductive thematic analysis was applied to the transcribed data. RESULTS: Two themes were identified. 1) Current practice for providing feedback on standing and walking ability is inconsistent. Participants reported that assessments were conducted by physical therapists and physical therapy assistants. The assessments described included evaluation of their strength, walking and balance. Some participants reported a high frequency of feedback provided by therapists, while others reported little or none. Therapists primarily shared feedback verbally, though occasionally in a written format. 2) Participants prefer to receive feedback related to standing and walking ability in a variety of formats. All participants expressed a desire for ongoing verbal feedback along with formal written feedback (e.g. physical therapy report card) at two distinct time points during their inpatient stay (e.g. at admission and discharge). Some participants expressed interest in electronic feedback for record keeping and the ease of sharing information with others. Limitations to using scores on standardized measures (e.g. Berg Balance Scale) as feedback were identified. For example, participants prefer feedback on tangible changes in functional mobility over the use of a change in numerical score. CONCLUSIONS: During inpatient SCI rehabilitation, practices for providing feedback on standing and walking ability to patients are varied and inconsistent. Individuals with SCI would prefer feedback in both verbal and written formats, with a focus on tangible mobility goals. The study findings will inform the development of strategies for sharing SWAT-related outcomes with individuals living with SCI. FUNDING: Praxis Spinal Cord Institute Grant # 2021-38

P3-Q-99: ***A VR-based and field training intervention for community walking post-stroke: preliminary results***

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BACKGROUND & AIMS: Independent community walking remains compromised in most stroke survivors. This is likely due to a lack of specificity and intensity of current rehabilitation interventions, particularly during the chronic stage. To address this, our team developed a virtual reality (VR) based intervention combined with field training practice that specifically targets five essential dimensions of community walking: endurance, speed, postural transitions, avoidance of pedestrians/objects and cognitive loading (i.e. dual-task walking). We also aimed to evaluate the extent to which stroke survivors with various degrees of walking capacity, visual perceptual disorders and cognitive deficits would benefit from this intervention. METHODS: The intervention involves three 1-hour supervised sessions per week for 4 weeks, as well as biweekly field training assignments carried out in the community. During the supervised sessions, participants walk on an omnidirectional treadmill (Cyberith) while immersed in walking scenarios visualized in a head mounted display (HTC Vive). They train on the 6 dimensions of community walking (5 above-mentioned dimensions along with a 6th level of integrated dimensions), each involving increasing levels of difficulty. Participants are assessed twice prior to (week0, week4) and after the intervention (week8, week12) on measures of walking speed (5m Walk Test), endurance (6-min Walk Test (6MWT)), dynamic balance (Dynamic Gait Index (DGI)), balance confidence (Activity Balance Specific Scale (ABC)) and life habits related to mobility and community life (Life-H). Acceptability of the intervention is assessed post-intervention using a questionnaire based on the Technology Acceptance Model (TAM). RESULTS: To date, two participants (72 & 75 years) with stroke (left CVA, 12 & 17 mo. post stroke) with intact cognition and visual-perceptual abilities completed the full cycle of the study. They had initial comfortable walking speeds of 0.66 and 0.83 m/s and 6MWT walking distances of 246 and 267m. Participants completed all supervised training sessions, reaching dimension 5 by the end of intervention. They further completed all field training assignments, with estimated walking distances of 300-500m over 20-30 minutes in both indoor (e.g. shopping mall) and outdoor (e.g. park) community environments for each session. Both participants showed clinically meaningful and/or substantial meaningful changes in the 5MWT (Δ=0.11 & 0.19 m/s) and the 6MWT (Δ=38 & 50m) immediately after vs. before the intervention. Those changes were maintained at follow-up. No changes were observed on the DGI, ABC and Life-H. Acceptability as per the TAM-based questionnaire was rated as 36 and 49 out of 56. CONCLUSIONS: Findings support the feasibility and potential of a task specific VR intervention combined with field training to enhance community walking post stroke. More participants are being recruited to determine who benefits the most from the intervention.

P3-Q-100: ***Association between abnormal gait patterns with an elevated degree of pain after daily walking: a preliminary study***

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Background and aim: There is robust evidence that pain interferes with a high pace, and regular and smooth gait patterns. However, whether abnormal gait patterns cause pain has not been well studied. This study aimed to examine whether having more and poorer abnormal gait patterns are associated with experiencing an elevated degree of pain after daily walking, as assessed by asking about pain experienced after walking in community-dwelling older adults. Methods: Two hundred twenty-three community-dwelling older adults

had assessment of pain experienced after daily walking by asking a simple question. This question asked about past experiences of an elevated degree of pain after walking for ≥400 m. Gait patterns were assessed using the Comprehensive Gait Assessment using the InerTial Sensor score. This score was derived from data measured by inertial sensors at the lower trunk and heel when subjects walked along a 15-m walkway at a self-selected, preferred speed. The score was the sum of 10 gait parameter scores (walking speed, mean stride time, coefficient of variation of stride time, coefficient of variation of swing time, autocorrelation coefficients in three directions, and the harmonic ratio in three directions), and it was validated by the authors in a previous study. The concept behind the method is that multiple abnormal gait patterns would overlap in older adults with severe problems in gait. Additionally, the 10 gait parameters were divided into four subgroups, and the sum of each was treated as a subscore comprising the pace score, variability score, regularity score, and smoothness score. Results: Twenty-four (10.8%) older adults reported that they experienced an elevated degree of pain after walking ≥400 m. In multiple logistic regression analyses, older adults with a lower total the Comprehensive Gait Assessment using the InerTial Sensor score had a significantly greater probability of past experiences of pain after walking (odds ratio [OR] = 1.11, 95% confidence interval [CI] = 1.03-1.20). The results of a second model showed that lower pace and smoothness scores were independently associated with a greater probability of experiencing pain after walking (OR = 1.34, 95% CI = 1.03-1.76; OR = 1.20, 95% CI = 1.00-1.45, respectively). Conclusions: This preliminary study suggests that having more and poorer abnormal gait patterns in older adults are associated with an elevated degree of pain after daily walking. Additionally, a lower pace and less smooth gait are independently associated with pain after walking. Considering past evidence, an abnormal gait pattern and pain may form a negative cycle in older adults; an abnormal gait patterns is an important pain-inducing factor, and pain affects the gait pattern. Further studies that implement a test to perform actual walking, such as the 6-minute walking test, and consider other limitations of this study are required to confirm this association.

P3-Q-101: ***Does a multi-modal mild traumatic brain injury rehabilitation program facilitate standing balance improvements relative to natural recovery?***

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BACKGROUND AND AIM: Balance deficits are common after mild Traumatic Brain Injury (mTBI). Vestibular rehabilitation is increasingly used to treat balance problems in this population. However, evidence supporting the effectiveness of rehabilitation for balance in this population is weak. Here, we present preliminary results of a randomized control trial study that examined the effectiveness of a multi-modal mTBI rehabilitation program aimed at improving balance relative to recovering naturally with no rehabilitation. METHODS: All subjects had sustained a recent mTBI (<12 weeks following injury), remained symptomatic, and completed both a baseline and 6-week follow-up test. Subjects were randomly assigned to either a non-rehabilitation (non-rehab) group or a rehabilitation (rehab) group. The non-rehab group (n=35) received no intervention during the 6-weeks between baseline and follow-up tests, which is the current standard of care. The rehab group (n=36) received 8 intervention sessions over 6 weeks that included cervical therapy, aerobic exercise, and vestibular rehabilitation (oculomotor exercises, gaze stabilization, static and dynamic balance). Baseline and follow-up balance tests were performed with the Central Sensorimotor Integration (CSMI) test. The CSMI test identified parameters that accounted for anterior-posterior center-of-mass (CoM) body sway evoked by repeated 20-s duration cycles of 2° peak-to-peak pseudorandom rotations of the stance surface during eyes closed stance. The CSMI outcome measures included: 1) 'vestibular weight', 2) normalized 'stiffness' and 'damping' factors that determine corrective ankle torque generation, and 3) the overall 'time delay' in the system. Results were evaluated with LME models that included fixed factors for group, time, group x time interaction, and random intercepts for with-in subject correlations. RESULTS: Among the interaction effects, stiffness trended toward significance (p=0.09), where stiffness increased in the rehab group by 1.4% but decreased in the non-rehab group by 2.3%. Otherwise, there were no other significant interaction effects. Reliance on vestibular cues significantly increased in both groups by similar amounts (rehab: 5.6%, p= 0.01; non-rehab: 6.3%, p=0.005). No other significant effects were noted. CONCLUSIONS: Increased vestibular reliance, which represents an improvement in balance control, occurred in both groups indicating that increased vestibular reliance occurs naturally over time and was not facilitated by the therapy used in this study. However, stiffness declined in the non-rehab group while it increased in the rehab group. The increased stiffness in the rehab group enhanced corrective control action leading to reduced sensitivity to balance perturbations while the opposite occurred in the non-rehab group. Overall results reveal some benefit, on average, of rehabilitation versus no treatment based on CSMI evaluations but variability was large and changes were modest.

S - Neurological diseases

P3-S-102: ***The 180 degree Turn Test in People with late Subacute and Chronic Stroke***

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BACKGROUND AND AIM Falls are multifactorial and can be caused by a variety of factors (Xu et al., 2018). The 180∘ Turn Test is reliable, and it is associated with clinical outcome measures, which examine the motor function in individuals with stroke (Robinson and Ng, 2017). It is still unknown whether the 180∘ Turn Test measures are associated with other fall risk factors, e.g., affective and cognitive factors. Thus, we aim to evaluate the relationship between the personal, motor, cognitive, and affective factors and the 180∘ Turn Test measures in people with late sub-acute and chronic stroke. METHODS Eight patients with ischemic stroke were evaluated (age 66.8 ± 5.02). Patients completed 180∘ Turns to the affected and non-affected sides. Turn time (sec) and step count (step) were calculated by two trained physical therapists. Personal characteristics included age, education, and gender, and the number of medications was recorded. Motor outcomes included five times sit-to-stand test (5XSTS), Berg Balance Scale (BBS), and 6-Minutes Walk Test (6MWT). The cognitive status was assessed using Montreal Cognitive Assessment (MOCA). Finally, affective status was evaluated using Pittsburgh Sleep Quality Index (PSQI) and Fatigue Severity Scale (FSS). Correlation of the 180◦ Turn time and step count with the personal, motor, cognitive, and affective measures were calculated using Spearman rho ($p<0.05$). RESULTS The 180◦ Turn time and step count correlated significantly with: (1) BBS (TIME: affected side r=-0.85, p=0.007, non-affected: r=-0.8, p=0.004; STEP COUNT: affected: r=-0.9, p=0.002, non-affected: r=-0.85, p=0.007), (2) 6MWT (TIME: affected r=-0.85, p=0.004, non-affected: r=-0.9, p<0.001; STEP COUNT: affected: r=-0.9, p=0.002, non-affected: r=-0.8, p=0.004), (3) 5TSTS (TIME: affected r=-0.7, p=0.02, non-affected: r=-0.76, p=0.02). (4) female gender (TIME: affected r=0.8, p=0.002, non-affected: r=-0.8, p=0.008; STEP COUNT: affected: r=0.8, p=0.008, non-affected: r=0.8, p=0.002), (5) number of medications (TIME: non-affected r=0.78, p=0.02), and (6) an older age (TIME: affected r=0.7, p=0.04). No significant correlations were found between the 180◦ Turn measures and MOCA, PSQI, or FSS. CONCLUSION Preliminary data show that the 180◦ Turn Test can indicate individuals with stroke' personal and motor characteristics. However, the small sample size is a limitation in the current report to make a general conclusion. Additional participants will be added to the study as it progresses. ACKNOWLEDGEMENTS AND FUNDING The author(s) received no financial support for this research. REFERENCES Xu, T., Clemson, L., O'Loughlin, K., Lannin, N. A., Dean, C., & Koh, G. (2018). Risk factors for falls in community stroke survivors: a systematic review and meta-analysis. Archives of physical medicine and rehabilitation, 99(3), 563-573. Robinson, R. L., & Ng, S. S. (2018). The Timed 180° Turn Test for Assessing People with Hemiplegia from Chronic Stroke. BioMed research international, 2018.

P3-S-103: ***Cerebellar rTMS for postural instability in progressive supranuclear palsy: preliminary results from a crossover study***

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BACKGROUND AND AIM: Treatments for severe balance impairment in progressive supranuclear palsy (PSP) are limited. Several groups have demonstrated that cerebellar modulation of motor control is impaired in PSP and may benefit from cerebellar stimulation (Shirota 2010, Brusa 2014, Dale 2019, Benucci 2019, Pilotto 2021). We evaluated objective measures of postural instability and resting state fMRI connectivity (rs-fMRI) before and after cerebellar repetitive transcranial magnetic stimulation (rTMS) compared to cerebellar sham TMS. Our crossover design limits important confounders such as cognition and physical therapy or medication effects. METHODS: Subjects received 10 sessions of 10 Hz rTMS and sham cerebellar TMS in a randomized, single-blinded crossover design. Medications were held constant during the trial, and subjects did not participate in other physical therapy programs. Sway while standing on a firm surface with eyes open was collected using center of pressure (CoP) measurements from a Neurocom force plate and accelerations from mobile sensors. Gait speed was quantified with mobile sensors. Rs-fMRI connectivity between the cerebellum, thalamus, and motor cortex was assessed before and after active and sham stimulation. RESULTS: Three subjects completed the entire protocol, two subjects completed the active portion only, and one subject completed the sham portion only (due to

pandemic interruptions). After cerebellar rTMS, CoP medio-lateral sway range in quiet stance with eyes open improved 23.4%, and total sway area improved 49.9%. Gait speed improved 12.2% and stride length improved 6.4%. Sham TMS did not improve gait and balance measures. One subject showed increased connectivity between the cerebellum and higher motor areas after active but not sham stimulation. Rs-fMRI feasibility in this population has been limited by motion artifact due to discomfort in the supine position related to muscular rigidity and dysphagia to oral secretions resulting in coughing. CONCLUSIONS: Objective posturography measures improved in subjects with PSP after cerebellar rTMS compared to sham in preliminary analysis, and subject recruitment for this study continues. Cerebellar rTMS should continue to be investigated in future rehabilitation trials, and as proof-of-concept for more durable cerebellar stimulation in PSP. ACKNOWLEDGEMENTS AND FUNDING: We thank our participants for generously donating their time. We also thank our funders: NIH KL2TR002370 (Jacoby/Dale), NC-NM4R (Dale), Collins Medical Trust (Dale).

P3-S-104: ***Negotiating Anticipated and Unanticipated Obstacles in People with Multiple Sclerosis***

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BACKGROUND AND AIM: Obstacle negotiation (ON) abilities may contribute to the high fall risk among people with multiple sclerosis (pwMS). Santinelli et al. (2021) reported reduced step-length and gait speed in 15 pwMS patients, compared to 15 controls, when clearing a single static obstacle. However, ON strategies and differences between anticipated and unanticipated obstacles have not yet been studied in pwMS. Here, we aimed to quantify how pwMS negotiate anticipated and unanticipated obstacles, compared to healthy controls, and the role of disease severity. METHODS: 41 pwMS (mean age: 40±12 SD; 66% female) and 31 healthy controls (HC) (mean age: 36±10 SD; 42% female) completed a computer-controlled, mechanized obstacle course that included a static block to test ON abilities with anticipated obstacles and unanticipated obstacles (e.g., the obstacle emerged from the ground as the subject approaches). Kinect cameras measured the distances between each foot and the obstacles and success in clearing the obstacles. Demographics, disease severity (i.e., Expanded Disability Status Scale, EDSS), and the Timed 25-Foot Walk test were also assessed. RESULTS: When negotiating anticipated obstacles, failure rates were 13±6% (mean±SE) in pwMS and 0% for HC (p=0.069); the distances between the foot and the obstacle were lower in pwMS, compared to HC, just before the obstacle, just after the obstacle, and for the clearance of the trailing leg above the obstacle (Fig. 1 top), but not for the leading leg above the obstacle. When negotiating unanticipated obstacles, the failure rates were 56±8% in pwMS and 55±9%in HC (p=0.91); the distance between the obstacle and the foot after the obstacle was lower in pwMS, compared to HC, but other distances were similar in both groups (Fig. 1 bottom). Among the pwMS, 14 had EDSS scores above 2 and 27 had a score below that. When negotiating anticipated obstacles, failure rates were

9.5±6.4% SE for mild and 22±14% for more severe participants (p=0.348) and the foot clearance distances were similar in the two groups. For unanticipated obstacles, mild and severe participants had 52±10% SE and 64±13% failure rates, respectively (p=0.447). The distance between the foot and obstacle was lower in those with more severe disease, compared to those with less severe disease, both before and after the obstacle (p<0.01), but not for clearance above the obstacle. 25-foot walk times were longer (p<0.001) in PwMS (4.57±0.2 sec) than in HC (3.6±0.1 sec). These times were not correlated to clearance distances except for negative correlation among MS participants in unanticipated obstacles. CONCLUSIONS: Success rates did not differ significantly between pwMS and the healthy controls, perhaps due to compensatory mechanisms. Nonetheless, clearance was reduced in pwMS, compared to controls, both during anticipated and unanticipated obstacles, and reduced further in more advanced disease. These alterations may form the basis of targeted interventions for reducing the risk of falls among pwMS. ACKNOWLEDGEMENTS AND FUNDING: This work was funded in part by a grant from the Israel Innovation Authority.

P3-S-105: ***Prevalence, progression and predictors of Freezing of Gait in early Parkinson's***

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Background and aim: Freezing of Gait (FoG) is a "brief episodic absence or marked reduction of forward progression of the feet despite the intention to walk"1 and is experienced by many people with Parkinson's. Identifying people at greatest risk of developing FoG earlier will help target interventions to delay FoG. Although several studies have identified predictors of FoG, results have been inconsistent and not focussed on newly diagnosed Parkinson's.e.g.2 The aims of this study were to establish the prevalence, progression and predictors of FoG in people recently diagnosed with Parkinson's. Methods: 119 people with Parkinson's were assessed as part of the ICICLE-Gait study3 primarily within six months of their diagnosis (baseline) and subsequently each 18 months for up to 72 months. Here, we summarise the prevalence of self-reported FoG at baseline (using the New FoG questionnaire)4 and timing of first FoG experience (assessed each 18 months) for those who were FoG naïve at baseline. For FoG naïve participants, univariate cox regression was used to identify baseline clinical, demographic, cognitive and gait features associated with a quicker time to FoG conversion. Results: Of the 119 people with Parkinson's assessed at baseline, 11 (10%) presented with FoG. An additional 23 (19%) people went on to develop FoG over the next 72 months. Mean time to FoG was 62 months. More severe postural instability and gait difficulty symptoms (subscore of the UPDRS), worse self-reported disease burden (MDS-UPDRS II), self-reported cognitive complaint and gait (lower step velocity and shorter step length, longer stance time and more asymmetric swing time) were significant predictors conversion to FoG (p <. 05). Age, sex, clinician rated disease severity (MDS-UPDRS III) and global cognition were not significant predictors. Conclusions: Despite FoG

often being considered a moderate-to-late stage symptom of Parkinson's, almost a third of people with Parkinson's in this study experienced FoG at some stage in the first six years after diagnosis. This is likely an underestimation as 48 FoG naïve participants left the study prior to the 72 month assessment. Our preliminary findings suggest clinical, gait or cognitive assessment may help identify people in the early stages of Parkinson's at greatest risk of developing FoG. Further multivariate analysis will allow us to develop a clinical tool for FoG prediction. References: 1 N Giladi N & A Nieuwboer. Mov Disord. 2008;23(Suppl 2) 2 N D'Cruz et al. J Parkinsons Dis. 2020; 10(2) 3 Lord S et al. J Gerontol A Biol Sci Med Sci. 2013; 68(7) 4 Nieuwboer et al. Gait Posture 2009;30(4)

P3-S-106: ***Detecting daily-living freezing of gait using wearables: towards clinical validation by way of comparison to self-report and performance-based tests***

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BACKGROUND AND AIM: Freezing of gait (FOG) is an episodic, debilitating phenomenon that is common among patients with Parkinson's disease (PD). This enigmatic phenomena is often difficult to capture and assess, due to its paroxysmal nature and variable presence. Multiple approaches have been used to quantify FOG, however, the relationship between them has not been well-studied. We aimed to better understand and validate measures based on daily-living FOG and to evaluate the association between FOG measured during unsupervised daily-living monitoring, structured in-home FOG-provoking tests, and self-report questionnaires. METHODS: 28 people with PD and FOG were assessed using: 1) self-report questionnaires, 2) percent time frozen (%TF) during supervised FOG-provoking tasks in the home OFF and ON dopaminergic medications, and 3) %TF evaluated using wearable sensors during one week of unsupervised daily-living monitoring. Correlations between those three assessment approaches were analyzed to quantify associations. Further, based on %TF during in-home testing OFF medication, the subjects were divided into mild and moderate freezers to evaluate differences in the other FOG measures. RESULTS: During the in-home testing 507 FOG episodes were provoked in the OFF state, compared to only 215 in ON medication. OFF medication, the %TF of the provoking protocol ranged from 0.4 to 57.9 %TF. The most provoking tasks were the turning tasks, both before and after medication intake. %TF during unsupervised daily-living was mild to moderately correlated with %TF during a subset of the tasks of the in-home testing OFF-medications, but not with ON testing or self-report. Subjects with mild and moderate %TF during in-home testing OFF medication did not show a significant difference in both self-report questionnaires and were similar in the %TF measured during unsupervised daily-living ($p>0.05$). The FOG item 3.11 of the MDS-UPDRS in the OFF-medication state was correlated with the %TF ($r=0.44$, $p=0.02$) and the number of FOG episodes per hour ($r=0.40$, $p=0.04$) during daily-living. Further, the levodopa equivalent daily dose (LEDD) was moderately correlated with the %TF ($r=0.43$, $p=0.02$) and

the number of FOG episodes per hour (r=0.39, p=0.04) during daily-living; subjects with a higher dosage of anti-parkinsonian medication had higher values of %TF during daily-living activities. CONCLUSIONS: %TF during daily-living is moderately related to FOG during certain in-home FOG-provoking tests in the OFF-medication state. However, this measure of FOG is not associated with self-report or FOG provoked during ON medication. These findings suggest that to fully capture FOG severity, it is best to assess FOG using a combination of all three approaches; unsupervised daily-living monitoring, self-reported questionnaires, and FOG-provoking tests provide different, complementary evaluation methods. When used together, a relatively complete and informative picture of a person's FOG severity and how it is perceived emerges.

P3-S-107: *Dual task gait and brain structure in people with PD with and without mild cognitive impairment*

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BACKGROUND AND AIM: People with Parkinson's disease (PD) experience greater difficulties during dual task (DT) walking compared to healthy controls (HC). Research suggest that gait is more affected during DT walking in people with PD with mild cognitive impairment (PD-MCI) than without MCI (PD non-MCI). Whether these differences in DT walking are also reflected in alterations in brain structure remains unknown. The aim of this study was therefore to explore the DT effect (DTE) in people with PD with and without MCI, and HC, and to investigate the underlying changes in grey matter (GM) volume across the three groups. METHODS: Single and DT spatiotemporal gait parameters were assessed using an electronic walkway system (GAITRite). An auditory Stroop task was used as the secondary task during DT gait assessment. The DTE was calculated for gait speed and step time variability. A neuropsychological test battery was performed to classify PD-MCI status according to the Movement Disorder Society task force level II category. Structural T1 weighted magnetic resonance imaging (sMRI) was acquired on a 3T Phillips Ingenia scanner. Comparisons of behavioral outcomes between groups were analyzed using ANOVA or Kruskal-Wallis Test as appropriate with statistical significance at p<0.05. Voxel-wise whole-brain comparisons of GM volume were computed in SPM12 using T-tests and corrected for total intracranial volume. Statistical significance level was set at p<0.05 corrected for multiple comparisons and for exploratory analyses at p<0.001. RESULTS: A total of 59 people with PD (35 PD non-MCI and 22 PD MCI) and 38 age- and sex-matched HC were included. The PD MCI and HC groups significantly decreased their gait speed during DT walking (mean DTE of -9.7% and -8.7%), whereas the PD non-MCI group did not (mean DTE of -1.7%), representing an across-group difference between PD non-MCI and the HC and PD MCI, but not between HC and PD MCI (p=0.959). The same pattern was reflected in step time variability which increased significantly in both PD MCI (median DTE 32.4%, p=0.001) and HC (median DTE 10.3%, p=0.008), but not in PD non-MCI (median DTE 6.3%, p=0.051). The difference in DTE on step time variability was not significant across groups (p=0.11). In whole-brain analyses no differences between HC and PD non-MCI were found. As compared

to HC, PD MCI had decreases in the frontal and temporal gyri, bilaterally. In the left hemisphere, the angular gyrus/supramarginal gyrus and frontal pole showed lower GM volume. Increased GM volume was only found in the left occipital pole. Of note, results did not survive correction for multiple comparisons. CONCLUSIONS: In contrast to our hypothesis, analyses revealed that HC and PD MCI groups followed a similar DTE pattern of decreased gait speed and increased step time variability whereas the PD non-MCI group did not. The DTE of the cognitive task as well as the prioritization of the motor and/or cognitive task needs further investigation. In line with the literature, no GM volume differences were found between HC and PD non-MCI. Fronto-temporal atrophy in PD-MCI as compared to HC did not survive corrections for multiple comparisons.

P3-S-108: ***Prediction characteristics of freezing of gait episodes based on bilateral leg stepping coherence in patients with Parkinson's Disease***

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BACKGROUND AND AIM: In the past decade, many studies investigated the use of wearable sensors to predict and detect FOG episodes. Impaired bilateral coordination of gait (BCG) was implicated with FOG in Parkinson's disease (PD). However, exploring automated algorithms to detect failed BCG prior and during FOG episodes has not been attempted. This work aims to evaluate the characteristics of a freezing of gait (FOG) detection algorithm based on continuous data from inertial sensors (placed bilaterally on the shanks) during ambulation of participants with Parkinson's disease. METHODS: Fourteen participants with PD (mean UPDRS 19.3±12.7) wore mobility sensors (APDM®, Oregon, USA) and performed over-ground gait trials which included FOG provoking circumstances (e.g., 180º turns, narrow paths, etc.) as well as voluntary stops (VOL), cued externally by a research assistant. Video recordings synchronized with the sensors were annotated post-hoc by a researcher, and onset and offset times of FOG episodes were recorded. Sagittal plane angular velocity signals from shank sensors were fed offline into a MATLAB-based algorithm that used wavelet analysis to assess the spectral properties of the signals over time. A coherence index was computed (i.e., between signals recorded from the two sensors), and the algorithm marked sudden drops in coherence. RESULTS: A total of n=128 FOG events were identified by post-hoc video viewing. The offline MATLAB algorithm detected upcoming FOG events 1.81[1.57] (Median [Inter-quartile range]) seconds prior to the researcher's video-based annotation. In contrast, voluntary stops (n=42) were marked by the algorithm 0.22 [0.76] seconds before the vide-based annotation. Time differences between coherence drop and onset of FOG/VOL events did not correlate with measures of disease severity or with gait speed, stride length or time prior to the FOG events. Figure 1 details the coherence drop (black vertical line) and video-based annotation of FOG/VOL onset (red vertical line) for FOG (left) and VOL (right) for a single participant. CONCLUSIONS: Wavelet coherence appears to be a promising tool in predicting an upcoming occurrence of a FOG episode, in agreement with the implication of impaired BCD with the symptom. We are currently aiming to adapt the algorithm to work in real time, to provide as early as possible warning prior to FOG and elicit a behavioral, or technological (e.g., external stimulation) response to avert the episode.

P3-S-109: ***Long-term home-based tDCS improved mobility and cognitive function in Parkinson's disease: a case study***

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BACKGROUND AND AIM: Transcranial direct current stimulation (tDCS) targeting the left dorsolateral prefrontal cortex (dlPFC) is a promising short-term therapeutic intervention (e.g., 10, once-daily sessions) to improve gait and mobility in Parkinson's disease (PD). The feasibility, safety, and effectiveness of longer-term interventions have not been well-studied. We present a case report of a patient with PD who completed a one-year, open-label, home-based tDCS intervention administered by a study companion and remotely-supervised by research staff. METHODS: The participant was a 68-year-old male (PD duration=15 years, MDS-UPDRS=53, Hoehn and Yahr=4). The participant's study companion (69yrs) completed a custom-developed tDCS administration training program. tDCS intervention included an intensive phase (ten, once-daily sessions over two weeks) followed by a 52-week maintenance phase (two sessions/week for the first 27 weeks; three sessions/week for the remainder at the request of the participant). tDCS was delivered using the Starstim HomeTM kit (Neuroelectrics Corp). Each tDCS session was 20-min with the goal of generating an average electric field of 0.25 V/m within the left dlPFC. Impedance, session progress, and side effects were queried each session. A combination of in-person and remote-assessments were completed (one hour after taking Parkinsonian medications) at baseline, after the intensive phase, and every three months thereafter. Assessments focused on dual task walking, mobility (Timed Up and Go, TUG), cognitive function (Trail Making Test, TMT; Montreal Cognitive Assessment, MoCA), and self-reported change in walking, mobility, and quality of life. RESULTS: The participant completed a total of 137 tDCS sessions, only missing two due to companion illness. No adverse events were reported. All tDCS side effects were minor, mild, and transient. The participant and companion self-reported improvement in the participant's walking, mobility, and quality of life at each assessment as compared to baseline. Normal and dual task gait performance was relatively consistent across assessments. TUG time (sec) was 15.3, 13.0, 13.0, 13.0, 14.0, and 15.3 seconds at the baseline, 2-week, 3-, 6-, 9- and 12-month assessments, respectively. Compared to baseline, improvements were observed in the TMT of executive function and the visuospatial/executive sub-score of the MOCA throughout the follow-up period. CONCLUSIONS: A one-year, caregiver-led and remotely-supervised tDCS intervention was well-tolerated, safe, and associated with both subjective and objective improvements in mobility and cognitive function in one patient with advanced PD. These results indicate that extending the treatment duration of tDCS to improve gait and mobility in a home-based setting is feasible, potentially allowing future efforts to personalize intervention characteristics and reach large numbers of vulnerable older adults with PD or other age-related movement disorders.

P3-S-110: *Freezing of Gait across the spectrum of normal, non-freezers, possible freezers and definite freezers*

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Background and Aims. FoG is common and debilitating in people with Parkinson's disease (PD). Clinical decision-making and research design is often based on classification of patients as 'freezers' or 'non-freezers'. The question is whether these states are clearly distinct or there is a continuum of freezing with progressive worsening. We recently introduced an objective measure of FoG, Freezing Ratio, based on the ratio of leg frequencies (0.5-3Hz and > 3 Hz) during a 360 degrees turning in place task. Higher leg frequencies represent trembling of the knees and could be helpful in tracking a potential continuum spectrum from absent to severe FoG. Here, we objectively assessed FoG severity from inertial sensors on the legs to characterize the continuum of FoG from absent to severe in people with PD and healthy controls. Methods. One hundred and forty-seven people with PD (Age: 69±8) off medication, and eighty-three healthy controls (Age: 68.5±8) turned 360 degrees in place for 2 minutes while wearing three wearable sensors (one on each shin and one on the waist) that were used to calculate FoG Ratio. People with PD were classified as: 'definite freezers', new FoG questionnaire (NFOGQ) score >0 and clinically observed FoG (N=42, MDS-UPDRS III: 48±13), 'non-freezers', NFOGQ=0 and no FoG clinically observed (N=81, MDS-UPDRS III: 36±11); and 'possible freezers', either NFOGQ>0 but no FoG observed or NFOGQ=0 but FoG observed (N=24, MDS-UPDRS III: 43±9). To investigate whether the Freezing Ratio differed between groups, linear mixed-models were fit accounting for disease severity (MDS-UPDRS Part III) as a covariate. Results. The Freezing Ratio progressively increased from healthy controls to non-freezers to possible freezers to definite freezers ($p<0.05$) and showed excellent test-retest reliability (ICC=0.85). Unlike the Freezing Ratio, sway, gait and turning impairments were similar across non-freezers, possible and definite freezers ($p>0.05$). The Freezing Ratio was significantly related to disease duration, balance confidence, and the SCOPA-Cog ($p<0.05$), but not to MDS-UPDRS Part III Motor signs nor sway, gait, or turning impairments. Conclusion. These preliminary findings suggest that an increase in Freezing Ratio, objectively assessed with wearable sensors during a turning in place test, may be of help in characterizing people with PD transitioning from non-freezers to freezers. An increase in Freezing Ratio, objectively assessed with wearable sensors during a turning in place test, may help to characterize people with PD transitioning from non-freezers to freezers. Future work should follow objective measures of FoG longitudinally over time.

P3-S-111: *Does gait stability change over the 6-minute walk test in persons with Multiple Sclerosis?*

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Background and aim: Persons with multiple sclerosis (pwMS) show lower limb gait deficits (Comber et al. 2017) and decreased gait stability compared to healthy control participants (Lin et al. 2020). Previous research identified walking-related motor fatigue in pwMS by assessing the percentage change in distance walked between minute 6 and 1 of the 6-Minute Walk Test (6MWT)(Leone et al. 2016). About one-third of PwMS showed this walking-related motor fatigue during the 6MWT. As gait instability is already evident in pwMS without clear gait impairments (Cofré Lizama et al. 2020), it was questioned whether pwMS would show a similar fatigue related change in gait stability between minute 6 and 1 of the 6MWT. Therefore, the aim of this study was to assess whether pwMS present with altered gait stability at minute 6 compared to minute 1 of the 6MWT. Methods: Participants were included if they had: (1) a diagnosis of MS, (2) an age between 18-65 years, (3) a disease severity score from 1 to 5.5 on the Expanded Disability Status Scale (EDSS), (4) the ability to walk without walking aids. Participants were excluded if they had: (1) a relapse three months, (2) a lower limb fracture 12 months, or (3) lower limb botulinum toxin treatment six months prior to the measurement. Participants performed the 6MWT on the CAREN system (Motek, NL). They were equipped with the Human Body lower limb and trunk model to allow calculation of spatiotemporal parameters and kinematics during gait. Participants walked as fast as possible using the self-paced mode. Two familiarization rounds of 3min, including breaks, were provided. Medio-lateral and backward margins of stability (ML-MoS, BW-MoS) were calculated as the position of the extrapolated center of mass (XCoM) relative to the lateral malleolus and heel of the leading foot, respectively (Hak et al. 2013). XCoM was defined as CoM plus its velocity times a factor: √(maximal CoM height/acceleration of gravity). Negative ML-MoS results in deviation from straight walking, and negative BW-MoS in interruption of forward progression. Average ML-MoS and BW-MoS were calculated for all steps in minute 1 and in minute 6. Additionally, MoS variability in the two directions (ML-sdMoS, BW-sdMoS) was determined over de MoS of all steps in minute 1 and in minute 6. A repeated measures ANCOVA was performed with 'time' as within factor, and the difference in walking speed between minute 6 and minute 1 as a covariate. Results: Preliminary results included data of 14 pwMS (Table 1). ML-MoS, BW-MoS and BW-sdMoS were not significantly different between minute 1 and minute 6 (ML-MoS: $F=1.275, p=0.281$; BW-MoS: $F=0.000, p=0.996$; BW-sdMoS: $F=0.569, p=0.465$). ML-sdMoS did differ significantly between minute 1 and minute 6 ($F=6.303, p=0.027$). Conclusions: Our preliminary findings indicate that variability of margins of stability in the medio-lateral direction increased significantly over 6 minutes of walking. Therefore, this measure of gait stability might be sensitive to assess walking-related motor fatigue in this population. Future research should confirm these preliminary results and should investigate possible asymmetry in gait stability between the most and least affected side.

P3-S-112: ***Does Non-contact Boxing Improve Functional Mobility in Parkinson Disease?***

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Background and Aim Thirty-eight to 87% of persons with Parkinson's disease (PD) fall each year, and two-thirds of these persons fall recurrently. The direct medical costs of PD fallers is estimated to double the costs of nonfallers. Improvements in gait and balance are associated with lower fall risks in persons with PD. Community boxing as an intervention has shown preliminary positive results regarding improvement of functional mobility in those with mild to moderate PD, but no specific balance training component has been included. The purpose of this investigation was to determine if a community-based boxing training program coupled with individualized balance training could improve functional mobility in persons with mild-to-moderate PD. Methods Twelve participants diagnosed with idiopathic PD were enrolled in a 12-week community-based non-contact boxing program and provided individualized balance training tailored to their domain of balance dysfunction. Mobility outcome measures were recorded at baseline and 12 weeks, and included the Berg Balance Scale, Timed Up & Go (TUG), Functional Reach Test, and Five Times Sit-to-Stand test (5-STS). The Activities-specific Balance Confidence Scale (ABC) was also administered to assess subjective confidence in balance during activities of daily living. A paired t-test was used to evaluate the before-and-after effects of the intervention, with Bonferroni corrections applied for multiple comparisons ($\alpha=0.01$). Cohen's d was used to determine effect sizes. Results After 12 weeks of training, participants had significantly faster TUG times ($d=1.17$, $p=0.002$). Additionally, there was a trend toward increased confidence in the ABC Scale with a large effect size ($d=0.741$) and an improved 5-STS score ($d=2.255$). Conclusions Community boxing training as an intervention for Parkinson's Disease has demonstrated the potential to improve functional mobility. When coupled with balance training tailored to individual deficits, participants can move with greater power and fluidity, which may decrease their overall fall risk. Large effect sizes for mobility outcomes also demonstrate a clinically meaningful impact. Acknowledgments and Funding This project was funded by the Idaho Elks Rehab Society and the National Institutes of Health / National Institute of General Medical Sciences, under subaward #GR11256 through the Mountain West CTR-IN

P3-S-113: ***Hand and leg motor cortices excitability in individuals with Parkinson's disease and freezing of gait***

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BACKGROUND AND AIM: Repetitive transcranial magnetic stimulation (rTMS) is a type of non-invasive brain stimulation that can modify the cortical excitability of the brain region stimulated. rTMS is drawing more and more attention as a therapeutic strategy for freezing of gait (FOG), a common motor symptom of Parkinson's disease. However, baseline cortical excitability has never been characterized in this population. Here we describe hand and leg motor thresholds, and their intra- and inter-individual variability, in people with PD and FOG. METHODS: Fifteen individuals with Parkinson's disease and FOG were recruited. Data was acquired on four separate days, all at the same time of the day, while participants were on their usual medication schedule. Motor evoked potentials (MEPs) were recorded from the left first dorsal interosseous (FDI) and from the left tibialis anterior (TA), which are the two muscles typically used as outputs in TMS studies for, respectively, the hand and the leg. Resting motor threshold (RMT) was acquired from the TA and the FDI with, respectively, a dome coil and a 25-mm figure-of-eight coil connected to a MagStim 200² stimulator. RMTs were defined as the lowest intensity that evoked ten MEPs of at least 0.05mV out of 20 TMS stimuli in the muscle at rest. Active motor threshold (AMT) was acquired from the FDI using a 50-mm figure-of-eight coil connected to a Magstim Super Rapid 2 stimulator. The AMT was defined as the lowest intensity that evoked ten MEPs of at least 0.1mV out of 20 TMS stimuli while the FDI was contracted at 20% of the participant maximal voluntary contraction. Finally, the percentage of maximal stimulator output necessary to produce MEPs of an averaged peak-to-peak amplitude of 1mV over 10 TMS trials was also acquired from the TA. RESULTS: Preliminary data was acquired and analyzed in 10 participants. Mean AMT of the FDI was 38% ± 7 (range: 27% to 50%), while the RMTs for the FDI and the TA were 40% ± 7 (range: 31% to 88%) and TA 50% ± 17 (range: 31% to 85%) respectively. Less interindividual variability was found in the FDI RMT than in the TA RMT (P=0.0001), but their intraindividual variability was similar (P=0.3036). Despite the necessity to maintain a voluntary muscle contraction, the intraindividual variability of the FDI AMT was not different from the one of the FDI RMT (P=0.2513). The mean stimulator output necessary to reach 1mV responses in the TA was 60% ± 16 (range: 32% to 76%). It was impossible to reach 1mV responses in the TA for two of the participants, and those participants were the ones with the highest TA RMT (65% and 85%). CONCLUSION: Even though the use of the TA as a muscular output for TMS is more appropriate than the FDI for gait impairments such as FOG, the latter seems to offer less variability and more feasibility.

P3-S-114: ***The effects of 4-weeks Split-Belt-Treadmill Training on Gait Adaptation in people with Parkinson's disease***

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Background and aim: The ability to adjust gait to internal and environmental factors is necessary to move independently and safely. Gait adaptation (GA) is compromised in people with Parkinson's disease (PD). Moreover, freezing of gait (FOG) in PD is associated with motor (and cognitive) switching deficits and often occurs during asymmetric movements such as turning and gait initiation. A Split-Belt treadmill (SBT), where two belts can run at different and changing speeds, has the potential to train complex and changing gait patterns within a safe environment. Additionally, in contrast to other complex gait training methods, SBT does not demand any cognitive requirements of the participant. The aim of this study was to compare SBT- with regular treadmill (tied-belt treadmill, TBT) training to improve GA and to investigate whether effects are retained 4 weeks later in people with PD. Methods: Fifty-two individuals with PD participated and were randomly assigned to either SBT- (n=27) or TBT training (n=25), for 4 weeks, 3 times a week. Testing was conducted by blinded assessors before (Pre), after (Post) and at 4-week-follow-up (Retention). Assessments consisted of a GA task on the treadmill with and without a dual task (DT, auditory Stroop test). A 3D Motion Capture System was used to analyze step length asymmetry during the GA task. Several other motor and cognitive tests were conducted. Linear mixed models were used to investigate the effects of time by training group (and FOG status as another factor for a sub-analysis). A Tukey correction was applied for multiple post-hoc comparisons. Results: A significant time*training-group interaction was found for GA (single task (ST) for total GA; ST and DT for early and late phase of GA) (p<0.001, respectively). Post-hoc comparisons revealed that the SBT group significantly improved from Pre to Post (p<0.001) and Pre to Retention (p=0.005) whereas the TBT group did not improve (Cohen's d for the time*training-group interaction Pre-Post: 0.97; Pre-Retention: 0.51; total GA). Correlating the changes in GA with baseline MDS-UPDRS-III, H&Y and disease duration did not show any significant correlation. The sub-analysis comparing people with PD with FOG (PD+FOG) with those without FOG (PD-FOG) did not show any significant time*FOG-status interaction for both training groups. Conclusions: Four weeks of SBT training were beneficial to improve GA in people with PD. SBT training was superior to TBT training and effect sizes were large. Training effects were retained 4 weeks after the training. Disease severity and disease duration did not impact effect of training for this sample. Furthermore, PD+FOG improved similarly to PD-FOG. SBT is less cognitive dependent than other complex gait training methods and therefore might be a promising novel therapeutic tool. The clinical relevance and whether these task-specific training effects may enhance patients' daily live mobility need to be investigate in future, larger trials.

P3-S-115: ***Longitudinal Recovery of Static Balance Control and Functional Balance Post-stroke***

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BACKGROUND AND AIM: Balance recovery following stroke is vital to overall recovery. Although functional and physiological recovery occurs primarily in the first 3 mos post-stroke, recovery into the chronic phase, beyond 6 mos, has been reported in some individuals. Few longitudinal studies probe balance recovery at 12 or 24 mos post-stroke. Functional performance measures like the Berg Balance Scale (BBS) and control measures like center of pressure (CoP) sway, may be used to evaluate balance post-stroke, but it is unknown how performance across these measures relate in the chronic phase of recovery. Further, there is little understanding of the relationship between these measures and the dynamic balance required for gait over this time. This study aimed to understand group and person-specific changes in balance recovery over two years post-stroke and the relationship between CoP, measures of functional balance, and gait. METHODS: A longitudinal retrospective analysis of balance and clinical measures was conducted on 47 individuals (mean age 61 ± 13.5 years) with mild to moderate stroke, at four time points: admission (<50 days post-stroke) and approximately 6, 12 and 24 mos post-stroke. Variability in CoP, stance symmetry, functional balance and independence as measured by BBS, Chedoke McMaster Stroke Assessment (CMSA), and Functional Independence Measure (FIM) scores were compared across time. In a subset of 27 individuals, gait speed and symmetry measures were examined. Correlational analyses examined longitudinal changes in the relationship between change scores in BBS and CoP measures and between these scores and changes in subjective recovery, gait, functional independence (FIM), and physical disability and impairment (CMSA). RESULTS: Group results revealed significant improvements in all balance and clinical measures within the first 6 mos post-stroke ($p<.05$). Changes were maintained at 12 and 24 mos. At the individual level, improvement and decline in balance and clinical measures were observed for proportions of participants during the chronic time points. Correlational analysis comparing BBS and CoP change scores at 6 mos revealed a moderate association (ρ (-0.585)), with none to moderate association (ρ(-.15 to -.62)) when compared with other change scores. No association was observed between BBS and CoP change scores at 12 or 24 mos or between these and other measures at 12 mos (ρ (-.07-.21)). There were a few weak to moderate associations between BBS, CoP, and other measures at 24 mos ((ρ (-.01-.51)). CONCLUSIONS: This study suggests that group level gains in balance function achieved by 6 mos post-stroke are maintained at 12 and 24 mos. Individual patterns of change, however, challenges the idea of a recovery plateau beyond 6 months. Current work is exploring the factors that may be associated with individuals whose recovery in the chronic phase decreased or increased. ACKNOWLEDGEMENTS AND FUNDING: Canadian Partnership for Stroke Recovery (CPSR).

P3-S-116: ***Gait response to internal and external cueing across mild to moderate stages of Parkinson`s disease***

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Background and aim: Gait deficits caused by Parkinson's disease (PD) reduce functional independence and increase the risk of falling. Various cueing strategies (internal and external) have been used to alleviate gait deficits in PD. However, it remains unclear as to which type of cueing strategy is most effective at different stages of PD severity. This study aimed to examine gait response to internal and external cues at different stages of PD severity. Methods: This ongoing single-site trial uses an exploratory observational design, with laboratory application of cues for gait deficit. Forty-eight people with PD were stratified into groups dependent on their disease stage (classified with the Hoehn and Yahr (H&Y) scale; n=11 H&YI; n=27 H&YII; n=10 H&YIII). Initially, participants walked without cues and then with randomized cueing conditions (internal, visual, auditory, tactile). Internal cues: participants were instructed to think about taking bigger steps. Visual cues: participants were instructed to step over transverse tapes (3 cm wide) as they walked; the distance between tapes was set at the individual step length (as measured during walking without cues). Auditory cues: participants were instructed to step in time to the beat of an electronic metronome set at their baseline cadence. Tactile cues: participants were instructed to step in time to metronome-like vibrations (set at baseline cadence) provided on their wrists through a pair of bracelets. Spatiotemporal gait parameters were measured with wearable inertial sensors (Mobility Lab, APDM). This trial is registered at clinicaltrials.gov (NCT04863560; April 28, 2021, https://clinicaltrials.gov/ct2/show/NCT04863560). Results: Linear mixed-effects models (group X condition) revealed no significant group X condition interactions ($p>0.05$), indicating that all PD groups responded similarly to cueing strategies. Significant condition main effects ($p<0.05$) were observed for multiple gait parameters. Post-hoc tests adjusted for multiple comparisons showed the following significant differences relative to walking without cues: internal and auditory cues increased gait speed, stride length, and arm range of motion; internal cues also increased foot strike angle; visual cues reduced stride length variability. No significant gait response to tactile cues was observed. Conclusions: These preliminary findings suggest that gait response to cueing is not influenced by mild to moderate PD stages. Specific gait improvements are achieved with different cueing strategies, supporting a personalized, deficit-driven approach for cueing application. Internal and auditory cues may be recommended to improve speed, stride length and arm swing while visual cues may be recommended to reduce stride length variability.

P3-S-117: *Exploring the relationship between anxiety, associated psychological factors and freezing of gait in people with Parkinson's.*

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Background and aim Freezing of gait (FOG) is one of the most debilitating symptom of Parkinson's. Several studies have shown that severity of FOG symptoms is associated with anxiety. However, little is known about the underlying psychological mechanisms that underpin this relationship. The current study aimed to evaluate these associations in two studies: first, through an exploratory qualitative analysis of interview data, Second, through a quantitative analysis of responses to the Gait-Specific Attentional Profile (G-SAP); a questionnaire rating various psychological processes during gait. Methods Study 1 (qualitative). We carried out in-depth in-person interviews with 27 people who experienced regular FOG. The topic guide solicited descriptions of memorable or recent FOG episodes and factors they considered to make FOG better or worse. Themes were identified and developed in to a conceptual model. Study 2 (quantitative). 440 people with Parkinson's self-reported how often they experiences FOG and completed the G-SAP which constitutes four sub-scales; i) anxiety, ii) conscious movement processing (CMP), iii) worrisome thoughts and iv) processing efficiency. We statistically compared scores from each G-SAP subscale between participant groups self-reporting 'no FOG', or freezing 'hardly ever', 'most days', or 'everyday'. Results Study 1. Analysis of interviews revealed several key themes. Factors that either reduced or exacerbated the severity of freezing were termed 'rhythm initiators' (thoughts that help one focus on movement goal) or 'rhythm inhibitors' (thoughts that serve as task-irrelevant distractors and exacerbate physiological arousal), respectively. Interpretations of past FOG events led to the generation of 'accumulated experiences' which could be categorised into positive (e.g. experiences leading to 'strategies of resilience') and negative (e.g., 'identity jeopardy' and 'loss of control') components. Importantly, negative

accumulated experiences served as 'amplifiers' for future rhythm inhibitors. In other words, experiences of prior FOG events led people to anticipate and ruminate about future freezes. Study 2. Scores for G-SAP subscales significantly increased from those who reported no FOG (N=231) to those who report FOG (N=182) (p's≤0.05). However, scores for rumination were the only sub-scale that showed any meaningful increase associated with more frequent FOG (p's<0.005). Conclusions Study 1 highlights potential mechanisms through which anxieties about FOG can develop over time and exacerbate FOG through the generation of ruminative and task-irrelevant thoughts. Study 2 provides further evidence that, in a much larger sample, ruminative thoughts (i.e. those processes highlighted in Study 1 as being problematic) are more prevalent in people who experience more frequent FOG. Collectively, this work presents opportunities to develop interventions that target specific mechanisms implicated in exacerbating FOG.

T - Orthopedic diseases and injuries

P3-T-118: ***Altered movement coordination may predispose to low back pain among female collegiate rowers***

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BACKGROUND AND AIM: Repetitive movements performed by skilled athletes may result in muscle activity patterns that reduce the body's ability to protect the spine, leaving it vulnerable to injury. Rowers have a particularly high incidence of low back pain (LBP) that correlates with training load, suggesting that cumulative trauma may contribute. Altered muscle activation patterns associated with chronic LBP is particularly prevalent in those who participate in asymmetric sports. Rowers who participate exclusively in sweep rowing, requiring repetitive asymmetric motions, could plausibly demonstrate altered muscle activation that could predispose to LBP. In addition, significant training occurs on land, using ergometers that promote symmetrical movements; a conflict between training activation patterns and those required for on-water competition may provide inadequate protection of the spine. The purpose of this study was to examine the muscle activation patterns of collegiate sweep rowers, to identify whether asymmetric muscle activation patterns are evident during symmetric ergometer rowing. METHODS: Six female collegiate rowers rowed on an ergometer for 30 minutes, divided equally between stationary trials (not presented) and trials where the ergometer was placed on slides to mimic on-water movement. For each condition, participants rowed for 5 minutes at self-selected pace, followed by rates of 20 (LOW) and 30 strokes (HIGH) per minute, for 5 minutes each, at a maximal work load. Surface electromyography of 10 trunk and hip muscles bilaterally, and 5 right arm and leg muscles were recorded with wireless electrodes (Delsys). An accelerometer was affixed to the ergometer handle to determine the rowing cycle and delineate drive and recovery phases. Paired t-tests assessed differences between stroke rates, while bilateral couplings among trunk and hip extensor muscles were assessed with Pearson correlations. RESULTS: As stroke rate increased, a significantly greater proportion of the rowing stroke was spent in

the drive phase (P<0.0001). The ideal ratio of drive:recovery phases is 1:2, as occurred at the LOW rate; however, at the HIGH rate, this ratio approached 1:1, significantly reducing recovery time for the muscles driving the stroke. Trunk muscle offsets were delayed at the HIGH rate indicating a longer relative duration of activity (P from <0.0001 to 0.12). Trunk and hip muscle onsets were highly coupled bilaterally at the HIGH stroke rate, whereas at the LOW rate bilateral coupling of abdominal muscles was diminished, although maintained at the trunk and hip extensors. CONCLUSIONS: These results suggest that at high stroke rates an inability to maintain the appropriate drive:recovery ratio compounded with prolonged trunk muscle activation could significantly increase load and fatigue. This cumulative load could hamper the ability of the trunk musculature to protect the spine during ergometer training and may increase susceptibility to LBP.

W - Sensorimotor control

P3-W-120: ***Power spectral analysis of center of pressure reveals increased postural control automaticity under cognitive and visual load***

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BACKGROUND AND AIM: How postural responses change with sensory perturbations while also performing a cognitive task is still debatable. Power Spectral Density (PSD) may shed light on the relative contribution of each sensory system to the performance of a standing balance task, specifically when a cognitive task is added. If a switch to more automatic control takes place with the addition of a cognitive task, an increase in high frequency components of sway and decrease in low frequency components are expected, since the former takes place via local short loop and the latter is considered associated with long cortical loops. We investigated this question using a comprehensive assessment of postural sway: traditional metrics of amount as well as frequency analysis via PSD. METHODS: Twenty-three healthy young adults stood on a force plate in tandem with eyes open or wearing the HTC Vive Head-Mounted Display (HMD) with a static or dynamic (i.e., movement in the anterior-posterior direction at 5mm [AP5] or 32mm [AP32] at 0.2 Hz) 3-wall stars display. On half of the trials, participants performed a cognitive serial-3 subtraction task. We analyzed the main effect of task (single, dual), vision (static, AP5, AP32) and the interaction between them on anterior-posterior and medio-lateral Directional Path, Root Mean Square Velocity, Variance; and PSD 1 (0, 0.25 Hz), 2 (0.25, 0.5 Hz), 3 (0.5, 1 Hz), and 4 (> 1 Hz) derived from center-of-pressure data. RESULTS: Medio-lateral path significantly increased with the cognitive task, particularly with dynamic visuals whereas medio-lateral variance decreased with the cognitive task. For medio-lateral, but not anterior-posterior, path, velocity PSD 3 and 4, we observed a significant task by visual interaction, such that the increase with the cognitive task was larger on the dynamic visual scenes. Variance and PSD 1 decreased significantly with the cognitive task in both directions regardless of visual load. No significant changes were observed for PSD 2. CONCLUSIONS: The results of this work appear

contradictory. The interaction effects between cognitive and visual load observed for path and velocity are often interpreted as increased challenge, whereas the decreased variance with the cognitive task is often interpreted as improved postural control. PSD analysis can solve this contradiction: together with decreased low-frequency movements (PSD 1) under cognitive load (suggesting reduced cortical control) we observed a significant interaction in high frequency segments (PSD 3 and 4) suggesting an increase in small fast corrective movements, i.e., a shift towards somatosensory information and reweighting of visual input. The fact that this increase in fast corrective movements under cognitive load was identified only when the visual scene was moving supports the idea that under a combined cognitive and visual load, a more automatic control of balance via short (i.e., mostly peripheral) feedback loops takes place. (Full paper to appear in the Journal of Motor Behavior)

P3-W-121: ***The effects of four hours of normobaric hypoxia on the vestibular control of balance***

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BACKGROUND AND AIM: Hypoxia impairs quiet standing such that postural sway is greater than normoxia. Currently the underlying sensorimotor factors influencing postural control alterations during hypoxia are unclear. Nevertheless, previous research has demonstrated that vestibular function, an important factor for balance control, is influenced by hypoxia. For example, high altitude leads to increases in spontaneous and positional nystagmus (involuntary eye movements), and in animal models, hypoxia increases neuronal firing rates within the fastigial nuclei. Thus, hypoxia-induced impairments in standing balance may be related to vestibular pathways. The purpose was to investigate if four hours of acute hypoxia influences the vestibular control of standing balance. We hypothesized that vestibular-evoked balance responses would increase during normobaric hypoxia compared to normoxia. METHODS: Nine participants (6 males; 3 females) stood on a force plate with their feet together, vision occluded with a blindfold, and head rotated facing over the right shoulder. Participants were subjected to 3 blocks of binaural, bipolar stochastic electrical vestibular stimulation (EVS) consisting of two, 90-s trials. The EVS signal (0-25 Hz, root-mean-square = 1.1 mA) was delivered via carbon rubber electrodes secured over the mastoid processes, while anterior-posterior forces (APFs) from the force plate and medial gastrocnemius (MG) electromyography (EMG) from the left leg were sampled. The relationship between the EVS input and motor output (APF and MG EMG) were estimated using the cumulant density function. Early (short-latency) and later (medium-latency) vestibular-evoked balance responses were evaluated at baseline (BL; ~21% fraction of inspired oxygen - FIO_2), as well as following ~2 (H2) and 4 hours (H4) of normobaric hypoxia (~11% FIO_2) in an environmental chamber. RESULTS: Oxyhemoglobin saturation was reduced by ~22% at both H2 ($p<0.001$) and H4 ($p<0.001$) compared to BL. The EVS-MG EMG short-latency peak amplitude was reduced at H2 (~22%; $p=0.03$) and H4 (~24%; $p=0.01$) compared to BL, while the EVS-APF short-latency peak amplitude was unaltered throughout the duration of hypoxia ($p>0.05$). The EVS-MG EMG and EVS-APF medium-

latency peak amplitudes were both reduced by ~15 (p=0.03), respectively, by H4 compared to BL, but no difference was detected for H2 (p>0.05). CONCLUSIONS: Contrary to our hypothesis, our findings indicate that vestibular-evoked balance responses are reduced with multiple hours of normobaric hypoxia exposure. Overall, it appears that the central nervous system may have a blunted response to vestibular-driven signals when producing postural adjustments in acute normobaric hypoxia ≥2 hours. As such, when evaluating the effects of hypoxia on motor performance during standing, factors related to the vestibular control of balance must be taken into consideration. ACKNOWLEDGEMENTS AND FUNDING: Natural Sciences and Engineering Research Council of Canada

P3-W-122: ***Improving gait control by fractal auditory-cued walking: perspectives from healthy individuals***

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BACKGROUND AND AIM: Gait is a complex human motor behaviour, involving multiple systems. In some cases, as in Parkinson's disease, these systems can be deficient and alter locomotion properties, thereby inducing major disability. One possibility to improve gait properties is to train individuals by asking them to walk with external auditory cues. There is evidence that variable rhythmic auditory stimulation (RAS), characterized by a variable inter-stimulus interval (ISI) with long-range correlations, fosters a natural fractal gait pattern. However, the amount of ISI variability contained in RAS leading to the most beneficial effects on gait is still unknown. One possibility is that the amount of ISI variability is optimal when it is below or at the threshold for conscious awareness, thus preventing attentional processes to interfere with gait control. METHODS: This pilot study included 12 young healthy adults. They were asked to walk at their preferred walking speed in a circular path for 3 minutes in the absence of stimulation, with a fixed-tempo RAS, and with variable (either random or fractal) RAS at several levels of variability (as assessed by coefficient of variation): 0%, 0.5%, 1%, 1.5%, 2%, 3% and 4%. We recorded gait kinematics with the Mobility LabTM system (APDM Inc.). The participants also judged whether or not they perceived changes of ISI in variable RAS as compared to the 0% variability condition. We computed synchronisation accuracy and consistency using circular statistics. Moreover, we analysed locomotion variability and complexity (statistical persistence/antipersistance) using coefficient of variation and detrended fluctuation analysis (a fractal-based analysis), respectively. RESULTS: The mean perception threshold of the group was 1.5 ± 0.4%. The participants successfully synchronized their walking to the RAS up to 2.5% of ISI variability after which synchronization consistency was altered ($F[1,7] = 20.32$, $p < 0.001$). The analysis revealed that both stimulus type and variability level had an effect on gait complexity ($F[1,7] = 5.59$, $p < 0.001$) and variability ($F[1,7] = 7.41$, $p < 0.001$), with differences between stimulus types starting at 1% of ISI variability. Given these results, we compared the fractal, random and natural walking at 1%, 1.5% and 2% levels. Only fractal RAS presented at 1% of ISI variability allowed the emergence of natural fractal walking pattern ($p = 0.68$ vs. natural walking). CONCLUSIONS: This pilot study provides preliminary evidence that ISI must contain a sufficient amount of fractal-like variability that remains nonetheless outside conscious awareness to induce beneficial effects on gait rhythm dynamics. Personalizing biologically-variable RAS properties by considering the individual's detection threshold at which variability is perceived may be relevant to sustainably restore walking complexity in individuals with movement disorders. ACKNOWLEDGEMENTS AND FUNDING: This pilot study was conducted at the EuroMov Laboratory (Montpellier University, France, www.euromov.eu) and was supported by the Languedoc-Roussillon Region.

P3-W-123: ***Muscle spindles of the multifidus muscle undergo structural change after intervertebral disc degeneration***

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BACKGROUND AND AIM: Somatosensory information is critical for control of posture and movement. Muscle spindles make a critical contribution. Proprioceptive deficits are common in low back pain. The multifidus muscle undergoes substantial structural changes (e.g., fat infiltration, fibrosus and muscle fibre changes) after back injury, but whether muscle spindles are affected is unclear. This study investigated whether muscle spindles of the multifidus muscle are changed by intervertebral disc (IVD) degeneration in a large animal model. METHODS: IVD degeneration was induced by partial thickness anulus fibrosis lesion to the L3-4 IVD in nine sheep. Multifidus muscle tissue at L4 was harvested at six months after lesion, and from six age-/sex-matched naïve control animals. Muscle spindles were identified in Van Giessen's-stained sections by morphology. The number, location and cross-sectional area (CSA) of spindles, the number, type and CSA of intrafusal fibres, and thickness of the spindle capsule were measured. Immunofluorescence assays examined Collagen I and III expression. RESULTS: Multifidus muscle spindles were located centrally in the muscle and generally near connective tissue. There were no differences in the number or location of muscle spindles after IVD degeneration and only changes in the CSA of nuclear chain fibres. The thickness of connective tissue surrounding the muscle spindle was increased as was the expression of Collagen I and III. CONCLUSION: Changes to the connective tissue and collagen expression of the muscle spindle capsule are likely to impact their mechanical properties. Changes in capsule stiffness may impact the transmission of length change to muscle spindles and thus transduction of sensory information. This change in muscle spindle structure may explain some of the proprioceptive deficits identified with low back pain. ACKNOWLEDGEMENTS AND FUNDING: Funding was provided by the National Health and Medical Research Council of Australia (APP1091302; APP1194937).

P3-W-124: ***Movement smoothness during dynamic postural control to a static target differs between autistic and neurotypical children***

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BACKGROUND AND AIM: Autistic children and adults have known differences in motor performance, including postural instability and atypical gross motor control. Few studies have specifically tested dynamic postural control. This is the first study to quantify movement smoothness and its relationship to task performance during lateral dynamic postural control tasks in autism. We aimed to test the hypothesis that autistic children would have less smooth movements to lateral static targets compared to neurotypical children, and that this difference would relate to specific movement strategies. METHODS: We used camera-based motion-capture to measure spatiotemporal characteristics of lateral movement of a marker placed on the 7th cervical vertebrae (C7) and markers comprising trunk and pelvis segments during a dynamic postural control task in an immersive virtual environment. Participants included 15 autistic children (Mage=10.47 yrs, SDage=1.77 yrs) and 11 neurotypical children (Mage=8.91 yrs, SDage=1.58 yrs). Participants were instructed to move a user-controlled object (29.21 cm diam) into a static safe zone (31.75 cm wide) to the left or right at 26.8 cm or 13.4 cm (far or near) from center. Four instances of each safe zone location (a total of 16) were displayed in randomized order. The user-controlled object was controlled by medial-lateral movement of the C7 marker. Trials were classified as a "hit" if 70% of the user-controlled object was within the target area for 0.2 s. RESULTS: Generalized linear mixed-effects models (GLMM) were used to regress trunk leaning range of motion (ROM) and medial-lateral ROM of the pelvis position onto fixed effects of group, distance, and age with a random intercept by participant. Autistic children exhibited more medial-lateral pelvic range of motion and used a stepping strategy more often than neurotypical children. GLMM analysis for dimensionless jerk cost yielded main effects of group, such that autistic children had higher jerk cost than neurotypical children for motion of the C7 marker and the trunk (Fig 1). All children had higher jerk cost for far versus near targets. Autistic children had longer trial durations, and younger children had longer trial durations than older children across groups. CONCLUSIONS: Movement smoothness has not previously been a prominent focus of autism research, but our results demonstrate that it relates to motor strategy and the efficiency with which a task is performed. Autistic children in our sample used a stepping strategy more often, exhibited higher jerk cost, and took longer to complete the task. Accuracy, efficiency, and flexibility in dynamic postural control are necessary for functional mobility. They are important determinants of how effortful and fatiguing a motor task is, and thus relate to quality of life. It is important to characterize the impact of movement smoothness on mobility in autism. In doing so, we will be better equipped to develop accommodations and interventions that support autistic individuals' ability to move more efficiently, safely, and comfortably. ACKNOWLEDGEMENTS AND FUNDING: We thank all of the children, adults, and caregivers who participated. Funding: NSF [SMA-1514495, NRI-1208621, CPS-1035913]; NIH [KL2-TR001103, K01-MH107774]

P3-W-125: ***Changes in Service Member dynamic balance after blast exposure using a novel smartphone app***

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BACKGROUND AND AIM: There is growing concern about the potential impact of repeated sub-concussive blast exposure (RSCBE), that can occur during training, on military Service Member's brain health. One method for measuring the functional consequence of neurologic damage is through neuromotor assessment, frequently accomplished via a static or dynamic balance test. Balance tests, however, are commonly subjective or too expensive and/or cumbersome to utilize in a field environment. To overcome these barriers, our team developed a custom smartphone app, AccWalker, which employs the phone's sensors to measure dynamic balance performance. The current Investigating Training Associated Blast Pathology (INVICTA) Study is exploring neurological changes from heavy weapons training (HWT) blast exposure in a large cohort of Service Members. The aim of this abstract is to present preliminary data from INVICTA examining the extent to which dynamic balance changes after RSCBE may be present in Service Members. METHODS: Active-duty US Military Special Operators (N=45) and control participants (N=13) performed a series of assessments, including the AccWalker test, at baseline and 6 hours, 72 hours, 2 weeks, and 3 months after RSCBE during HWT. During the AccWalker test, participants completed a step-in-place task for two trials of 70 seconds each with their eyes closed on a flat surface with a smartphone attached to their thigh. The app's sensor data was used to measure variability [i.e., coefficient of variation (CV)] of peak flexion (CV_PeakFlex) during the stepping-in-place task, an indicator of spatial variability in dynamic balance control. Multilevel modeling was used to examine the estimated marginal means across groups and timepoints. RESULTS: For the blast exposed group, a decline in CV_PeakFlex was observed from baseline (M=6.60, SE=0.29) to the 6-hour post-RSCBE testing time point (M=5.98, SE=0.33), t(128.29)=-1.86, p=.06. CV_PeakFlex rebounded at the 72-hour time point to baseline level and remained there through the 3-month time point. No CV_PeakFlex differences were observed in the control group between baseline (M=6.13, SE=0.40) and the 6-hour, 72-hour, and 2-week time points, but a trend suggesting alteration from baseline was observed at the 3-month time point (M=7.26, SE=0.58), t(46.97)=1.95, p=.06. However, this tread is interpreted with caution since the control data are preliminary with N=13 participants. CONCLUSIONS: The decline in CV_PeakFlex after RSCBE reflects a shift toward a more robotic and less flexible balance control, consistent with previous neuromotor research following a nervous system insult. This decline in movement variability is thought to reflect a reduction in the functional degrees of freedom within the nervous system, as the available resources after neurological insult may be directed toward a common movement pattern.

P3-W-126: ***Influence of age-related hearing loss on postural control***

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Background and aim: Previous epidemiological studies have shown that age-related hearing loss (HL) is associated with falls among older adults. This association may be due to poor postural control; however, it remains to be elucidated. The present study aimed to determine the effect of age-related HL on postural control, focusing on the center of pressure (CoP) displacement. Methods: We studied 107 older adults (mean age, 76.5 years; 80.5% women). Auditory acuity was measured using a pure tone average of hearing thresholds for 0.5-4 kHz tones in the better-hearing ear. Then, participants were stratified as follows: normal hearing, ≤25 dB; mild HL, >25 and ≤40 dB; and moderate to severe HL (moderate HL), >40 dB. The CoP displacement in the anterior-posterior (AP) and medial-lateral (ML) directions and their mean power frequency (MPF) were assessed in a bipedal quiet stance under eyes opened (EO) and eyes closed (EC) conditions. Results: Forty-four and twenty-five participants had mild and moderate HL, respectively. Analysis of variance, including factors of hearing levels and eye conditions, showed a greater CoP displacement in the ML direction under the EC condition compared to that under the EO condition among participants with moderate HL. However, there were no significant differences in the displacement under the EO condition between each hearing level. Increased MPF in the ML direction was also observed under the EC condition in those with moderate HL. Conclusions: We found that age-related HL influences CoP displacement in the ML direction under the EC condition. Our findings suggest that auditory information may help complement visual information, indicating its role in multimodal sensorimotor control.

P3-W-127: ***Activity of spinal motor neurons of the tibialis anterior during walking in humans as revealed by HDsEMG decomposition***

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BACKGROUND AND AIM: Investigation of spinal motor neuron (MN) activity provides basic information of neuromuscular control. MNs of neonatal rodents and human infants mainly controlled by spinal central pattern generator (CPG) show synchronous activity. The spinal CPG is also involved in neuromuscular control of walking in human adults. The cerebral cortex is also involved in walking control in human adults. Thus, the behavior of MNs during walking in human adults is probably different from other mammals and human neonates. In this study, we examined MN activity of the tibialis anterior (TA) in human adults during walking by using high-density surface electromyogram (HDsEMG) decomposition based on the blind source separation. METHODS: Fifteen healthy male participants walked on a treadmill for 9 minutes. They also performed an isometric dorsiflexion task. We measured HDsEMGs with a two-dimensional grid of 13×5 equally spaced electrodes from the TA, and then obtained spike trains of MNs by the EMG decomposition. We examined the following parameters of MN activity: 1) firing rate, 2) recruitment patterns, 3) synchronization of firings, and 4) doublets (two consecutive discharges with interspike intervals < 15 ms, contribute to strong or fast movements). MN synchronization was evaluated by cross-correlation and coherence. Regarding doublets, we evaluated the frequency of occurrence in a gait cycle. 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: 6.8±2.1, 12.3±3.1 and 21.0±5.8 MNs (mean±SD) were identified in the early swing and initial stance phases and isometric contraction, respectively. The firing rate was not significantly different among the conditions (13.1±3.8, 15.8±5.0, 14.0±4.3 spikes/s in early swing, initial stance, and isometric contraction, respectively). 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. Coherence was significant in 2.5-40 Hz in all the conditions. Coherence in the delta and alpha bands (2.5-12.5 Hz), which is regarded as spinal origin, was higher in the initial swing than isometric contraction. It in the high beta band (25-40 Hz), which is regarded as cortical origin, was high in the initial stance than the other two conditions. Doublets were frequently occurred just after the foot contact and around the foot off. CONCLUSIONS: We found differences in MU synchronization in both time and frequency domains between the gait phases and tasks. MN synchronization reflects the amount of common neural drives to MNs. Thus, our results suggest that, although MNs of TA during walking received both spinal and cortical origin common drives, the MNs received stronger common drives from the cortex during the initial stance than the early swing. ACKNOWLEDGEMENTS AND FUNDING: This study was supported by the Grant-in-Aid for Scientic Research (B) through Japan Society for the Promotion of Science (#21H03340).

X - Tools and methods for posture and gait analysis

P3-X-128: ***Inter-rater reliability when digitising the shoe perimeter: A personalised method for evaluating foot-ground interactions accounting for shoe shape***

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BACKGROUND AND AIM: Foot-ground interactions (i.e. identifying gait events; heel strike/toe-off, foot clearance) are often measured during clinical gait evaluations using 3-dimensional stereophotogrammetric systems. Movement of reflective markers affixed to the shoe are evaluated as trajectories reflecting a single location on the shoe (i.e. toe/heel;[1]) or may form part of a geometric model defining the foot segment[2]. Relying on a single marker for the detection of gait events or subsequent calculations of gait outcomes does not account for the variety of shoe shapes. Previous methods for digitising the foot have not investigated inter-rater reliability[3-5]. We propose a method for digitising the perimeter of the shoe that accommodates variation in shoe size, shoe shape and sole wear and evaluate inter-rater reliability. METHODS: Data was collected using a 10 camera motion capture system (Vicon MT160, 100Hz). A quality control (QC) check quantified systematic error from the calibration[6]. Two 14mm reflective markers were affixed to the shoe over the calcaneus and distal toe. A triad of 9mm markers were affixed to the lateral aspect of the shoe for tracking. A custom digitiser (length 460mm) was constructed with four 9mm reflective markers configured to create a 3D local co-ordinate system. Three raters performed the foot digitisation procedure (novice, experienced, expert) on the same Converse shoe (size 5). Three trials per rater were completed. The shoe was suspended in the air and orientated so

that the toes were pointing up. The digitiser point was used to guide tracing around the perimeter of the shoe (clockwise starting at the toe) and a virtual point was constructed (Matlab). The highest and lowest vertical point of the shoe were identified using peak detection and the forefoot/rearfoot were segmented. Virtual markers were distributed around the forefoot and rearfoot perimeter (Figure 1; inter-marker distance 6mm). The distance between the highest and lowest point of the shoe was quantified from the virtual markers and using a tape measure. RESULTS: The QC check indicated errors of 0.6mm and 0.2degrees for the dynamic calibration trial. Although the time to complete the foot calibration varied between rater, each rater performed the calibration successfully with the level of error only deviating in 1mm within rater and between rater, which is comparable to the systematic errors quantified from the system. The shoe length when measured manually was 261mm. The same metric extracted from the foot digitisation procedure was within 0.4% (mean of 260mm). CONCLUSIONS: Digitising the perimeter of the foot can reliably be completed. Analyses to evaluate the influence of marker location on other outcomes, such as gait events and foot clearance, is underway. REFERENCES: [1] Alcock 2018 J Biomech [2] Alcock 2013 Gait & Posture [3] Startzell & Cavanagh, 1999 Hum Mov Sci [4] Loverro 2013 J Biomech [5] Telonio 2013 J Biomech [6] Scott 2021 Sensors

P3-X-129: ***On the relationship between feet and pelvis speed during complex motor tasks***

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BACKGROUND AND AIM Average walking speed (ws) can be estimated from the kinematic data of several body points, the selection of which is often imposed by the sensing technology, with most approaches being based on data either from the feet (e.g., instrumented mat or stereophotogrammetry) or a location close to the centre of mass, such as the lower back (e.g., inertial sensors). Although during straight walking, ws computed from the pelvis and the feet should be identical for definition [1], it is still not clear whether this equivalence holds for complex and not curvilinear motor tasks. The aim of this study is to assess the relationship between the ws calculated from the pelvis versus from the feet in a variety of motor tasks executed at different speeds and including turnings. This will enhance comparability of results from different studies and foster development of accurate biomechanical models for the estimation of ws from centre of mass data. METHODS The 3D position of reflective markers placed on the lower back (L5) and both heels of twenty young healthy adults (13 males, age: 29.7 ± 9.0 yr., BMI: 23.2 ± 2.8 kg/m2) was acquired using stereophotogrammetry (fs = 100 Hz) while they performed different motor tasks (Figure 1: L-Test, Timed Up and Go, and Shuttle walk). Foot-to-ground contacts were detected from 3D heel maker velocity and used to identify both strides and steps. For each trial i, ws values were calculated as follows (Figure 1): Feet (vFeet): average stride speed, Pelvis(vCoM):

average speed. The root mean square differences (rmsd), linear relationship and relative agreement (Pearson coefficient (r), α = 0.05, Matlab R2021a) between feet and centre of mass velocities were evaluated merging data from the three tasks. RESULTS Figure 1 confirms the existence of a linear relationships between feet and centre of mass velocities (with a correlation coefficient almost equal to 1), which is maintained even if complex tasks are included in the analysis. The positive bias of 0.125 m/s shows an overestimate from the feet and an overall difference of about 0.05 m/s between the two values. CONCLUSIONS This study confirms the existence of the linear relationship between the walking speed estimated from the pelvis and feet, which is maintained also for tasks including turning. The observed rmsd and bias should be accounted for when comparing data obtained from the two locations during curvilinear walking. These results can also be used to optimise biomechanical models deriving stride speed from lower back data [1]. Ongoing research is exploring if this relationship varies in pathological gait (Parkinson's disease, Multiple Sclerosis, Chronic Obstructive Pulmonary Disease, and Proximal Femoral Fracture). ACKNOWLEDGEMENTS AND FUNDING This work was supported by the Mobilise-D project (IMI2 JU grant agreement No. 820820, receiving support from the European Union's Horizon 2020 and EFPIA). REFERENCES 1. Zijlstra W. & Hof. A.L. (1997) Gait Posture 6(3):249-62. Figure 1. Walking speed values calculated from the feet and pelvis in the three motor tasks in the young healthy adults. The linear relationship, correlation coefficient (r), and root mean square difference (rmsd) are also shown.

P3-X-130: ***Concurrent validity of the Garmin Vivofit®4 to accurately record step count in older adults in challenging environments.***

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Background: There is little evidence of the concurrent validity of commercially-available wrist-worn activity monitors with a long battery life to measure steps in older adults at slow speeds and with real-world challenges. This study aimed to address the aforementioned gap by assessing the concurrent validity of the Garmin Vivofit®4 with video observation and the ActivPAL3TM, at recording step count when walking on a treadmill at various speeds, in an indoor simulated-home environment and outdoor community environment in a group of older adults. Forty adults aged over 60 years performed a treadmill protocol at four speeds, a 50m indoor circuit, and a 200m outdoor circuit with environmental challenges while wearing a Garmin Vivofit®4, the ActivPAL3TM, and a chest-worn camera angled at the feet. The Garmin Vivofit®4 showed high intraclass correlation coefficients (ICC2,1, 0.98-0.99) and low absolute percentage error rates (< 2%) at the fastest treadmill speeds and the outdoor circuit. Step counts were underestimated at the slowest treadmill speed and the indoor circuit. The Garmin Vivofit®4 is accurate for older adults at higher walking speeds and during outdoor walking. However, it underestimates steps at slow speeds and when walking indoors with postural transitions.

P3-X-131: ***Decomposing the Timed Up and Go test to distinguish Early DLB from Early PD***

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BACKGROUND AND AIM: Synucleinopathies such as Parkinson's Disease (PD) and Dementia with Lewy Bodies (DLB) share etiology and symptoms that hinder early clinical differentiation. Whilst the "Timed Up and Go" (TUG) test, an assessment of balance and mobility, has been shown to be a useful motor marker that can aid in predicting the phenoconversion of idiopathic REM sleep behavior (iRBD) patients to a synucleinopathy, relatively little work has studied TUG performance of Early DLB compared to Early PD patients to determine whether they display similar or distinct deficits. This is important if the TUG is to be used as a biomarker to predict which synucleinopathy (PD or DLB) an individual might go on to develop. Classically, the time to complete the TUG test is quantified, however recent work has suggested looking beyond speed, and considering performance while turning could better discriminate PD patients from healthy controls. Given that TUG tests incorporate a turn, the current study sought to take a more detailed approach to investigate differences in TUG performance across the synucleinopathy spectrum (iRBD, Early PD, and Early DLB) compared to healthy controls. This study aimed to (i) examine whether Early DLB took greater time to complete the TUG compared to Early PD, (ii) decompose the TUG into three phases (i.e., Approach, Turn, Return) to examine differences between Early PD and Early DLB during the turning phase, and (iii) determine whether iRBD patients demonstrated any turning deficits compared to HC during the TUG. METHODS: A total of 66 participants (13 HC, 24 iRBD, 14 Early PD and 15 Early DLB) performed a TUG test across a Zeno walkway. They were asked to stand from a seated position, walk 3m, turn on the spot, walk 3m back and return to a seated position. Duration and percentage of time spent in double support (%DS) were obtained for the whole trial, and for each phase. RESULTS: Although there were no significant differences between Early PD and Early DLB during the total TUG trial duration, decomposing the TUG trial into phases revealed that Early DLB patients took significantly longer to complete the Approach ($p=0.022$), and the Turn phase ($p=0.006$) compared to Early PD patients. Performance in the Turn phase was also significantly slower in Early DLB patients compared to healthy controls ($p=0.035$). Whilst the %DS was significantly different between Early DLB and healthy controls across the whole trial ($p=0.021$), as well specifically during the Turn ($p=0.018$), and Return phase ($p=0.029$), there were no differences between Early PD and Early DLB. No significant differences were found between the iRBD and HC groups. CONCLUSIONS: Decomposing the TUG into phases may provide further insight into subtle differences between Early PD and Early DLB, particularly examining the turning phase. Future research should consider looking beyond speed while challenging motor performance using turning or dual-tasking.

P3-X-132: ***Validation of an algorithm to assess irregular gait based on inertial sensors***

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BACKGROUND AND AIM: Studies using inertial measurement units (IMUs) for gait assessment have shown promising results regarding accuracy of gait event detection and spatiotemporal parameters in healthy cohorts (1-3) and disease groups (1). However, accuracy of such algorithms is challenged in irregular walking patterns, such as in individuals with gait deficits. We developed an algorithm to detect initial contact (IC) and terminal contact (TC)and calculate spatiotemporal parameters based on (1-3). We aimed to validate this algorithm for normal and irregular gait patterns against a 3D optical motion capture system (OMC). METHODS: Twenty healthy participants (aged 59±12 years) were equipped with 26 reflective makers and 4 IMUs (MTw Awinda, Xsens) at both feet, sternum and lower back. IMU system and OMC both recorded at 100Hz. Participants walked on an instrumented treadmill for 2 minutes (i) twice with normal stride lengths and (ii) once with irregular stride lengths (±20% deviation) induced by stepping stones (light projection). Accuracy of the algorithm was evaluated on stride-by-stride agreement of IC, TC, stride time and stride length with OMC (4). Bland-Altman plots were made for stride time and stride length, while differences in detection of IC and TC time instances were shown in histogram plots. RESULTS: A total of 9272 strides in normal gait and 4217 strides in irregular gait were included for analysis. For both normal and irregular gait, the algorithm defined IC 0.03±0.01 s after and TC 0.01±0.01 s before OMC (Figure 1A-B). Stride time differed on average 0.00 s (95% CI: -0.02-0.02 s) in normal gait and 0.00 s (95% CI: -0.03-0.03 s) in irregular gait from OMC. Stride length was on average 0.08 m (95% CI: 0.01-0.15 m) higher in normal gait and 0.08 m (95% CI: -0.00-0.16 m) higher in irregular gait compared to OMC (Figure 1C-D). CONCLUSIONS: Our adapted algorithm shows good agreement with the gold standard, with differences in the same range compared to previous studies. The algorithm performed equally good for irregular and normal gait, suggesting that it can be used in irregular walking conditions for example due to disease or home situations. Future studies including patients with irregular walking patterns are needed to test applicability for clinical practice. REFERENCES: 1. Behboodi et al., Sensors, 2019 2. Mercer er al., Journal of Sports Science, 2003 3. Sabatini et al., IEEE Trans Biomed Eng., 2005 4. Zeni et al., Gait Posture, 2008

P3-X-133: ***The influence of methods for stride selection on gait parameters collected with wearable sensors***

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BACKGROUND AND AIM: When using inertial measurement units (IMUs) to assess gait, strides within the straight ahead portion are typically selected to represent gait capacity, accounting for acceleration and deceleration phases and irregular strides. Various methods to select strides representing preferred, steady state gait are reported in literature. The aim of this study is to identify the optimal method to select representative strides by evaluating the effect of different methods on means and variance of spatiotemporal gait parameters in gait tests including turns. METHODS: A total of 197 patients with hip or knee osteoarthritis (aged 29-85 yrs) wearing 4 IMUs placed at both feet, the sternum and lumbar level of the trunk, walked back and forth over 10 meters for two minutes (180 deg turns). Gait events and turns were identified using previously validated algorithms (1-3). Five definitions to include strides for gait analysis were compared. In all definitions, strides in turns were removed as in (3). Definitions were: (ALL) include all strides, (REF) remove first 2 strides after, and last 2 strides before turn (4), (ONE) remove first stride after and last stride before turn, (MED) filter out strides <63% of median stride length (5), (95CI) calculate mean and 95% confidence interval (CI) of gait speed over the strides included in REF, then include all strides within this 95%CI. Means and standard deviation (SD) of gait speed and stride length over strides were calculated for each trial. The most conservative definition, REF, was taken as reference value. Definitions were compared against REF using mean differences and their 95%CI. RESULTS: Means and SD of gait speed and stride length for definition REF, and the mean differences of each definition with REF are shown in Fig 1. The average number of selected strides ranged from 108 (REF) to 161 (ALL). Definitions ALL and MED had a significantly lower gait speed of -0.04(-0.07,-0.01)(m/s) than REF. Gait speed derived from ONE and 95CI did not significantly differ from REF. The SD of gait speed was significantly different for all definitions compared to REF, ranging from -0.004(-0.007,-0.002)(m/s) for 95CI to 0.10(0.09,0.10)(m/s) for ALL. Stride length did not differ from REF for any definition. SD of stride length differed significantly from REF for all definitions except 95CI, ranging from 0.004(0.001,0.007)(m) (ONE) to 0.03(0.03,0.04)(m) (ALL). CONCLUSIONS: Excluding only the first and last stride around each turn, or through outlier analysis, yielded highly similar means and variance of spatiotemporal gait parameters compared to conservative methods. Moreover, the alternative methods included more strides, which is beneficial for shorter trajectories and tests with multiple turns. REFERENCES: 1. Behboodi et al., Sensors, 2019 2. Sabatini et al., IEEE Trans Biomed Eng., 2005 3. El-Gohary et al., Sensors, 2014 4. Muir et al., Gait&Posture, 2013 5. Mariani et al., IEEE Trans Biomed Eng., 2013

P3-X-134: *Automated analysis of the lower-extremity motor coordination test (LEMOCOT)*

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Background and aims: The lower-extremity motor coordination test (LEMOCOT) is a performance-based measure used to assess motor coordination deficits in neurological populations. In the test, performed while sitting, participants are instructed to move their lower extremity as fast and accurately as possible and alternately touch with their big toe a proximal and a distal target on the floor. The number of targets touched in 20 s constitutes the score. We developed an algorithm to automatically compute the LEMOCOT score and aimed to estimate its validity. In addition, we aimed to extract quantitative parameters of performance accuracy. Methods: Twenty persons with stroke (PwS) and 20 healthy controls participated in the study. The LEMOCOT was performed on an electronic mat equipped with force sensors (Zebris FDM-T Treadmill, Zebris Medical GmbH, Germany). An algorithm and script were developed to determine the location of the big toe (i.e., the endpoint) from the distribution of the force data and to determine whether the endpoint fell within or outside the limits of the target. Then, the total score of in target touch counts was computed. To estimate the validity of our algorithm and script, we tested the correlation between the tester's count and the count produced by our script. To estimate the strength of the correlation we calculated the conditional pseudo R2. In addition, we estimated the agreement between methods. Finally, we extracted additional parameters to quantify performance accuracy: the contact area, the absolute and variable error of the end point and the center of pressure (COP) location for each touch. Results: Significant correlation between the examiner's count and the count produced by the script was found ($p < 0.001$) with a slope that was not significantly different from one ($\hat{\beta}$ = 1.03, 95% CI 0.96-1.10) but with a constant term that was significantly different from zero ($\hat{\beta}$ = 1.76, 95% CI 0.01-3.50), indicating a bias. Calculating the conditional pseudo R2 revealed that this model explained 97% of the variance in the sample, indicating that the algorithm produced valid results. Agreement between methods demonstrated a median difference of 1.5 touches with limits of agreement between −1 and 10.9. Also, we found that the difference between methods increased as a function of the examiner's count. We found significant differences in all parameters of performance accuracy, indicating worse performance in persons with stroke vs. controls. Conclusions: Our automated algorithm produced valid results, which might be of great importance as the LEMOCOT can be computed without the dependency on the tester. This is specifically important when movements become faster, increasing the examiner's cognitive load. Demonstrating valid results, the algorithm can be used to leverage the test by extracting quantitative data regarding accuracy such as absolute and variable error parameters.

P3-X-135: ***Criterion Validity And Test-Retest Reliability Of An Accelerometer-Based Measure For Steady State Balance Control***

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BACKGROUND & AIM: Traditionally, postural sway is evaluated by recording the trajectory of the Centre of Pressure (COP) using a force platform[1]. Low-cost accelerometers have been recommended as an alternative to facilitate testing in the real world[2,3]. However, information is lacking on criterion-related validity of accelerometer-based measures compared to the traditional COP measurements[4]. We aim to determine the criterion validity and test-retest reliability of an accelerometer-based measure for steady state balance control by comparing three different tri-axial accelerometers to the gold standard of the force platform. METHODS: Ten healthy adults (27 ± 15.3 years old, 5M/5F) performed five different 40-second balance tasks. Incremental difficulty was introduced by changing foot position (bipedal stance/semi tandem/unipodal stance), and vision (eyes open/eyes closed). Postural sway was concurrently measured in terms of 1) COP displacement (AMTI OR6-7, 1000 Hz., Watertown, USA) and 2) Centre of Mass (COM) acceleration (AX3, Axivity Ltd., UK; Trigno®, Delsys inc, USA; MOX1 Activity logger, Maastricht Instruments, The Netherlands; 100 Hz.) measured at L5-S1 level. Each task was repeated three times on two different days to examine test-retest reliability. Outcome parameters were the Root Mean Squared error of the COM acceleration (RMS_COMacc) and COP displacement (RMS_COP) along the antero-posterior (AP) and medio-lateral axis (ML). Statistical analysis was performed using IBM Statistical package version 28 (SPSS Inc, Chicago, IL). Criterion validity was assessed by spearman rank correlation between RMS_COMacc and RMS_COP. For test-retest reliability, we constructed Bland-Altman plots and estimated ICC values and their 95% confidence interval based on a mean rating (k = 3), absolute agreement, two-way mixed effects model. RESULTS: Figure 1 shows moderate to high correlation coefficients between RMS_COMacc and RMS_COP along the AP and ML axis for all devices. The test-retest reliability obtained for RMS_COMacc varied between the device and axis of interest. In AP direction, ICC values were lower than for RMS_COP, the gold standard. CONCLUSIONS: In general, accelerometer-based measures provide reliable and comparable information on postural sway when compared to the gold standard of the force platform. Interestingly, correlations and reliability are always higher in ML direction. The coupling between COM and COP is related to the inverted pendulum of postural sway [5], which is a valid model when an ankle strategy is dominant for remaining balance. Although related, values obtained from COM and COP signals estimate different physical quantities. Consequently, the moderate correlations suggest that also a hip strategy and control of angular momentum cannot be ignored in steady-state balance control. REFERENCES: 1. Paillard & Noé (2015) BMRI, 2015/ 2. Godinho et al (2016) JNER, 13(1), 1-10/ 3. Rigby & Ray (2018) Handbook of Rehabilitation in Older Adults (pp. 85-121). Springer, Cham/ 4. Ghislieri et al Sensors. 2019;19(19):4075/ 5. Winter (1995) Gait Posture, 3, 193-214.

P3-X-136: ***Understanding human walking interactions: An analysis of real-life videos using deep learning.***

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Background and aim Congested sidewalks and walking trails are a way of life in many cities. How do individuals avoid collisions? Although controlled laboratory experiments provide important insight into this question (e.g., Bourgaize et al. 2021; Rapos et al. 2021), they may be limited in their generalizability to the real world given the complexity of the natural environment. Here, we aimed to determine the factors that affect one's decision of whether to deviate from a straight path to avoid a collision within an unconstrained, real-life environment. Methods We captured real-life videos (at 60 Hz) of a public walking path in Vancouver, British Columbia, Canada over the course of several months. Pedestrians on the path did not know about this study and were likely unaware of being filmed. To characterize walking interactions, we used a deep learning computer vision algorithm and a questionnaire. The algorithm detected each pedestrian in the videos and calculated the anterior-posterior and medial-lateral (ML) position of each pedestrian at each iteration in time. We focused specifically on 1-versus-1 pedestrian interactions (i.e., two pedestrians walking toward one another). We extracted 51 cases of this interaction type. To determine whether one or both pedestrians deviated to avoid a collision, we used the extracted trajectories of each pedestrian. We defined path deviation as a change in ML position of greater than 3 SDs above/below the mean ML position calculated over the first one second

of relatively stable walking when each pedestrian entered the video frame and before any potential interaction. A questionnaire provided context about each interaction. Questions included the initial ML separation between approaching pedestrians, whether the pedestrian was distracted (e.g., using a cell phone), and whether obstacles were present (e.g., other pedestrians, bench). Two volunteers, blinded to the study purpose, answered the questionnaire for each interaction; if the two volunteers did not agree on the response, a third volunteer acted as a tie-breaker. Results 37% of interactions involved a path deviation. Of these deviations, 58% occurred when the initial ML separation between pedestrians was <130 cm. In contrast, we found only 25% of non-deviation interactions had an initial ML separation <130 cm. We observed few obstacles present during these interactions, which did not appear to consistently influence walking behaviour. Conclusions Our preliminary findings suggest that the initial ML separation between approaching pedestrians influences whether a path deviation occurs. This study is the first step in understanding real-life human walking interactions. Acknowledgements and funding Supported by the Natural Sciences and Engineering Research Council (NSERC) of Canada (RGPIN-2019-04440) and Mitacs through the Mitacs Research Training Award.

P3-X-137: ***Estimation of Planar Covariation of Elevation Angles During Gait Using Inertial Measurement Units***

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BACKGROUND AND AIM: The intersegmental coordination of the lower limbs is a sophisticated process inherent to gait, able to provide information beyond the biomechanical status of the limbs. Planar covariation has proven to be a valuable tool to follow gait recovery of patients under specific interventions. However, by using the gold standard (Optical marker-based Motion Capture System (OMCS)), evaluation is constrained to lab conditions. For this study, kinematic data was collected from Inertial Measurement Units (IMUs) and compared to data from OMCS to find out if IMUs data collection can be considered as an alternative option for collecting kinematic data and assess planar covariation in environments outside the lab. METHODS Gait segmental kinematics of 8 healthy participants were recorded using OMCS and 3 IMUs located each over one of the 3 segments of the leg. Different gait patterns were used (backwards, crouched, slow and regular walking, and stepping in one place). Elevation angles (EA) were calculated by projecting the rotation matrices collected by each IMU to the sagittal plane. Next, the EA from OMCS and IMUs were plotted together for comparison, and linear regressions were done as well. For planar covariation, a principal component analysis (PCA) was used to obtain the PC scores (PC1, PC2 and PC3), and linear regressions were used for comparison. Local characteristics of the spatial distribution of the data were assessed by using a nearest neighbors' analysis. RESULTS Initial analysis of EA showed adequate fitting between the curves drawn by data collected from IMUs and OMCS, and linear regression analysis showed a positive correlation between the 2 methods as well (R2 0.77-0.95. P-value <0.01). The R2 value for PC1 was found between 0.91 - 0.95 with a P-value <0.01 in all cases. However, the data for other PCs fitting was lower than PC1. The nearest neighbors' analysis showed no significant differences

between IMUs and OMCS for slow, regular and crouched patterns (Wilcoxon test; slow: 0.26, regular: 0.73, crouched: 0.45) in contrast to backwards and stepping patterns (Wilcoxon test <0.01). However, linear regression models showed good correlation between both evaluation methods (slow R2: 0.71, regular R2: 0.78, backwards R2: 0.92, crouched R2: 0.71, stepping R2: 0.77, P-value: <0.01 for all). CONCLUSIONS The present study evidence the feasibility of using IMUs for collecting data for planar covariation analysis. Linear regression models showed adequate fitting between IMU and OMCS for EA of each limb segment and as well for PC1 of planar covariation analysis in the different walking patterns. Local analysis with nearest neighbors did not show significant differences for slow, regular and crouched patterns suggesting that both methods had similar characteristics related to locally distributed datapoints. Using IMUs for collecting kinematic data opens an interesting path for gait analysis in healthy volunteers and patients as well.

P3-X-138: ***Estimating foot strike in bare-breasted running from the position of the sternum***

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BACKGROUND: When recording breast biomechanics with and without a bra, electromagnetic sensors can be attached directly to the skin of the breast to record breast motion, without the issue of marker occlusion in optical systems. However, as the sensors are wired and have a limited range, it is not practical to attach a sensor to the lower limb to establish gait events. Previous work e.g. [1] has used every other minimum position of the sternum (MINSTN) to divide running into gait cycles. With this latter method it is not possible to distinguish left and right foot strike. Secondly, due to the support moment [2], MINSTN is likely to occur after foot strike. AIM: To determine if foot strike during bare-breasted running on a treadmill determined from a marker on the foot can be estimated from the position of the sternum. METHODS: Twelve healthy female volunteers with a breast size of UK 34E (age=25±5 years, height=1.65±0.04 m, mass=63.8±5 kg, mean±SD) ran on a treadmill at 10 km/hr. Reflective markers were placed on the suprasternal notch (sternum), left nipple and left and right heel. Following a warm-up, data was recorded using a 15-camera system (Qualisys, Oqus, Sweden) for 10 seconds at 200 Hz. Data were processed in MATLAB (Mathworks Inc.) and Microsoft Excel. Marker trajectories were filtered using a Lowpass Butterworth Filter at 13 Hz. Foot strike was determined from the minimum vertical position of the heel marker (MINHEEL) [3]. Maximum and minimum medio-lateral (ML) position of the sternum were identified as left and right foot strike respectively. The MINSTN was calculated for each foot strike. A Bland-Altman analysis [4] was conducted using each step for the sternum ML position - MINHEEL and MINSTN- MINHEEL. RESULTS: Figure 1. shows on average a) sternum ML position was 20 ms (±60 ms) later than MINHEEL and b) MINSTN was 98 ms (±15 ms) later than MINHEEL. CONCLUSIONS: Although foot strike determined from sternum ML was closer to MINHEEL than MINSTN, it was more variable, occurring both before and after MINHEEL. Therefore, sternum ML can be used to distinguish left from right foot strike and MINSTN with an offset of ~100 ms could be used to estimate foot strike, when it is not possible to detect foot strike directly. Future work could refine this method using the

gold-standard means of establishing foot strike with vertical ground reaction force. Discriminating between left and right foot strike can allow us to study potential differences in breast motion at foot strike between the ipsilateral and contralateral side. REFERENCES: [1] Norris et al. (2020). BMJ OPEN SPORT EXERC. MED 6, 10. [2] Winter (1980). J. BIOMECH. 13, 923-927. [3] Fellin et al. (2010). J SCI MED. 13, 646-650. [4] BLAND, J. M. & ALTMAN, D. (1986). LANCET. 327, 307-310.

P3-X-139: ***Separate transmission pathways for early and late responses to cortical stimulation***

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BACKGROUND AND AIM: Transcranial magnetic stimulation has been shown to activate cells within the pontomedullary reticular formation of non-human primates. Cells in the same region of the brainstem have been shown to project to motoneurons innervating muscles of the upper limb and have been implicated in the emergence of abnormal flexion synergies in the upper limb following stroke. This study investigated the idea that human upper limb responses to TMS are partially transmitted along a cortico-reticulospinal pathway by determining the extent to which early and late portions of the response are independently modifiable. METHODS: TMS was applied to the primary motor cortex of ten healthy individuals, with responses recorded in the right flexor carpi radialis muscle. Test TMS pulses were applied with and without a suprathreshold TMS conditioning stimulus applied 80 ms prior to the test stimulus. The conditioning stimulus was demonstrated to induce a period of spinal and cortical inhibition lasting at least 100 ms. Test intensities of 100-130% of active motor threshold intensity were applied. The amplitudes of early (0-8 ms) and late (8-20 ms) portions of the TMS response were analysed separately for effects of the conditioning stimulus. RESULTS: The amplitude of early responses was reduced at all but the highest test TMS intensity (p), while late responses were only reduced when the test intensity was at threshold. CONCLUSIONS: These results demonstrate independent effects of the conditioning stimulus on early and late portions of upper limb TMS responses, supporting the idea that early and late portions of the response in humans are transmitted along different descending pathways. Any involvement of brainstem postural control circuits in late portions of the TMS response may allow TMS to be used as a tool for assessing the state of these circuits. ACKNOWLEDGEMENTS AND FUNDING: This study was funded through a grant offered by the Faculty of Science, Medicine & Health at the University of Wollongong.

P3-X-140: ***A Comparison of Armswing Measurement using Inertial Measurement Units versus Kinematic Motion Capture across Daily Walking Tasks***

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Background and Aim: Motor asymmetry associated with Parkinson's disease (PD) presents an opportunity for assessment through wearable sensors. Specifically, Asymmetry Index (ASI) for arm swing movement has been proposed as a candidate measure. While the criterion standard for measuring ASI is motion capture (e.g., Vicon), its use is limited to the laboratory. The ability to analyze free-living ASI affords potential for longitudinal analysis, with implications for PD assessment. Inertial measurement units (IMUs) have been proposed as a substitute for motion capture, including initial evidence that gyroscope signals can be used for arm swing characterization [1]. The present study aims to investigate IMU-based methods against motion capture across a range of free-living type tasks. Methods: Young, healthy participants (n=3 in this abstract, target n=20) performed a series of walking conditions including regular walking, walking while holding a phone, and walking with one hand in a pocket. Each condition was performed 2 times, on a treadmill, for >90 seconds. Vicon motion capture markers were placed bilaterally on the acromion, elbow, posterior superior iliac spine and wrist, to record 3D marker positions at 200Hz. Shimmer IMUs were placed bilaterally on the wrists, recording triaxial acceleration and angular velocity at 128Hz. Angular velocity data were processed (i.e., filtered, integrated) to generate arm swing angle according to the published algorithm [1]. Criterion standard shoulder angle waveforms were determined using Vicon skeletal modeling, with numerical differentiation for velocity estimates. Analysis of the full dataset will compare motion capture- and IMU-based methods to measure amplitude and ASI using Bland-Altman and Pearson correlation. Results: Mean root mean square (RMS) and ASI from both IMU and motion capture system during normal and right hand hold tasks for 3 participants is shown in Table 1 (target sample = 20). IMU-based estimates compared against criterion-standard measures demonstrated differences between 0.55-5.57 deg for RMS amplitude and 2.2-14.0% for ASI. Conclusions: Preliminary results compare well to reported differences between PD vs non-PD groups for RMS amplitude (1-9 deg) and ASI (~16-19%) [1]. More participant data is planned to robustly determine the relationship between IMU and motion capture methods for measuring free-living arm swing across a wider range of tasks and conditions towards developing suitable methods for free-living assessment in clinical populations such as PD. References: [1] Warmerdam, E.; Romijnders, R.; Welzel, J.; Hansen, C.; Schmidt, G.; Maetzler, W. Quantification of Arm Swing during Walking in Healthy Adults and Parkinson's Disease Patients: Wearable Sensor-Based Algorithm Development and Validation, Sensors, 20 (2020), 5963. doi.org/10.3390/s20205963

P3-X-141: ***Comparing dynamic balance measures and their correlation during different walking tasks***

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BACKGROUND AND AIM: Multiple measures have been proposed to evaluate dynamic balance during walking including variability of gait parameters, short- and long-term Lyapunov exponents (λs and λl), margin of stability (MOS), distance between desired center of pressure and measured center of pressure (dCOP-mCOP), and whole-body angular momentum (WBAM). However, it is currently unclear which of these parameters are more sensitive and precise to evaluate dynamic balance. Here we investigated which measure is most sensitive and precise in detecting differences in dynamic balance between walking conditions that included simulated unstable treadmill walking. In addition, we also aimed to investigate the relationship among dynamic balance measures. METHODS: This study included 10 healthy young male adults. The participants were asked to walk on a treadmill for 10 minutes in three conditions: (1) normal walking, (2) dual task walking with a Stroop task to simulate unstable walking, and (3) arm restricted walking with arms crossed on the chest to also simulate unstable walking. Mean and coefficient of variation (CV) of gait parameters, λs and λl for body center of mass (COM) velocity, lower limb COM velocity, and lower limb joint angles, mean and CV of MOS at heel contact and the minimum MOS, mean and CV of dCOP-mCOP, and mean and CV of range of WBAM were calculated and used for comparison. Effect size was calculated to quantify standardized magnitude of differences between walking conditions. The receiver operating characteristic (ROC) analysis was performed to investigate the precision of each balance measure between normal walking and unstable walking, i.e. dual task walking and arm restricted walking. Pearson correlation tests were performed to investigate correlations between dynamic balance measures. RESULTS: Our effect size and ROC analysis results indicate that λs of COM velocity, λs of hip joint angle, and the magnitude of mediolateral dCOP-mCOP at heel contact can identify differences in dynamic balance between normal and arm restricted walking with large Cohen's d value (> 0.8) and AUC (≥ 0.9). Correlation analysis identified relationships among the dynamic balance measures: λs had positive correlation with variability of gait parameters, dCOP-mCOP, and WBAM; mediolateral MOS at heel contact was correlated with most of balance measures. CONCLUSIONS: This study was the first attempt to systematically apply multiple dynamic balance measures to the identical gait trials with various stability levels. Our results indicate that λs and mediolateral dCOP-mCOP were able to identify the difference in dynamic balance between stable walking and unstable arm restricted walking. Our findings will provide new insight into the selection of sensitive and precise dynamics balance measures and understanding of dynamics balance measures. ACKNOWLEDGEMENT: This work was partially supported by JSPS KAKENHI Grant Number 20H04558. REFERENCE: [1] Takeshi Yamaguchi, et al., Misalignment of the Desired and Measured Center of Pressure Describes Falls Caused by Slip during Turning, Plos One, 11, 5, (2016) e0155418.

P3-X-142: ***Running gait asymmetry from a smartphone camera using artificial intelligence***

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BACKGROUND AND AIM: Running performance can be optimised and injury risk minimised by better understanding gait asymmetry [1]. Although measuring gait asymmetry within the clinic has seen extensive work, approaches often rely on wearable technology [2]. Consequently, such approaches may have a high cost, or rely on expert assistance of use, limiting their utility in low-resource environments. The aim here is to propose a method of measuring running gait asymmetry using artificial intelligence (AI) and computer vision from a smartphone camera. METHODS: 203 healthy adults and adolescents (91M:112F) ran on a treadmill for two minutes. Participants were filmed from three angles (front, rear, side) at 240 frames/second, providing a high-resolution reference standard. Feet were located within each video frame, and their location noted alongside initial and final contact events for each foot. Labelled data were input to a deep learning AI-based classifier to detect feet within video streams. Initial and final contact were then automatically extracted based on adapted traditional gait feature identification (gradient analysis, zero-crossing peak detection), based upon the location of the detected foot. Step time, stance time and swing time asymmetry were calculated by observing the time difference between left and right feet initial and final contact. RESULTS: Results are obtained through manual comparison between labelled data and the output of the AI system. Accuracy is calculated such that accuracy = total correct classifications/total classifications. Feet are identified within video streams at 89.1% accuracy, with identification of initial and final contact within a mean error of 0.014s. Based upon identification of initial and final contact, step time, stance time and swing time asymmetry correlate with manual labels ($p<0.04$), indicating strong preliminary results of the system. CONCLUSIONS: Gait asymmetry is an essential metric for informing gait optimisations and minimising injury risk in runners. The proposed work demonstrates a markerless identification of gait asymmetry utilising computer vision for use in low-resource settings. By providing a non-invasive, habitual means of running gait assessment, we begin to reduce reliance on complex equipment. Future work will assess the validity of the approach within normal walking gait, with possible clinical application in understanding walking gait features in a range of cohorts. REFERENCES [1] S. Mo et al., "Bilateral asymmetry of running gait in competitive, recreational and novice runners at different speeds," Human movement science, vol. 71, p. 102600, 2020. [2] A. R. Anwary, H. Yu, and M. Vassallo, "An automatic gait feature extraction method for identifying gait asymmetry using wearable sensors," Sensors, vol. 18, no. 2, p. 676, 2018.

Y - Vestibular function and disorders

P3-Y-143: ***Alterations in trunk yaw rotations during object circumvention following acute unilateral vestibular neuritis. Data indicating a direct role of vestibular signals during circumvention.***

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BACKGROUND: Walking among crowds avoiding colliding with people is described by vestibular deficit patients as vertigo-inducing. Accurate body motion whilst circumventing an impeding person in the gait pathway is dependent on an integration of multimodal sensory cues. However, the impact of acute vestibular loss on human balance control in the context of obstacle circumvention and its effect on spatial perception of distance and orientation to the impeding person has not been investigated to date. METHODS: We examined lower-trunk yaw motion during circumvention in 4 patients 2-5 days after onset of acute unilateral vestibular loss (aUVL) due to vestibular neuritis, and compared their results with age-matched healthy controls (HCs). Subjects performed 5 gait tasks with eyes open twice: walk 6m in total, but after 3m, circumvent to the left or right as closely as possible a cylindrical obstacle representing a person, then veer back to the original path; walk 6m but after left and right circumvention at 3m veer, respectively, to the right, and left 45 deg; and walk 6m without circumvention. Trunk yaw angular velocities (TYAV) were measured with a gyroscope-system. RESULTS: YAV peak amplitudes approaching to and departing from the circumvented object were always greater for aUVLs compared to HCs, regardless of whether passing was to the aUVLs' deficit or normal side. The departing peak TYAV was always greater, ca. 52 and 87%, than the approaching TYAV for HCs when going straight or veering 45 deg ($p \leq 0.0006$), respectively. For aUVLs departing velocities were marginally greater (12%) than approaching YAVs when going straight ($p<0.05$) and were 40% greater when veering 45 deg ($p=0.05$). The differences in departing TYAV resulted in significantly lower trajectory-end yaw-angles for veering trials to the deficit side in aUVLs (34 vs 43 degs in HCs). CONCLUSIONS: These results demonstrate, for the first time, the effects of acute vestibular loss on trunk yaw velocity control during the 3 phases of circumvention. Firstly, on approaching an obstacle, greater TYAV is programmed by aUVLs than for HCs. Secondly, the departing TYAV is programmed to be proportionally less, with respect to the approaching velocity than for HCs, resulting in larger deficit side passing yaw angles. Thirdly, aUVLs have yaw errors returning to the desired trajectory. These results could provide a basis for further studies on understanding the role of the peripheral vestbular system in spatial orientation during circumvention and also for rehabilitation protocols helping patients to avoid collisions while walking in crowded spaces.

P3-Y-144: ***The effect of foot posture on lower-limb and whole-body vestibular-evoked balance responses.***

Paige Copeland[1], Mathew Debenham[2], Phuong Ha[2], Kailey Newel[1], Chris McNeil[3], Brian Dalton[2]

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BACKGROUND AND AIM: When quietly standing, the central nervous system must integrate and process vestibular cues within the context of head-on-feet posture as provided by other sensorimotor information. Thus, the vestibular control of balance is considered craniocentric, whereby the postural adjustment of each muscle involved in the task and summation of whole-body balance responses are modified based upon head position relative to the feet. By convention, during anatomical posture, a positive medium-latency response within the left plantar flexors and a negative response in the right plantar flexors direct the vestibular-evoked whole-body balance response to the right. However, it is unknown whether the central nervous system can provide appropriate balance responses to a vestibular perturbation directed mediolaterally when consequences of the muscles' action are reversed (i.e., feet crossed). Thus, the aim was to investigate the effect of crossing the feet, while maintaining head and trunk posture, on vestibular-evoked balance responses in the lower limb. It was hypothesized that, when compared to an anatomical posture, switching foot position would lead to a reversal of the vestibular-evoked balance responses in the medial

gastrocnemii. This result would likely be owing to the right and left gastrocnemii requiring inverse activity, compared to anatomical position, to maintain upright stance. METHODS: Eight, healthy participants (30±8 years; four females) completed a total of six, 90-s trials of stochastic electrical vestibular stimulation (EVS; 0-25 Hz, root-mean-square = 1.1 mA). Participants stood facing forward on a force plate in three different foot positions (anatomical posture, right-foot-over-left, and left-foot-over-right). Electromyographic (EMG) signals were recorded from the right and left medial gastrocnemius. A cumulant density function was used to evaluate the relationship between the EVS signal and motor output (EMG and ground reaction forces) to characterize the vestibular-evoked balance responses within the time domain. RESULTS: When participants' feet were crossed, compared to anatomical position, the vestibular-evoked balance response was inverted in both lower-limb muscles ($p \leq 0.012$) while the polarity of whole-body vestibular-evoked balance response remained consistent in all participants, regardless of foot position. CONCLUSIONS: When a vestibular error signal is directed mediolaterally, our results indicate that vestibular-evoked balance responses are adjusted based on the relevance and action of the muscle to the postural task and keep the body upright while standing. ACKNOWLEDGEMENTS AND FUNDING: Natural Sciences and Engineering Research Council of Canada and The Stober Foundation Health Fund

P3-Y-145: ***Prediction of vestibular disorder based on gait patterns using machine learning***

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BACKGROUND AND AIM: The purpose of our study is to create an artificial intelligence algorithm that diagnoses disorders through gait patterns, based on research results that Dynamic Gait Index (DGI) appears to be associated with vestibular disorders. METHODS: The gait data of 1,559 participants from Kosin University Gospel Hospital was used to make machine learning algorithm. The data were collected by applying IMU sensor. The authors annotated the data with participants' information including whether they have vestibular disorder. We applied XGBoost which is the most popular gradient boosting method. To create a more general algorithm, we applied 5-fold cross validation method. The method splitted train data set to 5 parts and made 5 models using each of the 5 parts as a validation set. The authors obtained the final prediction by averaging the predictions of the five models. RESULTS: Performance metrics of the machine learning algorithm showed following results; Sensitivity 82.56 %, specificity 81.43%, and AUC 90.63%. Through analysis of the algorithm, we found out highly contributing features (Gait asymmetry index, Phase coordination index, Cadence, Range of movement during inversion and eversion (ROM_IE), Range of movement during dorsiflexion and plantarflexion (ROM_DP), and Height) and checked that the algorithm with normal speed gait index performs following results; Sensitivity 79.07%, Specificity: 78.57%, AUC 87.26%. CONCLUSIONS: The machine learning implementing XGBoost showed the possibility of diagnosis of vestibular disorders through gait data from daily life. It also showed the relationship between Range of Movement and vestibular disorders. This method helps us to have insight into creating quantitative diagnostic methods by providing highly contributing features. ACKNOWLEDGEMENTS: Supported by the National Research

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P3-Y-146: ***Isolated otolith dysfunction in persistent postural-perceptual dizziness***

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[Background and Aim] There are many patients suffering from chronic floating dizziness. Many of them have been remained undiagnosed. Recently, diagnostic tools of vestibular function such as vestibular evoked myogenic potential (VEMP) and video head-impulse test (vHIT) have been developed. Also, a new clinical entity. persistent postural-perceptual dizziness (PPPD) has been proposed with its diagnostic criteria (J Vestib Res 2017). Because the main symptom of PPPD is non-spinning dizziness, association between PPPD and otolith organ dysfunction is assumed. However, otolith organ function in PPPD patients has not been extensively studied. The aims of this study are to clarify otolith organ dysfunction in PPPD patients, especially isolated otolith organ dysfunction (with preserved semicircular canal function) and to show their postural unsteadiness in stabilometry. [Methods] Twenty patients diagnosed with having PPPD that fulfilled diagnostic criteria published in 2017 by Barany Society, were enrolled into this study. Subjects filled questionnaires (dizziness handicap inventory = DHI and Niigata PPPD questionnaire = NPQ) , undergoing pure-tone audiometry, VEMP testing, and vHIT and stabilometry. [Results] Majority of subjects had vestibular dysfunction. Ten of the 20 subjects showed isolated otolith organ dysfunction (decreased or absent otolith organ function with preserved semicircular canal function). [Conclusions] Otolith organ dysfunction seems to be a facor associated with with PPPD.

Z - Visual function and disorders

P3-Z-147: ***Visual perturbations during locomotion in a virtual reality environment***

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BACKGROUND AND AIM: Safe navigation is established by treating objects and goals in our environment as repellers and attractors respectively. We choose paths that provide us with more space and avoid obstacles. Optic flow contributes to safe navigation by providing information about the rate and direction of self-motion relative to environmental features. The purpose of the current study was to determine if a medial-lateral visual perturbation would cause individuals to quickly realign their locomotor trajectory with their original path or choose a new one. It was hypothesized that participants' desire to realign to their original locomotor trajectory would be dependent on the magnitude of the visual perturbation and the participants' attractiveness to their explicit goal. METHODS: The current study used an HTC Vive Pro head-mounted display unit to display the virtual world consisting of two poles

and a goal. Participants (N=8, 21-years) were asked to walk along an 8-meter pathway towards a goal and avoid colliding with obstacles (i.e., 2 poles creating a 1m aperture) located 5m from the starting position. Participants' body movements were recorded using an Optotrak camera system at 60Hz. On a small subset of trials, the visual world was be perturbed 10, 20, or 30 degrees, leftward or rightward when participants were 2m from the aperture to determine if and how a visual perturbation affects their locomotor trajectory. For instance, the 10° shift kept the participants within the aperture boundaries, the 20° shift put the participants in line with one of the poles, and the 30° shift visually placed participants outside the aperture. RESULTS: Kinematic data analysis at the time of passing the aperture was used to quantify participants' ML COM position to determine path selection. Preliminary results revealed that on a high proportion of trials (96% and 75% respectively) participants were motivated to pass through the aperture when perturbed 10° and 20°off their locomotor trajectory. However, when the virtual world was perturbed 30°, participants adjusted their pathway to walk through the aperture 23% of the time CONCLUSIONS: Young adults appear to realign with their original locomotor trajectory soon after a small to moderate medial-lateral visual perturbation. These findings suggest that young adults may be placing an implicit goal between the aperture, forcing them to be more strongly attracted to that location than they were repelled by the pole obstacles. However, larger medial-lateral perturbations forced participants to "ride out" the perturbation and establish a new locomotor trajectory by circumventing the aperture. Therefore, young adults are sensitive to visual information and adapt their behaviours to changes in visual information, even if that means changing their original locomotor trajectory. Future studies will investigate whether older adults are similarly sensitive to visual perturbations while locomoting through a visual environment or whether they will rely on other sensory information to guide their paths towards a goal.

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