O.1.1 Association between walking smoothness and measures of isometric hand grip and knee extension strength

Bård Bogen[1], Anette Hylen Ranhoff[1], Mona Aaslund[1], Rolf Moe-Nilssen[1]

[1]University of Bergen

Background: Walking speed is associated with both sarcopenia and frailty. However, there may be aspects of walking that are not disclosed in gait speed alone. Walking smoothness, expressed as harmonic ratios may be an indicator of motor control in elderly people. In previous studies, harmonic ratios have been found to be related to walking speed. In this study, we investigate to which extent harmonic ratios derived from trunk acceleration are associated with upper/lower extremity strength, also related to sarcopenia and frailty, even when adjusting for walking speed. The relationship between sarcopenia and motor control during gait is still not fully explored, and this study aims to shed light on how these phenomena are inter-related. Methods: Participants were home-dwelling volunteers between 70-81, and independently mobile. They walked back and forth 6 times at three different speeds wearing an inertial measurement unit (IMU) fixed to their backs. Data were then analyzed at a common speed of 0.9 m/s, as described by Moe-Nilssen and collaborators. Both hand grip and knee extension strength was tested while the participants were sitting, using a digital myometer. The knee extension strength was tested against fixed resistance from a sling. Associations were investigated using multiple regression models, with the strength measurements as dependent variables, and harmonic ratios and gender as predictor variables. Results: 85 persons were assessed. However, 3 persons had a slow speed that was higher than 0.9 m/s and 1 person had a fast speed that was slower than 0.9 m/s. Therefore, 81 persons were included in the analysis (61 percent women, average age 76 (SD 3.3)). Harmonic ratios for antero-posterior (AP) trunk movements were significantly associated with both grip strength (p=.040) and knee extension strength (p=.001), also mediolateral (ML) harmonic ratios were associated with knee extension strength (p=.047). Vertical (V) harmonic ratios were not associated with either strength measure. Conclusion: Walking smoothness in the AP direction was associated with isometric upper and lower extremity strength and walking smoothness in the ML direction was associated with isometric lower extremity strength in a sample of community-dwelling elderly, even after adjustment for speed. This suggests that indicators of sarcopenia are associated with motor control during gait, and that motor control may be an issue in persons with low strength.

O.1.2 Perceptions of gait speed, timing and risk: an experimental study of road-crossing behavior in older people

Annie Butler[1], Stephen Lord[1], Janet Taylor[1], Richard Fitzpatrick[1]

[1]Neuroscience Research Australia

BACKGROUND AND AIM: Crossing a road safely is a complex task requiring good sensorimotor function and integration of information about traffic speed, distances and one's own speed. Poor judgement through age-related sensorimotor or cognitive impairment or a predisposition to take risks could lead to errors with serious consequences. Three studies explored factors leading to appropriate crossing decisions by older people. METHODS: On a simulated roadway in a gait laboratory, a small "car" drove back and forth (see Figure). Participants (n=85, ≥70 years) were asked to cross in front of the car with a clearance as small as considered comfortable but to ensure they did not get hit in two conditions; (1) with nothing else to attend to (free crossing) and (2) with an additional task (a ball sorting task) while waiting to cross (task crossing). To ensure safety, the car was stopped abruptly if it would have collided

with a participant. In such trials, this outcome was recorded as the participant being "hit". Perception of own gait speed relative to actual was measured by indicating the time of arrival at set destinations during imagined walks. Perception of the speed of moving objects was measured by participants indicating the contact time of a hidden virtual object that had been previously seen moving at constant velocity. Physical and cognitive function were tested and a questionnaire assessed perceptions of risk-taking behavior. RESULTS: Participants perceived themselves as walking faster than their actual speed (´1.1) and also indicated an early arrival of the moving object during the time-to-contact experiment. Thus, underestimation of the time taken to cross a road might lead to collisions but estimation of an early vehicle arrival time might compensate for this. In free crossing, a wide range of gaps were observed but no participant was hit. In the task crossing, significantly smaller gaps were allowed and 10% of participants were hit while 13% missed the opportunity to cross altogether. Participants were categorised according to this crossing outcome (missed opportunity, hit, exact, safe, timid). Across a wide range of physical and cognitive measures, including perceived and actual gait speed, a consistent pattern was observed. The exact group performed best, the hit and timid groups performed less well while those who missed the opportunity performed worst. The exact group reported taking the greatest risks on questionnaire whereas the remaining groups reported being cautious. CONCLUSIONS: A divided attention road-crossing task elicited inappropriate and/or risky decisions in older people with poorer function. Surprisingly, those who who took excessive risks reported their behavior as cautious on questionnaire. In contrast, older people who made optimal crossing decisions performed best on all physical and cognitive tests. Their decisions were low risk despite reporting they were risk takers.

O.1.3 Biomechanical Characteristics of Balance Control in obese older adults

Itshak Melzer[1], Lars Oddsson[2]

[1]Ben-Gurion University, [2]Courage Kenny Rehabilitation Institute, part of Allina Health

Background and aim: Obesity is one of the most significant epidemiological trends of the last decades. About one-third of American suffers from obesity. Obesity is associated with medical conditions such as hypertension, diabetes mellitus, heart disease, cardiovascular morbidity. A growing body of evidence suggests that excessive body weight is inseparably connected with postural instability. We aimed to investigate the effect of obesity on balance control mechanisms in older adults. Methods: A total of 66 healthy older volunteers, 65-90-years-of-age, were recruited from a senior community center and senior living facilities in the Boston area. Subjects were instructed to stand upright and barefoot as still as possible on a force platform in a standardized stance, their feet abducted 10o and their heels separated mediolaterally by 6 cm and hands crossed behind their back. Ten 30-second quiet-standing trials in eyes open and 10 trials in eyes closed conditions were obtained from each participant. Parameters from stabilogram-diffusion analysis (SDA) and measures from summary statistics of foot center-of-pressure (CoP) displacements along the anterior-posterior (AP)- and mediolateral (ML)-directions in eyes open and eyes closed conditions were used to characterize postural control in obese, overweight and normal weight older adults. To compare the different groups (obese, overweight, vs. normal weight), one-way ANOVA followed by post hoc LSD comparisons were performed on the SDA and traditional stability parameters in the ML- and AP-directions for both eyes open and eyes closed conditions. Results: Of 66 older adults, 22 subjects were obese (30-<35 kg/m2), 26 overweight (25-<30 kg/m2), and 18 normal weight (18.5-<25 kg/m2). Obese group subjects demonstrated significantly greater transition displacement (Tdx), transition time interval (Ttx), and short-term scaling exponent (Hxs) in the ML-direction compared with normal weight group. In the AP-direction, however, only the short-term scaling exponent (Hys) was significantly different in obese group subjects when compared with the normal

weight group. Both traditional parameter of postural stability the average AP-CoP and ML-CoP ranges of COP sway were higher in the obese group compared with normal weight group. No differences in balance control were found between the overweight and normal weight groups. Conclusion: This work indicates an altered postural control process in obese older adults. A greater sway displacement before closed-loop feedback mechanisms are called into play was seen, especially in the mediolateral direction that may lead to a higher risk of instability and fall events.

O.1.4 Hearing loss negatively impacts balance and gait by increasing cognitive load

Nicoleta Bugnariu[1], Linda Thibodeau[2], Rita Patterson[1], Phillip Willson[2]

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

BACKGROUND AND AIM: Hearing loss affects a large percentage of older adults and may increase their risk of falls. A barrier in defining the relationship between hearing loss and balance impairments has been the disconnect that exists between findings obtained in soundproof booths, and the impact of these results in the real world where patients need to maintain balance and walk in noisy environments. We aimed to: i) develop a method to evaluate the interaction between balance/movement and hearing function by integrating standardized audiology tests in realistic, ecologically valid virtual environments (VE); ii) investigate the relationship between hearing function, balance and gait in adults with and without hearing loss, and iii) evaluate the effects of two hearing aid (HA) technologies on measures of balance and gait. METHODS: Twelve adults newly diagnosed with hearing loss, without vestibular or other neurologic impairments, and twelve age- and gender- matched healthy controls participated. They were tested at the time of hearing loss diagnosis and enrollment in the study and after a two months accommodation and use of their hearing aids. We systematically manipulated characteristics of auditory stimuli, physical and cognitive challenges present in VE, and measured the effects on balance and gait. Outcome measures included: standing center of pressure sway, performance on dual task involving cognitive decisions, performance on auditory task, and self-selected gait speed on flat and uneven terrain in VE. Testing conditions were: no HA, regular HA, HA Frequency Modulator (FM); auditory task : either listening only or repeating back sentences. ANOVA were conducted for each dependent variable with respect to: group; condition of HA and condition of auditory task. RESULTS: Center of pressure sway variability in M/L direction was increased ($p<.05$) in participants with hearing loss vs. controls when subjects had to perform a dual standing/cognitive task. Without HA, self- selected gait speed was lower ($p<.05$) in individuals with hearing loss vs. controls, as long as they attended to the auditory task. Use of HA FM significantly improved performance on auditory task but also increased self-selected gait speed ($p<.01$). CONCLUSION: Hearing loss negatively impacts balance and gait particularly in dual task conditions. When auditory inputs are reduced/conflicting, perception of the environment is incomplete and the cognitive resources allocated to effortful listening are increased, potentially leading to maladaptive balance responses. Use of HA, especially HA FM, significantly improves not only speech recognition but also measures of balance and gait. While laboratory hearing tests focus on sound localization and speech recognition, perhaps real-world outcome measures such as balance and gait while conducting a conversation are more meaningful for assessing the impact of hearing loss on patients' level of function and participation.

O.1.5 The effect of different walking types on dual-task performance among community dwelling older adults

Maayan Agmon[1], Einat Kodesh[1], Racheli Kizony[2]

[1]University of Haifa, [2]University of Haifa and Sheba Medical Center, Israel

Key words: dual task; gait; walking types, dual-task cost, attention allocation Background: Impairments in the ability to perform a cognitive task while walking, i.e., dual tasking (DT) are associated with an increased risk of falling. Ample studies on dual tasking have focused mainly on the influence of the cognitive component. However, locomotion in the real world challenges the motor component as well. But, only few studies have focused on its contribution to the performance of dual task. Aims: To explore the relative contribution of the motor component during dual-tasking by examining the effect of three walking types: forward, backward and sideways on DT walking performance among older adults. Methods: Thirty three community dwelling older adults (mean age 71.9±5.5 years) participated in the study. All were instructed to walk forward, backward and to the side during one minute intervals with and without a cognitive task (verbal fluency and subtraction). Additionally, participants were asked to perform a single cognitive task while sitting. The order of performance of single and dual tasks was random. Measurements of cognitive status, balance, and executive function were also administered. Dual-task cost (DTC) was calculated for both the motor and the cognitive tasks. We conducted ANOVA repeated measures to compare DTC of each task for the three types of walking. Results: Significant differences were found between DTC of the distance walked in the three walking tasks with subtraction ($F(2,31) = 8.55$, $p=.001$). The DTC during forward walking (mean ± SD 23.33% ± 17.62) was significantly lower than the DTC during side walking (38.90% ± 17.46) and backward walking (31.60% ± 21.39) ($F(1,32) = 17.37$, $p=.0001$; $F(1,32) = 6.78$, $p=.014$, respectively). The DTC during backward walking was significantly lower than the DTC during side walking ($F(1,32) = 4.52$, $p=.041$). Similarly, significant differences were found between DTC of the distance walked in the three walking types with verbal fluency ($F(2,31) = 7.64$, $p=.002$). The DTC during forward walking (mean ± SD 25.07 ± 17.45) was significantly lower than the DTC during side walking (37.9=01 ± 16.32) and backward walking (40.95 ± 20.15) ($F(1,32) = 8.91$, $p=.005$; $F(1,32) = 14.01$, $p=.001$, respectively). The DTC during backward walking was not significantly different from the DTC during side walking ($F(1,32) = 0.89$, $p=.35$). No significant differences were found between the DTC of the two cognitive tasks in the three walking types. Conclusions: As expected, walking forward is the less demanding task among the three. Interestingly, the attention allocation between the three tasks did not change regardless of the task difficulty; most subjects allocated their attention to the cognitive tasks. The current findings contribute to better understanding of motor control within the DT paradigm. In addition it leads to the formulation of a graded, guided and agreed upon protocol to improve DT performance

O.1.6 The influence of fear and anxiety on postural sway compensations under postural threat in young and older adults

Daina Sturnieks[1], Kim Delbaere[1], Stephen Lord[1]

[1]Neuroscience Research Australia

BACKGROUND AND AIM: Psychological processes can influence balance and may contribute to the risk of falls in older people. While fear of falling is associated with increased postural sway, induced fear can lead to attenuation of sway. This study examined associations between fear of falling and general anxiety on changes in postural control induced by postural threat. METHODS: Participants were 48 older adults (76±5 years) and nine young adults (31±5 years). Fear of falling was assessed using the Falls Efficacy Scale-International and participants were categorised as fearful if they scored >23. General anxiety was assessed using the Goldberg Anxiety Scale and participants were categorised as anxious if they scored >1. Postural sway (centre of pressure) data were collected while participants stood un-

harnessed on a force plate for 30 seconds at floor and elevated (65cm) levels. Electromyographical (EMG) activity of gastrocnemius and tibialis anterior muscles were collected. Heart rate, blood pressure, skin blood flow and skin conductance were continuously measured as indices of physiological arousal (fear response), and participants were asked to rate their level of concern on the completion of each condition on a 10-point Likert Scale. RESULTS: An arousal effect of the elevated condition was confirmed in the older group by an increase in skin conductance, blood pressure and self-reported concern. Significant age*height interactions for sway ($p<0.041$) indicated older adults reduced their sway range and variability, while young adults remained relatively unchanged (Figure 1A). Despite the fearful subgroup of older adults (n=18) reporting an increase in concern in the elevated condition relative to the non-fearful group (height*fear group interaction $p=0.002$), there were no such interaction effects ($p>0.108$) for any of the physiological arousal, EMG or sway measures. The anxious subgroup (n=10) of older adults were similar to non-anxious in physiological arousal measures (height*anxious group interaction $p>0.469$), indicating that the elevated condition induced a fear response in all participants. However, there was a height*anxious group interaction effect indicating relatively increased concern ($p<0.001$), sway range ($p=0.009$, Figure 1B), and sway variability ($p=0.023$) in the anxious subgroup. It appeared that the anxious subgroup also had increased tibialis anterior EMG compared to non-anxious. CONCLUSIONS: The results of this study provide evidence for an adaptive stiffening strategy in young and non-anxious older adults, however, this strategy was ineffective in reducing sway magnitude in anxious older adults. These findings suggest that general anxiety in older adults is associated with poorer control of posture under threatening conditions and indicate a need to consider the influence of psychological factors, in addition to physical factors, when measuring balance and for implementing interventions for improving balance in older people.

O.1.7 The effects of route previewing on older adults' gaze behavior and stepping accuracy during adaptive locomotion

Mark Hollands[1], Benjamin Curzon-Jones[2]

[1]Liverpool John Moores University, [2]University of Birmingham

Background and Aims: Safely navigating through our cluttered environment relies on visually identifying hazards and safe paths. We have previously shown that older adults, particularly those who have a high risk of falling, tend to look away prematurely from targets for safe foot placement to view future hazards. This behaviour results in a decrease in stepping accuracy and a corresponding increase in the likelihood of a trip or fall [1, 2]. We have also shown that this maladaptive gaze behavior is linked to increased anxiety about performing the walking task [3, 4]. The aim of this study was to determine the effectiveness of training older individuals to preview a route prior to initiation of walking in reducing anxiety and the incidence of maladaptive gaze behavior and improving associated stepping performance. Methods: Nine young adults (25.4 ± 1.8 years) and nine older adults (77± 8.3 years completed six, walks with three task complexities over two sessions (6x3x2 = 36 total trials). Each trial consisted of a stepping target box, followed by either 0 (Target Only - TO), 1 (One Obstacle - OO), or 2 (Both Obstacles - BO) 20cm raised wooden stepping obstacles. Participants started with their eyes closed, then on hearing a verbal signal, opened their eyes and initiated walking (session 1), or stood previewing the route for 10 seconds before setting off (session 2). Body kinematic data were collected at 200 Hz using a 13 camera Vicon MX motion analysis system. Gaze behavior was sampled at 25Hz using an Ergoneers Dikablis eye tracking system. Results: Mixed model ANOVA revealed a significant interaction between age group and session in the mean fixation duration of the stepping target ($F(1,16) = 5.2$, $p < 0.05$). Post-hoc tests revealed that older adults fixated the target for significantly longer during

walking when they had previewed the route prior to walking (mean = 2.5s) compared to the condition when they had not previewed the route (mean = 1.7s). Conclusions: Previewing the route prior to initiating walking can ameliorate the specific maladaptive gaze behavior of older adults previously shown to be causally linked to increased falls risk. We are currently in the process of analysing stepping kinematic and measures of anxiety to see if the changes in gaze behavior resulting from route previewing are associated with reduced anxiety and improvements in stepping accuracy. Acknowledgments: This work was supported by the Research into Ageing Fund, a fund set up and managed by Age UK. References: [1] Chapman G J & Hollands M A (2007) Gait & Posture 26, 59-67 [2] Chapman G J & Hollands M A (2006) Gait & Posture 24, 288-294 [3] Young WR & Hollands MA (2012) PLOS one 7(11):14 e49765 [4] Young WR, Wing AM & Hollands MA (2012) J Gerontol B Psychol Sci Soc Sci. 67(1):43-51

O.1.8 Balance control interferes with learning to trace a pattern with mirror-reversed vision in older persons

Normand Teasdale[1], Léandre Gagné Lemieux[1], Martin Simoneau[1], Maxime Billot[1], Jean-François Tessier[1], Jean Blouin[2]

[1]Université Laval, [2]Aix-Marseille Université

BACKGROUND AND AIM: When tracing a template with mirror-reversed vision (or distorted vision), the sensory information arising from the movement does not match the expected sensory consequences. In such situations, participants have to learn a new visuomotor mapping in order to trace the template with an accuracy and speed approaching that observed when tracing with direct vision. There are several suggestions that such visuomotor learning requires lowering the gain of the proprioceptive inputs. Generally, subjects learn this task in a seated condition offering a stable postural platform. Adapting to the new visuomotor relationship in a standing condition could add complexity and even hinder sensorimotor adaptation because balance control and processing of additional information typically interfere with each other. METHODS: Older individuals and young adults (on average, 70 and 22 years of age, respectively) were assigned to groups that trained to trace a shape with mirror-reversed vision in a seated or a standing condition for two sessions. For a third session, the seated groups (young and elderly) transferred to the standing condition while the standing groups continued to perform the tracing task while standing. This procedure allowed comparing the tracing perfor- mance of all groups (with the same amount of practice) in a standing condition. The standing groups also did a fourth session in a seated condition. RESULTS: Older participants initially exposed to the standing condition were much slower to trace the template than all other groups (including the older group that performed the tracing task while seated). This slowness did not result from a baseline general slowness but from a genuine interference between balance control and the visuomotor conflict resulting from tracing the pattern with mirror-reversed vision. Besides, the Standing-Old participants that transferred to a seated condition in the fourth session immediately improved their tracing by reducing the total displacement covered by the pen to trace the template. CONCLUSIONS: Interestingly, the results did not support a transfer-appropriate practice hypothesis which suggests that training in a standing condition (at the third session) should have benefited the performance of those individuals who initially learned to trace the mirror pattern in a standing condition. This has important clinical implications: training at adapting to new sensory contexts or environmental conditions in conditions that do not challenge balance control could be necessary if one desires to attenuate the detrimental consequences on the postural or motor performances brought up by the interference between maintaining balance and the sensory reweighing processes.

O.2.1 Inspiratory muscle training improves proprioceptive postural control and sit-to-stand-to-sit in individuals with recurrent non-specific low back pain

Lotte Janssens[1], Thierry Troosters[1], Alison McConnell[2], Madelon Pijnenburg[1], Kurt Claeys[1], Nina Goossens[1], Roeland Lysens[1], Simon Brumagne[1]

[1]KU Leuven (University of Leuven) , [2]Brunel University

BACKGROUND AND AIM: Individuals with recurrent non-specific low back pain (NSLBP) decrease their reliance on back muscle proprioception, enforcing the use of ankle muscle proprioception during postural control. Recently, we have shown that both healthy individuals, breathing against an inspiratory load, and individuals with chronic obstructive pulmonary disease exhibit proprioceptive postural control strategies that are similar to those of people with NSLBP. Since individuals with NSLBP show a greater susceptibility to diaphragm fatigue, it is reasonable to hypothesize that NSLBP, diaphragm dysfunction and proprioceptive postural control may be interrelated. The aim of this study was to investigate whether inspiratory muscle training (IMT) improves proprioceptive postural control in individuals with NSLBP. METHODS: Twenty-eight individuals with NSLBP were assigned randomly into an intervention (IMT) and placebo group (p-IMT) undergoing eight weeks of high-intensity or placebo IMT, respectively. The participants were instructed to breathe (twice daily, 30 times) through an inspiratory load of 60% of their maximal inspiratory pressure (Pimax) (IMT) or 10% of their Pimax (p-IMT). Proprioceptive postural control was evaluated using center of pressure (CoP) displacement during local muscle vibration (ankle, back, ankle-back) while standing on unstable support surface. Secondary outcomes were inspiratory muscle strength (Pimax), severity of pain (Numerical Rating Scale), and disability (Oswestry Disability Index). A repeated measures ANOVA was used and the level of significance was set at $p< 0.05$. RESULTS: In the IMT group, back muscle vibration elicited a significantly larger CoP displacement post-intervention (Ä 2cm; p=0.027), and ankle-back muscle vibration elicited a significantly smaller CoP displacement post-intervention (Ä 2.0cm; p=0.040). No difference was found during ankle muscle vibration (Ä 0.9 cm; p=0.665). A significant positive correlation was found between the change in Pimax and the change in CoP displacement during back muscle vibration (r= 0.44; p=0.034). Inspiratory muscle strength increased significantly in the IMT group post-intervention (94±30 vs. 136±34 cmH2O) (Ä 42 cmH2O; p=0.001). Severity of pain decreased significantly in the IMT group post-intervention (5±2 vs. 2±2) (Ä 3; p=0.001). Disability did not differ after IMT (19±9 vs. 13±10 %) (Ä 6 %; p=0.099). No such differences were apparent in the p-IMT group (p>0.05). CONCLUSIONS: After IMT, individuals with NSLBP increase their reliance on back muscle proprioception during postural control, in particular in those with improved inspiratory muscle strength post-intervention. Moreover, severity of pain appeared to be lower after IMT, not seen after p-IMT. The results of this study provide evidence that the altered proprioceptive postural control observed in individuals with NSLBP, due to relative over-loading of the inspiratory musculature, can be reversed by IMT.

O.2.2 The quick and the slow: separate time scales of control for human walking

David Logan[1], Tim Kiemel[1], John Jeka[2]

[1]University of Maryland, College Park, [2]Temple University

BACKGROUND AND AIM: Our goal in this work was to learn about the control of human walking by probing the underlying functions, or subtasks, of walking with perturbations to visual scene motion. We

used constraints to characterize the subtasks of positional maintenance and preservation of a fixed cadence. We constrained walking in two ways through: 1) a treadmill, which dictates that subjects actively maintain position and 2) a rhythmic auditory cue (RAC), which dictates cadence. We hypothesized that the RAC would interfere with those responses to visual scene motion that support the subtask of positional maintenance on the treadmill. METHODS: Subjects (n=20) walked on a treadmill (5 km/h) placed within an immersive, 3-screen room with a virtual scene consisting of randomly oriented triangles with or without a metronome (RAC) for six trials of 4 minutes in each condition. In all trials, a filtered white noise signal rotated the virtual scene about the subject's ankle in the sagittal plane. Full body kinematics and surface EMG of 16 muscles on the right side were recorded. The response variables were sagittal plane segment angles, anterior-posterior (A-P) displacements and rectified/filtered EMG activity. Phase-dependent impulse response functions (IRFs) were computed to characterize responses due to changes in visual scene motion. IRFs of changes in approximate phase from visual scene motion were computed to investigate phase-resetting (phase advances/ delays). RESULTS: A subset of subjects (13 of 20) followed the RAC within a margin of error of 1 beat period in the majority (4 of 6) of RAC trials and was the focus of the analysis. A phase advance (quicker step) due to visual scene motion was initiated within the first cycle in both non-RAC and RAC conditions, and plateaued 4 gait cycles from perturbation onset. This phase advance was suppressed in the RAC condition beginning at the 4th gait cycle denoted by the elimination of persistent phase-resetting in the IRFs of segment angles and EMG activity during the RAC condition compared to the non-RAC condition. Responses of A-P hip displacement were not changed, however, indicating similar positional maintenance between the two conditions even though phase-resetting properties were clearly different. CONCLUSIONS: Here we used constraints on the walking behavior coupled with perturbations of virtual scene motion and revealed two timescales of control: 1) a fast control initiated within the first cycle after a perturbation that serves the subtask of speed control (i.e., positional maintenance on the treadmill) and 2) a slow control initiated 4 cycles after a perturbation to suppress phase shifts when maintaining a fixed cadence. Thus, maintaining position on the treadmill is linked to phase shifts on a short time scale but can be unlinked on a longer time scale. Furthermore, the continuous maintenance of position while walking is prioritized over regulation of gait period.

O.2.3 Locomotor control strategies underlying acquisition of a skilled walking task when sensory stimulation is combined with motor practice

Amanda Chisholm[1], Tania Lam[1]

[1]University of British Columbia

Background and Aims: Intensive and repetitive training programs that challenge the motor system are required to induce the neural plasticity that underpins improved functional skills in many neurological populations. Improved motor function and re-learning motor skills after injury strongly depends on the presence of appropriate sensory input. It has also been suggested that sensory stimulation combined with motor practice can enhance function. A training program that challenges both motor and sensory pathways has the potential to further improve functional performance for skilled walking. The purpose of this study is to 1) compare the effects of paired and unpaired sensory stimulation of cutaneous and proprioceptive receptors on the performance of a skilled walking task, and 2) evaluate the locomotor control strategies involved in the acquisition of a skilled walking task in able-bodied adults. Methods: Subjects performed a skilled walking task focused on foot height during swing with the Lokomat robotic-gait orthosis. They were presented with real-time visual feedback of their foot height along with a virtual target that they were instructed to match during the swing phase. The target height changed randomly

for each of the 30 steps during the pre- and post-training tests. For the training bout, subjects were randomized to receive one of 4 different practice conditions: 1) no sensory stimulation, 2) cutaneous only, 3) proprioceptive only and 4) paired cutaneous and proprioceptive. Cutaneous stimulation was applied by brief trains of electrical impulses to the sural nerve. Proprioceptive stimulation was delivered as a Lokomat-applied resistance against hip and knee flexion during swing. Foot trajectory error was measured as the vertical distance between the target and actual foot height. We measured lower limb muscle activity and sagittal joint angles during the pre- and post-training tests. Results: Each group improved performance from pre- to post-training as demonstrated by a reduced foot trajectory error by 13.3%, 23.3%, 37.1%, and 21.2%, respectively. The paired stimulation group demonstrated stronger positive correlations after training between target height and biceps femoris activity at pre-swing (r= 0.44 pre, r= 0.59 post). Medial gastrocnemius activity at pre-swing was positively correlated to target height after training in the proprioceptive only group (r= -0.12 pre, r= 0.25 post). All groups had greater correlations between target height and peak knee angle during swing after training (r= 0.4-0.62 pre, r= 0.54-0.76 post). Conclusions: Our findings indicate that motor performance can improve after short-term training with enhanced sensory stimulation. Further data collection is warranted to confirm the benefits of enhanced sensory stimulation on skilled locomotor performance. Robotic-based training offers a unique method to target features of walking that are important for adapting the locomotor pattern to perform everyday tasks.

O.2.4 Addition of haptic information for postural control in young adults: Light touch reduces more body sway than does the "anchor system"

Renato Moraes[1], Eliane Mauerberg-DeCastro[2], Thais Costa[2], Stephanie Miranda[2], Mayara Pestana[2], Fabio Barbieri [2]

[1]University of Sao Paulo at Ribeirao Preto, [2]Sao Paulo State University

BACKGROUND AND AIM: The addition of sensory information contributes to a reduction in body sway during quiet standing. Haptic information has been extensively studied under the light touch (LT) paradigm on a rigid surface. Additionally, haptic information can be provided to the postural control system by the so-called "anchor system" (AS). This system consists of a flexible cable held in the hand, with a small mass attached to the other end, which rests on the ground. The present study compared the effects of both paradigms of haptic contact during a challenging postural task, as well as the amount of force applied in both paradigms (downward force in the LT and upward force in the AS). METHODS: Thirteen blindfolded adults remained for 30 seconds in a tandem position on a force platform. Participants performed the task under three conditions: (1) control (non-contact condition), (2) touching a surface (a strain gauge sensor) with the tip of the index finger (LT), and (3) holding a flexible cable (stretched taut), which was attached to a strain gauge sensor in contact with the ground (AS). For conditions 2 and 3, the right hand was used as the contact point. RESULTS: One-way ANOVA (3 conditions) for center of pressure (COP) path length revealed a main effect for condition ($p \leq 0.0001$). Post-hoc analysis showed that all pair-wise comparisons differed from one another ($p \leq 0.025$). Both haptic conditions (AS: 52.37 ±4.75 in | LT: 35.52 ±3.07 in) reduced body sway as compared to the control (65.47 ±5.13 in). Also, LT reduced body sway more than AS. For the force variables (average, peak and standard deviation of the temporal series), one-way ANOVAs (2 conditions) were carried out. For all three force variables, ANOVAs revealed main effects for condition (Average force: $p = 0.016$ | Peak force: $p = 0.002$ | Force variability: $p = 0.001$). The average amount of force applied was higher for the AS (1.59 ±0.34 N) than for the LT (0.73 ±0.17 N). Peak force was higher for the AS (5.14 ±1.05 N) than for the LT (1.19 ±0.24 N). Force variability increased for the AS (0.90 ±0.18 N) as compared to the LT (0.20

±0.05 N). CONCLUSIONS: Path length results showed that the addition of haptic information in both AS and LT paradigms facilitated postural control, but the LT provided better use of haptic information than the AS. In the LT there is a reduced number of degrees of freedom of movement (vertical and horizontal forces). However, the AS incorporates a large number of degrees of freedom in the task (e.g., upward pulling movements, movements in the anterior-posterior and medial-lateral directions, and varied possibilities of rotation of the hand/cable around the fixed contact on the ground), which expands redundancy for the exploratory system. The increased force variability observed for the AS supports this explanation. Since the AS involves an exploratory behavior that required participants to stretch the cable, they applied more force.

O.2.5 Cutaneous afferent sensitivity and perceptual threshold in the Human foot sole

Leah Bent[1], Nicholas Strzalkowski[1]

[1]University of Guelph

Background/aim: Four classes of cutaneous mechanoreceptors have been identified in the glabrous skin of the foot sole [1] and hand [2]. Each class of afferent exhibits unique firing patterns that differentially relay contact, slips and skin stretch. While naturally encountered stimuli encompass a spectrum of frequencies, it is of interest to understand activation specific frequencies for each afferent class. Such tuning curves have been established in the hand [2]. Skin properties differ between the hands and feet. Aim one: establish tuning curves for the foot sole skin - to identify vibration profiles that optimize activation of specific afferent classes. Aim two: relate afferent firing to vibration perceptual threshold (VPT). Decreased VPT have been used to infer functional loss, a process that may not be equal among afferent classes. Methods: Single low threshold afferents were recorded from the tibial nerve using microneurography. Cutaneous afferents were classified; fast adapting type I (FAI), type II (FAII); or slowly adapting type I (SAI), type II (SAII). A mini shaker (6mm probe, Bruel&Kjaer) delivered 2 second vibratory bursts over the receptive field of each afferent (3-250Hz). Vibration amplitude (0.001-2 mm peak-to-peak) increased in frequency-specific steps. Vibratory tuning curves were made for impulses per cycle (action potentials per indentation). Vibration perceptual threshold (smallest perceived displacement) was established using a step-wise increase/decrease search method. Results: Twenty eight single afferents were recorded from 12 participants (7 FAI, 4 FAII, 7 SAI, 10 SAII). Vibration tuning curves support upper limb findings; SA units were most sensitive at low frequencies (to generate 1:1 firing), FA units most sensitive at high frequencies. Notably the amplitude to elicit 1:1 firing was significantly higher than in the hand. Interestingly, FAI units were found to be relatively frequency independent, responding across frequencies from 3-100Hz with a fairly low amplitude (0.5mm). Perceptually, the amplitude to generate 1:1 afferent firing was higher across all afferent classes than perceptual threshold amplitude, suggesting perception does not require 1:1 firing. FA afferent firing closely followed the onset of perceived touch indicating these mechanoreceptors are likely responsible for VPT. Conclusions: The link between individual afferent firing, perception and functional responses remains unknown. Stimulation profiles for individual cutaneous afferents will improve our ability to optimize activation across subclasses, and thereby increase our understanding of how different receptor types contribute to tactile perception and postural control. VPT may underestimate the combined capacity of all receptor subclasses to contribute to functional tasks as it primarily targets declines that are apparent in the FA channels. [1] Kennedy, Inglis (2002) J Physiol 538:995-1002 [2] Johansson et al. (1982) Brain Res244:17-25

O.2.6 Unilateral or Bilateral vibration effects during postural control for young adults

Noémie DUCLOS[1], Luc MAYNARD[2], Serge MESURE[1]

[1]Institut of Movement Sciences, [2]CRF Valmante

Background and Aim: During normal standing, proprioceptive inputs from legs provide the most sensitive means of perceiving postural sway. The vibration of muscle tendons has become a frequent tool for studying the relative role of muscle proprioception in human postural control. The resulting displacement is a sign of integration of the perturbed information in the postural scheme and it's dependent on the duration of vibration [1]. Is this sensori-motor integration linear along time? Moreover, some mechanical aspects of the body could interact with this cerebral process: a lot of degree of freedom for the antero-posterior (Y) axis and a more rigid system along the medio-lateral (X) axis. These 2 directions are controlled by specific ankle muscles (Triceps Surae & Peroneus). Our objective is to determine how proprioceptive inputs from these muscles influence the entire postural control. Methods: We applied bilateral (BiVib) or unilateral (UniVib) vibration (20 seconds, 80 Hz) on Achilles or Peroneus tendons, to 21 young adults in standing position, in their preferred side-by-side feet position and without vision. Y and X positions of the Center of Pressure (CoP) and the covered lengthwere computed; their evolution along time by periods of 4 s. and characteristics of extreme (min & max) positions. Statistic analyze was realized through a repeated measures ANOVA Results: In all conditions, we observed a backward shift of the CoP. This displacement is not linear. The extreme backward position was reached before the suspension of vibration at around 12-16 seconds and then, the displacement didn't evolve any more. The Y-min position was always more posterior for BiVib compared to UniVib but was reached at a similar time for all conditions. X displacement occurred for UniVib on Achilles tendon only, towards the opposite side of the vibration. Vibration induced an increase of the covered length. The restoration of the initial stability is longer (until 4s more) after BiVib than UniVib, especially after Achilles vibration. Conclusions: The dependence of the magnitude of final CoP shift on the duration of vibration appears not true after 16s of vibration. We highlight phenomena of cerebral saturation of proprioceptive inputs, depending on time and not on amplitude of the displacement, with the stabilization around a new position of reference. The return to the initial state is longer when both hemispheres were stimulated. Concerning the mechanical aspects of the body sensory-motor control, the applied proprioceptive perturbation on Peroneus was not sufficient to displace the CoP in medio-lateral direction, in bipodal stance. Only unilateral perturbation, applied on an antero-posterior direction, permits to derive the CoP towards the opposite limb. This aspect is really interesting for all population with deficit or progressive restoration of weigth-bearing. [1] Capicíková N & al. Physiological research. 2006 Jan;55 Suppl 1:S129-34.

O.2.7 The mere planning of an imagined step movement suffices to trigger cortical facilitation of somatosensory inputs

Laurence Mouchnino[1], Anahid Saradjian[1], Aurélie Fontan[1], Jean Blouin[1], Charalambos Papaxanthis[2]

[1]Aix-Marseille University CNRS, [2]Université de Bourgogne INSERM

Motor imagery is a mental process during which an individual internally simulates body movements without actually executing them. Imagined actions use the same planning processes as their actual counterparts, but the central nervous system retains the release of the motor command. We have recently shown that the planning of gait initiation enables sensory facilitation of proprioceptive inputs indicative of a task-relevant sensory vigilance related to the necessity of monitoring the body's

equilibrium state prior to stepping (Saradjian et al. 2013). As motor imagery of a step movement is thought to only activate a premotor planning mode which takes into account the postural and equilibrium constraints required for the task, one could expect that a facilitation of somatosensory afferents should be observed in imagined gait initiation as in executed gait initiation. To test this hypothesis, we recorded somatosensory evoked potentials (SEPs) (electroencephalography, 64 electrodes) during the planning phase of imagined or real steps. The SEPs were obtained by averaging, for each participant and each condition, all epochs synchronized relative to the onset of 1s vibration of ankle muscles. details are needed to explain why the vibration occurred during planning. We found that the latency of the cortical response (i.e., early SEP) to the stimulation was shorter when it occurred during the planning of both a to-be-executed (75 ±14 ms) and a to-be-imagined step (80 ±15 ms) than during the Standing condition (participants were required to stand still , 90 ±11 ms). This suggests that the planning mode activated in the imagery task, may have selectively enhanced the cortical responsiveness to proprioceptive inputs. In addition, the late SEP activity recorded over the sensorimotor cortex was enhanced in the Stepping as well as in the Imagine condition as compared to the Standing condition. It was however smaller and latter in the imagery than in motor execution tasks. It is possible that the enhanced late SEP observed during the planning of motor imagery mainly relied on internal model of action involving the physical laws of motion (1g-model) that was activated by kinesthetic imagery of a whole body motion.. Saradjian AH, Tremblay L, Perrier J, Blouin J, Mouchnino L. (2013) Cortical facilitation of proprioceptive inputs related to gravitational balance constraints during step preparation. J Neurophysiol. 110:397-407

O.2.8 Correlation between structural properties of white matter pathways and proprioceptive postural control in individuals with recurrent non-specific low back pain and healthy controls.

Madelon Pijnenburg[1], Karen Caeyenberghs[2], Lotte Janssens[3], Nina Goossens[3], Kurt Claeys[4], Simon Brumagne[3]

[1]KU Leuven, [2]University of Ghent, [3]University of Leuven, [4]KULAB University of Leuven

BACKGROUND AND AIMS: Low back pain is a well-known socio-economic health problem. Current treatment of recurrent non-specific low back pain (NSLBP) provides modest short-term success, because underlying mechanisms of NSLBP are largely unknown. Individuals with NSLBP have been observed to decrease their reliance on back muscle proprioception during postural control. This proprioceptive impairment can be related to peripheral as well as to central changes. However, these central changes in individuals with NSLBP are not investigated yet. The aim of this study was to investigate the association between structural characteristics of sensorimotor white matter pathways and proprioceptive postural control (PPC) in individuals with NSLBP and healthy controls. METHODS: The contribution of proprioceptive input, from the ankle- and back muscles, to PPC was evaluated by local muscle vibration in 13 individuals with NSLBP and 13 healthy controls (matched for gender and age). Center of pressure (CoP) displacement as a result of the local muscle vibration was determined during upright standing. To examine whether this proprioceptive contribution is associated with structural characteristics of white matter pathways, diffusion tensor imaging (DTI) was applied (b-value of 1300 s/mm2, 60 non-collinear directions and an average of 5 b0-images). DTI parameters of the sensorimotor pathways were analyzed in ExploreDTI and correlated with PPC using a Pearson correlation analysis ($p< 0.05$). RESULTS: Individuals with NSLBP showed smaller CoP displacement on stable support surface in response to back muscle vibration (2.8±1.7 cm) compared to healthy controls (4.6±2.1 cm) ($p= 0.03$). The CoP displacement in response to back muscle vibration in both the individuals with NSLBP and the healthy controls was correlated with the fractional anisotropy (FA) and/or the radial diffusivity (RD) of

the posterior corona radiata (FA; r= -0.492, p= 0.011, RD; r= 0.435, p= 0.03), the cerebral peduncle (FA; r= -0.473, p= 0.015, RD; r= 0.401, p= 0.04) and the inferior cerebellar peduncle (FA; r= -0.453, p= 0.02). In other words, individuals with a smaller response to back muscle vibration showed higher integrity and lower radial diffusivity in the fibers passing through these areas. CONCLUSIONS: Individuals with NSLBP show a decreased reliance on proprioceptive input from the back muscles compared to healthy controls. The reliance on back muscle proprioception is correlated with central changes in the sensorimotor pathways involved in postural control. This correlation between brain white matter structure and behavior suggests an increased need for central processing in individuals who have a diminished ability to use back muscle proprioception. This is a first step towards a better understanding of the central processing of PPC and of major interest for improving efficient sensorimotor outcome in individuals with NSLBP.

O.3.1 Sensory reweighting of proprioceptive information in young and older adults: Improvement through adaptation

Mihalis Doumas[1]

[1]Queens University Belfast

BACKGROUND AND AIM: Sensory reweighting is a ubiquitous aspect of human postural control, necessary for the control of upright stance when environmental information (visual, vestibular and proprioceptive) changes. Previous studies have shown that sensory reweighting of vision and proprioception is affected by age related decline, however, little is known about whether this process can be improved through practice. The aim of the present study was to assess the ways in which young and older adults can improve sensory reweighting of proprioceptive information through adaptation to an environment comprising dynamic changes in the nature and amount of proprioceptive information. METHODS: Changes in proprioceptive information about body sway were achieved by means of moving the support surface in proportion to body sway, or support surface sway reference. Participants were asked to stand on a force platform. First, sensory reweighting was measured by means of fast transitions from a fixed to a sway-referenced surface and vice versa (pre-adaptation). Then, participants stood on a sway-referenced surface for 18 minutes, or on a surface switching from sway reference to reverse sway reference every 1 minute for 18 minutes. At the end of the session sensory reweighting was measured again as in pre-adaptation. Switch and sway reference conditions were performed in separate sessions. RESULTS: Results showed that after adaptation to the switch condition both young and older adults showed greater improvement in sensory reweighting compared with the sway reference only condition. CONCLUSIONS: Our findings illustrate that sensory reweighting can improve through specific practice in both young and older adults. This evidence can be utilized for the development of training programs aimed to moderate age-related decline in postural stability and to reduce fall accidents.

O.3.2 Gait rehabilitation: Does executive function status matter?

Kristin Lowry[1], Subashan Perera[2], Jessie Van Swearingen[2]

[1]Des Moines University, [2]University of Pittsburgh

BACKGROUND AND AIM: Poorer executive function (EF, e.g. cognitive flexibility, inhibition control) is related to falls and gait decline in older adults. The same cognitive domains may be important for participation and facilitation of motor learning in gait rehabilitation. A clinically important question is

whether EF ability impacts the response to rehabilitation focused on improving mobility in older adults. In this secondary data analysis from a RCT, we determined if baseline EF performance, visuospatial flexibility, and inhibition control, differentially impacted mobility outcomes of 2 types of gait rehabilitation. METHODS: Older adults with mobility impairment (abnormally slow and variable gait) who completed a 12-week, 2 times/week, RCT of physical therapy supervised gait interventions, either motor skill learning (M, n=23, mean age 76 ± 5.5 years) or impairment-based (I, n =24, mean age 78 ± 5.4 years) were included. The EF measures (Trail Making Test Part B, Trails B, and Stroop word color test, Stroop) were collected at baseline; measures of gait performance (energy cost ml/kg-m, gait speed m/s, stance time variability, Figure-of-8 Walk test time and number of steps, and the Gait Efficacy Scale) were recorded pre and post intervention. A series of linear models were fitted with pre-to post intervention change in each gait variable as the dependent variables; the intervention (M, I) and each EF measure and their interaction term as independent variables; and age, sex, and the baseline value of each gait measure as covariates. Intervention group specific slopes and their statistical significance were used to quantify the association between EF and mobility outcomes. RESULTS: At baseline, mean gait speed was slow (M, .87m/s; I, .85m/s) and performance was variable (step length, %of n: M, 50, I, 50; step width,% of n: M, 82.6, I,70.8). Mean baseline EF was below age-adjusted norms, mean Trails B (M, 130s; I, 137s) and Stroop (M, 42s; I, 48s); no between group differences. Gait performance outcomes of M and I were not differentially impacted by EF (interaction term p value range 0.2 - 0.9). There were also no significant associations between pre - to post changes in gait variables and baseline Trails B or Stroop within the M intervention (p value range 0.2 - 0.9) or within the I intervention (p range 0.1 - 0.9). CONCLUSION: While EF is known to be associated with gait performance and predictive of decline in gait among older adults with and without gait problems initially, EF did not alter the ability of older adults with mobility limitations to respond to gait interventions. EF deficits should not be considered a barrier to intervention-related improvements in mobility.

O.3.3 Can functional electrical stimulation of the hamstring muscles improve knee kinematics in stiff knee gait of stroke survivors?

Martin Tenniglo[1], Anand Nene[1], Anke Kottink[1], Erik Prinsen[1], Hans Rietman[1], Jaap Buurke[1]

[1]Roessingh Research and Development

Background and aim Stiff knee gait is an abnormal movement pattern characterized by a reduced peak knee flexion during swing phase commonly observed in stroke survivors, traumatic brain injury and cerebral palsy. The pathophysiology of stiff knee gait is only partly understood and several hypotheses are mentioned in literature. Different treatment options aimed at reducing stiff knee gait exist, including chemodenervation of the rectus femoris and rectus femoris transfer. Literature describing the effects of these interventions however is scarce and inconsistent. A possible alternative treatment to improve knee flexion during swing in stroke subjects walking with stiff-knee gait is electrical stimulation (ES) of the hamstrings. The aim of the present study is to study the effect of ES of the hamstring muscles on knee kinematics in chronic stroke survivors with a stiff knee gait. Methods Sixteen chronic adult stroke survivors were recruited for participation in this exploratory prospective cohort study. The recruited subjects received ES 3 times a week for 1 hour during a period of 5 weeks. The Odstock® two channel Stimulator (O2CHS II, Odstock Medical Limited, Salisbury, Wiltshire, UK) system was used for stimulation. 3D kinematics (Vicon®, Oxford, UK) was calculated while walking with and without hamstring stimulation before (t1) and after (t2) 5 weeks of training. Results Peak knee flexion during swing showed a significant mean increase of 8.7° (SD ± 8.3, p=0.001). Knee range of motion (ROM), defined as the maximum knee flexion minus the minimum knee flexion during the gait cycle, showed a

significant increase of 8.2° (SD ± 7.7, p=0.001). Knee angular velocity at toe off did not change significantly. The increase in peak knee flexion and knee ROM while walking with and without ES at t1 showed a significant correlation with the increase in peak knee flexion (p=0.001 r=0.75) and knee ROM (p=0.001 r=0.74) at t2. Conclusion Walking with ES of the hamstring muscles resulted in a significant increase of 8.7° in peak knee flexion and a significant increase in knee ROM of 8.2 °. These results are comparable to the reported effects of neuromuscular blocks on peak knee flexion. The significant correlations between the increases in the knee kinematics measured at t1 (with and without ES) and t2 (with and without ES) indicate that the possible effect of ES of the hamstrings muscles in the individual stroke patient can be predicted based on findings during the initial assessment. Future research should focus on the determinants for success of ES of the hamstrings muscles in stiff knee gait.

O.3.4 GAIT PRACTICE DURING INPATIENT REHABILITATION FOLLOWING STROKE

Suzanne Kuys[1], Louise Ada[2], Jennifer Paratz[3], Sandra Brauer[3]

[1]Griffith University, [2]University of Sydney, [3]University of Queensland

Background & aim: Retraining gait is a common goal of rehabilitation following stroke. Evidence indicates high intensity, task specific practice is required to optimise gait. Animal research suggests at least 1000 lower limb active repetitions per day are required to maximize neuroplasticity following stroke. It is unclear whether current rehabilitation practice meets this target. Thus, this study aimed to determine how many steps are routinely performed during inpatient stroke physiotherapy rehabilitation sessions/day, during what activities and if walking ability influences the number of steps completed. Methods: An observational study of people with stroke was conducted in two inpatient rehabilitation units in Brisbane, Australia. Participants were directly observed during three daily physiotherapy sessions and the number of repetitions of steps counted. Gait-related activities were recorded as preparatory (e.g. stepping), basic (overground walking) or advanced (e.g. obstacles). Additional categories included sit to stand and cardiovascular training. Steps were counted during all gait-related activities including stair climbing. Walking ability of participants was stratified using the Motor Assessment Scale (MAS); as good walkers if they scored 3 or more on Item 5 of the MAS (walking item) and as poor walkers if they scored 2 or less. RESULTS: 25 stroke patients were recruited; average age 71 (SD 13) years, 19 males (76%), 13 (52%) right side affected. On average, 469 (SD 333) steps were performed per day; with basic gait (overground walking) the most frequently observed gait related activity (47% of observed sessions). Good walkers took fewer steps (average 307 (SD189) compared to poor walkers (average 573 SD380) (p = 0.043). CONCLUSIONS: Stroke patients complete approximately 470 steps on average in a daily physiotherapy session during inpatient rehabilitation in Australia, with a wide variation reported across individuals. Walking ability did influence this, with good walkers taking less steps. Further investigation is required to determine how many steps are completed outside of physiotherapy treatment sessions and the relationship between steps completed, brain plasticity and functional recovery. This study was supported by a grant from the Office of Health and Medical Research, Qld Health, CIA Brauer.

O.3.5 Visual cue training to improve walking and turning after stroke: a multi-centre, single-blind feasibility RCT

Kristen Hollands[1], Trudy Pelton[2], Susan Jowett[2], Cath Sackley[3], Diane Whitham[4], Andrew Wimperis[5], Alan Wing[2], Paulette van Vliet[6]

[1]University of Salford, [2]University of Birmingham, [3]University of East Anglia, [4]University of Nottingham, [5]Birmingham Community Health Care NHS Trust, [6]University of Newcastle

Background: Vision is one of the most salient sources of information used to control walking and dependence on vision to maintain dynamic stability increases following stroke. Therefore, rehabilitation incorporating visual cues may be effective in triggering recovery and adaptability of gait following stroke. This feasibility trial measures recruitment rate, treatment adherence and probable response to gait training with visual cues in contrast to usual care rehabilitation of walking following stroke. Design: 3-parallel arm, multi-centre, single blind, randomised control trial comparing; Over-ground visual cue training (O-VCT), Treadmill visual cue training (T-VCT), and Usual care (UC). Participants were randomly assigned to treatments using computer generated random permutated balanced blocks of randomly varying size. The assessor was blind to allocation. Treatment was delivered by physiotherapists, twice weekly for 8 weeks; at out-patient hospital sites for O-VCT or UC and at the University for T-VCT. Participants: Individuals with gait impairment, due to stroke, with restricted mobility (speed < 0.8m/s), lower limb paresis and able to take part in VCT, (i.e. no severe visual impairments or comorbid medical contraindications for walking practice) were included. Measures: Primary outcomes of recruitment, retention and health economic resource-use data were recorded over 18months. Secondary outcomes were measured before randomisation, post-intervention and at three months and included gait speed and symmetry; time and steps taken to turn 180º; gait adaptability(success rate in target stepping); Timed-up and Go; Fugl-Meyer Lower Limb Motor Assessment; Berg Balance Scale; Falls Efficacy Scale, SF-12, and Functional Ambulation Category. Results: From 748 stroke patients, 386 were medically unsuitable for gait rehab or had premorbid gait deficits not due to stroke, 140 walked >0.8m/s, 12 had severe visual impairments and 55 poor cognition. From 155 eligible patients 36 required translators and 59 declined consent/were lost to contact. Recruitment rates averaged 3.5patients/month. A total of 60 patients consented and 56 randomized (18 T-VCT, 19 O-VCT, 19 UC). Analysis of secondary measures of potential efficacy is ongoing. Discussion: The VCT intervention is derived from a theoretical basis borne out in earlier studies which increased understanding of the mechanisms of gait deficits during walking and turning following stroke and proposed treatment effects. Rates of uptake, attrition and adherence to treatment give important indicators of whether current understanding of visuo-motor control of walking can be translated into a potentially efficacious intervention that can be feasibly delivered in rehabilitation services, credibly measured in a future definitive RCT and is acceptable to patients. Analysis of secondary measures indicating potential efficacy will be presented. (clinicaltrials.gov NCT01600391; Funding: NIHR RfPB;PB-PG-0609-18181)

O.3.6 Balance, Dizziness, and Kinesthesia in Patients with Chronic Whiplash Associated Disorders: A Prospective Randomized Study Comparing Three Exercise programs

Anneli Peolsson[1], Gunnel Peterson[1], Maria Landén Ludvigsson[1], Ann-Sofi Kammerlind[1], Julia Treleaven[1]

[1]Linköping University

Background and aim: No existing evidence for the benefit of physiotherapy in patients with chronic whiplash associated disorders (WAD) is evident, although physical activity is recommended. The aim of the study was to compare the effect of three exercise programs on balance, dizziness and kinesthesia in patients with chronic (6 months to 3 year of duration) WAD. Methods: A prospective randomized multi-center study with a one year follow-up including 216 individuals in working age (40.5 (SD11.4) years) with WAD grade 2 or 3. Exercises were performed twice weekly for 3 months and individuals were independently randomized to one out of three exercise program A) Physiotherapist-guided neck specific

exercise B) Physiotherapist-guided neck specific exercise, with a behavioural approach and C) Prescription of general Physical Activity. Questionnaires (UCLA Dizziness Questionnaire, Visual Analogue Scales (VAS) about dizziness at rest and during motion, and balance disturbances) were answered and a blinded test-leader performed physical measures (sharpened Rhomberg, walking in a figure of eight and kinesthesia). Complementary data: neck disability index (NDI), tampa scale of kinesiophobia (TSK), health related quality of life (EQ 5D and EQ VAS), active neck range of motion (ROM) and neck muscle endurance (NME) of the flexors and extensors were also used to compare individuals with and without dizziness at 12 month follow-up. Results: At baseline all three groups were comparable. At the 12 month follow-up the behavioural approach group had less dizziness (p=0.008) during motion compared with the general physical activity group. Rhomberg, figure of eight, UCLA improved over time for all three groups. Dizziness at rest and during motions and left kinesthesia improved over time for both physiotherapist led groups and right kinesthesia also improved for the behavioural group. At baseline 141 (66%) and at one year 91 (57%) reported problems from dizziness. Individuals still experiencing dizziness at the follow-up had worse results on self-reported NDI, TSK, and EQ 5D and EQ VAS), decreased neck ROM, NME of the flexors and worse results on Rhomberg´s test compared to those without dizziness. Conclusion: Both physiotherapist led groups had some advantages of their training compared with the general physical activity group. In future study exercises specifically addressed to balance, dizziness and kinesthesia need to be investigated.

O.4.1 Identifying individuals with difficulty in sit-to-stand movement using dynamic stability limits defined by center of mass acceleration

Masahiro Fujimoto[1], Li-Shan Chou[2]

[1]University of Maryland School of Medicine, [2]University of Oregon

BACKGROUND AND AIM: Poor performance of sit-to-stand (STS) movement has been identified as one of the predictors of fall risk among elderly adults. We have previously established the region of stability (ROS) using the whole body center of mass (COM) velocity and acceleration, and demonstrated that differences in STS strategies among individuals could be better distinguished with COM acceleration. This study examined the ability of the ROS to discriminate elderly adults with difficulty in STS movement from healthy individuals. METHODS: Whole body motion data while performing sit-to-stand were collected from 10 young [Young (Norm)], 10 elderly [Elderly] and 10 elderly subjects with difficulty in sit-to-stand [Elderly (DIFF)]. Young subjects were also asked to stand up with their trunk purposely bent forward [Young (Bend)]. The ROS was defined with the COM position at seat-off and its instantaneous velocity (ROSv) or peak acceleration (ROSa), using a single-link-plus-foot inverted pendulum model. The effectiveness of using the ROS to discriminate Elderly (DIFF) subjects from healthy subjects was assessed with the receiver operating characteristic (ROC) curve analysis. The area under the curve (AUC) was determined and tested against a null hypothesis of no discrimination (AUC = .50). RESULTS: When distinguishing Elderly (DIFF) subjects from a combined sample of Young (Norm) and Elderly subjects, significant AUC values were obtained using either ROSv or ROSa, with a greater AUC value for the ROSa (ROSv: AUC=.765, p=.02; ROSa: AUC=.895, p=.001). Identification of Elderly (DIFF) subjects using the ROSa approached sensitivity and specificity values of 80% and 90%, respectively. Using the ROSa also resulted in significant AUC values when identifying Elderly (DIFF) subjects only from Elderly subjects (AUC=.840, p=.01) or from Young (Bend) subjects (AUC=.780, p=.034), while those AUC values were not significant when the ROSv was used (AUC≤.740, p≥.07). In addition, 7 out of 10 Elderly (DIFF) subjects had two or more falls in the year either prior to or after the testing, based on follow-up check-ups. The ROC analyses revealed its excellent discriminative property of the ROSa to identify those 7 subjects from

other Elderly (DIFF), Elderly, and Young (Norm) subjects (AUC=.901, p=.002). CONCLUSIONS: The ROSa demonstrated a better ability than the ROSv to discriminate elderly adults with difficulty from healthy individuals. COM acceleration could be a more sensitive measure than COM velocity to distinguish individuals with different balance control abilities. The ROSa could provide a quantitative basis for assessing dynamic stability during STS movement, which allows us to identify individuals with difficulty in STS movement, who are most likely at a risk for imbalance or falls.

O.4.2 The quantity and quality of daily activities in relation with fall history and future falls in older adults

Kimberley van Schooten[1], Sietse Rispens[1], Petra Elders[2], Paul Lips[2], Jaap van Dieen[1], Mirjam Pijnappels[1]

[1]VU University Amsterdam, [2]VU University Medical Center

BACKGROUND AND AIM: Sedentary behavior and balance and gait impairments are important risk factors for falls in older adults. However, most studies investigated the relation with falls retrospectively, while this might be biased by fear of falling or recall. Moreover, subjective reports of physical activity are often used, while these are known to have limited validity and precision. In this study, we compared the associations between falls determined retrospectively and prospectively with potential risk factors as measured by accelerometry. METHODS: We measured 121 older adults with an average age of 75.5 (SD 7.1) years. Six-months fall incidence was retrospectively obtained by recall and prospectively by monthly telephone contact. In addition, all participants answered validated questionnaires assessing risk factors for falls and wore a 3D trunk accelerometer during one week. Based on the accelerometer data, five activities were classified: locomotion, sitting, standing, lying and an unclassified category. The total duration of these activities was calculated and for the locomotion bouts, variables describing gait quality were estimated. The associations of the questionnaires, duration of the activities and gait quality variables with retrospective and prospective falls were investigated using logistic regression. RESULTS Participants were classified as fallers if they experienced one or more falls in 6 months; 34% of the participants had a history of falls and 38% experienced falls during follow-up. Depression, cognition, fear of falling, grip force, processing speed and executive function were significantly associated with retrospective falls, as well as the accelerometry-derived index of harmonicity (gait smoothness), strength of the signal's dominant frequency (measure of gait variability), movement intensity and locomotion duration. Prospectively, none of the questionnaire results was significantly associated with falls. Accelerometry-derived walking speed, standard deviation and range of the signal (measures of intensity), harmonic ratio (gait symmetry), local dynamic stability, and the duration of unclassified activities were significantly associated with prospective falls. The best prediction model for future falls comprised local dynamic stability, the duration of the unclassified activities and fall history. Using these variables, 84.1% of the non-fallers and 55.8% of the fallers were correctly classified. CONCLUSIONS Our results show that variables associated with falls differ between retrospective or prospective analyses. Moreover, the employed questionnaires were not able to discriminate between future fallers and non-fallers, while the accelerometry-derived variables could.

O.4.3 Development and validation of a fall risk assessment tool from the InCHIANTI study

Pierpaolo Palumbo[1], Luca Palmerini[2], Luca Cattelani[2], Marco Colpo[3], Federico Chesani[2], Stefania Bandinelli[3], Lorenzo Chiari[2]

[1]University of Bologna, [2]Universita' di Bologna, [3]Azienda Sanitaria di Firenze

BACKGROUND AND AIM: Falls in the elderly are a prominent problem of public health. Identifying subjects at high risk, fall risk assessment tools play a key role in fall prevention. Our aim is to derive a novel risk assessment tool exploiting the dataset of the InCHIANTI study. METHODS: InCHIANTI is an epidemiological study focusing on changes and loss of mobility associated with aging [1]. A cohort of 1453 people has been enrolled at baseline and underwent three subsequent visits covering globally a 9-year follow-up. At each follow-up, subjects were asked about the occurrence of any fall in the previous 12 months. In addition, information were collected on socio-demographic status, extensive clinical signs and symptoms and performance in a number of standardized tests. We extracted a total of 2319 observations from 977 subjects aged 65 or more. We wanted to predict whether a subject would fall or not in the subsequent follow-up employing the risk factors reviewed by Deandrea [2]. All the observations were randomly split into a training and a validation dataset. Missing values were multiply imputed. Feature selection was performed with stepwise logistic regression and majority vote. RESULTS: Among the 29 candidate, the selected variables were: history of falls, number of drugs, visual acuity at 3 m, physical activity level, CES-D, number of disabilities on activities of daily living, Mini Mental State Examination (MMSE) raw score, and the interaction between MMSE and number of drugs. The Hosmer-Lemeshow (HL) test [3] showed no significant miscalibration (no significant difference between observed and expected number of events in groups of people with similar estimated risk). The area under the ROC curve (AUC) is in the range 0.636-0.638 in the validation dataset. CONCLUSIONS: The discrimination achieved in terms of AUC is slightly superior or comparable to other traditional tools (Tinetti Balance, AUC 0.62 [4], Timed-Up-and-Go test, AUC 0.61-0.62 [5,6]) or tools derived from mining data from geriatric in-patients (AUC 0.63 [7]). Future developments are planned to extend the set of candidate predictors, including features from instrumented tests, to improve the prognosis of falls. ACKNOWLEDGEMENTS: The research leading to these results has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement FARSEEING n° 288940 and by Sovvenzione Globale Spinner 2013. REFERENCES: [1] Ferrucci, L. et al. J. Am. Geriatr. Soc. 48, 1618-25 (2000). [2] Deandrea, S. et al. Epidemiology 21, 658-668 (2010). [3] Hosmer, D. W. & Lemeshow, S. Applied logistic regression. (John Wiley & Sons, 2000). [4] Raîche, et al. Lancet 356, 1001-2 (2000). [5] Lin, M.-R. et al. J. Am. Geriatr. Soc. 52, 1343-8 (2004). [6] Morris, R. et al. Age Ageing 36, 78-83 (2007). [7] Marschollek, M. et al. BMC Med. Inform. Decis. Mak. 12, 19 (2012).

O.4.4 Risk-taking, physical ability and falls in older people

Stephen Lord[1], Annie Butler[1], Janet Taylor[1], Richard Fitzpatrick[1]

[1]Neuroscience Research Australia

BACKGROUND AND AIM: Among older people, undue risk taking could lead to falls, irrespective of physical function and ability. In this study we investigated the interaction between risk-taking behavior and physical ability and its contribution to falls. METHODS: Participants (n=294, age≥70) were asked to walk as quickly as possible to a visible destination by choosing one of six paths that contained a raised plank that had to be walked along without falling (Figure A). The paths were graded so that the shortest path had the narrowest and tallest plank, and the longest path had the widest and lowest plank. Thus, the destination could be reached by shorter difficult paths or longer easier paths. A "default" path was provided that was very long but safe. For safety, participants were stopped before crossing a plank. In lieu, the probability of falling from the plank (risk) was calculated from each participant's ability to walk within a narrow path on the ground. Participants were classified in to risk quartiles (low, moderate, high and very high) based on the level of risk taken. A questionnaire assessed perceptions of risk-taking

behavior. Physical function was tested to determine physiological falls risk and one-year prospective fall rates were recorded. RESULTS: Older participants and those with poor physical ability chose easier planks (r=-0.29 and 0.26 respectively, p<0.001) but took higher risks. Participants with good physical ability consistently took a slight risk whereas poor performers took either overly risky or overly safe paths. Self-reports of risk taking were inconsistent with the objective measure of risk as those reporting cautious behavior on questionnaire took greater risks with their choices. Risk taken was strongly associated with falls during the subsequent year, independent of physical performance (OR=2.87, 95% CI 1.5-6.0; Figure B). Increased fall risk was most evident in those with high physiological risk who made very high-risk choices, where 71% reported falls in the prospective follow-up. CONCLUSIONS: Risk-taking can be identified by assessing behavioral choice relative to physical ability but neither the difficulty of a chosen action nor self-reports of risk-taking behavior are sufficient. Risk-taking behavior is an independent factor for falls and management of undue risk-taking might complement existing fall prevention strategies. Figure A. Participant undertaking the raised plank choice task. Figure B. One-year prospective fall rates according to behavioral risk taken for participants with low and high physiological fall risk. Fall rates were highest for those who took very high risks and had a high physiological risk.

O.4.5 Kinematic analysis of real-life falls in older adults

Woochol Choi[1], Stephen Robinovitch[1]

[1]Simon Fraser University

BACKGROUND: Falls are the leading cause of injury in older adults, including more than 90% of hip fractures and wrist fractures, and 60% of head injuries. However, most falls do not result in serious injury, suggesting that protective mechanisms are common and separate injurious and non-injurious falls. We conducted kinematic analysis of video-captured falls in older adults, to examine mechanisms that influence markers of impact severity, including the hip and head impact velocities. METHODS: From a library of falls captured with video cameras in long-term care, we selected 21 backward falls experienced by 20 older adults (of mean age 80). We digitized hip, head, and hand landmarks from fall initiation to impact, and reconstructed these landmarks using a 2-dimensional direct linear transformation algorithm, using calibration data specific to the fall location and orientation. We then differentiated position data to determine vertical and horizontal velocities at impact. In lab-based falling experiments, the measurement error had a mean value of 0.16 (SD = 0.23) m/s. RESULTS: The vertical impact velocity averaged 2.13 m/s (SD = 0.64) for the hip, 2.60 m/s (SD = 0.80) for the head, and 2.95 m/s (SD = 1.74) for the hand. For eight falls involving both hip and head impact, the vertical impact velocity was 38% greater for the head than the hip (2.60 (SD = 0.80) versus 1.88 (SD = 0.45) m/s) (Figure 1, Sample velocity traces). For seven falls involving hip, head, and hand impacts, the hand impacted the floor first, followed by the hip and then the head. The average vertical descent distance of the hip during the fall was 0.81 m (SD = 0.17). The vertical hip impact velocities were, on average, 47.8 % below simple free-fall predictions based on fall height ((2gh)^0.5). In falls involving stepping responses, the vertical hip impact velocity was 5% lower (2.10 (SD = 0.57) versus 2.21 (SD = 0.81) m/s), and the head impact velocity was 16% lower (2.68 (SD = 0.84) versus 3.19 (SD = 1.64) m/s). The vertical hip impact velocity was 9.2% lower in falls involved hand impact (2.09 (SD = 0.61) versus 2.31 (SD = 0.86) m/s). CONCLUSIONS: Several mechanisms contributed to reducing impact severity during backward falls in older adults. Initial hand impact and attempts at balance recovery by stepping reduced head and hip impact velocity. Joint energy absorption during descent also likely contributed to hip impact velocities being less than half the magnitude of free-fall predictions. Pelvis impact always preceded head impact, and likely had a key role in reducing head impact velocity. While further studies are required to examine

such mechanisms that differentiate injurious and non-injurious falls in older adults, our results provide important baseline measures of fall severity for the design of interventions for fall injury prevention (e.g., hip protectors, helmets, and compliant flooring), and insights for the improvement of "safe landing" strategies during falling.

O.4.6 Perturbation training while walking improves Balance Control and voluntary stepping parameters in Community Dwelling Elders: A Randomized Control Trial

Ilan Kurz[1], yoav Gimmon[2], Ronen Debi[3], Itzhak Melzer[2]

[1]Ben Gurion University, Beer-Sheva, Israel, [2]Ben Gurion University Of The Negev, [3] Barzilai Medical Center

BACKGROUND AND AIM: Age-related deterioration of gait and balance increases the risk of falls. Fall related injuries are a serious public health problem in terms of costs to society human suffering. Most fall prevention training programs dont include perturbation training while walking in their protocol thus ignoring the important aspect of training postural recovery reactions during gait. We propose a novel training program using an innovative Balance Measure and Perturbation system (BaMPer system) that combines unexpected perturbation of balance during walking. Our aim was to evaluate the effect of perturbation training while walking on balance and voluntary step functions in independent older adults. We hypothesized that the novel training program can improve Balance while standing as well as during voluntary stepping and decrease the fear of falling. METHOD: A Randomized Controll Trial of 57 elderly persons. The intervention group received 24 training sessions over three months that included unexpected perturbations during treadmill walking. The pertubations level progressed according to each subjects abilities. The control group received similar intervention including dual task exercises while walking but with no perturbations. Postural Stability in upright standing (e.g. sway prameters) and voluntary step execution during single and dual task conditions (e.g. reaction and step times) were evaluated using force plate (Kistler Ltd) before and after the intervention. RESULTS: Forty volunteers completed the 12 week training program (twice a week for 20 minutes) with seventeen drop outs (9 in the experimental and 8 in the controls). Results show significant improvement among both experimental and control groups. The experimental group showed significant improvement compare with the control in: postural sway parameters especially in the eyes closed condition and voluntary step execution times in both single and dual task conditions. Compensatory stepping reactions during walking and standing and fall rates in the following year are currently analyzed. CONCLUSIONS: Current results are promising, suggesting that significant benefits can be achieved using a specific and personally tailored training program that includes unexpected perturbations of balance while walking. This training program can improve several markers of balance control previously found to be related to increased fall and injury risk in older adults. Those benefits could not be attributed to walking alone and even to walking while preforming a secondary cognitive task. Further work is needed to determine whether a maintenance training program would help retain the training effects and to assess whether these benefits reduce falls in daily life.

O.5.1 The Immediate Effect of Subthalamic Deep Brain Stimulation on Sensory and Motor Aspects of Postural Control

Helen Bronte-Stewart[1], Lauren Shreve[1], Kaila Leck[1]

[1]Stanford University Medical Center

BACKGROUND AND AIM: We have reported that chronic subthalamic nucleus (STN) deep brain stimulation (DBS) improves abnormal sensory aspects of postural control and postural movement velocity but not postural reaction time in people with Parkinson's disease (PDs, Shivitz N et al. 2006). Our aim was to investigate the immediate effect of STN DBS on sensory and motor aspects of postural control in PD. METHODS:141 PDs with STN DBS consented to posturography (Neurocom Inc, Clackamas OR) using the Sensory Organization Test (SOT) and the Limits of Stability (LOS) test, and the Unified Parkinson's Disease Rating Scale motor (UPDRS III) immediately before and one hour after initial activation of bilateral STN DBS, in the off medication/OFF DBS (off/OFF) and off/ON states. Long-acting medication was stopped >24 and short-acting >12 hours before testing. In the SOT subjects attempt to maintain upright stance during normal and altered sensory feedback; in the LOS subjects lean in 8 different directions towards a visual target on a GO cue. Statistical analysis consisted of two-tailed paired t-tests or Wilcoxon signed rank test (SigmaPlot, Systat Software Inc, San Jose CA.) RESULTS: N = 141 PDs; age 61.7 +/- 9.0 years. The immediate effect of STN DBS was improvement in UPDRS III ($p<0.001$) and in the modified axial subscore (MAS, arising from chair, posture and postural stability, $p<0.001$). For the whole group SOT5 and SOT6 (SOT5/6) equilibrium scores improved ($p<0.001$) with fewer instances where they had to take a step to maintain balance (SOT=0, $p<0.001$ SOT5, $p=0004$ SOT6). Other SOT conditions did not change. When PDs were divided into ABNormal (<5% controls, N=80) versus Normal groups based on SOT5/6 in the off/OFF state, the SOTABN group improved in SOT5/6 ($p<0.001$) with fewer SOT=0 scores ($p<0.001$) whereas the SOTN group did not change. No difference between groups in age or UPDRS III. 112 PDs completed the LOS off/OFF and off/ON. The immediate effect of STN DBS was an improvement in postural reaction time and movement velocity, endpoint and maximal distance leaned in all directions except backwards ($p<0.05$). Directional control decreased ($p<0.05$). CONCLUSIONS: The immediate (after one hour) effect of STN DBS was an improvement in CoG sway in sway referenced with no or incongruent visual feedback conditions and in postural reaction time, movement velocity and distance leaned in all directions except backwards. There was a difference in the effect of DBS based on baseline SOT phenotype. Those with normal SOT5/6 showed no change ON DBS, whereas those with ABNormal SOT5/6 improved, suggesting the pathophysiology of postural instability in such conditions is in part due to altered sensorimotor control in corticobasal ganglia sensorimotor networks. The decrease in directional control (less straight sway path) may reflect trunkal dyskinesia, which is not uncommon in early stages of STN DBS.

O.5.2 Training-related improvements in step initiation using self-triggered sensory cueing reveals different expressions of start hesitation in persons with Parkinson?s disease

Robert Creath[1], Michelle Prettyman[2], Mario Inacio[2], Lisa Shulman[1], Marjorie Hilliard[3], Katherine Martinez[3], Colum MacKinnon[4], Marie-Laure Mille[3], Tanya Simuni[3], Jane Zhang[3], Mark Rogers[2]

[1]University of Maryland Medicine, [2]University of Maryland School of Medicine, [3]Northwestern University Feinberg School of Medicine, [4]University of Minnesota

BACKGROUND AND AIM: Start hesitation related to freezing of gait in Parkinson's disease (PD) is proposed to occur because the control relationship between anticipatory postural adjustments (APAs) and stepping is deficient. Recent results indicate that a novel type of step initiation training improves modulation of vertical (V) and anterior-posterior (AP) horizontal (H) ground reaction forces (GRFs), but individual results suggest that hesitation is expressed differently in the PD population. This analysis seeks to characterize start hesitation during step initiation in order to better understand the motor variability observed in the PD population. METHODS: Two PD groups received 6 weeks of self-initiated

step training for one of two stimulus conditions: 1) Drop. The stance side support surface dropped 1.5cm to enhance pre-stepping lateral weight shift; 2) Vibration. A 100ms vibratory timing cue stimulus was applied beneath the stance side support surface. Both stimuli were subject-triggered by a 5% reduction in vertical force under the stance foot during pre-stepping lateral weight shift. Testing was at baseline, post-training, and 6 weeks post-training. Measurements included timing and magnitude of AP V and H GRFs, force impulse, and step-by-step correlations between V and H GRFs for the time-normalized APA-stepping sequence. RESULTS: The vibration group showed a 79% increase in APA VGRFs beneath the stepping-foot from APA onset to peak force, and a 81% decrease in APA force loading, both of which were retained post training. APA changes were accompanied by increases in stepping speed (55%) and step length (39%). PDs produced lower peak HGRFs than healthy elderly subjects (HEs). Both PD groups showed increases in peak HGRFs after training, as well as slower times to reach peak force. PD values for stance-foot force impulse were significantly lower for the stepping foot than for HEs. The drop group showed high correlations between V and H GRFs for early APAs (r=.85-.90) and low correlations at step onset for the stepping foot, but consistently high stance foot correlations for the entire APA-stepping sequence (>.80). Training was ineffective in altering drop group correlations. At baseline, the vibration group showed stepping foot correlations similar to HEs, but stance foot correlations similar to the drop group. Training increased vibration group correlations for the stepping foot at step onset (.90-.98), but reduced the correlations for the stance foot except at APA onset (.98) and stance lift-off (.95). CONCLUSIONS: Self-triggered sensory-cued training improves step initiation in persons with PD. Start hesitation is expressed differently within the PD population as indicated by different deficits for V and H GRFs, as well as for correlations between V and H GRFs. The results suggest that training should be tailored to the individual's needs depending on the nature of the deficit.

O.5.3 Quantitative functional reach in high risk individuals for Parkinson´s disease

Sandra Hasmann[1], Markus Hobert[1], David Weiss[1], Christian Bormann[1], Johannes Streffer[2], Inga Liepelt-Scarfone[1], Daniela Berg[1], Walter Maetzler[1]

[1]University Hospital of Tübingen, [2]Janssen Research and Development, Janssen-Pharmaceutical Companies of Johnson & Johnson, Beerse, Bel

Background and Aim: There is preliminary evidence that subtle motor changes occur in Parkinson's disease (PD) even years before clinical diagnosis is possible. Quantitative assessment of prodromal motor signs of PD thus may have the potential to eventually enable diagnosis earlier as it is currently possible. To detect these subtle motor changes, challenging assessment strategies seem to be more effective than convenient conditions (Maetzler et al., 2012; Mirelman et al., 2011). The functional reach (FR) test is a clinical measure of balance and margin of stability (Duncan et al., 1990), which has been proven to discriminate between PD patients and controls (Smithson, 1998). Based on this observation we were interested in the potential of the FR to detect differences between individuals with an increased risk for PD, and controls. We used an instrumented version to get also information about sway characteristics in this extreme balance position. Methods: In this cross-sectional analysis we investigated quantitative FR parameters in 13 patients with PD, 13 controls and 31 individuals at high risk for PD (HR). High risk for PD was defined by hyperechogenicity of the substantia nigra on transcranial sonography and either one motor sign (e.g. slight bradykinesia) or two of a set of well-established risk and prodromal markers of PD (positive family history, depression, hyposmia, one-sided reduced arm swing). All participants were asked to reach with their right arm forward as far as possible and hold this position for 10 seconds. During this period sway parameters were assessed with an accelerometer (Dynaport®, McRoberts, The Hague, The Netherlands) worn at the lower back (L4/5). The statistical approach was as

follows: parameters which differed significantly between PD patients and controls were included in a model to differentiate HR from controls. Results: Parameters which differed significantly between PD patients and controls were FR distance (shorter in PD) as well as acceleration in the anterior-posterior (lower in PD) and medio-lateral direction (larger in PD). When using these three parameters for a model to differentiate HR from controls, the area under the curve yielded 0.72, with a sensitivity of 45% and a specificity of 92%. Conclusion: Results suggest that the instrumented version of the FR introduced here has some potential to differentiate HR from controls. Longitudinal observation of the study cohort will prove whether it is indeed predictive for future PD.

O.5.4 Functional neuroimaging of prefrontal cortex in Parkinson?s disease: effects of cognitive task during seated and standing postures.

Graham Kerr[1], Mark Muthalib[1], Roger Pegoraro[1], Luisa Roeder[1], Tim Piatkowski[1], Ian Stewart[1], Simon Smith[1]

[1]Queensland University of Technology

BACKGROUND AND AIM: Cognitive impairment, particularly of executive function and attention, is prevalent in people with Parkinson's disease (PD). Reduced cognitive function, particularly executive function, has been associated with poorer quality of life, decreased activities of daily living and increased balance and gait disturbance. The concurrent performance of cognitive tasks, while standing or walking has also been shown to increase postural instability. Neural circuits involving activation of prefrontal cortex and involved in executive function are thought to be critical for control of balance and gait. The aim of this study was to utilise functional near-infrared spectroscopy imaging to determine how prefrontal cortex activation is affected during concurrent cognitive and balance tasks. METHODS: We utilised functional near infra-red spectroscopy (fNIRS) to examine pre-frontal cortex alterations in concentration of oxy- (O2Hb) and deoxy-haemoglobin (HHb) in cerebral microcirculation blood vessels during performance of a cognitive task (verbal fluency) involving executive function. During this task participants were either seated or standing quietly on a force plate (Hur Labs, 100Hz). Groups of early stage Parkinson's disease and healthy control participants were assessed according to the following protocol repeated 5 times during sitting and standing: Baseline (30s), Verbal Fluency (30s), Recital of days of the week (30s). RESULTS: Both the control and the PD groups had similar performance in the verbal fluency and the week day recital tasks. In the control group, neuronal activation during the verbal fluency task (relative to baseline) caused an increase in regional blood flow (i.e., neurovascular coupling), which was characterised by an increase in O2Hb and a decrease in HHb in the right dorsolateral prefrontal cortical (DLPFC) region during the seated condition. These changes were observed in the DLPFC bilaterally during the standing condition. For the PD group during the verbal fluency task there was a bilateral increase in DLPFC O2Hb during the seated condition but this was greatly reduced in amplitude. During the standing condition there was negligible change in DLPFC O2Hb in both hemispheres for PD participants. There was negligible change in O2Hb during the week day recital task for both groups. CONCLUSIONS: These changes in O2Hb indicate that PD participants have reduced activation of the DLPFC during the performance of cognitive tasks involving executive function. Furthermore, during standing, activation of the DLPFC is further reduced, in contrast to control participants who have increased bilateral activation. This indicates that people with PD have either reduced activation of the same neural circuits or utilise different neural circuits to complete these tasks.

O.5.5 The effect of concurrent cognitive loading and asymmetric walking in patients with Parkinson`s disease with and without freezing of gait

Farshid Mohammadi[1], Zrinka Potocanac[1], Sjoerd Bruijn[2], Sabine Verschueren[1], Alice Nieuwboer[1]

[1]KU Leuven, [2]VU University Amsterdam

Background and aim: Freezing of gait (FOG) is known to occur in situations that pose environmental constraints or require elevated attention demands such as dual-tasking. Moreover, asymmetric demands on gait are strongly associated with FOG. The interaction between these motor and cognitive components of FOG is not well understood. The purpose of this study was therefore to investigate the effect of normal and asymmetric walking on cognitive performance in freezers, non-freezers and healthy controls. Furthermore, we evaluated if the concurrent cognitive loading and asymmetric walking would lead to FOG. Methods: Twenty-two patients with Parkinson`s disease (10 freezers and 12 non-freezers; matched for executive function (MoCA), disease severity and duration, OFF-medication) and 12 age-matched controls participated in the study. Cognitive performance was evaluated using an auditory Stroop task, including congruent (identical word and pitch) and incongruent (different word and pitch) stimuli during sitting, normal walking (3 km/h) and asymmetric walking (one belt at 3 and the other at 4 km/h) on a split-belt treadmill. The duration of each condition was 2 min. To test the differences in cognitive performance between sitting, normal walking and asymmetric gait, 3 × 3 (Group × Condition) repeated measures ANOVAs were performed on accuracy and reaction time of the stimuli. Results: Analysis showed that there was no significant difference in Stroop performance in terms of accuracy and reaction time between groups in sitting ($p > 0.05$). In response to the incongruent stimuli, a significant Group by Condition interaction was seen for accuracy and reaction time ($p = 0.02$ and $p = 0.03$, respectively). During normal walking, freezers and non-freezers similarly increased error rates in response to the incongruent stimuli, compared to the sitting condition ($p = 0.03$). When gait became asymmetrical, only freezers further increased their error rates and reaction times for responses to the incongruent stimuli, compared to their normal walking condition ($p = 0.01$ and $p = 0.02$, respectively). During the whole experiment, one episode of freezing of gait occurred during normal walking and simultaneously carrying out the Stroop task. Conclusions: During asymmetric walking, freezers rely on attention more than non-freezers, as shown by deteriorated dual task performance.

O.5.6 Balance and Gait Rehabilitation in Patients with Cerebellar Damage of Vascular or Degenerative Origin

Anna Turcato[1], Marco Godi[1], Marco Schieppati[2], Antonio Nardone[1]

[1]Fondazione Salvatore Maugeri (IRCCS), Scientific Institute of Veruno, [2]Fondazione Salvatore Maugeri (IRCCS), Scientific Institute of Pavia

Background and aim: Cerebellar damage typically leads to ataxia with limb incoordination and unsteadiness of gait and balance, increasing the risk of falls (1,2). As pharmacological treatment appears to have little effect on ataxia (3), rehabilitation represents an alternative to help reduce motor impairment (4,5,6). However, studies on the effects of rehabilitation in these patients are few and the results somewhat limited and controversial (6). Our purpose was to investigate whether the response to rehabilitation differs between patients with abnormalities of balance and gait due to vascular or to degenerative cerebellar disease. Methods: We reviewed the outcome of 27 cerebellar patients, 14 with vascular and 13 with degenerative cerebellar disease. Subjects underwent a 3-week inpatient physical therapy program for 5 days/week, for a maximum of 90 min/day, focused on balance and gait. Body

sway area during quiet stance with eyes open and eyes closed, and gait velocity, stride length, cadence and step width were recorded. The Berg Balance Scale (BBS) and Functional Independence Measure (FIM) were administered. All measures were performed before and after treatment. Results: Before treatment, both groups showed comparable values in all sway and gait variables and in BBS. FIM score was higher in degenerative than vascular patients. After treatment, a significant reduction of body sway area was observed under both visual conditions in both groups. Gait velocity, stride length and step width improved more in the vascular than in the degenerative patient group. BBS improved in both groups whilst FIM improved to a larger extent in the vascular patients. Conclusions: Short-term treatment may not be sufficient to produce definite improvement in locomotion in degenerative as much as in vascular patients, even if clinical and functional signs of balance improve in both groups. Possibly, vascular and degenerative patients require different and even personalized rehabilitative treatment in order to get the best results. References: 1. Morton, S.M. and Bastian, A.J. (2007). Cerebellum, 6 (1): 79-86. 2. Van de Warrenburg, B.P. et al. (2005). Mov Disord, 20 (4): 497-500. 3. Trujillo-Martín, M.M. et al. (2009). Mov Disord, 24 (8): 1111-1124. 4. Bultmann, U. et al. (2013). Gait Posture, doi:pii: S0966-6362(13)00606-1. 5. Ilg, W. et al. (2010). Mov Disord, 25 (13): 2239-2246. 6. Martin, C.L. et al. (2009). Clin Rehabil, 23 (1): 15-26.

O.5.7 Vestibulo-cerebellar influences on gait control

Klaus Jahn[1], Roman Schniepp[1], Max Wuehr[1], Sabrina Huth[1], Cauchy Pradhan[1], Thomas Brandt[1]

[1]University of Munich

Background: Downbeat nystagmus (DBN) is a common form of acquired fixation nystagmus with key symptoms of oscillopsia and gait disturbance. Gait disturbance could be a result of impaired visual feedback due to the involuntary ocular oscillations. Alternatively, a malfunction of cerebellar locomotor control might be involved, since DBN is considered a vestibulocerebellar disorder. Methods: Investigation of walking in 50 DBN patients (age 72 ± 11 years, 23 females) and 50 healthy controls (HS) (age 70 ± 11 years, 23 females) using a pressure sensitive carpet (GAITRite®). The patient cohort comprised subjects with only ocular motor signs (DBN) and subjects with an additional limb ataxia (DBN). Gait investigation comprised different walking speeds and walking with eyes closed. Results: In DBN, gait velocity was reduced ($p<0.001$) with a reduced stride length ($p<0.001$), increased base of support ($p<0.05$) and increased double support ($p<0.001$). Walking with eyes closed led to significant gait changes in both HS and DBN. These changes were more pronounced in DBN patients ($p<0.001$). Speed-dependency of gait variability revealed significant differences between the subgroups of DBN and DBN ($p<0.05$). Conclusions: (I) The gait of patients with DBN is impaired due to a disturbed balance control. (II) Impaired visual control caused by involuntary ocular oscillations cannot sufficiently explain the gait disorder. (III) Analysis of gait variability allows distinguishing DBN from DBN : Patients with DBN only show a speed dependency of gait variability similar to that of patients with afferent vestibular deficits. In DBN , gait variability resembles the pattern found in cerebellar ataxia.

O.5.8 Post-stroke lower limb spasticity alters the interlimb spatial and temporal synchronisation of centre of pressure displacements across multiple timescales

Jonathan Singer[1], George Mochizuki[1]

[1]Sunnybrook Research Institute

BACKGROUND AND AIM: Standing balance requires the ability to regulate centre of pressure (COP) displacements from each lower limb. As the sensorimotor consequences of stroke are most often unilateral, the ability to regulate muscle force output from the affected limb is altered (Teixiera-Salmela, 1999), which further complicates the maintenance of stability (Mansfield, 2012). A prominent sensorimotor consequence of stroke is spasticity - a velocity-dependent increase in tonic stretch reflexes. Our previous research has suggested that stroke survivors with lower limb spasticity face additional balance control challenges, due to impairments in between-limb temporal synchronisation of COP displacements. The present work sought to advance the understanding of the influence of lower-limb spasticity on standing balance. To further probe the determinants of the observed challenges in between-limb temporal synchronisation, the present work examines indices of inter-limb temporal synchrony and spatial symmetry of COP displacements across multiple timescales. We hypothesised that individuals with lower limb spasticity would exhibit reduced interlimb spatial and temporal synchronisation of COP displacements among the higher frequency components in the COP time series (>0.40 Hz), indicative of challenges executing rapid reactive balance corrections. METHODS: 91 stroke survivors were retrospectively categorized into two groups with (n=33) and without (n=58) lower limb spasticity of the knee and/or ankle, as assessed using the Modified Ashworth Scale. Individual-limb and net-COP displacements in the anteroposterior direction were calculated during 30 seconds of quiet-standing on adjacent force platforms. The Daubechies (db2) wavelet function was used to perform an 8 level decomposition of the COP time series from each limb. Interlimb temporal synchrony and spatial symmetry were assessed at each timescale using cross-correlation and RMS amplitude ratios, respectively. RESULTS: There was a group-by-decomposition-level interaction for both temporal synchrony, $F(8,712)=2.10, p=0.03, \eta p^2=0.02$, and spatial symmetry, $F(3.50,311.55)=3.42, p=0.013, \eta p^2=0.04$. Follow-up independent samples t-tests at each level revealed reduced cross-correlation coefficients at zero phase lag for the group with spasticity at levels D2-D6 (6.25-0.20 Hz). Further, follow-up independent samples t-tests at each level revealed reduced RMS COP ratios among the group with spasticity at levels D4 and D6 (1.56-0.78 Hz; 0.40-0.20 Hz). CONCLUSIONS: Our results suggest that balance dyscontrol among individuals with post-stroke lower limb spasticity may arise from reductions in both spatial and temporal synchronisation of COP frequency components associated with the more rapid balance corrections. Given the potential impairment of reactive contributions to stability control, individuals with spasticity may be less able to respond to balance perturbations and may experience increased fall risk.

O.6.1 Quantifying Individual Components of the Timed up and Go Using the Kinect in People Living with Stroke

Ross Clark[1], Stephanie Vernon[1], Kelly Bower[2], Kade Paterson[2], Jennifer McGinley[2], Kimberley Miller[3], Yong-Hao Pua[4]

[1]Australian Catholic University, [2]University of Melbourne, [3]University of British Columbia, [4]Singapore General Hospital

Background and Aim: Analysing the movement strategies used by people living with stroke as they perform functional tasks may provide additional and independent information which cannot be derived from standard single-outcome clinical tests. The Microsoft Kinect is a simple, inexpensive and portable method of examining the independent components of the Timed Up and Go (TUG) without any intrusion on the patient. This study examined the reliability of these measures, and whether they improved prediction of performance on common clinical tests. Methods: Thirty individuals living with stroke (age = 68 ± 15 years, height = 166.7 ± 9.4 cm, mass = 72.5 ± 11.9kg, 73% infarct and 63% right side lesion, time

since stroke = 21 ± 19 months) completed four clinical assessments including the TUG, 10m walk test (10MWT), Step Test and Functional Reach test on two testing occasions. The TUG was assessed using the Kinect to determine seven different functional components, specifically peak trunk flexion angle during standing, peak trunk flexion angular velocity during standing, first step length, first stride length, gait speed, turn time and total TUG time. Test-retest reliability was assessed using intraclass correlation coefficient (ICC), redundancy using Spearman's correlation, and score prediction on the clinical tests using multiple regression. Results: All Kinect-TUG variables possessed excellent reliability (ICC(2,k)>0.90) except trunk flexion angle (ICC=0.73). Trunk flexion angle and first step length were non-redundant with total TUG time. When predicting 10MWT and Step Test scores, adding step length into regression models comprising age and total TUG time improved model performance by 7% (P<0.01) and 6% (P=0.03), respectively. Specifically, an interquartile range increase in first step length (0.19m) was associated with a 0.15m/s faster gait speed and 1.8 more repetitions on the Step Test. These effect sizes were comparable to our minimal detectable change scores of 0.17m/s for gait speed and 1.71 repetitions for the Step Test. Conclusions: Our results suggest that instrumenting the TUG using a Kinect can provide reliable measures of a range of distinct components of the test. These additional variables could provide unique and important information about a patient's physical function when compared with the commonly reported time taken to complete. Given the low cost and widespread availability of the Kinect system, this tool may provide a means for conducting large scale clinical assessments of physical function and potential falls risk following stroke.

O.6.2 Estimating gait characteristics from accelerometer recordings - agreement between sensor locations

Sietse Rispens[1], Mirjam Pijnappels[1], Kimberley van Schooten[1], Peter Beek[1], Andreas Daffertshofer[1], Jaap van Dieën[1]

[1]VU University Amsterdam

BACKGROUND AND AIM: Estimates of gait characteristics may suffer from error due to discrepancies in accelerometer location. This is particularly problematic for gait measurements in daily life settings, where consistent sensor positioning is difficult to achieve. We therefore investigated the effect of sensor location on estimates of gait characteristics derived from trunk accelerations. METHODS: We equipped 21 healthy adults with tri-axial accelerometers at the mid and lower lumbar spine and anterior superior iliac spine (L2, L5 and ASIS) while continuously walking back and forth (20 times) over a distance of 20 meters outdoors. We compared 35 gait characteristics between sensor locations by absolute agreement intra-class correlation (2, 1; ICC). We repeated these analyses after applying a new method for off-line sensor realignment providing a unique definition of the vertical and, by symmetry optimization, of the two horizontal axes. RESULTS: Agreement between L2 and L5 after realignment was excellent (ICC > 0.9) for stride time and frequency, speed and their corresponding variability and good (ICC > 0.7) for stride regularity, movement intensity, gait symmetry and smoothness and for local dynamic stability. Sensor realignment had a benificial effect on the ICC values. Agreement between ASIS and the lumbar locations was less strong, in particular for gait characteristics like symmetry, smoothness, and local dynamic stability (ICC generally < 0.7). This lumbar-ASIS agreement did not benefit consistently from sensor realignment. CONCLUSIONS: Our findings show that gait characteristics are robust against limited repositioning error of sensors at the lumbar spine, in particular if our off-line realignment is applied. However, larger positioning differences (from lumbar positions to ASIS) yield less consistent estimates and should hence be avoided.

O.6.3 Wavelet-based functional ANOVA to reveal statistically-significant contrasts between EMG and kinematics recorded in different experimental conditions

Johnathan McKay[1], Torrence Welch[2], Brani Vidakovic[2], Lena Ting[2]

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

BACKGROUND AND AIM: We often want to compare the shapes of waveforms that are functions of time such as EMG or kinematic data, but traditional statistical tests cannot reveal differences between curves without sacrificing temporal resolution or power. Waveform features identified with visual inspection may not be revealed by t-tests or ANOVA applied across time points due to the large number of comparisons, requiring the experimenter to identify features or time periods of interest. We developed wavelet-based functional ANOVA (wfANOVA) to solve this problem. In wfANOVA, ANOVA is performed in the wavelet domain because differences between curves tend to be represented by a few temporally localized wavelets. Differences are then transformed back to the time domain for visualization. In a previous study, we used standard statistical techniques to identify variation in EMG signals during automatic postural responses to perturbations as the peak acceleration and peak velocity of the support surface translation perturbation were varied (Welch and Ting, J Neurophysiol 2009). The aim of the present work was to compare the ability of wfANOVA and ANOVA performed in the time domain (tANOVA) to identify similar patterns of variation without requiring the experimenter to assume features or time bins a priori. For generality, we also demonstrate applications of wfANOVA to kinematic data. METHODS: We applied wfANOVA and tANOVA to EMG waveforms recorded during translation perturbations of the support surface designed so that platform peak acceleration and peak velocity could be varied independently (acceleration: 3 levels; velocity: 4 levels). In wfANOVA, EMG waveforms were transformed to the wavelet domain and analyzed with three-factor fixed-effects ANOVA. Wavelet coefficients with significant initial F-tests ($P<0.05$) were evaluated for significant contrasts across velocity or acceleration levels with post-hoc Scheffé tests. Wavelet coefficients retained after post-hoc were then assembled into wavelet-domain contrast curves and transformed back to the time domain. In tANOVA, an identical analysis was performed in the time domain. RESULTS: In experimental EMG data, wfANOVA revealed the continuous shape and magnitude of significant differences over time consistent with previously described scaling relationships without a priori selection of time bins. However, tANOVA revealed only the largest differences at discontinuous time points, resulting in features with later onsets and shorter durations than those identified using wfANOVA ($P<0.02$). wfANOVA required significantly fewer ($<1/4$; $P<0.015$) significant F-tests than tANOVA, resulting in post hoc tests with increased power. CONCLUSIONS: wfANOVA may be useful for revealing differences in the shape and magnitude of neurophysiological signals (e.g., kinematic and kinetic data, EMG, M- and H-waves, firing rates) across multiple conditions with both high temporal resolution and high statistical power.

O.6.4 Defining optimal filtering frequencies in electromyographic signal contaminated with movement artefact.

Stephanie Smith[1], Daniel Rafferty[1], Scott Telfer[1], James Woodburn[1], Martijn Steultjens[1]

[1]Glasgow Caledonian University

Background and aim: Electromyography (EMG) signal during physical activity contains both EMG and noise. Noise is electrical signal from our environment that contaminates and corrupts the true EMG signal, is unavoidable and potentially leads to erroneous interpretations. To improve quality, EMG data is commonly filtered to reduce movement artefact. However, it is unclear from the wide spectrum of

corner frequencies, what the most effective frequency is to remove as much movement artefact as possible whilst retaining as the EMG signal. The purpose of this study was to quantify movement artefact during gait and consequently determine optimum corner frequencies for filtering. Optimal corner frequency refers to the frequency which removes as much movement artefact as possible whilst retaining as much of the original EMG signal as possible. Methods: EMG and triaxial accelerometer data were collected from the vastus medalis (VM), rectus femoris (RF) and medial gastrocnemius (MG) of the dominant leg from ten healthy males and females. Participants performed 6 walking trials at self-selected normal speed and 3 maximal voluntary isometric contractions (MVIC). The frequency spectrums were calculated for the acceleration and EMG signals with a 0.904s window. Group mean optimal corner frequencies were calculated from individual mean percentages of noise from movement artefact removed, total EMG signal lost and optimal corner frequencies. Figure 1 depicts an algorithm for defining optimal corner frequencies, with stage by stage schematic representation of raw EMG and acceleration signal (A), individual trial FFT (B), individual average FFT (C), individual percentage of acceleration removed and total EMG signal retained (D), and individual optimal corner frequency ? and mean optimal corner frequency for the cohort. Results: The total EMG signal and noise from movement artefact were highly variable within and between individual participants, with no single corner frequency found to optimally fit all muscles or test conditions without inadequately removing noise from movement artefact or substantially removing total EMG signal. Filtering at 10, 20, 30 Hz removed between 70 and 99% of the movement artefact signal however this has to be counter balanced in that between 0 and 35% EMG signal was removed. However, within muscle groups during similar activities muscle activation appears to be alike and as a result may show similar corner frequencies. Using the algorithm shown the optimal corner frequencies for filter for VM, RF, and MG were determined to be 28, 29, 22 Hz respectively. These resulted in 90, 89 and 95% of the artefact being removed respectively whilst retaining 90, 86 and 95% of the EMG signal. Conclusion: For optimal removal of noise from movement artefact, different corner frequencies should be used dependent on muscle and type of activity.

O.6.5 Electrical vestibular stimulation for the clinic: enhancing vestibulo-motor output and improving subject comfort

Patrick Forbes[1], Christopher Dakin[2], Anoek Geers[1], Martijn Vlaar[1], Riender Happee[1], Gunter Siegmund[3], Alfred Schouten[1], Jean-Sébastien Blouin[2]

[1]Delft University of Technology, [2]University of British Columbia, [3]MEA Forensic Engineers & Scientists

BACKGROUND AND AIM: Electrical vestibular stimulation is often used to assess vestibulo-motor and postural responses. It has found popularity as a research tool [1] but is rarely used clinically [2,3]. Stochastic vestibular stimulation (SVS) is a recently established technique with many advantages over its square-wave counterpart [4]; however, the evoked responses remain relatively small. Although vestibular-evoked responses can be enhanced by increasing the stimulus amplitude, subjects often perceive higher intensity electrical stimuli as noxious or painful [5]. The aim of the current study was to develop multisine vestibular stimulation (MVS) signals that include precise frequency contributions to increase signal-to-noise ratios (SNR) of stimulus-evoked muscle and motor responses. METHODS: Subjects (n=8) stood on a force plate with their head rotated left 90° while exposed to three different MVS and one SVS stimuli (all 0-25 Hz; Fig. 1A). Surface EMG was collected from the right medial gastrocnemius. The first MVS signal (MVS-S) excited all 62 frequencies from 0.4-24.8 Hz to show that MVS signals evoke equivalent vestibulo-motor responses compared to SVS while improving subject comfort and reducing testing time. The other two MVS signals excited a limited set of frequencies from

0.4-24.8 Hz including: 1) a uniform distribution of every fourth frequency (MVS-4; 16 frequencies) to show that stimulus-evoked vestibulo-motor responses are reliably estimated as a linear system, and 2) a logarithmic distribution focusing power at lower frequencies (MVS-L; 35 frequencies) to show that specific components of the time domain vestibulo-motor responses can be targeted by controlling the frequency content of the input MVS. Subjective measures of comfort were evaluated using a visual analogue scale where subjects rated the level of signal intensity and unpleasantness. RESULTS: Compared to SVS, MVS signals improved SNR by 3-6 times while lowering stimulus amplitudes. This in turn reduced the minimum required testing time by 85% and improved subjective measures of comfort by 20-80% (Fig. 1B). Coherence estimates between the input stimulus and motor output responses (EMG/force) increased with MVS (Fig. 1C) and vestibulo-motor responses were not substantially affected by nonlinear distortions. In addition, by limiting the contribution of high frequencies within a MVS stimulus, the magnitude of the medium latency time domain motor response was increased by 58% (Fig. 1C). CONCLUSIONS: These results demonstrate that MVS stimuli improve subjects comfort, reduce testing times and can be designed to target and enhance vestibulo-motor output responses. These methods should prove beneficial for basic research or in clinical settings when studying subjects with disturbed vestibulo-motor processing. REF: 1. Fitzpatrick et al. J. App. Phys. 2004, 2. Tax et al. Clin. Neurophys. 2013, 3. Iles et al. Brain 2004, 4. Dakin et al. J.Phys. 2007, 5. Fitzpatrick et al. J.Phys. 1994

O.6.6 A four domain model of gait in older hip-fracture patients based on factor analysis

Pernille Thingstad[1], Espen A. Ihlen[1], Kristin Taraldsen[1], Jorunn Helbostad[1], Rolf Moe-Nilssen[2]

[1]Norwegian University of Science and Technology, [2]University of Bergen

BACKGROUND AND AIM: A variety of spatial and temporal gait characteristics are reported in the literature. At present there is little consensus on which gait characteristics should be reported and which are redundant. Such knowledge would be important when selecting outcome variables in intervention studies and to better understand how features of gait are related to underlying deficits and to guide intervention. Three to five distinct domains of gait have earlier been identified using factor analysis in relatively healthy community dwelling older adults, but there are few reports using a similar approach to identify independent domains of gait in older persons with impaired gait. METHOD: Two hundred and fifty four elderly hip-fracture patients who were home dwelling prior to the fracture, participating in The Trondheim Hip Fracture trial, mean age 83.3(6.0) and 74% women, were assessed for gait 4 months following surgery. Patients walked back and forth an 8m (4.66m active length) instrumented walkway (GAITRite) at preferred speed. Factor analysis (FA) was conducted on 15 gait variables with reference to earlier works which identified 3 to 5 distinct factors from similar variables (Lord et al, 2013, Holman et al 2011, Verghese et al, 2007). Meyer Olkin measure of sample adequacy was fairly good (0.71) indicating that factor analysis is useful. Number of factors was decided based on inspection of scree plot and eigenvalue > 1 . The factor loadings were identified by principal components analysis based FA with varimax rotations and with Kaizer's normalization. RESULTS: A four factor model explained 77.7 % of common variance. All variability parameters except step width variability clustered into one variability factor (30 %) and all asymmetry variables onto an asymmetry factor (22.3%). Temporal mean parameters clustered onto a timing factor (16.5%), while stride width and stride width variability clustered into a postural control factor(8.8%). CONCLUSION: In this population of hip fracture patients, variability, asymmetry and timing turned out to be three clearly distinct domains of gait. Both the variability and asymmetry factor explained relatively more of the variance in this population compared to a model based on a healthy population. Further speed and mean, coefficient of variation and asymmetry of step length cross loaded onto several of the factors suggesting that these parameters

represent a less distinct factor than reported in healthier populations. These results indicate that variability and asymmetry become more influential features of gait in populations with impaired gait and that the relevance of different domains of gait is dependent on the population of interest.

O.6.7 Subtle changes in gait domains over 18 months in Parkinson?s disease

Sue Lord[1], Brook Galna[1], Dadirayi Mhiripiri[1], David Burn[1], Lynn Rochester[1]

[1]Newcastle University

Background: A recently validated model of gait in older adults and in Parkinson's disease describes five distinct domains of gait associated with selective motor, cognitive and behavioural characteristics [1]. The model facilitates a structured approach to assessment of gait and aids interpretation of pathology, but has not been validated over time. Aim: To examine the change in the structure of a 5 domain model of gait over 18 months in PD and controls. Methods: Ninety-six people with incident PD (average age 69.2 +/- 8.7 years) were assessed at 18 month follow-up for 16 spatio-temporal gait variables using a 7m instrumented walkway (GAITRite) whilst walking for 2 minutes under single task conditions. Principal Components Analysis (PCA) and Factor Analysis (FA) 'varimax' procedure were used to examine relationships between variables. The follow-up model was compared with the original model derived from baseline assessment. Results: The same 5 gait domains emerged with comparable total variance explained (84.6 % original, 82.3 % follow-up). Subtle differences in loadings emerged for 3 of the 16 gait characteristics. Step time and stance time variability loaded onto pace not variability, and step length asymmetry loaded onto asymmetry not postural control. Amount of variance explained by each domain differed between models, with increase occurring predominantly in the pace domain (20.9% at baseline to 29.0% at follow up) (Fig 1). Discussion: A 5 domain model of gait is stable over 18 months in PD. The pace domain was strengthened by the addition of two temporal variability characteristics, which in the original model were split between variability and pace domains. Temporal variability is aligned with the pace domain whilst spatial variability is independent of it. In the 18 month model, step length asymmetry is more sensibly represented by the asymmetry domain. These findings reflect subtle change in gait pathology in PD over 18 months which impact on the factor structure, and in doing so enable a more thorough understanding of gait evolution in PD. Future 18 month follow-up analysis will be reported for n = 106 PD. Changes to the model over 18 months will also be reported for n = 100 healthy, age-matched controls. Reference: Lord S, Galna B and Rochester L (2013) Moving forward on gait measurement: Towards a more refined approach Mov Disord 28:13:1534-43.

O.6.8 Comparison of methods for the detection of freezing of gait (FOG) in patients with Parkinson's disease

Gwang-Moon Eom[1], Sang-Hoon Park[1]

[1]Konkuk University

BACKGROUND AND AIM Freezing of gait (FOG), typical in Parkinson's disease, is the symptom that patients are temporarily unable to initiate or continue locomotion. FOG is a common cause of falls in PD, interferes with daily activities, and significantly impairs quality of life. Visual, auditory and somatosensory cueing are reported to be more effective than conventional therapy in alleviation of FOG. Fast and reliable detection of FOG is important for the appropriate application of cueing when FOG occurs. Moore et al. [1] and Bächlin et al. [2] developed FOG detection systems which utilized the

frequency characteristics of acceleration at body parts. However, the practicality of the method is limited because Fourier transform used to derive frequency spectrum needs large amount of calculation. The purpose of this study was to compare the amount of calculation and also the performance of time-domain and frequency domain methods for the detection of FOG. METHODS Twenty two patients with Parkinson's disease (67.5±4.9 yrs) participated in this study. Three-axes acceleration at the heel of an insole were used for the detection of FOG. Subjects were instructed to repeatedly walk for 12m in their comfortable speeds. From the investigation of raw acceleration signals, we hypothesized that the mean amplitude of acceleration for a moving window may reside in a certain range if FOG occurred. Accordingly, time domain methods were designed so to recognize the time instant as FOG if the mean acceleration is in a certain range. Frequency domain methods were also tested for comparison. In both methods, the effect of the length of moving window (0.2s-8s) was investigated. The parameters of both methods were optimized for each patient by simulated annealing. The amount of calculation and the performance were compared among the detection methods. RESULTS The performance of the time domain method was comparable to that of frequency domain method. The speed advantage of time domain method were about 300 times of the frequency domain method. Window length affected the performance ($p<0.05$) and the best performance was achieved with 4s of window length. CONCLUSIONS We confirmed that the time domain method can improve the calculation speed up to 300 times of the frequency domain method, and with comparable performance. This may help the practicality of FOG detection by fast presentation of cueing. ACKNOWLEDGEMENTS This study was supported by the Ministry of Education, Science and Technology of Korea (No. 2011-0015824). REFERENCES [1] Moore ST, MacDougall HG, Ondo WG., "Ambulatory monitoring of freezing of gait in Parkinson's disease.," J, Neurosci, Methods. Vol. 167, No. 2, pp. 340-348, 2008. [2] Bächlin M, Plotnik M, Roggen D, Maidan I, Hausdorff JM, Giladi N, Tröster G., "Wearable assistant for Parkinson's disease patients with the freezing of gait symptom.," IEEE Trans. Inf. Technol. Biomed., Vol. 14, No. 2, pp. 436-446, 2010.

O.7.1 Differences in gait balance control recovery from concussion between adolescents and young adults

Li-Shan Chou[1], David Howell[1], Louis Osternig[1]

[1]University of Oregon

BACKGROUND AND AIM: Recent consensus statements have indicated adolescents may take more time to recover from concussion than young adults, but few studies compare these cohorts. As cortical development rapidly occurs during adolescence, these individuals may be more sensitive than adults to brain trauma, such as that which occurs during concussion. The purpose of this study was to examine how gait balance control is affected by concussion in young adult and adolescent age groups from the time of injury and throughout the two months following injury. METHODS: Twenty three adolescents (mean age 15.3 ± 1.2 years; 3 F) and 15 young adults (mean age 20.8 ± 4.7 years; 7 F) were identified as suffering a concussion. Each was tested within 72 hours as well as 1 week, 2 weeks, 1 month, and 2 months after injury. Each concussion subject was matched with a control subject by age, sex, and activity (adolescents n = 23, mean age 15.5 ± 1.1 years, 3F; young adults n = 15, mean age 21.1 ± 5.1 years, 7F) and completed the same protocol in similar time increments. 29 reflective markers were placed on bony landmarks and body movement was recorded using a ten camera motion analysis system. Whole body center of mass (COM) displacement and velocity were analyzed as subjects walked while completing a continuous auditory Stroop test. Total COM medial/lateral displacement (MLdisp) was identified during the gait cycle and MLdisp cost was calculated as the percent change for concussion

subjects in reference to their respective control group mean on MLdisp. A 2-way mixed effects ANOVA was used to analyze each dependent variable. A-priori independent t-tests were also used to examine the between group differences at the 72 hour time point. RESULTS: A main effect of group for MLdisp (p = .013) indicated adolescents with concussion displayed significantly more MLdisp than control subjects, and no significant differences between young adult groups. MLdisp cost analysis also showed no differences across time, but adolescents with concussion demonstrated greater change from controls within the first 72 hours of injury compared with young adults (p = .049, effect size d = 0.86). CONCLUSIONS: In reference to a matched control group on measures of gait balance control during dual-task walking, adolescents display a significantly greater initial deficit from concussion than young adults as well as deficits for up to two months compared with an age matched control group. Caution should be warranted in the diagnosis and assessment of recovery in the adolescent population, as dual-task ability following injury may be affected to a greater degree than young adults.

O.7.2 Spatial navigation in patients with cognitive impairment - assessed by the Floor Maze Te

Gro Tangen[1], Knut Engedal[2], Astrid Bergland[3], Anne Marit Mengshoel[1]

[1]University of Oslo, [2]Norwegian Centre for Ageing and Health, [3]Oslo and Akershus University College of Applies Sciences

Spatial navigation in patients with cognitive impairment - assessed by the Floor Maze Test
BACKGROUND AND AIM: Impairments in spatial navigation (the ability to plan and maintain a route from one place to another) and gait are considered to be early signs of Alzheimer's disease (AD). The Floor Maze test (FMT) combines a navigational task with walking[1], and we will in this study examine if the FMT scores differ between patients with Subjective Cognitive Impairment (SCI), Mild Cognitive Impairment (MCI) and mild AD. Further, we explore the relationship between performance on the FMT and cognitive tests, adjusted for demographic factors. METHODS: One hundred and twenty-seven patients were recruited from a memory clinic where they had been through a comprehensive diagnostic procedure. Eighteen patients were classified with SCI, 20 with MCI and 89 with mild AD. Spatial navigation was assessed by the FMT; a 7´ X 10´ maze made of white tape on blue carpet. The patients were shown the entry and the exit of the maze, and told to find their way through. Timed measures were 1) Planning time (PT): time from end of instructions to maze entry and 2) Immediate Maze Time (IMT): time from maze entry to exit. Wrong turns during walking were noted, and the performance of IMT was dichotomized into error-free vs. with error. Cognitive function was assessed by the Wordlist Learning Test, Clock Drawing Test, Trail Making Test (TMT) A and dichotomized score of TMT B (0=gave up/ time worse than -2SD of age-adjusted norms vs. 1 = time better than -2SD of norms) and the Mini Mental Status Examination (MMSE). RESULTS: The patients' mean (SD) age was 70 (8) years, 69 (54 %) were men and median (inter-quartile range) MMSE was 26.0 (4). Patients with SCI performed faster than patients with MCI on both PT (p=0.013) and IMT (p=0.021). There were no differences between patients with MCI and mild AD on PT or IMT. More error-free performance on the IMT was seen in patients with MCI than in patients with mild AD (p=0.007), there were no differences between SCI and MCI. Fourteen (11.1%) gave up to complete the IMT, all had mild AD. After adjusting for age, gender, education and gait speed, the logistic regression analyses identified the Wordlist learning test (OR=1.14, 95 % CI =1.02, 1.26) and the TMT B test (OR=4.35, 95 % CI = 1.57, 12.05) as independent predictors of error-free performance on the IMT. CONCLUSIONS: The results of the FMT did differ between our three groups with mild cognitive deficits. Error-free performance on the IMT was associated with learning part of memory and executive function, measured by the Wordlist learning test and TMT B. The FMT appears to be a promising tool to identify navigational deficits in patients with cognitive impairment. [1]Sanders AE,

Holtzer R, Lipton RB, Hall C, Verghese J. Egocentric and exocentric navigation skills in older adults. J Gerontol A Biol Sci Med Sci 2008;63:1356-1363.

O.7.3 Contributions of the Montreal Cognitive Assessment (MOCA) to Dual Task Gait Performance

Isabelle Killane[1], Orna Donoghue[2], George Savva[3], Hilary Cronin[2], Rose-Anne Kenny[2], Richard Reilly[4]

[1]Trinity College Dublin, [2]The Irish Longitudinal Study on Ageing, Trinity College Dublin, [3]University of East Anglia, [4]Trinity Centre for Bioengineering, Trinity College Dublin

BACKGROUND AND AIMS: Further understanding of the relationship between gait performance and cognitive domains, and their influence on global cognitive performance, might aid clinical assessment. Visuospatial executive (Vsexec) domains measured using the Montreal Cognitive Assessment (MOCA), a clinical screening tool for mild cognitive impairment, have been linked to functional status post Stroke(1). We explored the relative contributions of MOCA total score, domains and subscores to dual task gait performance in older adults. METHODS: Cross-sectional data was used from The Irish Longitudinal Study on Ageing (TILDA), a nationally representative population of older healthy adults (n=4658, 55% women, mean±sd: age; 62.4±8.2 years, MOCA: 25.20±3.26). Walking speed was recorded from a GAITRite® pressure sensing mat during two complex walks: cognitive walk (reciting alternate letters), motor walk (carrying a glass of water). MOCA total score, MOCA groups, eight MOCA domains and twenty five MOCA subscores were measured. Two MOCA subscores were included that do not contribute points to MOCA total score: (i) second memory trial and (ii) number of words recited with the letter F (No. Of Words). Poor, Intermediate and Good MOCA groups were defined as those with <23, 23-26 and >26 MOCA total score respectively. Four multiple linear regression models, adjusting for age, gender, education, depression and height, were constructed to predict the relative contribution of (i) MOCA total score, (ii) MOCA domains and (iii) MOCA subscores to walking speed, in addition to exploring (iv) MOCA group-domain interactions with walking speed. RESULTS: Higher MOCA total scores significantly contributed to faster walking speeds for both walks ($p<0.005$). For the cognitive walk this association was driven by Vsexec and Language domains, specifically the Cube and Letter Fluency (No. Of Words) subscores (see Figure 1). For the motor walk, the association was driven by the Vsexec domain, specifically the Letter Fluency (No. Of Words), Abstraction (SIM 2: watch-ruler) and Orientation (Month) subscores (see Figure 1). CONCLUSIONS: These results indicate that there may be important information embedded within MOCA that is not included in the MOCA total score. Further research is needed to explore the effect of MOCA subscores, in particular those with an executive component, on MOCA total score during healthy aging and pathology. Future research should focus on this MOCA group-domain relationship and its association with performance in complex gait tasks longitudinally to aid in highlighting markers for early mild cognitive impairment. ACKNOWLEDGEMENT: Study participants, Trinity Centre for Bioengineering and TILDA contribution and support by Atlantic Philantropies, Irish Government, Irish Life plc and Trinity College Dublin. REFERENCES: 1. Toglia et al Arch Phys Med Rehabil 2011;92: 792-798

O.7.4 Is cognitive flexibility the key to healthy older adults' ability to prioritise attention in dual-task walking and counting?

Linda Maclean[1], Arlene Astell[2]

[1]University of St Andrews, [2]University of Sheffield

BACKGROUND AND AIM: Walking is a motor action to which we unconsciously allocate attention. Older adults have less steady gait when they walk and concurrently perform a secondary cognitive task, such as counting, possibly due to: a decrease in available attentional resources, difficulty in efficiently allocating these resources or to an interaction between the two. Less steady gait is directly linked to executive function (EF), higher-level cognitive processing which is integral to performing complex every-day tasks. Cognitive flexibility, a component of EF, can be measured in how attention is allocated between two concurrent tasks. This study uses explicit prioritisation instructions to investigate healthy older adults' cognitive flexibility in allocating attention between concurrent walking and counting, and how this relates to their underlying EF. METHODS: In a within-subject longitudinal design, seventy-two healthy older adults (M=73 years) performed a single walking (ST) task and two counting STs (subtracting 3s and 7s) at Time 1(T1) and Time 2 (T2), 12-months apart. These measures were compared with dual-task (DT) performances of walking and counting backwards at two difficulty levels, 3s and 7s (DT3s and DT7s). Explicit instructions to prioritise attention were given in separate DT conditions: no prioritisation (NP), prioritising walking (PW) and prioritising counting (PC). Outcome measures were step-time variability, velocity and number of correct responses to the counting task (CCR). Changes in performance outcomes between T1 and T2 were compared with standardised tests of cognition, including MMSE (for general cognition), memory and executive function (EF) at T1, for predictors of successful attention-allocation during DT performance. RESULTS: Baseline MMSE, memory and specific EF scores did not change from T1 to T2 ($p > 0.05$). In the more cognitively-demanding task, DT 7s, there was a significant decrement in participants' gait and cognitive performances, across all performance measures, but only when participants prioritised walking ($p < 0.05$). Multiple linear regression analyses revealed that an index of EF at T1 predicted both the decline in step-time variability ($p < 0.001$) and the lower number of number of correct cognitive responses ($p < 0.01$). Participants' ability to count backwards in DT 7s, when no prioritisation was specified ($p > 0.05$) significantly improved, at no cost to their gait, and was also predicted by a measure of EF at T1 ($p < 0.01$). CONCLUSIONS: Explicit instructions to prioritise attention during a DT provide a window into how well healthy older adults maintain their ability to efficiently allocate attention. These findings were predicted by executive function/set-shifting and working memory capacity tests, measures of cognitive flexibility, and support the concept of a specific age-related executive coordination function.

O.7.5 Transcranial direct current stimulation (tDCS) alters the multi-scale complexity of dual-task postural control in older adults

Junhong Zhou[1], Brad Manor[2], Ying Hao[1], Ye Wang[1], Jue Zhang[1], Jing Fang[1]

[1]Peking University, [2]Harvard Medical School

Summary: A single session of transcranial direct current stimulation (tDCS) targeting cognitive brain regions alters the multi-scale complexity of postural control in older adults. Background: Our previous research indicates that a single session of tDCS targeting the dorsolateral prefrontal cortex (dlPFC) reduces the size and speed of standing postural sway, particularly during concurrent performance of a cognitive task. Here, we performed a secondary analysis of existing data to examine the effects of tDCS on the multi-scale complexity of postural sway using multi-scale entropy analysis. Methods: 16 healthy older adults completed two study visits in which postural control was assessed immediately before and after a single 20-min session of either real or sham (i.e., control) tDCS targeting the dlPFC. Postural control was assessed by recording postural sway for 60sec while standing with eyes open with and without concurrent performance of a serial-subtraction cognitive dual task. We focused this analysis on anterioposterior sway fluctuations (Figure 1A). First, we utilized empirical mode decomposition to

remove non-stationary trends within each time-series. We then utilized sample entropy and a course-graining technique to quantify the irregularity of the time-series at 12 different time scales, ranging from 8- to 100-milliseconds (Figure 1B). A complexity index was then calculated by calculating the area under the multi-scale entropy curve, where greater area reflects greater complexity. We further examined the effects of tDCS on complexity by calculating the percent change in entropy from pre to post tDCS at each scale; i.e., C%=rSE/sSE, where rSE is the entropy following real tDCS and sSE is the entropy following sham. The "percent complexity curve" was then plotted and the area under this curve was compared across conditions, calculated as the summation of C% from scale 2 to 24 for each subjects. Results: tDCS did not affect complexity index values when standing quietly with eyes open. It did, however, lead to increased entropy values over all examined time scales--and thus a higher complexity index (p=0.05)--under cognitive dual-task conditions (Figure 1B). A significant increase (p=0.02) in the percent increment change of dual-task complexity between real and sham tDCS was also observed (Figure 1C and Figure 1D). Conclusion: A single session of tDCS appears to increase the multi-scale complexity of postural sway when standing and simultaneously performing a cognitive task. As such, this form of noninvasive brain stimulation may be a safe strategy to acutely improve function by enhancing the ability of the older adults to adapt their postural control to cognitive stressors.

O.7.6 Pathways Linking Regional Hyperintensities in the Brain and Slower Gait

Niousha Bolandzadeh[1], Teresa Liu-Ambrose[1], Howard Aizenstein[2], Tamara Harris[3], Lenore Launer[3], Kristine Yaffe[4], Stephen Kritchevsky[5], Anne Newman[2], Caterina Rosano[2]

[1]University of British Columbia, [2]University of Pittsburgh, [3]NIH, [4]UCSF, [5]Wake Forest Baptist Medical Center

BACKGROUND AND AIM: Cerebral white matter hyperintensities (WMHs) are involved in the evolution of impaired mobility and executive functions. Executive functions and mobility are also associated. Thus, WMHs may impair mobility directly, by disrupting mobility-related circuits, or indirectly, by disrupting circuits responsible for executive functions. Understanding the mechanisms underlying impaired mobility in late life will increase our capacity to develop effective interventions. Our aim was to identify regional WMHs most related to slower gait and to examine whether these regional WMHs directly impact mobility, or indirectly by executive functions. METHODS: Twenty-one WMH variables (i.e., total WMH volume and WMHs in 20 tracts), gait speed, global cognition (Modified Mini-Mental State Examination; 3MS), and executive functions and processing speed (Digit-Symbol Substitution Test; DSST) were assessed. A L1-L2 regularized regression (i.e., Elastic Net model) identified the WMH variables most related to slower gait. Multivariable linear regression models quantified the association between these WMH variables and gait speed. Formal tests of mediation were also conducted. RESULTS: Our sample consisted of community-based 253 adults (mean age: 83 years, 58% women, 41% black). The main outcome measure was gait speed. In older adults with average gait speed of 0.91 m/sec, total WMH volume, WMHs located in right anterior thalamic radiation (ATRR) and frontal corpus callosum (CCF) were most associated with slower gait. There was a >10% slower gait for each standard deviation of WMH in CCF, ATRR or total brain (standardized beta in m/sec [p value]: -0.11 [p=0.042], -0.15 [p=0.006] and -0.15 [p=0.007], respectively). These associations were substantially and significantly attenuated after adjustment for DSST. This effect was stronger for WMH in CCF than for ATRR or total WMH (standardized beta in m/sec [p value]: -0.08 [p=0.144], -0.12 [p=0.018] and -0.11 [p=0.038], respectively). Adjustment for 3MS did not change these associations. The mediation analyses also found that DSST significantly mediated the associations between WMHs and gait speed. CONCLUSIONS: The impact, direct or indirect, of WMHs on gait speed depended on their location. Thus, multi-faceted

interventions targeting executive control functions as well as motor functions, such as balance and strength training, are optimal candidates to maintenance of mobility across the lifespan.

O.7.7 Improvement in dual tasking when walking is more closely linked to dual task interference than cognitive function in people with Parkinson's disease.

Sandra Brauer[1], Robyn Lamont[1], Marjorie Woollacott[2], Meg Morris[3]

[1]University of Queensland, [2]University of Oregon, [3]Latrobe University

Background & aim: Gait impairments and cognitive function such as executive function have been demonstrated to be associated with dual task interference with gait in people with Parkinson's Disease (PD). While some people with PD can demonstrate improvements in gait when dual tasking with training, it is unclear whether baseline factors can predict who might show greatest improvements. This study aimed to determine whether baseline measures of demographics, gait or cognitive function were associated with improvements in dual tasking when walking in people with PD. Methods: Sixty-three people with PD were recruited into a parallel group randomised trial with concealed allocation, assessor blinding and intention to treat analysis. Of these, 32 were randomly allocated to a dual task walking training program of 12 hours over 4 weeks. The primary outcome measure was step length over an 8m GAITRite mat when performing a working memory language task. Baseline measures included demographics (age, PD severity: UPDRS, Hoehn & Yahr, falls history, walk aids), gait ability over 8m (step length, velocity, cadence under single and dual tasks), and cognitive function assessed by a neuropsychologist (attention, executive function, digit span, anxiety, depression). Relationships were investigated using correlational and regression statistics. Results: Previous reports showed a mean improvement in step length under dual task conditions of 9.6cm from pre to post (95%CI 1.5 to 6.7). There was no relationship between change in step length under dual task conditions from pre to post and baseline age ($p > 0.618$) or PD severity ($p > 0.320$), but greatest improvement in those with >1 fall ($r = -0.393$, $p = 0.042$), or who used walking aids ($r = -0.555$, $p = 0.003$). Greatest improvements after training were found in those with greatest dual task interference with step length at baseline ($r = -0.593$, $p = 0.001$), and those who walked slowly under single task conditions ($r = -0.392$, $p = 0.043$), but not for other gait variables. Improvements in dual tasking when walking were associated with depression ($r = -0.404$, $p = 0.036$), but there was no relationship between improvement and baseline attention or executive function scores (stroop, trail-making tests, tests of everyday attention). Conclusions: A one-on-one, individualised training program of dual task walking training had its greatest effect on improving dual task interference in those who showed greatest interference at baseline, who walked slowly, used gait aids and had a history of falls. Improvements were less related to cognitive impairment. Tests of dual task interference may be useful in identifying who might benefit most from training. This study was supported by NHMRC project grant ID#511170, CIA Brauer.

O.7.8 Discerning effect of cognitive capacity on dual task in Parkinson's disease and healthy controls

Lynn Rochester[1], Sue Lord[1], Brook Galna[1], David Burn[1]

[1]Newcastle University

Background: Dual-task interference during gait is common in older adults and people with Parkinson's disease (PD), however the underlying processes are poorly understood and confounded by methodological differences which impact on test results. Aim: To examine dual-task interference during

gait using a cognitive task titrated to individual capacity. Methods: Baseline forward digit span (single task) was established and then recorded over 2 minutes in 121 people with early PD and 189 controls. Controlling for baseline cognitive task demand in this way allowed for any between-group differences to be attributed to interference rather than differences in capacity or resource allocation. Participants walked for two minutes at preferred pace under single and dual-task (forward digit span recall) conditions. Task demand was increased (forward digit span 1) in a subgroup (n = 55 control, n = 44 PD) to assess the impact of cognitive capacity on dual-task interference. We also examined task prioritisation (trade-off) of performance between gait and digit span under dual-task conditions. Partial correlations were used to test the relationship between dual-task interference and motor control (Postural Instability and Gait Disorder subscore of the UPDRS III), and cognitive function (global cognition, attention and executive function), controlling for order of dual-task presentation. Results: PD and controls responded similarly to the dual-task for all gait characteristics except for step width and step width variability and this was the same when task demand increased (dual 1). Control participants took wider steps ($p = .006$) and step width variability increased significantly for controls ($p = .001$) but not PD. Digit span error rates were not significantly different between groups during dual-task performance. There were no significant correlations with dual task interference and global cognition, motor deficit, and executive function for either group. Response to dual task was highly individual. Discussion: The effects of dual-task on gait performance are two-fold and specific to the gait characteristic. For both PD and control they reflect an age related reduction in gait performance (especially forward progression), possibly due to reduced working memory capacity. Secondly, the results show that postural stability during walking in early PD is disproportionately affected. Further work is required to identify the cognitive, executive and motor correlates of dual-task interference from which inferences about underlying cognitive processes can be made.

O.8.1 Haptically mediated inter-personal entrainment depends on postural coordination dynamics during frequency scaled rhythmic sway

Vassilia Hatzitaki[1], George Sofianidis[2], Mark Elliott[3], Alan Wing[3]

[1]Eidikos Logariasmos Kondilion Erevnas A.P.TH, [2]Aristotle University of Thessaloniki, [3]University of Birmingham

BACKGROUND AND AIM: Posture is organized around two intuitively stable coordination modes described by the phase relationship between the ankle and hip rotations [1]. When couples sway rhythmically while maintaining haptic contact, their sways synchronize spontaneously [2]. We asked how the haptically mediated interpersonal entertainment interacts with ankle-hip coordination when rhythmic sway is up/down scaled by a metronome. The effect of dance expertise on the relationship between postural and interpersonal coordination was also examined. METHODS: Thirty-six young and healthy volunteers formed three types of couples based on their prior dance experience (Dancers: n=12, 22.57 ± 4.17 year; Novices: n = 12, 25.05 ± 4.69 years; Mixed couples: n=12, 23.78 ± 5.37 years). Couples swayed rhythmically side by side at a progressively increasing (from 0.25 to 0.7 Hz) or decreasing (from 0.7 to 0.25 Hz) tempo with and without light fingertip touch between them. Ankle and hip kinematics (Vicon Motion Systems, Oxford, UK) were used to calculate the cross-spectral coherence and Relative Phase (RP) as measures of inter-segmental (ankle-hip) and interpersonal (hip - hip, ankle-ankle) coordination. The effect of group, touch and tempo was evaluated employing a 3 x 2 x 10 repeated measures ANOVA. RESULTS: Analysis revealed a decrease in coherence ($F(9,198) = 3.47$, $p<.01$) and increase in the ankle-hip RP($F(9,198) = 13.277$, $p<.001$) with increasing frequency in novice couples but not in dancers. Interpersonal touch did not affect the ankle-hip coordination but resulted in a decrease

of the ankle-ankle ($F(1,15) = 14.198$, $p<.01$) and hip-hip($F(1,15) = 7.220$, $p<.01$,) RP towards in phase coupling. The effect of touch on interpersonal synchrony was lost at higher frequencies in the novice group only ($F(18,135) = 1.839$, $p<.05$). CONCLUSIONS: Ankle-hip coupling during frequency-scaled rhythmic sway, which is stronger in dancers, is not affected by interpersonal haptic contact. Loss of the ankle-hip coupling at higher frequencies however seems to modulate the strength of the haptically mediated interpersonal entertainment when touch is provided by a non-expert (non-dancer) in movement timing. REFERENCES 1. Bardy, B.G., et al., . J Exp Psychol Hum Percept Perform, 1999. 25(5): p. 1284-301. 2. Sofianidis, G., et al., . Hum Mov Sci, 2012. 31(3): p. 553-66. ACKNOWLEDGEMENTS: Funding by the European Union (ESF) and Greek funds through the Program "Education and Lifelong Learning" of NSRF - Research Program: Heracletus II

O.8.2 Temporospatial relationships between axial body segments during standing turns is predominantly determined by turning speed

Rebecca Robins[1], Mark Hollands[1]

[1]Liverpool John Mooores University

BACKGROUND AND AIM: Whole body turns are usually characterized by a sequential "top down" coordinated reorientation of the axial body segments starting with the head, and ending with the feet. Previous attempts to describe segmental coordination during turns have focused on the latency of reorientation onset of each axial body segment with respect to a cue to turn. However, without studying the temporospatial relationships between segments across the entire turning movement and how these variables change as a function of turn behaviour, understanding underlying neural mechanisms and interpretation of differences between groups is problematic. Our aim was to develop analysis techniques that are better suited to empirically describe the coordination between axial segments over the entirety of the movement and characterise how coordination patterns are affected by factors such as turn speed or size. METHODS: Five young male adults (age 25.2 ± 3.7) completed five on-the-spot turns for each of the following conditions: direction (right or left), speed (moderate and fast), and angle (45°, 90°, 135°, 180°). Each trial began with an animation demonstrating turn conditions followed by a "go" signal. Kinematic data was recorded using Vicon. Segment reorientation onsets and turn completion were determined for each trial and displacement data was time normalized from turn onset to turn completion; time-normalized angular difference profiles of segments were calculated for head-thorax, head-pelvis, and thorax-pelvis. RESULTS: Repeated measures ANOVA revealed a significant speed x segment interaction for reorientation onset latency. Post-hoc analysis revealed that significant differences in onset were found only between the head and pelvis during fast turns. RM ANOVA also showed significant main effects of speed and amplitude on maximum angular difference between head, thorax, and pelvis segments. There was a significant positive correlation ($r2 = 0.65$, $p < 0.001$) between peak head velocity and the maximum head-pelvis separation. There was no significant correlation between orientation onset latency and maximum head-pelvis angular separation. CONCLUSIONS: Our results clearly show that measures of onset latency are insufficient to describe the coordination between segments and to determine whether the segments are being moved en bloc. The extent to which the head leads the other segments is linearly related to the speed of turning but not to the latency of turn initiation. Our results predict that head and pelvis move en bloc at movement speeds below around 80 °/sec. These results have important implications for understanding the CNS control of turning and for interpreting age and pathology-related differences in turning characteristics.

O.8.3 Potential different functions in discrete regions of the psoas major muscle at the spine and hip during gait

Rachel Park[1], Andrew Cresswell[1], Paul Hodges[1]

[1]The University of Queensland

BACKGROUND AND AIM: Little is known about the activation of the psoas major muscle during gait. The relationship between different regions of this muscle to spine and hip control during certain postural tasks suggests similar differences may be present during gait. This study aimed to investigate activation patterns from discrete regions of psoas major that arise from the transverse processes (PM-t) and vertebral bodies (PM-v) of the lumbar spine during gait in healthy young participants. METHODS: Eleven volunteers walked on a treadmill at 1.5 ms-1 for 3 min. Fine-wire electrodes were used to record electromyography (EMG) from PM-t and PM-v on the right side. EMG recordings of right abdominal and paraspinal muscle activity were made using surface electrodes. Data were time-normalised and averaged between successive right heel strikes. RESULTS: Muscle recruitment patterns differed between the two discrete regions of PM. Similar to ES, right PM-t was recruited in a biphasic manner with a burst of activity occurring during late swing and early right stance, with peak activity at ~10% of gait cycle. A second burst of PM-t activity occurred during late right stance to mid-swing, with increased activity at the initial swing phase (~70% of gait cycle). In contrast, PM-v was activated in a single, long duration burst of activity that commenced just prior to swing (i.e. just prior to toe-off; ~50% of gait cycle) and increased during mid-swing and early stance (i.e. ~80% and 10% of gait cycle, respectively) of the gait cycle. CONCLUSIONS: Despite their close proximity, the differences in activation of the discrete regions of PM imply potential different roles during gait. Activation of PM-t closely matched that of ES suggesting a role in control of lumbar spine flexion. Activation of PM-v implied a significant role in hip flexion. The findings of this study suggest a complex function of PM differs substantially from the conventional view that the muscle is only involved as a hip flexor during gait.

O.8.4 Experimentally induced hip muscle pain alters single-leg dynamic balance performance in healthy young adults

Anna Hatton[1], Kay Crossley[1], Francois Hug[1], James Bouma[1], Bonnie Ha[1], Kara Spaulding[1], Kylie Tucker[1]

[1]The University of Queensland

BACKGROUND AND AIM: Musculoskeletal pain commonly accompanies hip disease and injury and can have a major impact on functional ability, including balance performance. Due to the cross-sectional design of previous studies, in patient populations with established hip pathology, it is difficult to determine whether pain is a driver of balance impairments. Using a repeated measures design, this study explored the effects of acute, experimentally induced hip muscle pain on static and dynamic balance performance in healthy young adults. This evidence is essential as pain is a potentially modifiable patient-reported outcome in individuals with hip problems, and modification of this factor, through optimal rehabilitation strategies, may alter balance impairments. METHODS: Twelve healthy young adults (4 female, mean [SD] 27.1 [3] years) performed three randomised balance tasks: single-leg standing with eyes closed, single-leg squat with eyes open, and forward step up, whilst standing on two Kistler force platforms, under two conditions - before and after receiving an injection of hypertonic saline (1ml, 5% NaCl) into the right gluteus medius muscle. Centre of pressure (CoP) total path velocity, total excursion, and the range and standard deviation (SD) of CoP movement in the mediolateral (ML range and MLSD) and anterior-posterior direction (AP range and APSD) were extracted. Self reported

pain intensity (using a Numerical Rating Scale; from 0 to 10), and area of pain was recorded. Balance data were analysed using paired-samples t-tests with alpha set at 0.05. RESULTS: Pain was reported local to the injection site and was rated as mean [SD] 3.7 [1.7]/10 during the painful tasks. When performing the single-leg squat on the painful leg, participants showed reduced AP Range (P=0.027), APSD (P=0.041), and CoP Velocity (P=0.020). Significant reductions in AP Range (P=0.002), APSD (P=0.003) and CoP Total Excursion (P=0.028) were also observed during pain for the non-painful leg during this task. No changes in ML measures were observed during pain (all P>0.05). Balance performance during the single-leg standing and forward step up tasks did not differ between conditions for either leg (all P>0.05). CONCLUSIONS: Experimentally induced hip muscle pain alters balance performance during a single-leg squat task in healthy young adults, but not during a single-leg standing or forward step up task. Improvements in dynamic balance performance, specifically in the AP direction, may be indicative of physiological responses to acute gluteus medius pain such as compensatory, synergistic hip muscle activity. It is also possible that local pain is associated with altered attention to the task, which may lead to altered motor performance. Further investigation is required to explore whether acute hip muscle pain alters joint movement, muscle activation, or sensory function, which may also underlie changes in balance performance.

O.8.5 Direction specific adaptation of trunk muscles during direction related induced experimental pain

Martin Eriksson Crommert[1], Wolbert van den Hoorn[2], Paul Hodges[2]

[1]Family Medicine Research Centre, Örebro, Sweden, [2]The University of Queensland

BACKGROUND AND AIM: Trunk muscle activation changes during pain. In association with real and anticipated pain it has generally been observed that some muscles increase activation, possibly to stiffen and protect the spine, whereas other muscles (often the deeper muscle layers) have been observed to have reduced/delayed activation. Here we aimed to determine how muscle activity adapts when pain is induced in a predictable and unpredictable manner during a task in which participants generate isometric force in a circular manner. We predicted that muscle activation would only be augmented around the period of pain when its timing was predictable, but would increase in a generalised manner when pain was unpredictable. METHODS: Healthy participants sat in a semi-seated position with the trunk fixated in the upright position by four horizontal cables attached to the front, back, left and right of a chest harness. All cables were attached to load cells. Force exerted on the cables was used to calculate the direction of force. Feedback of direction and force amplitude was provided as a dot on a screen at eye level. Participants followed a target that moved in a circular clockwise pattern repeated 10 times. Participants exerted force against the resistance of the cables equivalent to 10 % of their bodyweight in a circumduction pattern. The task was conducted during a pain free condition and during 3 conditions where the participants received painful electric superficial stimuli to the sacrum either in a predictable manner (at the same point of the circle every "lap", either forwards or backwards pushing direction) or unpredictably (randomly throughout the task). Trunk muscle EMG was recorded with intramuscular (2 muscles, unilaterally) and surface (12 muscles, bilaterally) electrodes from 20 participants with no history of low back pain. Linear envelopes were created and mean EMG amplitude was calculated during 16 periods each representing 22.5 degrees of the circular motion. RESULTS: When the pain stimulus was predictable and always occurred when force was exerted forwards, there was an increase in activation of some abdominal (including transversus abdominis) and back muscles around the painful stimuli, above that from the pain free condition. Although a similar tendency was observed when the pain was predictably applied in the backwards direction this was not significant. When the

pain occurred randomly throughout the circle there was no change in activation level relative to the pain free condition. CONCLUSIONS: One interpretation of these data relates to the balance between protection and energy cost. The nervous system appears to accept the increased energy demand of greater muscle activation for protection when the timing of pain can be predicted and the protective strategy can be adopted for a short duration, but does not favour protection when the augmented muscle activation would be required over an extended period.

O.8.6 Advanced preparation of automatic postural responses occurs during perturbations with predictable and unpredictable directions

Elizabeth Pasman[1], Taylor Cleworth[1], Adam Campbell[1], J Timothy Inglis[1], Romeo Chua[1], Mark Carpenter[1]

[1]University of British Columbia

BACKGROUND AND AIM: Recent studies, using a Startling Acoustic Stimulus (SAS) to trigger prepared responses, have revealed automatic postural responses (PRs) may be prepared in advance of support surface perturbations. For example, Campbell et al [1] have shown some aspects of a conditioned PR can be prepared in advance of a lateral translation with predictable onset and direction. Nonnekes et al [2] extended these findings by evoking prepared PRs to anterior-posterior translations without cues. However, prepared PRs for uncued perturbations were limited to forward translations, and thus, were considered to be directionally specific [2]. The purpose of this study is to: a) determine if PRs can be prepared in advance of uncued perturbations in the frontal plane, and 2) determine whether the pattern of prepared PRs differs when the direction of perturbations is predictable compared to unpredictable. METHODS: Lateral support-surface translations were administered in 6 healthy participants using a platform mounted on a linear motor. Participants performed a 60s quiet standing trial after which a SAS (~120dB, 1000Hz, 40ms duration, ~1ms rise-time) was presented through an overhead speaker to induce a generalized startle response. Each participant then experienced three blocks of perturbations, presented in random order. Two blocks consisted of perturbations presented in a series of predictable directions to either the right or left. The third block consisted of unpredictable perturbations that were randomized between right and left directions. Each block of perturbations was followed by an unexpected SAS-only trial without any accompanying platform movement. Surface electromyography, kinematic and kinetic responses were recorded, and synchronized with the onset of the platform acceleration or SAS. RESULTS: Prepared PRs were seen for conditions involving perturbations in both predictable and unpredictable directions. The responses during SAS-only trials after the perturbation blocks differed from the generalized startle response seen during the initial SAS-only trial. Following the block of perturbations with a predictable direction the SAS-only trial induced lower body angular displacement in the direction of the perturbation, ie to the right after rightward perturbations. The responses in the trunk and arms were less clear. In contrast, when the SAS-only trial followed the block of perturbations with an unpredictable direction, there were relatively large, bilateral movements of the arms, with no observable response in either the lower body segments or trunk. CONCLUSION: Advanced preparation of automatic PRs is not directionally specific and occurs even when perturbation direction is unpredictable. However, the pattern of the prepared PRs differs when subjects experience a series of perturbations of predictable and unpredictable direction. REFERENCES: [1] Campbell et al. Journal of Neurophysiology, 2012; [2] Nonnekes et al. Neuroscience, 2013

O.8.7 Adaptation of dynamic balance between unpredictable gait perturbations in healthy participants

aurélie méreu[1], Simon Croteau[1], cyril Duclos[1]

[1]Université de Montréal

Postural responses to mechanical perturbations, e.g. support surface alteration or forces applied on the body, have been described in standing and walking. Balance adaptations have been observed with the repetition of such perturbations, as well as generalization of these improved postural responses toward another type of perturbation. However, adaptation may be functionally irrelevant against perturbations in different directions and of different intensities. Because perturbations are of unpredictable intensity and direction in everyday life, it seems important to determine how such perturbations affect balance difficulty during gait. In this study, the objective was to determine balance difficulty in young healthy participants between 12 unpredictable mechanical perturbations. Ten healthy young subjects (22.3 years old (SD 1.7), 61.5 (9.6) kg, 1.70 (0.07) m) were asked to walk on a split belt treadmill at comfortable speed during a 1-minute control gait trial and during 5 trials (150-180s duration) with perturbations. Perturbations were applied randomly during right or left stance phase of one gait cycle every 6 to 15 steps. Six levels of perturbations were produced by changes of the velocity of the stance belt at 50%, 70%, 90%, 125%, 150% or 175% of the comfortable belt speed. Three-dimensional whole-body kinematics (NDI Certus, sampling at 60 Hz, 3D-link-segment model, 15 rigid body segments) and kinetics (Bertec Fit treadmill, sampling at 600 Hz) were recorded. The base of support was digitized by probing the contour of the shoe soles. These data were used to determine the difficulty to maintain postural and dynamic balance during the trials, using the stabilizing and destabilizing forces, and their stability index. Only steps between perturbations (from the 7th step post-perturbation to the 2nd before the next perturbation) were analyzed here. ANOVAs were used on each balance variable 1) to compare balance difficulty during gait without perturbation and after each intensity of perturbation, and 2) to compare balance difficulty during comfortable gait to the first and last 40 steps between perturbations, and between trials. When analyzed after each type of perturbation, balance difficulty was not affected during gait between perturbations compared to control gait (Stabilizing force: $p=0.392$; destabilizing force: $p=0.40$; stability index: $p=.06$). However, balance difficulty increased between the beginning and the end of the perturbation trials ($p<.01$ for each variable). However, balance difficulty was higher at the end of the perturbation trials than in control conditions only in the first 3 experimental trials (0.05). Increase in balance difficulty during gait within trials with unpredictable perturbations suggests that adaptation did not occur in these conditions. It may rather indicate a feeling of postural threat due to the inability to predict perturbations, which tended to decrease over repeated trials.

O.8.8 The relationship between plantar-surface pressure and muscle activity during gait

Stephen Perry[1], Brittany McGregor[1]

[1]Wilfrid Laurier University

BACKGROUND AND AIM: Decreased plantar-surface sensation is associated with a number of changes in gait characteristics. Older adults often experience age-related sensory loss in the plantar surface of their feet which can predispose them to falls leading to injury. Previous research has shown how gait can be altered by decreasing plantar sensitivity; however, to date the relationship between plantar cutaneous mechanoreceptors and the muscles of the leg has not been quantified during gait. Observing this relationship will provide insight into how the body uses foot pressure to adapt to changes in walking

terrain and other instabilities during gait. METHODS: Twenty-one (10 male, 11 female) healthy young adults were recruited from the university population (mean age= 22, SD=3.37). Each participant completed 10 normal walking and 20 randomized uneven terrain walking trials along a 10m walkway. Participants were equipped with 8 electromyography (EMG) electrodes (AMT-8, Bortec Inc., Calgary, AB) on the left and right legs, and wore standardized shoes containing size-matched pressure sensors (Medilogic Inc., Germany). Uneven terrain conditions were induced using wooden wedges placed in the walking path at each step location. Uneven terrain (UT) conditions were slanted platforms in the anterior, posterior, lateral and medial directions (relative to the stance foot) in order to assess a variety of plantar pressure situations. RESULTS: A significant negative correlation was found between loading rates under the contralateral great toe and the magnitude of tibialis anterior (TA) during normal walking in both short and long latency periods, as well as in posterior, lateral and medial UT conditions. A significant positive correlation was found between the loading rates under the ipsilateral heel and the magnitude of the TA activity in normal walking, posterior and lateral UT conditions in the short and long latency response periods. Lateral and medial UT conditions showed altered muscle activity in the TA in order to respond faster to the medial-lateral perturbations and to increase the surface area in contact with the walking surface for improved cutaneous input. The anterior UT condition showed a significant positive correlation between TA magnitude and the contralateral great toe loading as the COM was slowed due to the upward slope and a stronger push off was required. Alternatively, the posterior UT condition showed increased TA activity, thought to be required to maintain a slowed dorsiflexion on a downward slope to prevent tripping and maintain a comfortable COM speed. CONCLUSIONS: This study provides evidence of a relationship between plantar cutaneous mechanoreceptors and the magnitude of muscle activity during gait. This quantifiable relationship can be used in future research to determine gait abnormalities, as well as in the development of walking aids to better support the body and provide the appropriate input for stability.

O.9.1 Does pharmacological abatement of postural imbalance in acute unilateral vestibulopathy counteract vestibular compensation?

Andreas Zwergal[1], Lisa Günther[1], Guoming Xiong[1], Klaus Jahn[1], Marianne Dieterich[1], Christian la Fougere[2], Roswitha Beck[1]

[1]University of Munich, [2]University of Tübingen

Background and aim: The present study aimed to investigate the symptomatic effect of 4-Aminopyridine (4-AP) treatment on postural control in early acute vestibulopathy and its long-term consequences for vestibular compensation by behavioural testing and serial [18F]-Fluoro-desoxyglucose ([18F]-FDG)-µPET in a rat model of acute unilateral chemical labyrinthectomy (UL). Methods: 16 Sprague-Dawley rats underwent a left-sided chemical labyrinthectomy (UL) by transtympanic injection of bupivacaine and arsenilate. 8 animals were treated with 4-AP p.o. (0.1mg/kg per day) for 3 days after UL, the other animals received a pure 0.9% NaCl-solution p.o. as a control group. Behavioural testing for symptoms of vestibular imbalance including registration of nystagmus and postural asymmetry was performed at day 1 pre UL and days 1, 2, 3, 7, 9, 15, 21 post UL. On days 1-3 additional behavioural testing was done 2h after 4-AP or NaCl administration. In addition, sequential whole-brain [18F]-FDG-µPET was performed before and on days 1, 3, 7, 15, 21 after UL. Results: All rats showed clinical signs of an evolving vestibular syndrome following bupivacaine/arsenilate injection with a maximum at day 2/3. Administration of 4-AP at days 1-3 did not have any effect on the intensity of the spontaneous nystagmus, but significantly improved postural imbalance 2h after treatment as compared to the status prior (on average by 45% in the postural asymmetry scores). However, the effect of 4-AP on postural imbalance was only transient

and tended to fade out 6h after administration. Remarkably, animals in the 4-AP group showed a prolonged and impaired course of vestibular compensation as compared to the control group (i.e. on average 35% increase in postural asymmetry scores on day 21). µPET showed a significant cerebellar increase of regional cerebral glucose metabolism (rCGM) after administration of 4-AP. However, as compared to the control group asymmetry of rCGM in the vestibular nuclei persisted until day 21 in the 4-AP group. Conclusions: Early administration of 4-AP transiently improves postural imbalance in acute unilateral vestibulopathy. However, reduction of the symptom burden during the acute phase of the vestibular syndrome seems to hamper the course of vestibular compensation. This confirms two principles which are well established in the practical treatment of patients with acute vestibulopathy: 1) Pharmacological treatment for acute symptom relief should be given only on demand and as short as possible. 2) Early postural challenge may increase symptomatic pressure and thereby accelerate vestibular compensation.

O.9.2 The severity of vestibular dysfunction influences postural compensation

Lara Thompson[1], Csilla Haburcakova[2], Conrad Wall III[2], Adam Goodworth[3], Daniel Merfeld[2], Richard Lewis[2]

[1]University of the District of Columbia, [2]Massachusetts Eye and Ear Infirmary, Harvard Medical School, [3]University of Hartford

BACKGROUND AND AIMS For human and non-human subjects suffering from severe peripheral vestibular disorders, maintaining balance may prove to be challenging for daily activities (e.g., standing or walking in dimly-lit environments that provide limited visual cues or on uneven or compliant surfaces that provide fewer support surface cues). Previous studies of the effects of vestibular function on human and animal postural responses have focused predominantly on either normal vestibular function or severe vestibular dysfunction. However, it has not been previously addressed how posture strategies change as a function of level of vestibular dysfunction. More specifically, can a vestibular-impaired subject adopt postural strategies (either on their own or with expert training) in order to compensate for their loss? METHODS To investigate the effects of different levels of vestibular dysfunction on posture, one rhesus monkey (R2) was studied for normal and mild bilateral vestibular hypofunction (mBVH) state and the other (R1) in a state of severe bilateral vestibular hypofunction (sBVH). A stationary balance platform was used to assess rhesus monkey posture for test conditions that have proven challenging to humans with severe vestibular dysfunction. The animals were provided only limited visual information (via a dimly-lit, black tarp environment). Platform support surface conditions were varied between a compliant foam or hard gum surfaces and stance widths between wide and narrow. Furthermore, a proprioceptive reference cue was modified through use of two configurations: light-touch cue and no light-touch cue. Trunk root-mean-square (RMS) roll for each animal was quantified as a function of test condition. Furthermore, to determine mechanisms used for different levels of vestibular impairment, a quiet-stance feedback controller model (used previously only to describe human posture) was implemented. Simulated trunk roll was validated by comparing model-simulated results to those derived from the measured data and model parameters were determined. RESULTS When comparing normal to mBVH states of R2, there were either no observed change or even decreases in trunk roll. Based on previous severe vestibular-impaired human studies, we had expected an increase in sway (even for a mild level of impairment). Consistent with human findings, R1 in the sBVH state showed instability. However, we found that when R1 with severe vestibular dysfunction was provided an additional reference cue (light-touch) it was able to reduce its trunk sway. CONCLUSIONS The experimental and model results were consistent with: 1) R2 in the mBVH state being able to

increase intrinsic/short-latency muscle stiffness and increase trunk stability and 2) R1 in the sBVH state becoming unsteady and utilizing long-latency mechanisms due to larger trunk sways present. Because R1 could not stabilize, an additional cue (light-touch) was needed to maintain balance.

O.9.3 Clinical characteristics of idiopathic otolithic vertigo

Toshihisa Murofushi[1], Yukiko Tsuda[2], Eriko Yoshimura[1]

[1]Teikyo University School of Medicine , [2]Yoshimura ENT Clinic

BACKGROUND AND AIM: Otolith organs, saccule and utricle, are sensors of linear acceleration. Therefore, it is expected that disorders of the otolith organ could cause abnormal translational or tilting sensation. Vestibular evoked myogenic potential (VEMP) testing has been clinically applied as a test of the otolith organ. We have proposed diagnostic criteria of idiopathic otolithic vertigo.The aim of this study was to clarify clinical characteristics of patients diagnosed as having idiopathic otolithic vertigo according to diagnostic criteria which we have proposed and to get basic data for hypotheses concerning pathophysiology of idiopathic otolithic vertigo. METHODS: Patients diagnosed as having idiopathic otolithic vertigo were enrolled in this study. Diagnostic criteria of idiopathic otolithic vertigo were as follow. Subjects must have one of the following symptoms; episodic tilting or translational sensation in the roll plane or in the pitch plane. Subjects with the following medical history or signs/symptoms are excluded; a medical history of rotatory vertigo, a medical history of loss of consciousness or severe head trauma, symptoms or signs of central nervous system dysfunctions or proprioceptive dysfunctions, or a definitive diagnosis of a disease known to cause disequilibrium (e.g. Meniere's disease, vestibular migraine, etc.). In these patients, features of their vertigo, findings of clinical testing, and association of symptoms with test findings were studied. Clinical tests included ocular VEMP, cervical VEMP, and stabilometry. RESULTS: The most prominent feature of test findings was abnormal cVEMP and/or oVEMP. Patients who had abnormal sensation in the roll plane showed tendency of abnormal oVEMP, while patients who had abnormal sensation in the pitch plane did tendency of abnormal cVEMP. In majority of patients episodes of vertigo lasted for several minutes. CONCLUSIONS: VEMP testing is a key examination for idiopathic otolithic vertigo, which might be caused by transient ischemia in the otolith organ. Contribution of endolymphatic hydrops for idiopathic otolithic vertigo is remained to be elucidated.

O.9.4 Increased gain of vestibulospinal potentials evoked in neck and leg muscles when standing under height-induced postural threat

Eduardo Naranjo[1], John Allum[2], John Inglis[1], Mark Carpenter[1]

[1]University of British Columbia, [2]University of Basel

Background and aim: Older adults are more likely to fall when they feel fearful or anxious, due to the strong influence that negative emotional changes exert on postural control. In order to better understand this relationship, studies have measured balance changes when standing at high heights known to increase state anxiety, fear and arousal [1]. One potential source of anxiety-related changes in balance is the vestibular system. There are strong neural connections between vestibular nuclei and emotional processing areas of the brain, and increased gain of vestibulo-ocular reflexes has been associated with chronic anxiety, panic disorders and increased arousal [2]. However, less is known about how vestibulospinal reflexes (VSR) involved in the control of balance, are influenced by changes in state

anxiety and fear, with prior work using galvanic vestibular stimulation providing contradictory results [3,4]. Vestibular Evoked Myogenic Potentials (VEMPs) offer an alternative to GVS as reliable tool for investigating modulation of VSR pathways. The aim of this study was to measure the changes in the amplitude of cervical VEMPs and VEMPs elicited from upper and lower limb muscles, when inducing fear, anxiety and arousal by manipulating surface height. Methods: 28 subjects were tested while standing at a platform under 2 height conditions: low (0.8m from the ground and high (3.2m). Surface electromyography (EMG) was recorded from the ipsilateral sternocleidomastoid (SCM), biceps brachii (BB), flexor carpi radialis (FCR), soleus (SOL) and medial gastrocnemius (MG). Subjects were stimulated at each height with 256 air-conducted tone bursts of 4ms of duration and 500Hz of frequency at an intensity of 125 dB SPL. Muscle background activity was controlled. VEMP amplitudes were compared between heights and correlated with changes in state anxiety and fear, measured using questionnaires, and arousal recorded using electrodermal activity (EDA). Results: Height significantly increased fear, anxiety and EDA ($p<0.001$). VEMP amplitude was significantly increased with height in SCM, SOL and MG ($p<0.05$) but not BB and FCR ($p>0.05$). Changes in VEMP amplitude of SOL was significantly correlated with EDA ($r=0.37$, $p=0.03$), and anxiety $r=0.37$, $p=0.03$). Likewise changes in VEMP amplitude in SCM was significantly correlated with anxiety ($r=0.45$, $p=0.02$) and fear ($r=0.46$, $p=0.02$). Conclusion: Height-induced fear and anxiety had an effect on VSR gain, as reflected in a significant increase in cervical and leg VEMP amplitudes. Our findings not only imply a strong contribution of the vestibular system to postural threat responses, but also suggest a strong influence of emotions on the outcomes of clinical VEMP testing. References: [1] Carpenter et al. Exp Brain Res 2001;138(2):210-8. [2] Staab et al. Semin Neurol 2013;33:297-306. [3] Osler et al. Eur J Neurosci 2013;38:3239-47. [4] Horslen et al. ISPGR World Congress 2012;O.22.2.

O.9.5 Spatial characteristics of the muscle response to electrical vestibular stimulation in humans

Billy Luu[1], Eric Pospisil[2], H.F. Machiel Van der Loos[2], Elizabeth Croft[2], Jean-Sébastien Blouin[2]

[1]Neuroscience Research Australia, [2]University of British Columbia

BACKGROUND AND AIM: During unsupported standing, electrical vestibular stimulation induces medio-lateral sway when the head is facing forward and antero-posterior sway when the head is facing left or right relative to the dependent legs[1]. Although the plantar flexors operate in the antero-posterior plane, the vestibular-evoked muscle response is still present in these muscles when the head is facing forward[2]. Here, we investigate the effect of head position on the vestibular-evoked muscle response when the body is constrained to a single antero-posterior plane of motion. METHODS: Nine healthy subjects participated. Subjects were supported upright on top of a robotic balance platform that rotated the body in the antero-posterior plane about the ankle joints. The platform was programmed with the mechanics of an inverted pendulum to simulate the load of the body. To keep the supported body upright in space, subjects were required to adjust their plantar flexor torque to balance the platform. Stochastic vestibular stimulation (±4 mA, 0-25 Hz) was delivered at the mastoid processes as subjects balanced the robotic platform with the head facing forward, and with the head turned to the left at 15 degree increments up to 90 degrees. Surface electromyograms were recorded from the right soleus. RESULTS: The largest muscle response to vestibular stimulation was observed when the head was turned 90 degrees to the left, with the response diminishing as the head was turned towards a forward facing position. A small but significant muscle response was recorded in only three subjects with the head forward position. The change in peak-to-peak amplitude of the muscle response at intermediate head angles was described by the cosine transformation of the muscle response obtained with the head rotated 90 degrees. CONCLUSIONS. The present study describes the spatial transformation of the

muscle response to electrical vestibular stimulation as the head rotates relative to the dependent leg muscles. These data show that only the vestibular-motor pathways that are appropriate to counteract the electrically-induced sway are recruited as part of the balance response rather than a generalised response to all dependent postural muscles. 1. Lund & Broberg. 1983. Acta Physiol Scan, 117:307-309. 2. Dakin et al. 2007. J Physiol, 583.3:1117-1127.

O.9.6 Polymodal areas in the right brain support the human sense of upright

Céline PISCICELLI[1], Julien Barra[2], Christophe Lopez[3], Olivier Detante[1], Dominic Pérennou[1]

[1]University Hospital of Grenoble, [2]Paris University , [3]Marseille University CNRS

Background and aim: In Humans, the sense of upright is a fundamental reference for bipedal behavior and spatial cognition. The information related to the upright of the body, assessed by postural vertical (PV), and that of the extrapersonal space, assessed by visual vertical task (VV), must be merged in the brain. Our current understanding of these neural bases is limited to the visual perception of gravitational orientation or motion of objects in the extrapersonal space. The neural bases of the sense of body upright remain to be discovered so as their overlap with the polymodal vestibular cortex. Due to methodological constraints functional neuroimaging cannot be used to investigate the sense of upright. Here, we analyzed the correlates between altered sense of upright (VV and PV) and brain structures in stroke patients, in relation to a mapping of the vestibular cortex. Methods: VV and PV were assessed in 66 first hemisphere stroke patients (58±15 years, 25F-41M, 41right-25left). Cerebral lesions were reconstructed with MRIcro from patients MRI axial slices (axial AC-PC, T2 flair, 4mm thickness) and analyzed by a Voxel Lesion Behavior Mapping statistical approach (VLBM). Anatomical data of verticality perception were then compared with a recent meta-analytic mapping of the vestibular cortex.using caloric and galvanic vestibular stimulations. Results: The VV tilts were contralesional in 45% and ipsilesional in 9% of patients. By contrast, PV tilts (42%) were always contralesional. Transmodal tilts (PV+VV) were significantly more frequent after right (16/41 patients, 39%) than left lesions (2/25, 8%, Khi2=7.54, p=0.005). Tilts in vertical estimates were significantly more pronounced after right than left lesions for both VV (-4.2° vs. -1.7°; t(64) = -2.11; p =0.03) and PV (-5° vs. -0.7°; t(64) = -4.67; p< 0.01). Tilts were also significantly more frequent after right lesions for PV (25/41(60%) vs. 3/25 (12%); Khi2=0.008). The difference was not significant for VV (21/41(51%) vs. 9/25(36%); Khi2=0.45).In right lesions, polymodal areas of sense of verticality were the inferior parietal cortex, parietal operculum, posterior insula, pre- and postcentral gyri, and the posterolateral thalamus. Only 14 % of this core for the sense of verticality overlapped the vestibular areas. In left lesions, the rarity of PV tilts (3 patients) made irrelevant any VLBM analysis. As compared to the right hemisphere, neural circuits involved in VV were as much spread but four times less dense (6221 vs 25973 voxels) and only 5% of this network overlapped with vestibular areas centered on inferior parietal cortex, parietal operculum and the posterior insula. Conclusion: We identified the operculo-insular cortex and posterolateral thalamus as the core polymodal regions for the human sense of upright, with clear right hemisphere predominance. Contrary to a widely accepted view, those polymodal areas overlapped weakly with vestibular areas.

O.10.1 Association between Walking Patterns during Community Ambulation and Cognitive function in patients with Parkinson's disease: Further insights into motor-cognitive links

Aner Weiss[1], Talia Herman[2], Marina Brozgol[2], Ariel Tankus[2], Nir Giladi[3], Jeff Hausdorff[2]

[1]Tel Aviv Sourasky Medical Center, [2]TLVMC, [3]Sagol School of Neuroscience and Sackler Faculty of Medicine

Background and Aim: Gait is generally evaluated based on testing in the lab or clinic, but may not always reflect real-life function. A single test in the clinic may be sensitive to "White-coat" syndrome that causes a disparity in performance. The aim of the present study was to test whether long-term, continuous monitoring of 72 hours is associated with cognitive function in patients with Parkinson's disease (PD). Methods: 107 PD patients (age: 64.9±9.3yrs, UPDRS Motor score "Off": 40.4±13.2; Hoehn & Yahr "Off": 2.6±0.7; 25.23% women) wore a 3D accelerometer on the lower-back for 3 consecutive days. In the lab, subjects completed a computerized battery that measured several cognitive domains including: Global cognitive Score (GCS), Executive Function (EF) and Attention. Quantity measures derived from the 3-day recordings included total-activity (%) and step count. Gait quality measures included stride-regularity, harmonic-ratio, and frequency-measures (amplitude, width and slope of the power spectral density, psd), which reflect gait variability and consistency. We compared between the subjects of the lowest versus highest tertiles of cognitive function (n=26 and n=27, respectively). The groups were similar with respect to age and gender. Results: Subjects with better GCS had significantly higher gait consistency (vertical stride regularity, $p=0.008$) and lower step variability (vertical amplitude and slope, $p<0.022$) as well as higher gait smoothness (vertical Harmonic ratio, $p=0.039$), as compared to the subjects with worse global cognitive scores. People with better EF had significantly lower step variability (vertical amplitude, $p=0.035$), lower step duration ($p=0.016$), and higher gait smoothness (anterior-posterior Harmonic ratio, $p=0.038$). People with better attention had lower step variability (vertical amplitude and slope, $p<0.029$), lower step duration ($p=0.002$), as well as higher anterior-posterior acceleration range ($p=0.047$). Conclusions: These findings suggest that metrics derived from a 3-day worn body-fixed sensor are sensitive to cognitive deterioration in patients with PD. These findings further supporting the idea that the gait pattern may be altered as cognition declines. Perhaps the cognitive demands of walking in complex and challenging daily-living environment are the source for this link. The present findings promote our understanding of the motor cognitive interaction needed for safe and effective community ambulation. This work was supported in part by the European Commission (FP7-ICT-2011 - Contract no. 288878); and MJFF

O.10.2 Time Spent Standing and Walking Post-Stroke: a Three Year Follow up study.

Dorit Kunkel[1], Carolyn Fitton[1], Malcolm Burnett[1], Ann Ashburn[1]

[1]University of Southampton

BACKGROUND AND AIM: Regaining functional independence and resumption of walking and previously valued activities is a key aim of individuals participating in stroke rehabilitation. Little is known about how activity levels change over time post stroke and which factors might impact on activity levels post stroke. To examine activity levels in a sample of people with stroke, longitudinally, at four time points (in hospital and then at one, two and three years' post-stroke post) in relation to other clinical measures and factors that may impact on activity levels. METHODS: At each assessment point, activity levels were measured used the activPAL Activity Monitor as well as completing clinical outcomes measures (Barthel Score (BS), Functional Ambulation Category (FAC), Rivermead Mobility Index, Berg Balance Scale, Hospital Anxiety and Depression Scale, Timed Get up and Go Test. RESULTS: Seventy-four people with stroke (mean age 76 (SD 11), 39 men) participated in the study and completed at least one of the assessments (n=61 in hospital, n=30 at Year 1, n=44 at Year 2 and n=37 at year 3). In hospital 94% of time was spent in sitting and lying and 4% standing and 2% walking. Activity levels improved over time;

time spent sitting/lying decreased (P=0.001) and the time spent standing, walking and number of steps increased (P=0.001, P=0.028 and P=0.03 respectively). At year 3, participants spent 18% of time in standing and 9% of time walking. Time spent upright correlated significantly with BS (r=0.69 on admission, r=0.68 on discharge, both P<0.01) and FAC (r=0.55 on admission, 0.63 on discharge, both P<0.05); correlations remained significant at one, two and three years' post stroke. Similarly, depression in hospital, left hemisphere infarction (Years 1-2), visual neglect (Year 2), poor mobility and balance (Years 1-3) correlated with poorer activity levels (all P<0.05). CONCLUSIONS: People with stroke were inactive for the majority of time, in hospital and in the community. Time spent upright improved significantly between the hospital at one year assessment; but these improvements appeared to slow down thereafter. Poor activity levels correlated with physical and psychological measures. Larger studies are indicated to identify predictors of activity levels and to explore targeted interventions that promote physical activity in people with stroke living in the community.

O.10.3 Feasibility of relating continuous monitoring of turning mobility to fall risk and cognitive function

Martina Mancini[1], Mahmoud El-Gohary[2], James McNames[2], Jeffrey Kaye[1], Fay Horak[1]

[1]Oregon Health & Science University, [2]APDM, Inc.

Background. Difficulty turning, or changing direction of walking, is a major contributor to mobility disability, falls and reduced quality of life in older people and people with movement disorders. A complex coupling of balance and locomotor systems, required for turning, gradually deteriorates with age, especially for people with chronic neurological disorders. We speculate that turning speed may be even more sensitive than gait speed to predict future falls, measure benefits or side-effects of treatment and indicate physical health. The objectives of this study were to determine the feasibility of continuous monitoring of turning during spontaneous, daily activity and its association with fall risk and cognitive function. Methods. Thirty-five elderly participants (age: 85+8years) wore 3 Opal sensors on the belt and on each foot throughout 7 consecutive days in their homes. The algorithm classifies periods of walking activities inside and outside the home, and calculates the number of turns (>35°) and corresponding turn metrics during each hour of the day. Turning metrics included average and coefficient of variation (CV) of: 1) number of turns per hour, 2) turn angle amplitude, 3) turn duration, 4) turn rotational rate, 5) number of steps. In addition, activity rate and gait bouts were measured. Neuropsychiatric assessment included cognitive domain z-scores: Executive function, Working memory, Attention/Processing speed, Memory, and Visuospatial function. Based on the history of falls participants were grouped into non-fallers (N=16), fallers (N=12), and recurrent fallers (N=7). Results. Quality of turning, quantified by mean turn duration, mean peak speed of turning, and mean number of steps to complete a turn were significantly compromised in recurrent-fallers compared to non-fallers (p<0.05). Active Rate (% of time when subject is walking compared to the full time of recording), gait bout characteristics, and mean number of turns/h were similar across the 3 groups. The mean turn angle was also similar across the groups. However, recurrent fallers had a significantly lower CV of turn angle compared to non-fallers and fallers (p<0.05). Visuospatial and attention domain z-scores were associated respectively with variability of turn duration and step duration (r=0.44, p=0.02; r=0.52, p=0.006). Discussion. We show that continuous monitoring of natural turning during daily activities inside or outside the home is feasible for older people who have high fall risk. This preliminary study suggests a less variable, cautious turning strategy in elderly subjects with a positive history of falls. Mobility was related to different aspects of cognition, consistent with shared neural resources for cognitive and dynamic balance

functions. We believe that characterizing functional turning during daily activities will address a critical barrier to clinical practice and clinical trials: objective measures of mobility in real life environment.

O.10.4 Usability and Effects of an Exergame-Based Balance Training Program

Seline Wüest[1], Nunzio Alberto Borghese[2], Michele Pirovano[2], Rolf van de Langenberg[1], Eling D. de Bruin[1]

[1]Institute of Human Movement Sciences and Sport, ETH Zurich, Switzerland, [2]University of Milan

Background: For best recovery results post-stroke, a structured, intense, challenging, and repetitive therapy program is required over an extended period of time. In order to achieve such sustained rehabilitation practice, patient motivation is crucial. Creating an engaging rehabilitation environment should thus be a primary concern when developing a rehabilitation program. Virtual reality applications have emerged as a promising tool for creating such an engaging environment and, thus, for promoting motor recovery post-stroke. The present paper tested the usability and effectiveness of a newly designed exergame-based rehabilitation program primarily aimed at minimizing stroke-induced walking impairments. Untrained yet otherwise healthy elderly formed the target population of the present study. Objective: To assess - in an untrained healthy elderly convenience sample - (1) the usability of the rehabilitation program in terms of acceptance, adherence and attrition and (2) the effect of the program on measures of balance and gait. Methods: Sixteen elderly subjects (76.5 ± 5.4 years; 13 females / 3 males) performed the rehabilitation program. Three supervised 20 minute training sessions were performed each week for a period of 12 weeks. Participants were thus required to absolve 36 training sessions. Adherence, attrition and acceptance were assessed, the latter by means of an adapted version of the Technology Acceptance Model (TAM) questionnaire. Measures of effectiveness were (1) Berg Balance Scale, (2) 7-Meter Timed Up and Go test, (3) Short Physical Performance Battery, (4) force platform stance tests and (5) gait analysis. Results: 13 participants completed the study (attrition rate = 18.8%), all without missing a single training session (adherence = 100%). Participants showed high acceptance of the intervention as expressed through their TAM score at the end of training. With respect to the measures of effectiveness, no changes in COP area during quiet stance on both stable and unstable surfaces and no changes of walking parameters were detected. In contrast, scores for the Berg Balance Scale ($p = .007$; $r = .51$), the 7-Meter Timed Up and Go test ($p = .002$; $r = .56$) and the Short Physical Performance Battery ($p = .013$; $r = .48$) all increased significantly with moderate to large effect sizes. Conclusions: Participants positively evaluated the usability of the virtual reality exergame-based training intervention. Furthermore, although improvements in gait parameters could not be shown directly, results did show that the intervention improves gait and balance related physical performance measures in healthy elderly. Taken together, the present results warrant a larger clinical exploratory study to investigate the usability and effectiveness of the exergames based program in stroke patients.

O.10.5 Effects of a highly challenging and systems-specific balance training program on balance, gait, physical activity and fear of falling in Parkinson's disease

Erika Franzén[1], David Conradsson[1], Niklas Löfgren[1], Håkan Nero[1], Agneta Ståhle[1], Maria Hagströmer[1]

[1]Karolinska Institutet

Background and aim: There is increasing scientific knowledge concerning the influence of physiological (motor, sensory and cognitive) systems and on balance and gait impairments in Parkinson's disease (PD).

Exercise is nowadays regarded as an essential component in the management of PD, however several questions remain unanswered, particularly regarding programs with a systems-specific approach on balance and gait. We have developed a new balance training regime, emphasizing on specific components of balance control related to PD symptoms by using highly challenging, progressive and varying training conditions (1). We have tested the feasibility of this group training in a pilot study and also validated its progression, hence the aim of this study was to evaluate the efficacy of this new balance training program in comparison to care as usual in mild to moderate PD. Methods: 101 elderly with PD were randomized either to the training group (n= 51) or to the control group (n=50), and of these participants, 91 (90%) completed the study (Trial registration: NCT01417598). The groups had similar characteristics: training group, n=47; mean age 72.9 years (SD 6.0), 28 males, UPDRS III mean score 35.9 (SD10.3) and control group, n=44, mean age 73.6 years (SD 5.3), 23 males, UPDRS III mean score 37.0 (SD10.6). In this 10 week, 3 times/week group training program, four main subsystems underlying balance control were emphasized and movement complexity in combination with dual-tasking was increased. Main outcomes, assessed before and after the intervention, were balance performance (mini-BESTest), gait (speed with and without a cognitive dual-task), physical activity level (mean steps/day during 7 consecutive days) and fear of falling (Falls efficacy scale-International). Results: The training program was well received: average attendance rate was high (90%) and the incidence rate was low (0.9%). Balance performance and gait velocity were improved in the training group in comparison to the control group (interaction effects $p<0.001$ and $p=0.009$). Physical activity level showed a tendency to a significant interaction effect ($p=0.052$). Gait speed when walking with a cognitive dual task increased in both groups (main effect, $p<0.001$) however, the training group improved their performance of the cognitive task during walking ($p=0.007$) while the control group remained similar. Both groups improved their fear of falling (main effect $p<0.001$). Conclusions: The results of this study implies that a system-specific and highly challenging balance training is important to improve balance and gait in elderly with mild to moderate PD. Interestingly, the training group showed a tendency to a short term improvement in physical activity level which are of importance for overall health. The up-coming long term follow-up (6 and 12 months post intervention) will further explore these effects. Reference 1) Conradsson, Löfgren, Ståhle, Hagströmer, Franzén. BMC Neurol. 2012: 12:11

O.10.6 Move up! Exergames training in children with advanced degenerative ataxia

Matthis Synofzik[1], Martin Giese[1], Ludger Schöls[1], Winfried Ilg[1], Cornelia Schatton[1]

[1]Hertie-Institute for Clinical Brain Research

Background: We recently delivered first evidence that whole-body controlled video games ("exergames") can be used as a rehabilitation tool in degenerative cerebellar disease. More specifically, we have shown that intensive and continuous coordinative training based on "exergames" can improve ataxia symptoms including posture and gait in children who were mild-to-moderately affected (able to walk without aid) (Ilg et al 2012, Neurology). Here we now test the hypothesis that thiss technology might present a treatment tool for coordinative training also in children with advanced degenerative ataxia (i.e. not or barely able to stand without aid). Methods: We examined the effectiveness of a 12-week coordinative training for 7 children (age: 16.9±8.6 years) suffering from progressive degenerative ataxia (SARA score: 21.5±5.2). Training exercises were based on 4-7 Wii® video-games which were chosen specifically to exercise upper- and whole-body balance. Training was divided into two phases. The first phase started with a directed laboratory-based one-week training phase, followed by 6 weeks training in children's home environment focused on upper-body balance. All patients started with the same 4 games. The consecutive second phase started with a two days lab-based training followed by

another 6-weeks home environment training. This allowed toadapt the focus of training according to each individual's training improvements achieved in the first phase. Specifically, some patients learned to stabilize their upper-body so that they were able to train also in a standing position in the second phase. For patients who were still not able to get in a standing position we focused on dual task performance. Training effects were assessed by an ataxia rating scale (SARA) and by quantitative movement analysis of upper-body balance. Additionally, patients subjectively selected relevant goals for their individual goal attainment score (GAS). Assessments were performed two weeks before the first training phase (E1), immediately prior to (E2), after the first (E3) and second phase (E4). Results: Significant reduction of ataxia symptoms (SARA, $p=0.04$) as well as improvements in subjectively selected relevant goals (GAS, E2/E4: 1.125 points on average) were observed after intervention (E4). Movement analysis revealed a significantly reduced lateral sway in sitting with eyes closed (E1/E4, $p<0.02$), indicating an improvement in body perception and postural control. Children experienced feelings of success about their own movements and were highly motivated. Conclusion: Our study shows that movement controlled video-games present a highly motivational and efficient rehabilitation tool to train upper-body balance and interaction with dynamic environments also in children with advanced degenerative ataxia. Acknowledgements: This study is supported by Ataxia UK, Ataxia Ireland, the German Hereditary Ataxia Foundation (DHAG), and the Katarina Witt-Stiftung.