ISPGR Oral Abstracts

O.1 Tools and Methods I

O.1.1 The instrumented Timed Up and Go test: Potential for assessing alterations in Parkinson's disease clinical subtypes

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Background: The Timed Up and Go test (TUG) is a simple, quick clinical performance-based measure of mobility and fall risk, used also in Parkinson's disease (PD). However, it is not known whether the TUG is sensitive to the PD clinical subtypes: postural instability gait difficulty (PIGD) or the tremor dominant (TD). Aim: To evaluate if the instrumented TUG (I-TUG) can better differentiate between the PIGD and the TD, and to identify behavioral and cognitive correlates. Methods: PD symptoms and severity were measured using the Unified Parkinson's Disease Rating Scale (UPDRS). Gait, balance and cognitive function were also evaluated. Subjects performed the TUG test at "off" wearing a body-fixed sensor extracting signals from 3 acceleration axes and 3 angular velocity axes. The different TUG subtasks were studied: overall TUG duration, walking parts, transition (sit-to-stand and stand-to-sit) and turning. Results: Thirty PIGD and 31 TD patients were studied. Both groups were similar with respect to age and disease duration ($p>0.7$). The PIGD group took significantly longer to complete the TUG than the TD; 10.29±3.59 sec Vs. 8.62±1.80 sec, ($p<0.026$), respectively. The PIGD group took significantly longer to complete the walking parts (excluding the transitions and turns): PIGD 5.57±2.90 sec, TD 4.34±1.10 sec; $p<0.039$. In addition, the PIGD performed more steps to complete the walking parts: 10.19±5.23 steps compare to only 7.88±1.78 steps in the TD group, $p<0.031$. However, the average step duration did not differ between the groups, $p=0.936$. The PIGD exhibited a lower step-to-step variability in the V and AP axis ($p<0.03$). The PIGD exhibited a longer time to complete the sit-to-stand transition ($p<0.03$), had a lower AP sit-to-stand jerk ($p<0.04$), and a lower pitch sit-to-stand range ($p<0.004$). While both groups didn?t differ in their turn durations, the PIGD showed a significantly lower yaw amplitude in both turns compared to the TD ($p<0.02$). Significant correlations were found between most acceleration measures and the PIGD score. For example, with walking time $r=0.453$, AP jerk during transition $r=0.323$, Yaw amplitude $r=0.407$, $p<0.001$ and inverse correlation with the pitch duration $r= -0.419$. In contrast only the Yaw duration was mildly correlated with the TD score $r=0.197$, $p=0.043$. Conclusions: These findings demonstrate, for the first time, that even one single sensor worn while performing the TUG can provide additional information and reveal fine alterations between the PIGD and TD clinical phenotypes.

O.1.2 Structural instability of human gait

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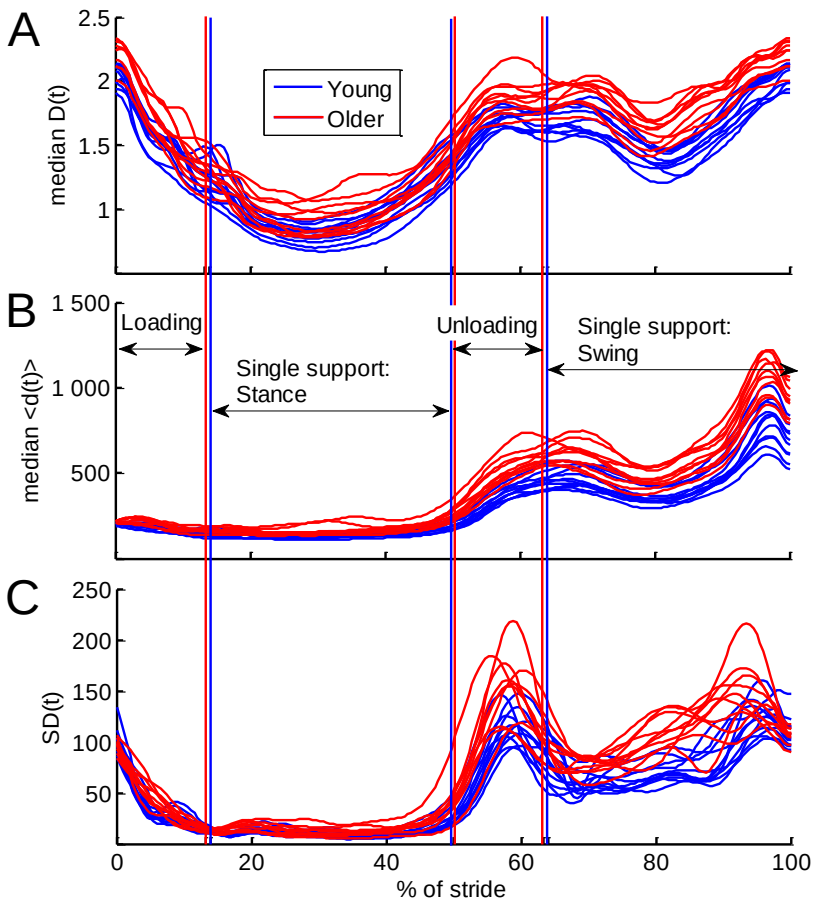
Introduction Nonlinear time series analyses quantify local dynamical and orbital instabilities in human gait kinematics. However, these methods assume that there are no phase transitions in the gait dynamics such that gait stability can be defined by a single parameter. The present study presents a multi-methodological approach that identifies intra-stride transitions, called structural instabilities, in gait dynamics in healthy younger and

older persons. Methods Three methods are introduced: 1) Intra-stride changes in the variability of gait kinematics, 2) Intra-stride changes in local dynamical stability [1], and 3) intra-stride changes in the dimensionality of gait dynamics [2]. Methods 2 and 3 are based on a 30-dimensional state space reconstruction of the gait dynamics using the 3D position and 3D velocity for the toe and heel markers together with the estimated ankle, knee, and hip joint centers. The methods were employed to a data set of 10 healthy young and older persons for 10 min treadmill walking at preferred, - 20 % and + 20 % of preferred gait speed. Results and discussion Decreases and increases in dimensionality D(t) of the gait dynamics reflect coupling and decoupling of functional degrees of freedom in the transitions between single and double support phase, respectively (see Panel A). This coupling and decoupling leads to state space convergence and divergence, respectively, of the gait dynamics (see Panel B) and an intra-stride modulation of the variability of the gait kinematics (heel marker velocity, see Panel C). Median D(t), median and SD(t) were different ($p < 0.01$) between healthy young (blue traces) and older adults (red traces) at the points of transition between single and double support phase, but not within the single support stance phase. This indicates that structural instability appears during weight transfer, which marks an intra-stride phase transition in the gait dynamics. The multi-methodological definition of structural instability is therefore a more valid concept of gait stability compared to local dynamical and orbital instabilities that assumes no phase transitions in the gait dynamics. Thus, the multi-methodological definition of structural instability can identify critical intra-stride phases for gait instabilities that might be important for detecting gait problems and for rehabilitation of gait following injuries and disease in older persons. References [1] Ihlen EAF, Goihl T, Wik PB, Sletvold O, Helbostad J, Vereijken B. Phase-dependent changes in local dynamical stability of human gait. J Biomech 2012: 45; 2208-14 [2] Ihlen EAF, Goihl T, Wik PB, Sletvold O, Helbostad J, Vereijken B. Phase-dependent changes in the dimension of human gait dynamics. J Biomech



O.1.3 Postural control during real and virtual obstacle avoidance

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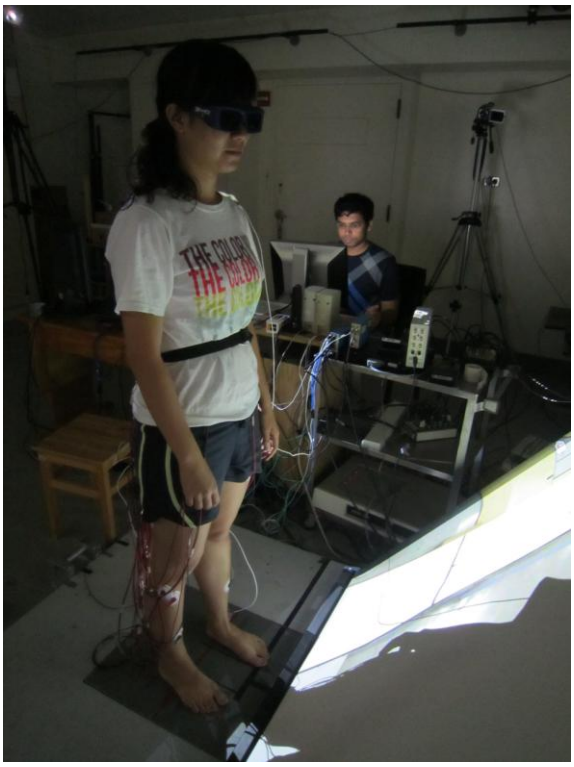
BACKGROUND AND AIM: In daily life, humans commonly rely on available visual information while avoiding a collision with an external obstacle. However, the efficiency of utilizing visual information could be affected when the environment is virtual. The purpose of the study was to determine the effects of various types of visual display on postural control during obstacle avoidance. METHODS: Ten healthy adults were asked to stand upright and avoid colliding with either a real or virtual approaching block by lifting their left leg. The approaching blocks of three heights (small, medium, and large) were used. The display conditions were real, stereoscopic head mount display (HMD) for computer graphics animation that displayed a movement of a computer-generated block (Figure A), and stereoscopic DLP (Digital Light Processing) projector displaying a video clip of the moving block (Figure B). The vertical acceleration of the lifting leg and surface electromyography (EMG) signals of the trunk and lower limb muscles were collected. RESULTS: A two-way ANOVA (Display × Height) for the peak vertical ankle acceleration showed a significant interaction, and post-hoc analyses indicated that the peak acceleration value increased with the block height. For the muscles of the lifting side, three-way ANOVAs (Phase

× Display × Height) showed significant interactions for the Display factor in biceps femoris and erector spinae muscles. Post-hoc analyses revealed that these differences did not reach statistical significance. However, for the muscles of the supporting side, three-way ANOVAs showed a significant interaction for the Display factor in tibialis anterior, and also was statistically significant for the main effects of Display in tibialis anterior, gastrocnemius medialis, rectus femoris, external oblique, and rectus abdominis muscles. Furthermore, post-hoc analyses demonstrated that there was at least one significantly different pair between the real condition and non-real condition (HMD or DLP projector) in all these muscles except for rectus femoris. CONCLUSIONS: The results indicated that the muscle activities of supporting side were sensitive to the change of the visual display used. In contrast, the display type appeared to have less effect on the muscle activities of lifting side. These findings suggest that the type of visual display may critically affect the postural control, even though the muscle activities that directly related to the limb displacement are comparable between the real and virtual environment.

A  B 

O.1.4 Vestibular stimulation by static magnetic fields

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BACKGROUND AND AIM: Patients and operators sometimes experience vertigo and instability in and around MRI scanners. This has been thought to be due to time and/or spatially varying magnetic fields stimulating the vestibular system [1]. However, based on eye movement recordings, it was recently reported that static, spatially homogenous magnetic fields stimulate the vestibular system [2]. The suggested mechanism involves interaction between static magnetic fields and natural ionic currents in the endolymph, producing continuous Lorentz forces strong enough to displace semicircular canal cupulae [2,3]. The main purpose of the present study

was to measure perceptual and eye-movement responses to a strong 7T magnetic field to investigate whether the Lorentz-force mechanism could also contribute to vertigo in magnetic fields. METHODS: Participants were pushed slowly into a 7T MRI scanner in darkness on a custom made bed designed to minimise motion cues. No imaging was performed, so only the main static magnetic field of the MRI scanner was present. Initially, naïve participants (n = 14) were investigated to obtain unbiased perceptual descriptions. Subsequently, participants (n = 17) reported their perception of rotation using hand-held switches whilst bed motion was recorded and eye movements were recorded using videooculography. RESULTS: In naïve participants, vertiginous perceptions started during entry on average at 5.0T with the dominant perception (present in 86%) being one of continuous rotation in the horizontal plane (Figure 1). Quantification of this perception demonstrated it was present whilst participants were stationary in the homogenous field at the centre of the bore, that it lasted on average 51s and had an average peak magnitude of 15 deg/s. Nystagmus responses were similar to the previous report [2], and had a mean onset at 1.6T. Nystagmus outlasted the perceptual response. CONCLUSIONS: Like the eye movement response, the perceptual response indicates that static magnetic fields stimulate the vestibular system. The rotational nature of the perception strongly implicates a mechanism involving the semicircular canals. Although there was a difference in time course of perceptual and eye movement response, this has been observed previously in response to constant acceleration stimuli [4] suggesting that a common, continuous stimulus can account for both. Thus, the Lorentz force is a viable mechanism for vertiginous responses evoked by magnetic fields. Static magnetic field evoked vestibular stimulation potentially has negative implications for functional neuroimaging but might offer a novel means for exploration of vestibular function. REFERENCES: 1. Glover et al. Bioelectromagnetics 28: 349-61, 2007 2. Roberts et al. Curr Biol 21: 1635-40, 2011 3. Antunes et al. Phys Med Biol 57: 4477-87, 2012 4. Guedry & Lauver. J Appl Phyiol 16: 215-220, 1963

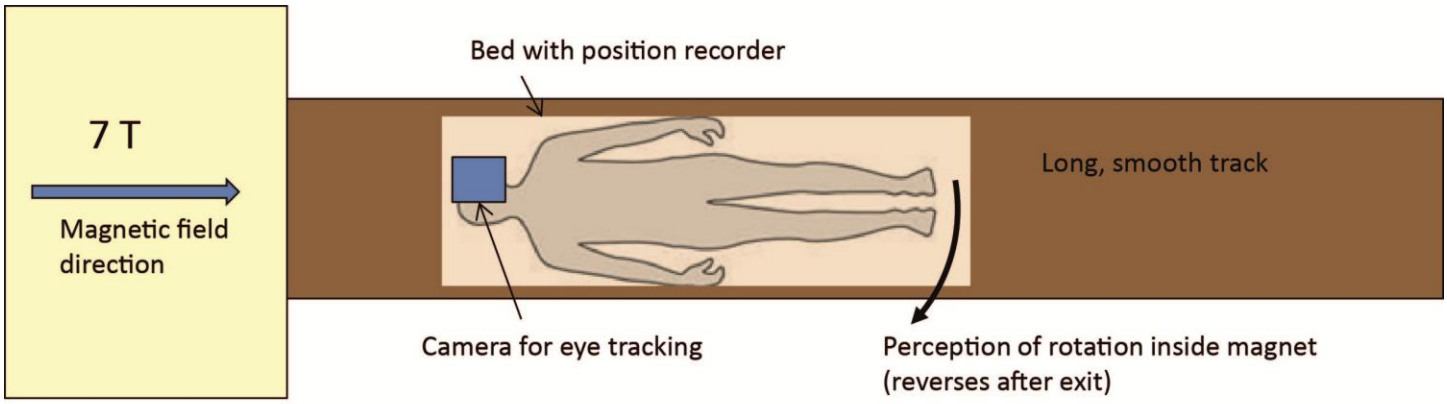

Figure 1. Schematic summarising setup and perception of rotation

O.2 Tools and Methods II

O.2.1 Plantar arch analysis during stepping on asperities to design a mechanical foot

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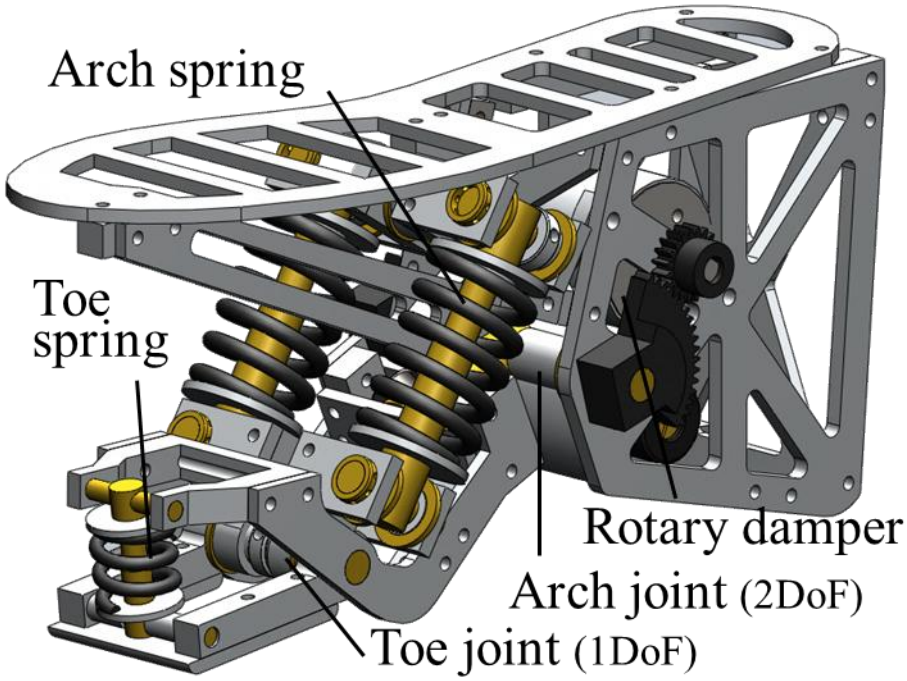
BACKGROUND AND AIM: Human's plantar arch is an important component during walking. The viscoelastic property helps to absorb the shock at heel-touch[1]. Moreover, plantar arch movements seem to absorb the asperity of the ground. This function is inseparable with biped walk, there are not many researches dealing with the effect of plantar arch during walking on the irregular ground. If prosthetic or robot foot has a joint to absorb the asperity, it could improve the walk on the irregular ground. The aim of this research is to find out the role of the plantar arch during stepping on an asperity, and reconstruct it artificially in order to be applied to prosthetic foot. METHODS: To evaluate the role of the plantar arch, we did four types of experiments, where we changed two conditions: (1) the ground surface, (2) a prosthetic restraint to limit the plantar arch movements. C1: natural walking, C2: with asperity, C3: with restraint, C4: with asperity and restraint. The asperity is a wooden plate set on the floor and the subject walked stepping on it without specific approach, and the restraint is the orthotic made by 10mm thick acrylic plate to restrain the function of the plantar arch. Evaluation value is the joint torque during the 4 different conditions. The joint torques of each joint of the leg and foot are calculated by inverse-dynamics using identified subject's link inertia for the whole body[1]. Motion capture systems and force plate are used to observe subject's motion and ground reaction force to calculate the joint torque. Finally using this joint torque, we identified the viscoelastic parameters of the plantar arch as a passive joint. PARA[1] G. Venture, et al., "Identification of Human Mass Properties From Motion", Proc. of the 15th IFAC Symp. on Sys. Identification, 2009. RESULTS: Increase in the joint torques of the knee and the ankle joint are found in C4. From foot flat to mid-stance, the joint torque of the knee in C4 is about twice as large as that in C1. In the foot flat phase and toe-off phase, the ankle joint torque in C4 is 20% larger than that in C1. This confirms that the plantar arch is effective when walking on asperities. The results of identified viscoelastic parameters are very good because the associated standard deviation is very small, the stiffness is 577.0Nm/rad (S.D. 2.70%), the viscosity is 16.44Nm/(rad/s) (S.D. 6.77%) over 10 trials. CONCLUSIONS: We proved that the plantar arch absorbed the asperity during walking from the experiments, as indicated by the change of the joint torques. We estimated the plantar arch viscoelastic properties quantitatively using inverse-dynamics method. The mechanical foot will be constructed using these identified viscoelastic parameters to validate the parameters. Moreover, we will confirm the plantar arch is effective as shown using the mechanical device as a prosthetic foot or a biped robot foot through more experiments.



O.2.2 Walking Stability Measurement Based On Plantar Skin Deformation

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Walk is fundamental motion in daily life. Everyday life isn't without walk. However, walk always involves risk of falling. Falling does not become the serious problem for the young people, however it becomes a serious problem for infant and elder people. In particular, the 10% - 40% elder have experienced falling for one year and 5% of fallers have a serious fracture accident. It is a serious problem for the aging society of Japan. However there are many unexplained parts of a walking mechanism. An elucidation of the uncertainty walking mechanism is urgent necessity. This study was focused on a plantar skin deformation during a walk. An analyzed plantar skin deformation can be a marker of a walking stability. The plantar skin deformation was measured by images of plantar skin while the stance phase during a walk. This research investigated the plantar skin deformation and variability in elder and young. The changes of plantar skin contact area, slipped contact area and non-slipped contact area were measured and compared while the stance phase. A total of 30 (10 normal young males (22±2 years) and 20 normal elders (73±5 years)) human subjects were recruited in the research. Subjects ware asked throughout the experiment to walk at a comfortable speed on a walkway four times per one trial. Images of plantar skin of the right foot while stance phase were collected by a high speed camera. Feature points of plantar skin were calculated by using Harris corner image processing method. Changes of plantar skin contact area were calculated by using binarization images. As results, the changes of plantar skin contact area in the elder were significantly higher than the young group while the 2nd phase ($p<0.05$). The standard deviation of the changes of plantar skin contact area and non-slipped contact area in elder group were

significantly higher than in young group while the 2nd phase and the 5th phase ($p<0.05$). The results suggested that the elder have more risk of falling than young while the 2nd phase and the 5th phase ($p<0.05$). The changes amount of plantar skin contact area only slipped area in the elder group were significantly higher than the young group while the stance phase ($p<0.05$), this phenomenon suggested that the elder group tend to sliding feet while the stance phase. In conclusion, the plantar skin deformation measurement has a potential to estimate the walking stability and risk of falling.

O.2.3 Wearable technology in Freezing Gait of Parkinson's disease: Literature Review

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BACKGROUND AND AIM: Freezing is one of the most distressing symptoms of people with Parkinson's disease (PwPD). Current literature has underreported the effectiveness of freezing rehabilitation in PwPD as the management of this degenerative disease has not been perfected to cater the physical needs of these individuals. Challenges met during implementation of conventional techniques include the lack of accuracy and objectivity of freezing episodes at real time and the limited carry over effects of external cues in the environment. The ideal management of PwPD with freezing issues identified herein would comprise of monitoring of freezing episodes and facilitating external cued therapy in the community according to the individuals' perspectives. Recently, the use of wearable technology has been proposed to offer solutions to these challenges. The study aims to (1) contribute to a better understanding of the functions available in wearable devices and (2) explore their effectiveness to improve freezing and facilitate client- based rehabilitation according to the ICF model. METHODS: 311 citations were obtained from searches in 5 databases (CINAHL, MEDLINE, PEDro, Pubmed and Cochrane) and snowball technique from 2 key papers. They were appraised using the STROBE and PEDro checklists. 18 experimental and observational studies are subsequently chosen based on their methodological quality score. RESULTS: The study reports that the 16 wearable devices with monitoring, cueing and smart functions could well bring functional benefits to the users with freezing issues. On the other hand, most of these devices have yet been validated for its monitoring purposes in freezing events or in the community settings. In addition, the perspectives from PwPD and physiotherapists have not been investigated and could limit the potential of wearable tools to facilitate holistic management. CONCLUSIONS: The current state of wearable technology has yet been qualified as the ideal freezing rehabilitation tool for PwPD with freezing issues. However, the study adds to the current literature and makes recommendations to develop wearable technology more ideally to cater the specific needs of the PwPD with freezing.

O.2.4 An instrumented 3-day activity monitoring in Parkinson's disease clinical subtypes

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BACKGROUND AND AIM: Patients with the Postural Instability Gait Difficulty (PIGD) subtype of Parkinson's disease (PD) generally exhibit more deficits in gait and balance, compared to the Tremor Dominant (TD) subtype. However, the quality of gait in real-life and the home-setting was not yet tested in those clinical subtypes. The study aimed to evaluate the possibility of using a single body-fixed sensor worn continuously for 3 days to quantify gait in PD subtypes as they carry out their routine daily life activities. METHODS: 109 PD patients were

studied (age: 65.1±9.2 yrs; UPDRS Motor Sum "off": 40.45±13.03; Hoen& Yahr "off": 2.57±0.69; 24.5% women). Parkinsonian symptoms and disease severity were measured using the Unified Parkinson's Disease Rating Scale. Acceleration axes included: vertical (V), anterior-posterior (AP) and medio-lateral (ML). Analysis of gait features was performed [1]; quantity measures included total percent of activity and step-count. Quality measures included step and stride regularity, harmonic ratio, average step duration and frequency measures (amplitude, width of the power spectral density) which reflect gait variability and consistency. RESULTS: Predominant TD and PIGD subtypes were identified (p-PIGD: n=30, p-TD: n=32). The p-PIGD and p-TD subtypes did not differ in their amount of activity but in their gait quality. The p-PIGD exhibited higher gait variability in the V and AP axis, as observed by the lower amplitude and slope of the V psd (V-Amplitude: p-PIGD: 0.58±0.20 prs, p-TD: 0.69±0.16 prs; p=0.025), and higher width of the AP psd (AP-Width: p-PIGD: 0.72±0.04 prs, p-TD: 0.68±0.02; p=0.0006). Nevertheless, in the ML axis they showed lower gait variability, as observed by the higher amplitude of the ML psd (ML-Amplitude: p-PIGD: 0.20±0.15 prs, p-TD 0.12±0.06 prs; p=0.011). The p-PIGD group also showed a significantly lower V stride and step regularity and AP stride regularity compared to the p-TD group (V-Stride-regularity: p-PIGD: 0.46±0.12 prs, p-TD 0.57±0.09 prs; p=0.0009). The p-PIGD had reduced gait smoothness both in the V and AP axes compared to the p-TD (AP-Harmonic ratio: p-PIGD: 1.83±0.46, p-TD 2.18±0.46; p=0.004). We explored the added value of using the accelerometer to discriminate between each subtype using binary logistic regression. Acceleration measures alone were able to correctly classify 77% of the subjects (79.3% p-PIGD, 75% p-TD). CONCLUSIONS: These results suggest that PIGD subjects differ from TD subjects in more than one locomotor construct. The quality gait measures (i.e., variability) may represent the increased fall risk in the PIGD subtype. This newly proposed method may provide a sensitive tool to detect subtle alterations among the different clinical phenotypes in PD, and may shed light on real-life behavior compared to a structured and "sterile" lab evaluation.

O.3 Neurological Diseases I

O.3.1 Asymmetric pedunculopontine network connectivity in freezing of gait from Parkinson's disease

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[1]Oregon Health and Science University, [2]University of Idaho

BACKGROUND AND AIM: Gait is no longer considered merely an automated motor activity and is known to require executive function and attention, processes involving frontal cortical areas. FoG is an episodic arrest of forward progress in locomotion due to an inability to take normal steps. We hypothesized that FOG is associated with impaired connectivity between midbrain locomotor regions (PPN) and the medial frontal cortex. The aim of the current study was to identify the relationships between degradation of the structural pedunculopontine (PPN) network and declines in executive function in patients with Parkinson's disease who experience freezing of gait (FoG). METHODS: 26 mild to moderate patients with PD and 15 age-matched healthy controls (HC) were studied. Parkinson's patients were tested in the morning off antiparkinsonian medications overnight and were classified as either FoG (n = 14) or FOG- (n = 12) based on their scores on the revised freezing of gait questionnaire. Diffusion weighted images were collected, and probabilistic tractography originating from the PPN was performed in both hemispheres. In addition, participants performed the Stroop task to assess executive function. RESULTS: FoG participants had significantly reduced PPN tract volume solely in the right hemisphere compared to FoG- and HC. The reduction in tract volume was a consequence of a decline in fiber tracts projecting from the PPN to the frontal and pre-frontal cortices. Furthermore, linear regression revealed that the

more left-lateralized the PPN tract volume, the poorer the speed and accuracy on the Stroop test, specifically within FOG patients. CONCLUSIONS: Declines in the PPN network of the right hemisphere are related to declines in executive function in PD patients with FoG. We suggest that impaired connectivity between midbrain locomotor regions and the right medial frontal cortex likely underlies the previously documented association of declines in executive function and FoG. Supported by NIA R37AG006457-24

O.3.2 Supra-spinal Control of Locomotion in Freezers and Non-freezers with Parkinson Disease

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BACKGROUND AND AIM: Freezing of gait (FoG) is a debilitating and dangerous symptom often elicited during complex gait tasks. The underlying neural pathology of FoG is not well understood, however several brain regions including premotor cerebral cortex, basal ganglia, and brainstem may be related to FoG. Gait imagery during functional magnetic resonance imaging (fMRI) is used to probe the neurological underpinnings of normal and pathological human gait, taking advantage of the overlap in brain activation between imagined and overt movement. However, few studies have investigated neural changes in PD during complex gait tasks which typically elicit FoG, such as turning. The aim of this study is to better understand neural pathology related to PD and FoG, particularly during forward walking and turning. METHODS: 20 healthy adults (mean age ±SD=67.4 ±7.6 years), 7 people with PD who do not experience freezing (non-freezers; 61.3 ±7.5), and 8 people with PD who do experience freezing (freezers; 66.4 ±7.1) imagined forward walking and turning in a small (0.6m radius) circle during fMRI. During each scan, blood oxygen level dependent (BOLD) signal was measured during alternating imagined gait tasks (approximately 15 seconds each) and rest periods (11 seconds). Subjects completed 2 imagined walking scans, each lasting about 9 minutes, as well as an imagined stand scan to serve as baseline. A region of interest analysis was conducted to quantify changes in BOLD signal during imagined gait in the following locomotor regions bilaterally: supplementary motor area (SMA), putamen, globus pallidus (GP), mesencephalic locomotor region (MLR), and a midline cerebellar region just anterior to the fastigial nuclei (cerebellar locomotor region; CLR). RESULTS: Imagined walking resulted in a greater change in BOLD signal with respect to stand in the SMA (non-freezers), putamen and GP (all groups), CLR (control and non-freezers), and MLR (controls and non-freezers). No BOLD signal differences were observed during turning with respect to forward walking. With respect to healthy controls, individuals with PD exhibited reduced BOLD signal change during imagined gait in the left GP. Within the PD group, BOLD signal change in the CLR was lower among those who experience freezing. PD motor symptom severity (UPDRS-III) and balance (MiniBESTest) were indirectly related to BOLD signal in the putamen and GP, indicating greater change in BOLD signal predicted less movement dysfunction. CONCLUSIONS: Though imagined turning did not differ from forward walking, those with PD exhibited reduced signal change in the GP, and, within individuals with PD, freezers exhibited reduced signal change in the cerebellar midline. These results, along with indirect correlations between disease severity and signal in multiple regions, suggest reduced signal change in the basal ganglia may represent global PD pathology while reductions in cerebellar signal may relate particularly to FoG.

O.3.3 Increased activation of the frontal lobe is associated with freezing of gait in patients with Parkinson's disease: an fNIRS study

Inbal Maidan[1], **Hagar Bernad-Elazari**[1], **Eran Gazit**[1], **Marina Brozgol**[1], **Nir Giladi**[1], **Anat Mirelman**[1], **Jeffery Hausdorff**[1]

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BACKGROUND AND AIM: Recent MRI and neuropsychological studies have suggested that deficits in executive function contribute to FOG. However, direct evidence of changes in frontal lobe activation before or during FOG episodes is lacking. The aim of this study is to examine whether frontal brain activation changes are associated with freezing of gait (FOG) episodes using functional near-infrared spectroscopy (fNIRS). METHODS:10 PD patients (Hoehn & Yahr stages: 2-4) with a history of FOG (mean age: 69±10.1 yrs) performed a protocol designed to provoke FOG while walking in the wearing off state. Frontal brain activation was assessed by measuring the oxygenated hemoglobin (HbO2) levels using fNIRS. For every FOG episode during a turn, three intervals were studied: the first two intervals of 5 seconds reflect the level of frontal brain activation before FOG; and the third interval reflects the level of frontal brain activation during the FOG episode. In addition, three intervals; two of 5 seconds before a turn without FOG and one of 3 seconds during turns without FOGs were compared. The mean percent changes in frontal brain activation between the three intervals were determined. RESULTS: 42 FOG episodes during were recorded turns. The duration of the FOG episodes was between 2-5 seconds. HbO2 significant increased, by 2.7±0.3% (p=0.045), before FOG. This increase was followed by a significant decrease of 7.4±0.4% (p=0.05) in HbO2 during FOG. In contrast, no significant changes in HbO2 before 42 turns without FOG were observed (p=0.178). A trend toward a decrease of 12.3±0.1% in HbO2 was found during turns without FOG (p=0.06). CONCLUSIONS: The increase in HbO2 before FOG could be interpreted as increased frontal brain activation just prior to FOG. This increased activation may be one of the factors that leads to FOG. While further work is needed to confirm and investigate these findings, the present results are apparently the first evidence of a direct association between FOG and changes in frontal brain activation.

O.3.4 A practical system for detection of freezing of gait in patients with Parkinson's disease

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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. Deep brain stimulation (DBS) and medication are conventional treatments for FOG but their effect is very limited. Visual, auditory and somatosensory cueing are reported to be more effective than DBS and medication. 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 freeze index (FI) from frequency characteristics of acceleration at body parts. However, the practicality of the method is limited because the attachments of sensors to the body using straps are burdensome and Fourier transform used to derive FI needs large amount of calculation hence hard to implement in a small system. The purpose of this study is to develop a more practical system where the sensors are integrated in shoes and the amount of calculation to detect FOG is smaller. METHODS: Two patients with Parkinson's disease (67.5±4.9 yrs) participated in this study. We inserted three-axis accelerometers in toe and heel of a shoe and the accelerations were transmitted to PC by wireless (Bluetooth) communication (Fig. 1). Subjects were instructed to repeatedly walk wearing the shoes for 12m in their comfortable speeds. We applied root mean square (RMS) algorithm for the detection of FOG, where RMS of each axis acceleration is calculated for a window of 4s and the FOG is determined as the periods when all RMS values are between their low and high thresholds. Thresholds for each axis and for each patient were optimized from the genetic algorithm with the sum of sensitivity and specificity as cost function. RESULTS: FOG detection results showed the sensitivity of 87.8% and specificity of 96.6%. Detected

and reference FOG periods are exemplified in Fig. 2. This is comparable to the result of Bächlin et al. (sensitivity: 88.6%, specificity: 92.4%) [2]. CONCLUSIONS: We developed a practical system for FOG detection with the sensor-integrated shoes and a simple RMS algorithm. It showed the performance similar to those in literature which used body attached sensors and FFT. We expect the suggested system to be practical in the real-time detection of FOG. ACKNOWLEDGEMENTS: This study was supported by the Ministry of Education, Science and Technology of Korea (No. 2011-0015824, No. 2012-025502). REFERENCES: [1] Moore ST et al., "Ambulatory monitoring of freezing of gait in Parkinson's disease., " J, Neurosci, Methods. Vol. 167, No. 2, pp. 340-348, 2008. [2] Bächlin M et al., "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.

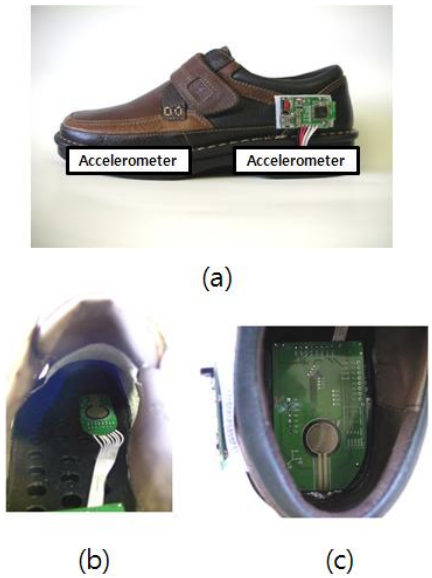

Fig. 1 Sensor integrated shoe (a) and insertion of sensors in toe (b) and heel (c)

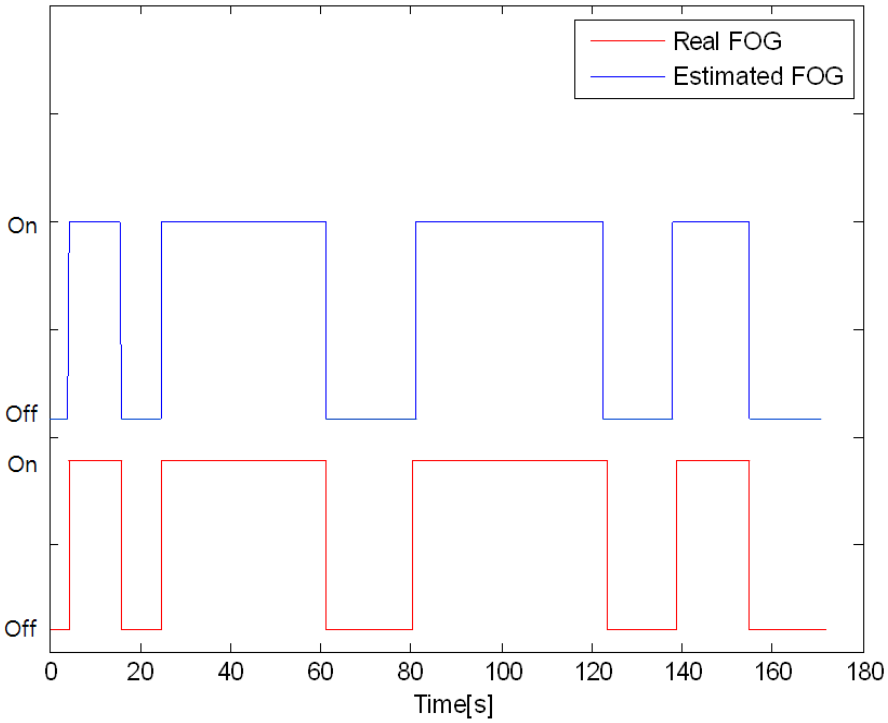

Fig. 2 Detected periods and reference periods of FOG (one subject)

O.4 Neurological Diseases II

O.4.1 White matter hyperintensities in Parkinson's disease: Do they explain the disparity between the postural instability gait difficulty and tremor dominant subtypes?

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Background and aim: Brain white matter hyperintensities (WMHs) commonly observed on brain imaging of older adults are associated with balance and gait impairment and have also been linked to cognitive deficits. Parkinson's disease (PD) is traditionally sub-classified into the postural instability gait difficulty (PIGD) sub-type, and the tremor dominant (TD) sub-type. Considering the known association between WMHs and axial symptoms like gait disturbances and postural instability, we hypothesized that WMHs might contribute to the disparate clinical sub-types. Methods: 110 patients with PD underwent a clinical evaluation and a 3T MRI exam. Based on the Unified Parkinson Disease Rating Scale, the patients were classified into TD or PIGD, and scores reflecting PIGD and TD symptoms were computed. We compared white matter burden using three previously validated methods: one using a semi-quantitative visual rating scale in specific brain regions and two automated methods. Results: Overall, MRI data were obtained in 104 patients. The mean WMHs scores and the percent of subjects with lesions in specific brain regions were similar in the two subtypes, p= 0.678. The PIGD and the TD scores did not differ even when comparing patients with a relatively high burden of WMHs to patients with a relatively low burden. Across most of the brain regions, mild to moderate correlations between WMHs and age were found ($r=0.23$ to 0.41; $p<0.021$). Conversely, no significant correlations were found between WMHs and the PIGD score or disease duration, after adjusting for age. In addition, depressive symptoms and cerebro-vascular risk factors were similar among the two subtypes. Conclusions: In contrast to what has been reported previously among older adults, the present study could not demonstrate any association between WMHs and the PIGD or TD clinical sub-types in patients with PD.

O.4.2 Differences in Gray Matter Atrophy between Parkinson's Disease Motor Subtypes: possible Role of GM as a Mediator between Motor and Cognitive Function

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BACKGROUND AND AIM: To assess differences in gray matter (GM) atrophy between two Parkinson's disease (PD) subtypes: the Tremor Dominant (TD) subtype and the Postural Instability and Gait Difficulty (PIGD) subtype and to evaluate the role of GM volume as a mediator between motor and cognitive function in PD patients. METHODS: Patients were classified as belonging to the predominately-PIGD (p-PIGD, n=30) or predominately-TD (n=29) subtype. Voxel-based-morphometry (VBM) was used to compare GM in these two subtypes and to evaluate correlations between predefined regions of interest and the degree of symptoms. In the regions where GM atrophy was associated with symptoms, the relationship between GM volumes and functional connectivity was examined. The role of GM as a mediator or moderator between motor and cognitive function was examined using the path analysis causal model or interaction analysis, respectively. RESULTS: GM was reduced in the p-PIGD group, compared to the p-TD group, in areas that involve motor, cognitive, limbic and associative functions (p-value<0.05, FDR corrected). Lower GM volumes in the pre-supplementary motor area (SMA) and in the primary motor area were associated with increased severity of PIGD symptoms ($r=-0.42$, $p<0.001$, $r=-0.38$, $p<0.003$, respectively). Higher GM volumes within the pre-SMA were associated with stronger functional connectivity between the pre-SMA and the putamen ($r=0.415$, $p<0.025$) in patients with p-PIGD. For all patients, GM volume in the precentral gyrus was found to play a causal role as a mediator between motor (pull test) and cognitive function ($z=-2.605$, $p<0.0092$), and not as a moderator between them ($t=0.225$, $p=0.823$).

CONCLUSIONS: In patients with PD, PIGD symptoms are apparently associated with GM atrophy in motor related regions and decreased functional connectivity. The p-PIGD subgroup showed GM degeneration and a related decrease in spontaneous co-activation between cortical and subcortical motor planning areas, which may partially account for the unique clinical characteristics of a subset of PD patients. A possible mechanism for the PD symptoms might be related to the role of GM in mediating motor and cognitive function.

O.4.3 Does dysfunction of brainstem reticular structures underlie postural instability in Parkinson?s disease?

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INTRODUCTION: Dysfunction of brainstem reticular structures may contribute to postural instability in Parkinson's Disease (PD). A StartReact paradigm, in which a startling auditory stimulus (SAS) is applied simultaneously with a postural perturbation, may provide more insight into the functional integrity of these structures in PD. A SAS accelerates the latencies of movement responses in simple ballistic movements as well as postural responses (StartReact effect). In patients with severe freezing of gait (FOG) and postural instability, however, Thevathasan et al. (2011) reported an absent StartReact effect when performing a simple ballistic arm movement. It is not clear yet whether this observation relates to FOG and/or postural instability. We therefore evaluated the StartReact effect on postural responses in PD patients with vs without postural instability and with vs without FOG. METHODS: Twenty-five patients with idiopathic PD and 15 healthy control subjects were included. Patients were classified as having postural instability if they were unable to recover from a pull-test . Eleven patients had postural instability (6 freezers) and 14 patients had no postural instability (5 freezers). Participants performed a simple reaction time task involving dorsiflexion of the foot. In 25% of trials a SAS was given with the imperative 'go' signal. In addition, we tested postural responses by translating a balance platform forwards, resulting in a backward balance perturbation. In 25% of trials a SAS accompanied the start of the platform translation. Muscle activity of the tibialis anterior (TA) was measured using surface electromyography and 3D kinematics were measured using a motion analysis system. RESULTS: The onset of automatic postural responses in TA did not differ between PD-patients (147 ms) and controls (146 ms). A SAS similarly accelerated the postural responses in PD-patients (14 ms acceleration) and controls (24 ms, SASxgroup; p=0.131), and also similarly in patients with and without postural instability (SASxgroup; p=0.950). However, the acceleration in freezers (5 ms) was significantly smaller compared to non-freezers (20 ms, SASxgroup; p=0.037). The reduced StartReact effect in freezers was also observed during the simple reaction task (20 ms acceleration in freezers vs 45 ms in non-freezers; SASxgroup=$p<0.001$), with no differences in reaction times without SAS. Differences between PD patients with and without postural instability were evident in underscaled amplitudes of the postural response (p=0.007) and step lengths (11 vs 19 cm; p=0.007). DISCUSSION: Underscaling of both the automatic postural response and the first step to recover from balance perturbations contributes to postural instability in PD. We found no evidence of dysfunction of brainstem reticular structures in patients with postural instability. Freezers, however, showed an overall reduced StartReact effect. Further research should investigate how this relates FOG.

O.4.4 Pedunculopontine nucleus-thalamic cholinergic correlates of postural sensory organization functions in Parkinson disease

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BACKGROUND AND AIM: Postural control involves the cerebellum, brainstem, striatum, and cortical brain structures. Parkinson disease (PD) is characterized by nigrostriatal dopaminergic denervation. There is also, to a more variable degree, cholinergic loss in PD. There are two principal cholinergic projection systems; cortical activity reflecting basal forebrain integrity and thalamus activity reflecting pedunculopontine (PPN) integrity. The thalamus serves as a conduit for the cerebellum, which also receives projections from the PPN. The aim was to investigate the effect of thalamic and cortical cholinergic, and striatal dopaminergic denervations on postural sensory integration functions in PD. METHODS: 110 PD subjects without symptoms of freezing upon clinical examination (29 F; 65.7 ± 7.8 yrs old; 5.7 ± 4.1 yrs motor disease duration; modified H&Y mean 2.3 ± 0.5, MDS-UPDRS part III motor score 30.1 ± 12.7) underwent dopaminergic 11C-DTBZ vesicular monoaminergic transporter-2 (VMAT2) and cholinergic 11C-PMP acetylcholinesterase positron emission tomography (PET) and the Sensory Organization Test (SOT) balance protocol on the NeuroCom® EquiTest® platform. All assessments were performed in the dopaminergic 'off' state. Measures of dopaminergic and cholinergic availability, i.e. striatal 11C-DTBZ distribution volume ratio (DVR) and thalamic and cortical 11C-PMP hydrolysis rates (k3) were calculated. For each of the 6 SOT conditions total center of pressure (COP) excursion (speed) and COP variability (root mean square; RMS) were determined. Principal component analysis with varimax rotation was performed to reduce postural sensory organization functions to factors with an Eigenvalue greater than 1. Factor scores were then entered as dependent variables in separate stepwise linear regression models. Independent variables for each of the models were striatal 11C-DTBZ DVR, thalamic and cortical 11C-PMP k3, age, MDS-UPDRS part III motor score, and motor disease duration. RESULTS: Graphical Scree plot analysis showed a 2-factor solution which explained 50.5% of the total variance. The first rotated factor solution reflected mostly COP speed for each of the SOT conditions and the second factor reflected COP RMS for SOT conditions #1 and #2. Stepwise regression models were significant for both factors (factor score #1: $F=7.0$, $p=0.01$; factor score #2 $F=15.6$, $p<0.0001$). Thalamic 11C-PMP k3 independently predicted factor score #1 ($\beta=-0.255$, $t=-2.64$, $p=0.01$. Factor score #2 was predicted by MDS-UPDRS part III motor score ($\beta=0.367$, $t=9.95$, $p<0.0001$). There was no effect of cortical 11C-PMP k3 or striatal 11C-DTBZ DVR for any of the models. CONCLUSIONS: Postural sensory integration control functions, in particular total sway excursions, in PD subjects are modulated by PPN-thalamic but not cortical cholinergic innervation. Cholinergic function of the PPN and its efferent projections can be hypothesized to play a role in balance functions in PD patients.

O.5 Cognitive and Cognitive Impairments

O.5.1 Spatial orientation deficit as an early clinical sign of hippocampal dysfunction in mild cognitive impairment

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[1]University of Munich

BACKGROUND AND AIM: Deficits in spatial orientation and navigation appear early in the course of Alzheimer's dementia. In the present study the spatial orientation strategy and brain activation during real navigation were compared in patients with amnestic mild cognitive impairment (MCI) and age-matched healthy controls. METHODS: 16 normal persons and twelve patients with MCI were included in the study. The neurocognitive status was tested by the CERAD-plus test. To investigate spatial orientation ability subjects had to perform a navigation paradigm in a complex unknown spatial environment of an outpatient clinic. The area, in which five items had been placed as target points for navigation, was shown to the subjects first. Afterwards FDG was injected and subjects had to find the items in a pseudo-randomized order over the next 10min. Subjects carried a gaze-controlled head-camera throughout the experiment to document their visual exploration behaviour. PET-scans were done 30min after FDG-injection. Brain activation patterns were compared between groups and correlated with the recorded visual exploration behaviour during navigation. RESULTS: During navigation in normal persons an increase of regional cerebral glucose metabolism (rCGM) was found in the pontine brainstem tegmentum and the right anterior hippocampus. In comparison MCI patients had less navigation-induced rCGM increase in the right anterior hippocampus. Severity of cognitive impairment correlated with reduced activation of the right anterior hippocampus during navigation. Analysis of visual exploration behaviour indicated a severely impaired navigation performance in all MCI patients. Confusion of targets and ineffective path trajectories were most common. Patients showed significantly more visual fixations to items along the path, which however seemed to be distributed more randomly thus indicating failure to encode specific landmarks. CONCLUSIONS: Deficits in spatial orientation and navigation occur already in MCI and correlate with dysfunction of the right anterior hippocampal. Therefore testing of navigation performance may be a reliable diagnostic tool to identify and differentiate early cognitive impairment.

O.5.2 EFFECTS OF CONCUSSION ON LOWER EXTREMITY INTER-JOINT COORDINATION DURING OBSTACLE CROSSING AND DUAL-TASK WALKING

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[1]University of Oregon

BACKGROUND AND AIM: While studies have demonstrated that mild traumatic brain injury concussion) would increase the risk of tripping during obstacle crossing or gait imbalance while engaging with a concurrent cognitive task, single joint kinematics during level walking were found unchanged. Discordant lower limb coordination may influence postural alignment and result in gait deviations or tripping. Therefore, the purpose of this study was to investigate the acute effect of concussion on inter-joint coordination during walking, obstacle crossing, and walking with a concurrent cognitive task. METHODS: 23 healthy subjects (14 men, age = 21.4 ± 3.2 yrs) and 23 subjects suffering a concussion within 48 hours prior to the testing (14 men, age = 21.8 ± 3.6 yrs) were recruited for study. A 10-camera motion analysis system was used to collect the whole body motion data during level ground walking (Level), walking and crossing an obstacle of 10% body height (OB), and walking while engaging with a concurrent question and answer task (ATT). Continuous relative phase (CRP) was derived from the phase portraits of two adjacent joints (hip-knee or knee-ankle) and was used to examine the pattern and variability of inter-joint coordination. Effects of OB and ATT on CRP patterns were assessed using cross-correlation measures and root-mean-square (RMS) difference which compared the ensemble mean curves of OB or ATT to Level condition. The variability of inter-joint coordination for each subject was calculated as the average standard deviation of all points on the ensemble CRP curve over a gait cycle and was termed the deviation phase (DP). The leading limb (LOB) and trailing limb (TOB) during obstacle crossing were examined separately. Group and task differences in cross-correlation measures, RMS difference, and DP values were examined using a mixed-model analysis of variance with repeated measures and walking speeds as covariates.

RESULTS: For hip-knee and knee-ankle CRP patterns, RMS differences between OB and Level and between ATT and Level in concussed subjects were significantly greater than those of healthy adults. No significant group differences were detected for the cross-correlation measures of hip-knee and knee-ankle CRP patterns. In stance phase, significant task effect on DP values was detected in hip-knee inter-joint coordination. For knee-ankle inter-joint coordination, concussed subjects showed significantly greater DP values than healthy controls during OB and ATT. In swing phase, concussed individuals showed greater DP values in hip-knee and knee-ankle inter-joint coordination compared to healthy controls. A significant task effect on DP values was detected in knee-ankle inter-joint coordination. CONCLUSIONS: Our findings suggested that the ability to select appropriate coordination patterns and steadiness of neuromuscular control could be affected by a concussion, which may contribute to gait control variability.

O.5.3 Associations Between Gait Variability And Sustained Attention In A Community Dwelling Nationally Representative Population Sample

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

[1]Neural Engineering, Trinity College Dublin, [2]The Irish Longitudinal Study on Ageing (TILDA), Lincoln Gate, Trinity College Dublin, Dublin 2., [3]Neural Engineering, Trinity Centre for Bioengineering, Trinity Biomedical Sciences Institute, Trinity

BACKGROUND AND AIM: Gait variability is thought to reflect disruptions in intrinsic motor control. Increased variability in temporal gait parameters as we age have been associated with Alzheimer's disease and with increased risk of falling [1].PARA Links between gait variability and broad domains of cognitive function, such as executive functions, have been investigated previously; however, there has been less focus in the literature on the link with more specific cognitive domains such as sustained attention. Sustained attention is the ability to maintain attention to task over a period of time and has been linked to frontal lobe damage [2] and higher risk of falling[3]. PARA The aim of this study is to explore the association between real life attentional measures; endogenous attention, lapses in attention, and their relationship to gait variability. METHODS: Cross-sectional data from the first wave of The Irish Longitudinal Study on Aging was used. A 4.88 m GAITRite pressure sensing mat was used to measure gait variability by recording stride time standard deviation during a walk at normal pace. Participants with Parkinson's disease, Stroke and those with less than 8 steps per walking condition were excluded (n=3180, 56% women, mean±sd: age; 62.4±8.2 years). PARA Sustained attention was measured using a sustained attention to response task (SART)[2]. Repeated digits were presented sequentially from '1' to '9' on a screen while participants pressed a button for every digit except the digit "3" (300ms inter stimulus interval, 207 numbers). The measures of sustained attention used were variation in response times and errors of commission (pressing on '3'). Errors of commission, thought to measure a "drift" of controlled processing into an automatic response, have been linked to frontal lobe damage [2], while greater variation in response time linked to higher risk of falling[3]. PARA Multiple Linear Regression was used to examine if gait variability differed across sustained attention measures. RESULTS: An increase in stride time variability was independently associated with greater response time variation (ß=0.0040, p=0.002) (Figure 1) but not with greater errors of commission (ß=0.00008, p=0.172) after adjusted for age, height, gender, depression, education and factor affecting gait and, weighted in order to be nationally representative. CONCLUSION: Sustained attentional capacity was independently associated with stride time rhythmicity. Lower sustained attention scores correlated with higher

stride time variability for a simple gait task in this a healthy older population sample. Further research is needed to explore how recruitment of endogenous attention, lapses in attention and gait variability change within individuals over the duration of a gait task using more ecological conditions such as more complex gait tasks, thus benefitting quality of life issues. REFERENCES: Callisaya et al 2010, Robertson et al (1997), O'Halloran et al (2011).

ASSOCIATIONS BETWEEN GAIT VARIABILITY AND SUSTAINED ATTENTION

IN A COMMUNITY DWELLING NATIONALLY RESPRESENTATIVE POPULATION SAMPLE

Killane, I[1], Donoghue, O[2], Savva, G [2], Cronin, H[2], Kenny, R.A.[2], Reilly, R.B. [1]

[1] Trinity Centre for Bioengineering, Trinity College Dublin [2] The Irish Longitudinal Study on Ageing (TILDA)

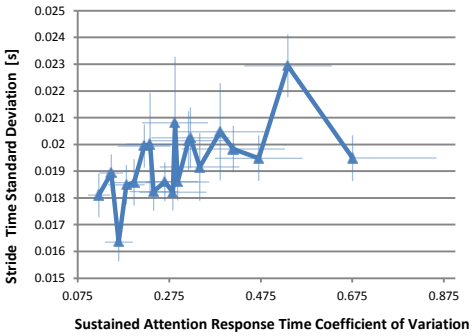

Figure 1: Adjusted Stride Time Variability values over SART Response Time Variability.

Adjusted for age, height, gender, depression, level of education, self-rated vision, presence of a chronic disease, Arthritis, Osteoporosis, disability and hip fracture, participants who used a walking aid and with hip or knee pain and weighted to remove potential biases in data collected at health assessment in order to be nationally representative

O.5.4 Dual-tasking during locomotor skill acquisition impairs the expression of the locomotor after-effect

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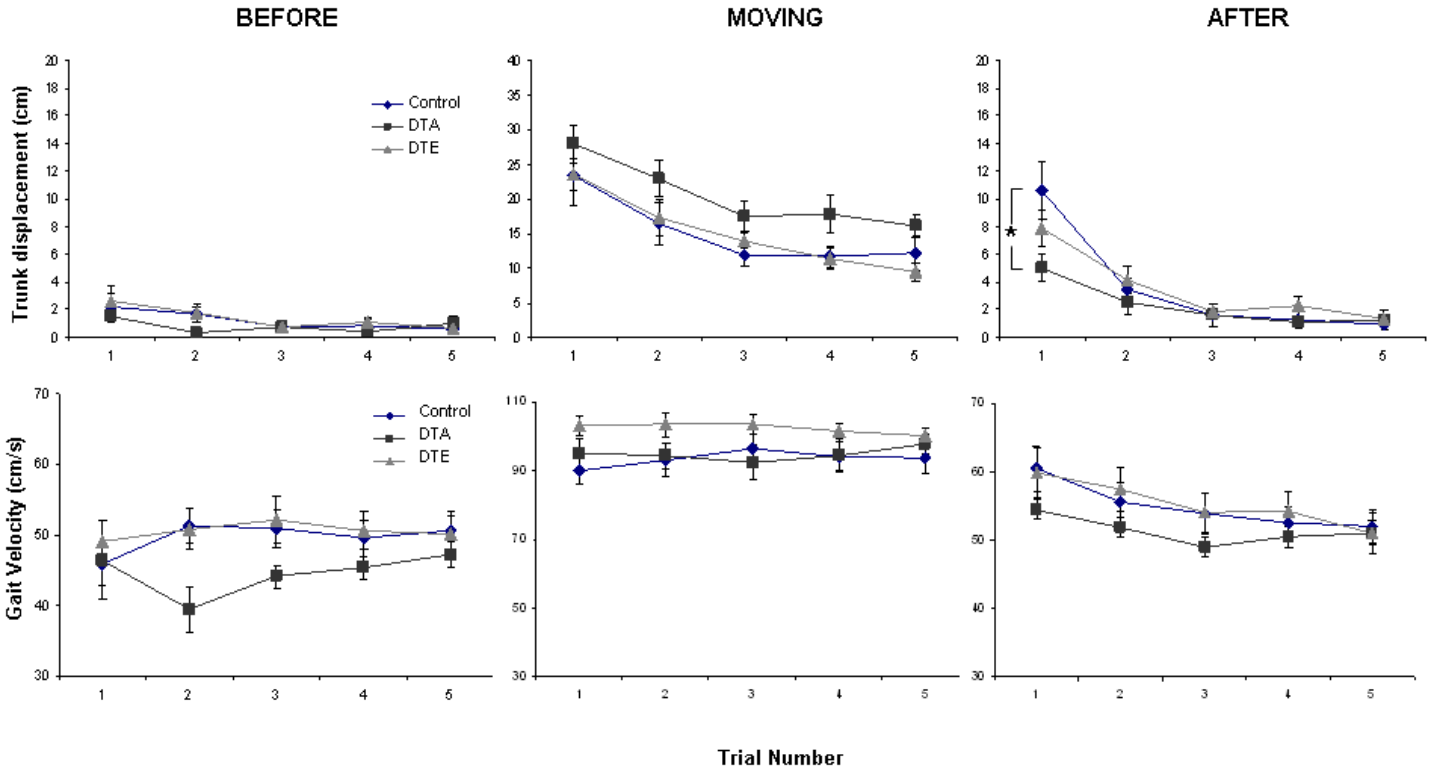
BACKGROUND AND AIMS:The experience of stepping onto a broken escalator can cause a stumble. This stumble is the consequence of the locomotor after-effect (LAE) and attests to a process of motor adaptation. It is unknown whether this adaptive learning process is predominantly implicit or explicit, and whether diverting attention modifies the motor learning process and subsequent expression of the LAE. Given that implicitly learnt motor skills are less susceptible to dual-task interference, in the present study, we diverted attention in the acquisition and expression stages of the LAE by loading these stages with a secondary cognitive task (naming differing categories of entities e.g., vegetables, fruits, and colours). METHODS: Subjects were 36 healthy adults assigned to 3 equally sized groups. They performed 5 trials stepping onto a stationary sled (BEFORE trials), 5 with the sled moving (MOVING or adaptation trials) and 5 with the sled stationary again (AFTER trials). A 'DualTaskAcquisition (DTA)' group performed the dual-task in the motor skill acquisition (MOVING trials) phase and the 'DualTaskExpression (DTE)' group in the expression phase (i.e., AFTER trials). The 'Control' group performed no dual-task. Measurements were of trunk displacement, gait velocity and muscle activity of the lower legs. RESULTS: During the MOVING trials, the DTA, but not the DTE group, had larger levels of trunk sway

compared to Controls. A LAE was seen in the first AFTER trial (AFTER trial 1) in all groups. The DTA group, however, had a smaller trunk LAE compared to Controls but there was no difference between the DTE group and Controls. Gait velocity was unaffected by the secondary cognitive task. CONCLUSIONS:Attentional resources are involved in the acquisition of the LAE: diverting attention impaired this motor learning process resulting in its reduced expression. Once learnt however, expression of the LAE was unaffected by diverting attention i.e., it was automatically executed. These findings reflect different neural processes involved in acquisition versus expression of this locomotor task.



O.6 Habilitation and Rehabilitation

O.6.1 The relationship between physical capacity and both fatigue and fatigability in older people?

Thorlene Egerton[1], **Per Bendik Wik**[1], **Ole Petter Norvang**[1], **Jorunn Helbostad**[1]

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BACKGROUND / AIMS: Aging-related fatigue is an evolving concept which is still relatively poorly understood. The distinction been fatigue (asthenia) and fatigability (exertion fatigue) has recently received attention. Self-reported fatigue may be part of an accelerated ageing process, is persistent, unpleasant, non-functional and un-relieved by rest; while fatigability is an acute response to a bout of activity and may be related to de-conditioning. 'Fatigue' is reported to be a cardinal feature of the frailty syndrome along with slower gait speed, reduced activity and reduced muscle strength, and it may be the first sign of imminent rapid decline in function

and health. However, frailty studies have variously reported fatigue, fatigability and endurance under the umbrella term of fatigue. Fatigability is likely to worsen secondary to fatigue, however, despite the inter-relatedness and likelihood of co-existence, many now believe them to be separate constructs. Our aim was to compare the associations between measures of physical capacity, including gait speed and leg muscle strength and power, with fatigue and fatigability. We hypothesised that fatigability would be more strongly associated with physical capacity than fatigue. METHODS: Ninety people (70-75yrs, 48% male) were asked to rate from 1-7 their level of fatigue ("I feel tired all the time") and fatigability ("I become quickly exhausted with exercise"). Preferred and maximum gait speed was measured using GaitRITE. Average speed during an instrumented sit-to-stand test was used to indicate leg power. Peak voluntary isometric leg muscle strength was measured during a leg press. Spearman's rank correlation analyses were carried out between fatigue/fatigability and the physical capacity measures. RESULTS: The median score for the fatigability question was 2.5/7, with 36% scoring 1 and 24% scoring ¡Ý 5. However, the median score for fatigue was 1/7, with 68% scoring 1 and only 7% scoring ¡Ý 5. Fatigue and fatigability were significantly but only moderately correlated ($r=0.43$, $p<0.01$). Significant ($p<0.05$) correlations were found between fatigability and leg strength ($r=0.38$), leg power ($r=0.34$), preferred gait speed ($r=0.26$), and fastest possible gait speed ($r=0.34$). However, for fatigue, a significant correlation was found only with leg strength which was relatively poor at $r=0.21$. CONCLUSIONS: That only 7% of the study sample reported fatigue ¡Ý 5 out of 7 is not unexpected as fatigue at this level is a serious and debilitating problem, however the ceiling effect is a limitation of the analysis. Our results suggest that our two questions measured different constructs. In support of our hypothesis, fast gait speed (capacity) was more strongly associated with fatigability than preferred speed. In addition, we demonstrated associations between fatigability and all the physical capacity measures, which suggests that de-conditioning leads to higher fatigability but not necessarily fatigue.

O.6.2 The Effect of Visual Motion Stimulation on Visual Dependency in Patients with Visual Vertigo

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BACKGROUND AND AIM: Patients with long-term vestibular disorders often become visually dependent, which leads to aggravation of dizzy symptoms in certain visual surroundings with moving objects (traffic and supermarkets aisles). It is known that vestibular rehabilitation is effective for the symptoms, which often incorporates optokinetic stimulation (OKS). Despite the undoubted efficacy of such visual stimulation therapy, whether exposure to OKS reduces visual dependency in patients with visual vertigo is unknown. Moreover, the optimal intensity of the OKS treatment has not been clarified. The aim of the study is to investigate whether short-term intensive, graded exposure to OKS incorporated with vestibular rehabilitation provides better benefits for patients with visual vertigo in both the short and long term. METHODS: Thirty-two patients with a peripheral vestibular disorder and visually-induced dizziness were randomly allocated into two treatment groups, customised vestibular rehabilitation with (Group OKS) and without (Group C) optokinetic stimulation. Individuals attended therapy sessions for five consecutive days and were provided with a customised home exercise programme afterwards. Response to treatment was assessed at baseline, after the five-days of daily treatment sessions, and at four and eight weeks following the supervised therapy. Assessment included tests for visual dependency (rod-and-disc test and visual roll-motion posturography) and the Functional Gait Assessment (FGA) to assess the patient's ability to perform complex gait tasks (i.e. walking with eyes closed). Subjective questionnaires concerning symptoms, symptom-triggers, perceived handicap from symptoms, and psychological

state, were also used to evaluate treatment outcome. RESULTS: Twelve patients in each group completed treatment. Migraine was triggered in total 20 patients (12 in Group OKS and 8 in Group C) during the treatment week. Both groups showed significant reductions in subjective visual vertical deviation with the rod-and-disc test at the last assessment. Total sway path induced by the rotating stimulus significantly decreased for both groups, but only Group OKS showed significant improvements on the Kinetic Quotient (disc rotation/eyes open sway path ratio) at week 8. FGA scores significantly improved for both groups. Significant improvements on visual vertigo symptoms, perceived handicap from dizziness, functional ability, and emotional status were noted in both groups. (All $p<0.05$). CONCLUSIONS: Although customised exercises in isolation provide improvements for subjective symptoms, functional gait and subjective visual vertical measurements, only customised vestibular rehabilitation incorporating OKS exposure provides improvements in visual roll-motion posturography. However, the intensive OKS exposure appears to be quite challenging for the patients with visual vertigo. A less intense exposure programme may require further investigation.

O.6.3 Effects of preparatory cued step training on gait performance in people with Parkinson's disease

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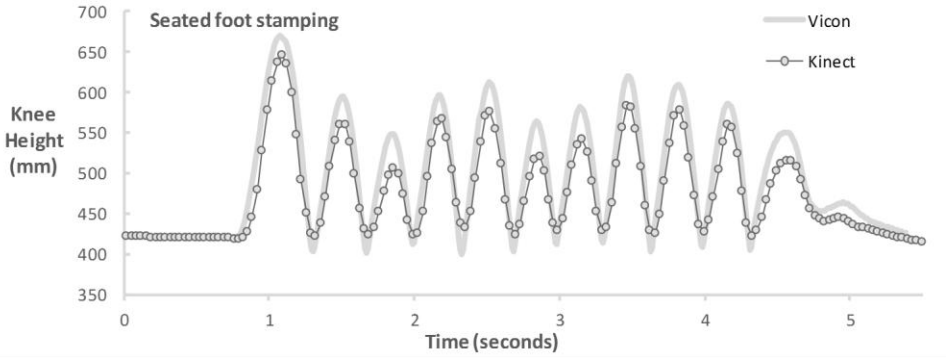
BACKGROUND AND AIM: Walking training using external cues has been found to enhance gait speed, stride length and cadence in people with Parkinson's disease (PD). Some studies reported that the effects of cued training lasted for a duration of 3 months but the treatment effect beyond 3 months is not known. We designed an intervention using preparatory visual cues to train the step speed and amplitude. We examined whether 12-week step training with preparatory cues is effective to enhance spatiotemporal gait characteristics of people with PD at completion of treatment and at 12-month follow-up. METHODS: It is a randomized controlled trial with assessor blinded to group assignment. Forty-five patients with PD completed all training and they were randomly assigned to an experimental (EXP) group who were given repetitive step training with preparatory visual cues, or control (CON) group receiving lower limb strength training for 12 weeks. Outcome measures included spatiotemporal gait characteristics. All tests were conducted before and after training at patients' on-medication state. Subjects were invited to perform a re-assessment at 12 months after treatment completion. Two-way repeated measure ANOVA was employed to examine the within-group and between-group differences. RESULTS: Immediately after treatment completion, both EXP and CON groups significantly increased the gait speed (by 7-9%, $p<0.001$). The EXP group significantly increased the stride length (by 13%, $p<0.001$) and decreased the cadence (by 9%, $p<0.05$) while CON group significantly increased the cadence (by 3%, $p<0.001$). At 12-month follow-up, both subject groups significantly increased their gait speed (by 7%, $p<0.001$) when compared with the pre-training baseline value. The EXP group maintained their improvement in the stride length (by 12%, $p<0.001$). Between-group comparison revealed that the change of stride length from the baseline was significantly larger in the EXP than CON subjects at both post-treatment and 12-month follow-up ($p<0.05$). CONCLUSIONS: Repetitive step training with preparatory cues enhanced both gait speed and stride length and the effects carried over to 12 months after treatment ended. Since patients with PD were found to have more difficulties to modulate their stride length than cadence, the positive findings suggest that step training with emphasis on both speed and amplitude can alleviate bradykinetic movement associated with PD. The long term effect on walking performance suggests that motor learning is possible in patients with PD.

O.6.4 Retraining function with exercise based computer games for people with Parkinson's disease: PD-Kinection

Brook Galna[1], **Dan Jackson**[1], **Patrick Olivier**[1], **Gillian Barry**[1], **Dadirayi Mhiripiri**[1], **Madeline Balaam**[1], **Roisin McNaney**[1], **Mary Webster**[1], **Lynn Rochester**[1]

[1]Newcastle University

Background: Exercise is emerging as an efficacious therapy to complement the management of motor symptoms in Parkinson's disease (PD) such as poor gait and postural control. Computer based gaming systems can facilitate complex task practice, enhanced sensory feedback and action observation in novel, relevant and motivating modes of exercise which can be difficult to achieve with standard physiotherapy. The appropriateness of current Kinect gaming software for rehabilitation in PD is limited and the accuracy of movement detection has not been established. Aims: Develop a computer game to rehabilitate dynamic postural control in people with Parkinson's disease (PD) using the Xbox Kinect; and assess the feasibility and validity of the Kinect system to provide rehabilitation and symptom monitoring in people with PD. Methods: A rehabilitation game aimed at training dynamic postural control was developed in collaboration with people with PD and their carers. The game consisted of multi-directional reaching and stepping, with increasing cognitive complexity across 11 stages. Nine people with PD played the game for one 30min session. Participant feedback to identify issues relating to acceptability, feasibility and safety of rehabilitation gaming for people with PD were collected using a semi-structured interview. To establish reliability and validity for gaming and monitoring, we recruited nine PD participants and 10 controls to perform a range of movements measured by a 3D motion capture system (VICON) and Kinect system concurrently. Results: People with PD generally enjoyed the game and all felt safe whilst playing the game. Eight out of the nine participants said they would buy the game, especially if they felt it would improve their balance. However, some participants found interacting with game objects appearing to move towards them difficult and some had difficulty combining the stepping and reaching tasks. The Kinect accurately measured gross movements such as multi-directional stepping and reaching, and sit-to-stand, as well as estimated relative timing and amplitude of distal movements such as hand clasping and foot tapping (Figure1). The Kinect was also able to estimate a consistent pattern of knee flexion when walking. Discussion: Computer based rehabilitation games can be delivered in a safe and enjoyable way using the Xbox Kinect for people with PD. However intervention trials are needed to test the game's efficacy. In addition, the Xbox Kinect can accurately measure the timing and overall pattern of movements used in clinically based tests but not with the same spatial accuracy as the gold standard three-dimensional motion analysis equipment.



O.7 Falls and Falls Prevention I

O.7.1 White matter integrity and fall risk in older people: A diffusion tensor imaging study

Kim Delbaere[1], **Carola Tuerk**[1], **Lin Zhuang**[1], **Wei Wen**[1], **Stephen Lord**[1], **Jacqueline Close**[1], **Henry Brodaty**[1], **Perminder Sachdev**[1]

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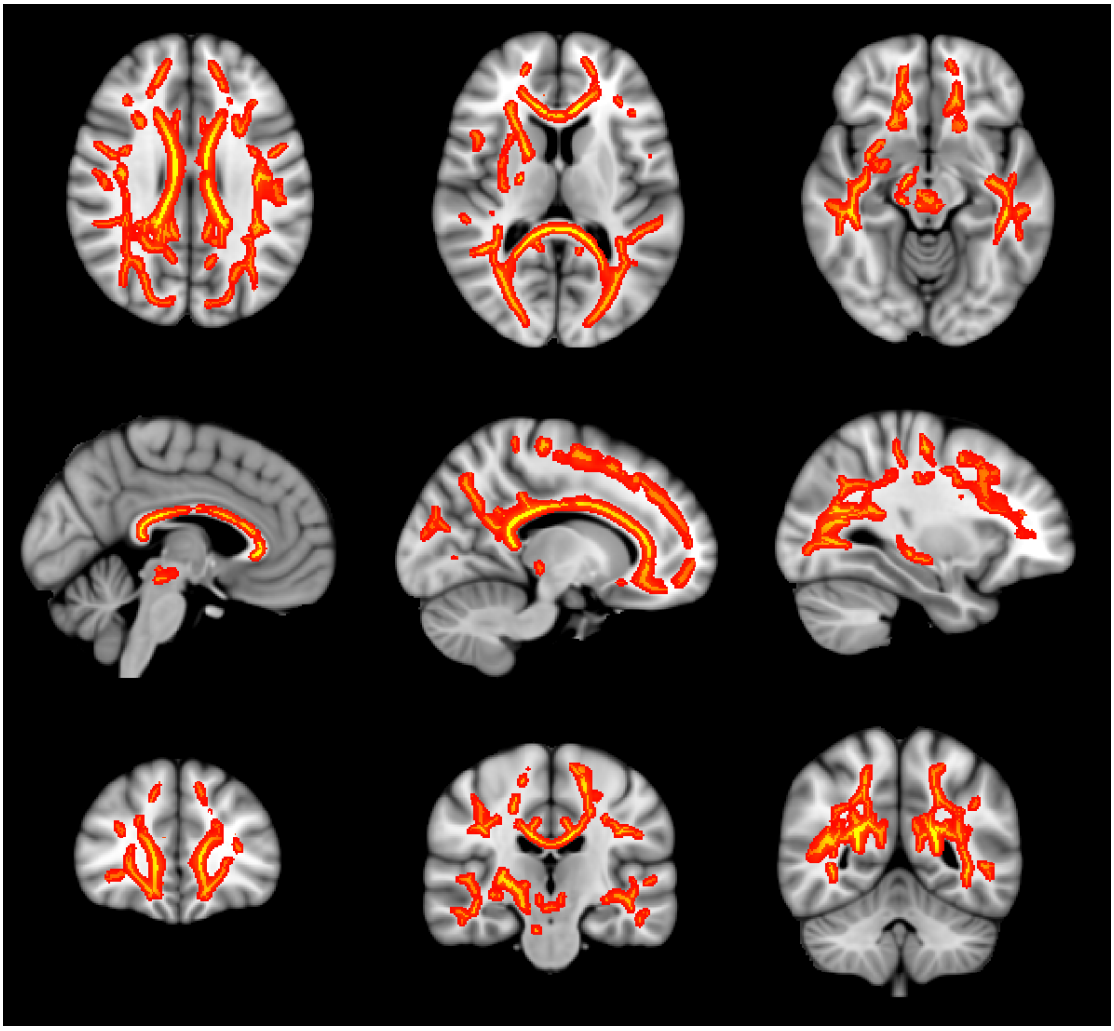
BACKGROUND AND AIM: White Matter Hyperintensities (WMH) on T2--weighted magnetic resonance imaging (MRI) are common in the brains of older individuals. Previous studies have suggested a nonlinear relationship between WMH and fall risk with the clinical manifestations only evident in people who have the most severe degree of WMH. Diffusion tensor imaging (DTI) has emerged as a useful method for detecting deterioration of white matter (WM) integrity based on water diffusivity. WM integrity plays a crucial role in physical functioning and is associated with several fall risk factors including impaired balance and gait. Therefore, we investigated the association between WM integrity using DTI and physiological risk of falling in a large sample of older men and women. METHODS: 312 community-dwelling older people aged 70 - 90 years underwent structural brain MRI and a comprehensive medical assessment. WMHs volumes were quantified using an automated method. The DTI-index Fractional Anisotropy (FA) of white fibre tracts was used to measure white matter integrity of the brain. The Physiological Profile Assessment (PPA) was used to estimate physiological fall risk. The PPA contains five validated measures of physiological function: visual contrast sensitivity, proprioception, lower limb strength, reaction time, and postural sway. Tract-based spatial statistics (TBSS) were applied to investigate the relationship between FA and PPA measurement on a voxel-by-voxel basis. The significance threshold was set at $p<0.05$, and corrected for multiple comparisons using family-wise error correction. RESULTS: After adjusting for age, gender, years of education, total intracranial volume and cardiovascular risk, PPA was correlated with WMH ($r(p) =0.12$, $p\leq0.05$). After adjusting for age, gender, and years of education, DTI analyses showed significant negative correlations between PPA and FA measures in almost all parts of the brain as shown in Figure 1 ($p<0.05$ after multiple comparison correction). These regions include the frontal, temporal, parietal and occipital lobes; the left and right superior longitudinal fasciculi connecting the frontal, temporal, parietal and occipital lobes; the limbic system, the corpus callosum, the basal ganglia, the thalamus, and the midbrain among various other regions as shown in Figure 1. CONCLUSIONS: DTI is a sensitive way to capture white matter abnormality in WM that appear to be normal in T2 scans. Our study results support the importance of overall brain integrity in multiple neural systems. The DTI analyses highlight that fall risk is not only related to WM abnormalities, but that fall risk is further compromised by the disruption in neural networks and connectivity caused by these cerebral WMHs. These findings may have important implications for clinical fall risk assessments. FIGURE 1: WM regions showing a negative correlation between PPA scores and white matter integrity (FA measure)

Figure 1: WM regions showing a negative correlation between PPA scores and white matter integrity (FA measure).



O.7.2 White matter microstructural organization and gait stability in older adults

Sjoerd Bruijn[1], **Annouchka Van Impe**[1], **Jacques Duysens**[1], **Stephan Swinnen**[1]

[1]K.U. Leuven

BACKGROUND AND AIM: Decreased stability in the elderly may be due to losses in force production, proprioception, vision, and vestibular function. In addition, gait stability may be compromised because of an age-related decline in both gray and white matter microstructure of the brain. While the influence of peripheral factors on gait stability has received ample attention in the literature, research on the effect of central factors such as age related decrements in gray and white matter structure has been limited. Thus, we studied the relationship between white matter microstructural organization using Diffusion Tensor Imaging (DTI) and gait stability measures with ageing. We hypothesized that cortico-subcortical connections play a role in the maintenance of gait stability. METHODS: 15 healthy young adults (range 18-30 years) and 25 healthy older adults (range 62-82 years) were measured. They underwent instrumented gait analysis on a treadmill, from

which stability parameters (step time, step width, amplitude of mediolateral trunk motions, safety margin, maximum Lyapunov exponent) were calculated, as well as a DTI scan. Gait stability parameters were correlated to white matter structural integrity (fractional anisotropy, FA) using Tract Based Spatial Statistics (FSL). RESULTS: Only stride time and the maximum Lyapunov exponent (which quantifies how well subjects are able to attenuate small perturbations) were found to decline with age. White matter microstructural organization (FA) was lower throughout the brain in older adults. We found a strong positive correlation between FA in the left anterior thalamic radiation and left corticospinal tract on the one hand, and step width and safety margin (indicative of how close subjects are to falling over) on the other (r=0.74 for both. These correlations indicated that older subjects with lower white matter FA in these tracts walked with narrower step widths and smaller safety margins. CONCLUSIONS: These findings suggest that white matter FA in particular tracts connecting subcortical and cortical areas are important for the implementation of an effective stabilization strategy.

O.7.3 Higher level gait disorders: the role of midbrain neurodegeneration

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[1]CR-ICM 1er étage CIC, [2]CRICM-3ème étage, [3]Service de Neuroradiologie Hôpital Rangueil, [4]UFR STAPS, Université de Paris Sud-11, [5]Service de Neuroradiologie, CHRU Lille, [6]Département de Neuroradiologie, Groupe Hospitalier Pitié-Salpêtrière, Assistance Publique-Hôpitaux d, [7]CR-ICM

Objective: To determine the role of focal brain atrophy and deep white matter lesions (DWML) in the gait and balance disorders presented by elderly people with Higher-Level Gait Disorders (HLGD). Methods: We characterised 20 HLGD patients using a combined approach with standardized clinical assessment, quantitative gait initiation recordings and morphological brain MRI, with a special reference to the mesencephalic locomotor region (MLR), in comparison to 20 age-matched controls. Results: HLGD patients presented clinical 'non-axial' hypokinetic-rigid motor signs, associated with a frontal executive deficit, mainly related to the DWML severity. 'Axial' hypokinetic-rigid signs such as gait and balance disorders were found to be correlated with step velocity and braking index (measured on the vertical velocity of the centre of gravity), respectively. HLGD patients also showed a near-normal preparatory phase of gait initiation but a severe alteration of the first step execution, with a deficit in both postural and locomotor parameters of gait initiation execution. In comparison to controls, HLGD patients showed a bilaterally reduced grey matter in the MLR and the left primary motor cortex. Lastly, the severity of postural adjustments deficit was mainly related to the mesencephalic atrophy. Conclusions: These data suggest that the gait and balance deficits in HLGD mainly result from the lesion/dysfunction of the pathway linking the primary motor cortex and the MLR, brain regions known to be involved in the control of gait and balance in humans, whereas cognitive and hypokinetic-rigid signs in HLGD mainly result from a lesional disconnection between the basal ganglia and the frontal lobe.

O.7.4 Predicting Falls among People with Parkinson's Disease with and without Cognitive Impairment

Ann Ashburn[1], **Carolyn Fitton**[1], **Khaled Amar**[2], **Helen Roberts**[1], **Emma Stack**[1]

[1]University of Southampton, [2]Royal Bournemouth and Christchurch NHS Trusts

Background: Falls and cognitive impairment (CI) are common features of Parkinson's disease (PD). Dementia is an independent predictor of falling in PD; it has been reported that 1 in 5 fallers versus 1 in 20 non- fallers

present with dementia. Aim: To evaluate two potential predictors of further falls among people with Parkinson's disease (PwPD) with and without CI over three months using a) a simple mobility test and b) a history of repeated falls. Methods: We wrote to everyone with PD under one geriatrician's care; 317/489 (65%) allowed us to examine their notes and we recruited 40% each from those with normal mini mental state examination (MMSE) and mild and moderate abnormalities in their notes and 27% with no recorded MMSE. We visited PwPD and their carers at home, recorded performance on the MOCA (Montreal Cognitive Assessment), and took a detailed history of falls over the previous 12 months with the help of carers. We video-recorded participants performing the SS-180 turn test. We left a falls diary for three-month completion. We telephoned participants throughout the follow-up period to remind them about when and how to complete the diary. Results: Of the 101 participants recruited (68 with carers), 40 scored normally on the MOCA, 36 mildly and 25 moderately abnormally. The average age was 76 years with an average of 6 years from diagnosis, 53 were men, 31 had mild condition (Hoehn &Yahr [H&Y] I & II) and 70 had moderate to severe (H&Y III-IV). Sensitivity (predicting falls) of repeated previous falls was 69% among those with CI and 57% among those without; sensitivity of the turn test was 69% and 36%, respectively. Conclusion: The value of both a history of repeated falls and SS-180 in predicting falls was similar among 61 people with and 40 without CI, sensitivity was higher. These findings suggest that if supported by carers, we need not exclude people with CI from fall prediction studies in the future.

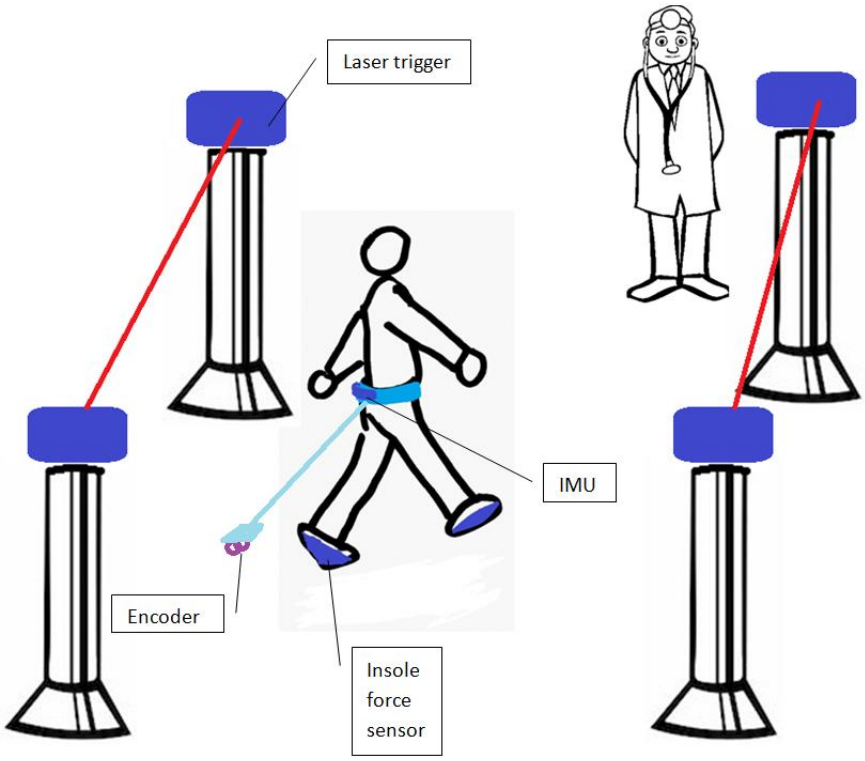
O.8 Tools and Methods III

O.8.1 Reliability and Validity of a Modular-Based Gait Analysis System for Assessing Temporal Spatial Gait Parameters in Normal Subjects

Pootithan Phonrod[1], **Prakarnkiat Youngkong**[1]

[1]King Mongkut's University of Technology Thonburi

BACKGROUND AND AIM: Gait parameters are important factors for physicians to diagnose and/or monitor patients. Our aim is to develop a system that could obtain gait parameters such as step and stride lengths, step and stride times, and time spent in single and double support. Our system is easy-to-use and light weight enough for clinical tests that could be simply finished within 15 minutes. The system is designed especially for people in developing countries with an affordable cost, so that in the future people might use it at home and directly send results back to their physicians. METHODS: Our system consists of two parts. Part I provides insole pad with force sensors, IMUs and encoders that are attached on patients' pelvis. Part II is an infrared-based setup that allow users to easily and accurately determine starting and ending points. The data is only recorded while the patients are in the testing area. Raw data are kept in a micro SD card which could be connected to a computer for analyzing. Our subjects are 10 healthy adults ages between 20-30 years old (avg. 25 years old). RESULTS: Gait parameters as mentioned above were successfully obtained. In multiple 10-meter trials with different subjects, the intraclass correlation coefficient (ICC) > 96 was obtained in spatial measurements when paper-and-pencil-based and our system were compared. And, ICC > 95 was obtained in temporal measurements when VICON and our system were compared. CONCLUSIONS: Our new modular-based gait analysis system is reliable and valid. Besides the existing complex gait devices, this system is definitely an alternative for assessing temporal and spatial gait parameters.



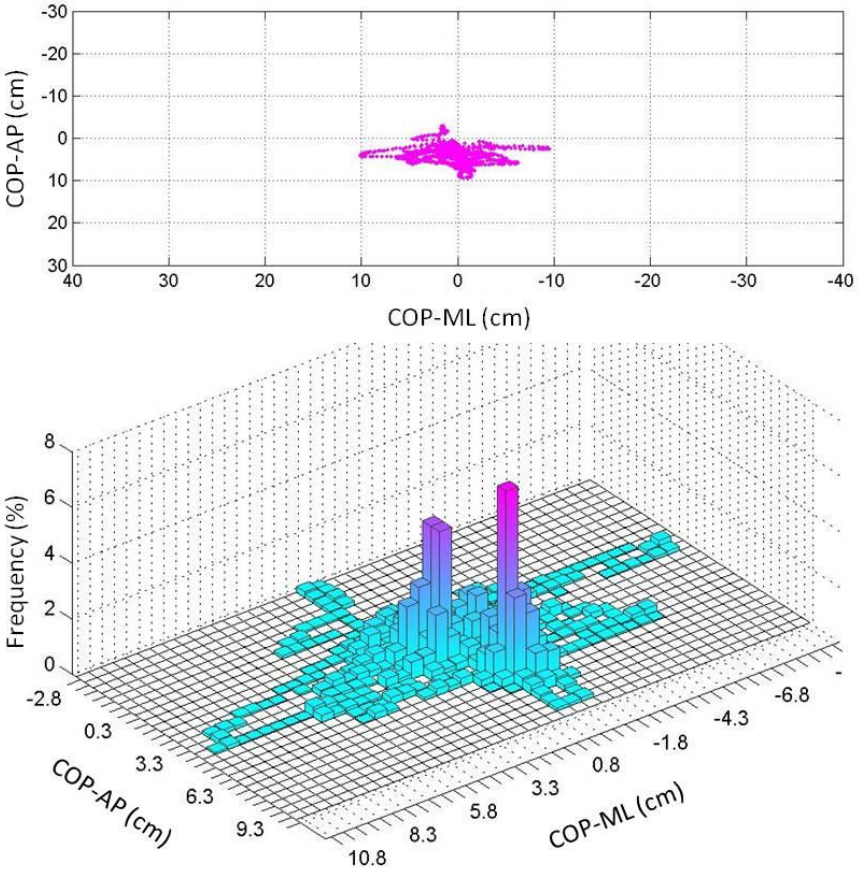
O.8.2 A 3D-stabilogram as a new method to visualize and analyze postural sway during standing

Beatrix Vereijken[1], **Xiangchun Tan**[1], **Nina Skjaeret**[1], **Espen Ihlen**[1]

[1]Norwegian University of Science and Technology

BACKGROUND AND AIM: One of the most commonly studied variables in standing posture is the center of pressure (COP). COP movements in anterio-posterior (AP) and mediolateral (ML) directions are typically represented in a 2D stabilogram. Recent studies on unconstrained relaxed standing have revealed that people regularly shift their weight between their feet, resulting in preferred regions of standing in the stabilogram. However, traditional 2D stabilograms provide little information about the density of the CoP trace in different areas of the stabilogram and, consequently, little information about potential preferred regions of standing. The aim of the current study was to develop a new 3D-stabilogram that takes into account the density of the COP trace, thereby allowing visualization and quantification of preferred regions of standing. We collected data on healthy adults to develop the method, and on adults with Cerebral Palsy (CP) to test application of the new method. METHODS: COP data was collected from 12 healthy adults (mean age 21.8 ± 3.5 years) and 9 adults with CP (mean age 20.6 ± 2.8 years) in three different conditions: one minute quiet standing (QS), one minute relaxed standing (RS), and 10 minutes relaxed standing (RM). Data were collected using two Kistler force plates. The traditional 2D stabilogram was divided in regions of .5 x .5 cm and the frequency calculated with which each region was visited by the COP trace (in %). The 3D-stabilogram was constructed by plotting COP-AP x COP-ML x Frequency. Preferred regions of standing were defined as local peaks in the 3D stabilogram. RESULTS AND DISCUSSION: Preliminary analyses of the QS and RS trials showed that both healthy adults and adults with CP managed to stand quietly, as reflected in small COP movements and a single local peak indicating 1 preferred

region of standing. When standing relaxed for 1-minute, all participants but 1 with CP and 5 controls introduced additional preferred regions of standing. These regions were not visible in the traditional 2D stabilogram. Figure 1 show an example of the traditional 2D and the new 3D stabilograms for a young healthy participant standing relaxed for 1 minute. As can be seen in the lower panel, this participant had 2 local peaks while standing relaxed. Further analyzing the 3D stabilograms for each foot separately revealed that additional preferred regions in the CP group were present in the non-affected leg but not in the affected leg. This result extends earlier findings that the CP group controls postural sway mostly with the non-affected leg (1). These preliminary results indicate that the 3D stabilogram is indeed capable of identifying preferred regions of standing. Further analyses of the data focus on the 10-minute RM trials and quantification of preferred regions of standing in both the CP and control groups in all 3 conditions. (1) Skjæret et al. ISPGR 2012



O.8.3 Detailed ambulatory 3D gait analysis with only body worn sensors - quality and clinical relevance in multi-moment progress monitoring in post operative ACL rehabilitation

Chris Baten[1], **Rob Schoot uiterkamp**[1], **Wm Hullegie**[2], **Ruben Wassink**[1]

[1]Roessingh Research and Development, [2]Fysiogym

BACKGROUND AND AIM: This paper examines data quality and reliability of a body worn sensor application for monitoring knee kinematics plus its practical feasibility in the context of potential clinical relevance. Knee

cyclical 3D kinematics are assessed in on-site follow up recordings in a typical post ACL surgery physical therapy program. Nature and magnitude of clinically relevant data features and tendencies are discussed relative to estimated smallest detectable difference (SDD) bands. METHODS: 10 males in a standard post ACL surgery physical therapy program (age 18-40, semitendinosus-gracilis technique, first time, single sided,) participated in four 15-minute on-site gait analysis sessions at one month intervals. Recorded were 3D accelerations, angular velocities and orientations of motion sensors on thighs, shanks, feet, pelvis and thorax (8 Xsens Mtx sensors, 100 sps). At start and end of each session 2 helical axes based 'Segment calibration' trials were done, enabling estimation of body segment orientation from motion sensor data, independent of sensor placement orientation [Baten, 2000]. Gait cycle analysis results were instantly available based on automated left and right heel strike detection. RESULTS Analysis of repeated segment calibrations revealed: calibration related orientation uncertainty of 1-2 degree and sensor mounting uncertainty within sessions of the same order. Angle and angular velocity 95% conf .bands (SEM, n=5) of 1-2 degree were found with SDD values of ca. 3 degrees. In all subjects in the affected leg several gait cycle features, judged relevant for monitoring, changed consistently over time towards values found in the unaffected leg, while others remained identical (effect >> uncertainty). Little or no change over time was found in unaffected leg data. These effects included diminished knee flexion in mid-stance and diminished extension at push off. (Fig 1) CONCLUSIONS It was observed that: 1. Estimation reliability of kinematic data is small compared to absolute values and value changes in measures and phenomena relevant to clinical decision making, 2. Repeated segment calibrations provides a robust means for an instant quality check in every session and should be included in any clinical application. 3. consistency of data appearance for the unaffected leg as well as parts of the affected leg and consistency of segment calibration data suggest high repeatability over sessions. These observations together form strong evidence that the proposed method indeed bears potential for effective and efficient routine clinical decision making in ACL recovery. PARA Wide spread routine clinical application seems feasible with the arrival of wireless motion sensor versions (solving practical mounting impracticalities) and expected general price drop of this technology. Similar studies support also larger scale field applications in sports and ergonomics.

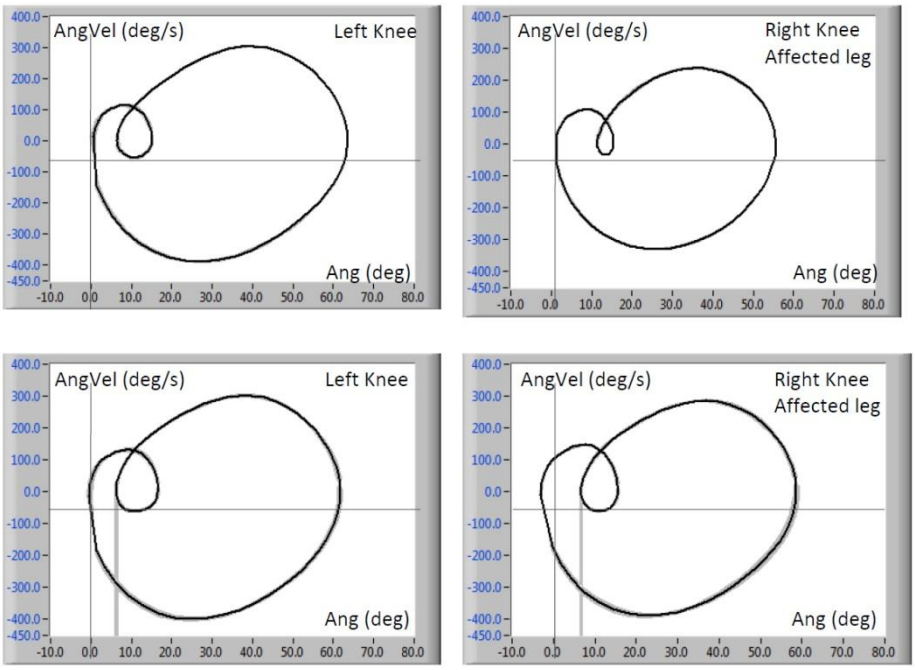


Figure 1: Phase plots (angular velocity vs. angle) of 1 subject during normal walking of left and right knee respectively 1st and 4th session (15 weeks apart)

O.8.4 Gait asymmetry assessment by Dynamic Time Warping applied to motion capture data

Adam Switonski[1], **Henryk Josinski**[1], **Agnieszka Michalczuk**[1], **Romualda Mucha**[1], **Konrad Wojciechowski**[1]

[1]Polish-Japanese Institute of Information Technology

Bilateral asymmetry, defined as discrepancy between movements of corresponding joints of left and right body parts, is usually the first symptom of any gait disorder. Thus, effective assessment of such an asymmetry has a key role in early diagnosis of any gait abnormality. The method based on motion capture measurements which utilizes Dynamic Time Warping (DTW) to compare movements of selected pairs of joints to assess asymmetry is proposed. In the first stage gait is segmented into adjacent steps performed by left and right lower limbs on the basis of detected extremes of distances between feet. It allows to match stance and swing phases for both legs. In the next step, a similarity matrix containing distances between selected left and right joints in subsequent time moments is calculated. DTW determines monotonic path connecting edge points of similarity matrix with lowest cost, calculated across the path as a cumulative distance. The cost corresponds to movements dissimilarity and the path reflects left and right side synchronization. The crucial choice of DTW is the way joint states are compared. In a classical approach joint rotations are coded by Euler angles, thus default distance metrics of vector spaces can be applied. However much more efficient are unit quaternion.. There are numerous distance functions defined in a quaternion space. The distance can be stated as the shortest path on the unit hypersphere S3 in four dimensional space, it possible to transform quaternion to tangent space by logarithm operator or to calculate product of the first and conjugated second quaternion. In case when more than one pair of joint is selected, weighted sum or square root of sum of squares can be utilized to aggregate impact of subsequent joints on the left to right side difference. The absolute value of warping path cost does not give us clear and directly interpretable result. That is a reason why we propose to normalize such an obtained value by dividing it by dissimilarity of movement of the same joints in two adjacent steps. The proposed approach is

flexible and allows to specify pairs of joints which are compared. What is more, it is independent on the choice of phase: corresponding stance, swing or both phases can be analyzed, only proper gait segmentation of the preprocessing stage has to be supplied. The method was examined on group of patients with motion abnormalities related to coxarthrosis and brain strokes diseases. The model based data with 72 degrees of freedom registered by motion capture laboratory of Polish-Japanese Institute of Information Technology equipped with Vicon software and hardware was applied. The obtained results are consistent with assessments of medical experts, thus there is a correlation between clinical state of patients and their determined bilateral asymmetry. ACKNOWLEDGMENT The project was supported by The Polish National Science Centre on the basis of decision number DEC-2011/01/B/ST6/06988.

O.9 Neurological Diseases III

O.9.1 Gait is selectively affected by disease severity in early Parkinsons disease

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

[1]Newcastle University

Background: Gait disturbance is a cardinal feature of PD, however little is known about the selective involvement of gait characteristics with respect to disease severity. Understanding gait across the spectrum of disease will help inform treatment of gait disorder in PD and help identify discriminatory and responsive gait outcomes as the disease progresses. Aim: To describe gait with respect to disease severity in a community-based representative cohort of incident Parkinson's disease (PD). Methods: One hundred and twenty-one newly diagnosed PD participants and 189 healthy controls were examined for demographic, clinical and gait features. Gait characteristics from five broad domains of gait [1] were correlated with UPDRS III scores and LOESS regression used to visualise the relationship between gait variables over the spectrum of disease. Results: Clinical and gait outcomes were significantly worse for all PD subjects compared with controls. The mean ± SD (range) UPDRS III score for PD was 25.5 ± 10.4 (7 - 50). Five key features of gait deficit with respect to disease severity were observed: 1) gait speed reduces and then stabilizes; 2) reduction in gait speed is congruent with decreased stride length and increased step time; 3) step length variability is linearly related to disease severity; 4) step width increases with disease severity; and 5) both step asymmetry and step width variability differ from controls but remain stable across disease severity (Fig 1). Conclusions: Gait disturbance is evident in incident PD even for people with low UPDRS scores. Gait impairment appears to be preferentially involved across the disease spectrum, which has implications for understanding the evolvement of PD gait dysfunction and disability. Future research on this longitudinal data set is required to confirm this finding. Reference: Lord S, Galna B, Verghese J, Coleman S, Burn D, Rochester L. Independent domains of gait in older adults and associated motor and non-motor attributes: Validation of a factor analysis approach. J Gerontology. 2012; doi: 10.1093/gerona/gls255

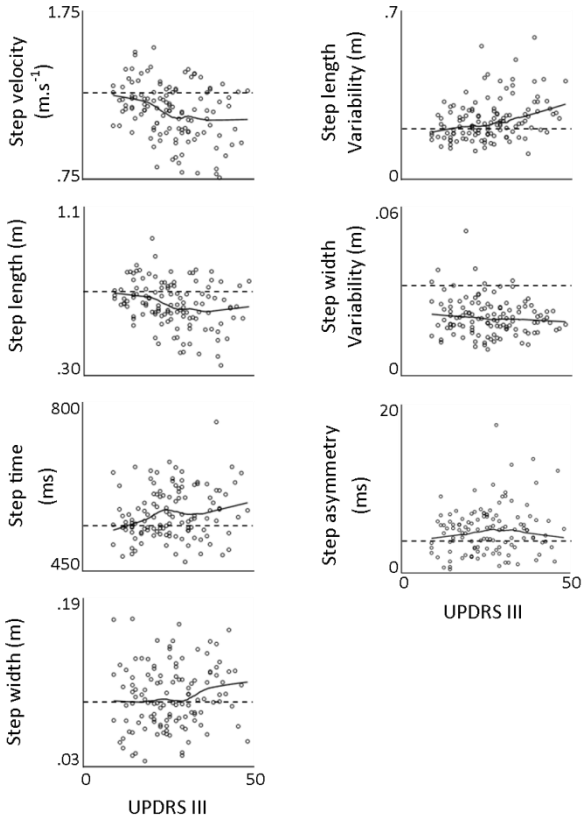


Fig 1. Gait as a function of UPDRS III. A LOESS regression line is shown as a solid black line. The dashed lines represent means for each gait variable from 189 age-matched control participants.

O.9.2 The effect of a 4-week training program in people with Parkinson's Disease on actual mobility: a single blind randomised clinical trial

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

[1]University of Queensland, [2]The University of Oregon, [3]LaTrobe University

BACKGROUND AND AIM: People with Parkinson's Disease (PD) have difficulty walking when performing added tasks and this is proposed to contribute to reduced mobility levels. A 4 week, 12hr program of dual task walking training has been shown to improve the ability to dual task in the laboratory. This study aims to determine whether participation in a 4 week intensive dual tasking walking training program improves actual mobility 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 dual and 31 to single task walking training. Actual mobility was measured using an ActivPAL accelerometer affixed to the anterior thigh for three days at four time points - baseline 1, 2, post and at 6mths follow up. Both groups undertook one-on-one progressive gait training. The dual task training group performed these gait tasks whilst also undertaking progressively difficult added tasks. Generalised linear models were performed to determine the effect of group and time on outcomes. RESULTS: There were no differences between groups in

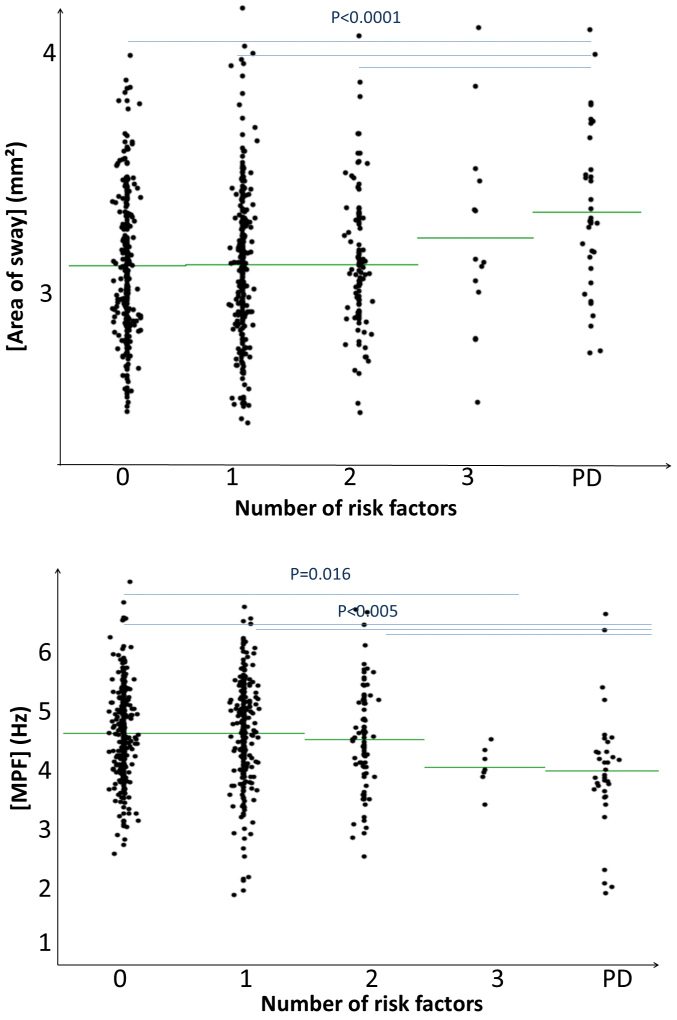
demographic, severity, spatiotemporal gait or mobility measures at baseline (p > 0.056). There were no group, time or group x time interactions for the total or average number of steps taken daily. Participants performed approximately 4200 /- 2700 steps/day (range 753-13,051), with this increasing on average by 400 steps post training. There was similarly no change in the average time spent sitting or lying, standing or stepping over time (p > 0.419). There was a group x time interaction (p = 0.046) for those who did <4000 steps/day at baseline to increase their average number of steps after dual tasking (from 2420 to 3920 steps) and remaining above baseline levels at follow up (2800), whereas those in the single task walking training group remained the same (2590 to 2560 to 2650 steps). CONCLUSIONS: A one-on-one, individualised training program of dual task walking training had its greatest effect on increasing the steps taken daily by people with PD who walked little at baseline. A wide variation in mobility was likely to contribute to the little change in actual mobility across the whole group. This study was supported by NHMRC project grant ID#5121170, CIA Brauer.

O.9.3 Individuals with none, one, two, but not three risk factors of Parkinson´s disease differ significantly to Parkinson´s like postural deficits in 715 healthy elderly

Sandra Hasmann[1], **Sinja Meyer**[1], **Markus Hobert**[1], **Jana Godau**[1], **Raphael Niebler**[1], **Gerhard Eschweiler**[1], **Daniela Berg**[1], **Walter Maetzler**[1]

[1]University of Tuebingen

BACKGROUND AND AIM: Quantitative assessment of prodromal signs of Parkinson's disease (PD) may be the key to eventually enable diagnosis earlier as it is currently possible. Recent observations show that postural deficits in PD may be detectable even before clinical diagnosis can be made. Moreover, a higher number of risk factors for PD (examples are hyposmia, depression, and REM sleep behavior disorder) in an individual is associated with an increased risk for the disease. We therefore hypothesized that individuals with a high number of risk factors for PD have altered sway characteristics. METHODS: In the baseline assessment of the TREND study (www.trend-studie.de), 715 older individuals with and without risk factors for PD, and 35 PD patients without clinical evidence for a postural deficit were investigated. Quantitative static balance assessment was performed with the McRoberts Dynaport® sensor at the lower back. Participants were asked to stand for 30 seconds on foam in semitandem stance (i) with eyes closed and (ii) with eyes open. Parameters of area of sway, velocity, acceleration, JERK and mean power frequency (MPF) of sway were analyzed. RESULTS: No relevant differences were detected between the cohorts under eyes-open conditions. Under eyes-closed conditions, PD patients had a larger area of sway and a lower MPF of sway, respectively, than individuals with no (N=206), one (N=302) and two risk factor(s) (N=146) (all p-values 0.33). MPF was lower in the cohort with three risk factors than in the cohort without any risk factor (p=0.016). Differences were more pronounced in the anterioposterior than in the mediolateral direction. CONCLUSION: This quantitative analysis of static sway in a large cohort demonstrates that, under challenging conditions, sway parameters of healthy individuals with three risk factors for PD are comparable to those of PD patients.



O.9.4 The effects of localised temperature changes on walking and neuromuscular function in Hereditary and Spontaneous Spastic Paraparesis

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BACKGROUND: Spastic Paraparesis is caused by axonal degeneration of the corticospinal and spinocerebellar tracts and dorsal columns. People with Spastic Paraparesis (pwSP) often report that walking ability is worse in cold weather. This study explored the effects of localised temperature changes on neuromuscular function and walking ability METHODS: Twenty-two pwSP were compared to 18 healthy controls. On two separate occasions water at either 7 or 37o C was pumped for 30 minutes around a wrap applied to the shank of the clinically most affected leg. Before and after the intervention measurements were taken of (a) skin and core temperature (b) maximal walking speed and time taken to tap the foot x10 (c) tibial nerve conduction velocity (d) central motor

conduction time (e) passive and stretch-evoked muscle stiffness of the ankle plantarflexors assessed using 15o perturbations at either 5 or 175 o/s (f) the rate of rise (MVCdt) and amplitude (MVCamp) of a maximal voluntary contraction of the ankle plantar- and dorsi-flexors. RESULTS: Compared to the control group, pwSP had a significantly slower walking speed; higher passive and stretch-evoked stiffness, lower MVCamp and MVCdt and a more prolonged central motor conduction time. Cooling and warming the limb resulted in a 12.1 ± 11.1 oC decrease and a 8.9 ± 9.9 oC increase in skin temperature respectively but no change in core temperature. In both groups cooling led to a decrease in walking speed, reduction in conduction velocity and decrease in MVCamp and MVCdt, whilst warming had the opposite effect ($P<0.05$). Changes in re physiological measures were similar between the groups. However, pwSP showed greater reductions in foot tap time with warming and greater increases in walking time with cooling. In pwSP changes in foot tap time with warming / cooling were related to the change in peripheral nerve conduction velocity and were in turn related to the change in walking time. CONCLUSIONS: Cooling and warming affect localised neuromuscular functions. The impact on gross functions such as walking are more complex possibly reflecting the ability of other body parts to compensate for the localised alteration in neuromuscular function. Localised warming and/or avoidance of marked limb cooling may be beneficial in pwSP. We would like to thank the Physiotherapy Research Foundation and the HSP society for their support.

O.10 Neurological Diseases IV

O.10.1 Sensory integration in postural control of dyslexic children

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BACKGROUND AND AIM: Besides difficulties in mastering literacy, dyslexic children also show poor postural control that might be related to how sensory cues coming from different sensory channels are integrated into proper motor activity. Therefore, the aim of this study was to examine postural control performance and the relationship between sensory information and body sway, with vision and touch manipulated independent and concomitantly, in dyslexic children. METHODS: Thirty dyslexic and 30 non-dyslexic children stood upright inside a moving room that remained stationary or oscillated back and forward at frequency of 0.2. In addition, participants stood upright, eyes closed or opened, lightly touching a moveable surface. Participants performed 7 trials, each lasting 60 seconds: no vision and no touch; independent vision or touch manipulation; moving room and stationary touch; stationary room and moving bar; congruent and incongruent vision and touch manipulation. Body sway magnitude and the relationship between the movement of the room/moveable surface and body sway were examined. RESULTS: Dyslexic children oscillated more than non-dyslexic children in both stationary and moving room and moving bar conditions. Visual and light touch manipulation induced body sway in all children. In those trials with independent vision or touch manipulation, there was no difference between dyslexic and non-dyslexic children. In those trials with conflicting vision and touch manipulation, dyslexic children were less coherent to the stimulus manipulation compared do non-dyslexic children. Finally, dyslexic children showed higher body sway variability and used higher applied force levels in the touch trials compared to non-dyslexic children. CONCLUSIONS: Dyslexic children use visual and somatosensory information to postural control with the same underlying processes as non-dyslexic children; however, dyslexic children show poorer performance and more variability while relating visual and somatosensory information and motor action even in a task that does not require an active cognitive and motor involvement. Besides, in conditions

that visual and touch cues were conflicting, dyslexic children experience difficulties in sensorimotor integration because they may suffer from fusing sensory cues coming from multiple sources.

O.10.2 Trunk bradykinesia and foveation delays during whole-body turns in spasmodic torticollis

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We have investigated how the abnormal head posture and motility in spasmodic torticollis interferes with ecological movements such as combined eye-to-foot whole body re-orientations to visual targets. Eight mildly affected patients and 10 controls voluntarily rotated eyes and body in response to illuminated targets of eccentricities up to +/-180º. The experimental protocol allowed separate evaluation of the effects of target location, visibility and predictability on movement parameters. Patients' latencies of eye, head, trunk and foot motion were significantly prolonged but showed a normal modification pattern when target location was predictable. Peak head-on-trunk displacement and velocity were reduced both ipsi- and contralaterally with respect to the direction of torticollis. Surprisingly, peak trunk velocity was also reduced, even more than in previously studied patients with Parkinson's disease (Mov Disord 2011; 26:2201-11). As a consequence, patients made short, hypometric gaze saccades and only exceptionally foveated initially non-visible targets with a single large gaze shift (4% of predictable trials as opposed to 30% in controls). Foveation of distant, targets was massively delayed, by more than half a second on average. Spontaneous dystonic head movements did not interfere with the execution of voluntary gaze shifts. The results show that neck dystonia does not arise from gaze (head-eye) motor centres, however, the eye-to-foot turning synergy is seriously compromised in spasmodic torticollis. For the first time we identify significant 'secondary' complications of torticollis such as trunk bradykinesia and foveation delays, in turn likely to cause significant additional disability in patients. Eye movements per se are intact and compensate for the reduced head/trunk performance in an adaptive manner.

O.10.3 Cutaneous reflex modulation and self-induced reflex attenuation in cerebellar patients

Wouter Hoogkamer[1], **Frank Van Calenbergh**[1], **Stephan Swinnen**[1], **Jacques Duysens**[1]

[1]KU Leuven

BACKGROUND AND AIM: Modulation of cutaneous reflexes is important in the neural control of walking. It has extensively been studied, but knowledge about underlying neural pathways is still incomplete [1]. Recent animal studies have suggested that the cerebellum is important for the modulation of cutaneous reflexes during gait [2]. Other studies in humans have shown that such reflexes can be attenuated when stimulation is self-induced and it was suggested that the cerebellum is important for this [3]. Here, we evaluated these cutaneous reflex features in cerebellar patients. METHODS: We analyzed cutaneous reflex activity during walking, both in patients with a focal cerebellar lesion and in healthy controls. We recorded electromyography bilaterally in the tibialis anterior, gastrocnemius medialis and biceps femoris muscles. Stimuli were applied to the sural nerve at the ankle. Reflex modulation patterns were compared between groups. Additionally, we compared reflexes after standard (computer-triggered) stimuli to reflexes after self-induced stimuli in both groups. Self-induced stimuli were triggered by the participants through pressing a handheld button. RESULTS: Cutaneous reflex modulation patterns were similar between healthy controls and cerebellar patients, but cerebellar patients were less able to attenuate reflexes to self-induced stimuli in the tibialis anterior muscle of the stimulated leg. In healthy controls, these reflexes to self-induced stimuli were more often attenuated than in the patient group, mainly at the end

of the stance phase and during the swing phase. CONCLUSIONS: The results suggest that the cerebellum is important in anticipation of the consequences of motor actions but that it has probably no major role in cutaneous reflex modulation in humans. PARA REFERENCES: 1. Zehr EP & Stein RB. Prog Neurobiol 58: 185-205, 1999 2. Pijpers A, et al. J Neurosc 28: 2179-2189, 2008 3. Baken BC, et al. J Physiol 570: 113-124, 2006

O.10.4 Effect of dual-tasking on intentional versus reactive balance control.

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[1]University of Illinois

Background: While concrete evidence indicates that dual-tasking (DT) results in decreased gait performance or mobility in Stroke survivors, there is conflicting evidence on its effect on the balance performance. This could partly be attributed to the complexity arising from intentional (feed-forward) versus reactive (feedback) components within the balance control system. Although studies have examined effect of dual-tasking on postural sway under different sensory environments, to the best of our knowledge there are no studies examining interaction of DT on feedforward and feedback systems of balance control in this population. The aim of this study was examine effect of a simple cognitive task on intentional versus reactive aspects of balance controls. We postulated that DT would result in a significantly more negative impact on intentional than the reactive balance task. Methods: Community dwelling people with hemi-paretic stroke (N=10) performed two selected tests on the NeuroCom Smart Balance Master which included the Limits of Stability (LOS) test with intentional-cum-directional weight shifting and the reactive Motor Control Test (MCT) - alone (single-) and under dual-task conditions with word list generation (WLG). For LOS, subjects were tested only in the forward (FWD) and backward (BWD) conditions. For the MCT subjects were tested only on the largest perturbation magnitude for both FWD and BWD directions. Subjects performed the WLG task in sitting condition for the same duration as the two balance tests. Cognitive ability was recorded by the number of words enumerated all 6 conditions. The difference in reaction time (RT) between the ST and DT defined as the "balance cost" ([ST-DT]/ST) was compared between the two tests. The "cognitive cost" was similarly defined and compared. Further, the difference in movement velocity (MV) and maximum excursion (MX) of the center of pressure between ST and DT conditions was examined. Results: The RT under DT was significantly greater for the LOS test than the MCT leading to a higher balance cost for the LOS ($p < 0.01$). Subjects demonstrated greater MV and MX for the DT compared to the ST condition ($p<0.05$ for both variables for FWD and BWD). The cognitive task scores were significantly lower on both balance tests during the DT condition than the ST, resulting in a significantly increased cognitive cost in DT for both balance tests ($p<0.05$). Conclusions: The results confirm the hypothesis that cognition affects intentional balance tasks but may have little effect on reactive balance corrections in individuals with Stroke. Further they suggest sharing of plasticity-mediated attentional resources between the WLG task and intentional control of limits of stability, (since both tasks deteriorated under DT compared to ST conditions). Lastly, the fact that performance on the WGL decreased task during the MCT compared to sitting, indicates CNS' prioritization of balance over cognition.

O.11 Sensormotor Control I

O.11.1 Effects of limiting anterior displacement of the center of foot pressure on anticipatory postural control during bilateral arm flexion

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BACKGROUND AND AIM: In bilateral arm flexion while standing, no preceding activation of triceps surae with respect to the focal muscle has been found. Considering that the preceding activation would become a good indicator of anticipatory postural controllability, we tried to induce the preceding activation by limiting the anterior displacement range of the center of foot pressure in the anteroposterior direction (CoPap). Our working hypothesis was that during bilateral arm flexion with limitation of CoPap anterior displacement, the preceding activation of the triceps surae would be induced, with the backward inclination of the whole body pivoting at the ankles. METHODS: Subjects were 13 healthy young adults. In response to the response signal which was presented 2 s after the warning signal, subjects flexed the arms at maximum speed, stopped voluntarily at the shoulder level, and maintained this position for 3 s. The arm flexion trials were repeated 20 times on the flat floor (no-limitation condition). The 50% range of CoPap anterior displacement caused by arm flexion was calculated, and the floor inclined by the subject's weight when CoPap extended beyond that range. Subjects were instructed to try to prevent inclination of the floor during the arm flexion (limitation condition). The arm flexion trials in the limitation were repeated 20 times. CoPap displacement and movement angles of the ankle, knee and hip joints caused by arm flexion, and activation onset times of erector spinae (ES), biceps femoris (BF), gastrocnemius (GcM) and soleus (Sol) as postural muscles were measured. RESULTS: CoPap displacement caused by arm flexion was significantly smaller in the limitation than in the no-limitation. In the limitation condition, the whole body inclined backward more largely compared with no-limitation, with larger plantarflexion of the ankle, remarkable extension of the knee, and no change of the hip joint. In the no-limitation condition, preceding activations of postural muscles with respect to AD were found only in ES and BF. The limitation resulted in preceding muscle activations of all postural muscles (ES, BF, GcM and Sol), although no significant differences in onset time were seen for any muscles. CONCLUSION: By the limitation of CoPap anterior displacement, the preceding activation of the triceps surae could be induced with the backward inclination of the whole body pivoting at the ankles. The preceding activation of the triceps surae would become a good indicator of anticipatory postural controllability and this method could be applied to estimate the muscle training effect of the triceps surae on dynamic postural control, especially for the elderly.

O.11.2 Transient sensory reorganisation for body sway regulation with intermittent finger tip feedback is affected by inhibition of the left prefrontal cortex using rTMS

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BACKGROUND AND AIM: Skin contact with an earth-fixed referent provides augmented body sway feedback resulting in less variable body sway. Studies on the time course of sway before, during and after intermittent touch periods indicate that stabilisation of sway is a time-consuming integrative process (Rabin et al., 2006; Sozzi et al., 2012), which might involve regions within dorsolateral prefrontal cortex (Bolton et al., 2012). Using repetitive transcranial magnetic stimulation (rTMS), we aimed to investigate the effect of inhibiting left posterior parietal cortex (PPC) as well as left lateral prefrontal cortex (PFC) on the time course of sway stabilisation following touch onset as well as sway destabilisation after touch removal. We expected that inhibition of both regions disrupts processing of tactile feedback for sway control as indicated by delayed and attenuated sway reduction. METHODS: In two sessions, 10 adults received 20 minutes of 1 Hz rTMS stimulation at 110% passive motor threshold over the left PPC (CP3) and left lateral PFC (F3) respectively. Before and after each stimulation

interval, blind-folded and ear-plugged participants stood quietly on a force plate with their right forearm as well as two fingers of the right hand extended. In this posture, the fingers were held at hip level slightly above a contact plate of which its vertical position was controlled by a linear motor. Body sway was assessed in terms of antero-posterior Centre-of-Pressure (CoP) motion and trunk kinematics. Within each of 6 trials of 120 s duration, 5 pairs of touch onset and removal were timed at random intervals by controlling the vertical contact plate position. The minimum time period between subsequent onsets and removals was 7 s. Time course of sway was evaluated across 3 s before and after each contact event. RESULTS: Sway reduction with tactile feedback was attenuated after PFC inhibition but was not affected by PPC inhibition. This was especially apparent when comparing steady-state sway during touch contact against increased body sway after touch removal. CONCLUSIONS: 1Hz rTMS over the left lateral PFC disrupts intermittent sensory reorganization following removal of tactile body sway-related feedback. Our results corroborate findings reported by Bolton et al. (2012). Surprisingly, PPC inhibition had no effect on touch integration and removal. PARALITERATURE: Bolton, D. A., Brown, K. E., McIlroy, W. E., & Staines, W. R. (2012). Transient inhibition of the dorsolateral prefrontal cortex disrupts somatosensory modulation during standing balance as measured by electroencephalography. Neuroreport, 23, 369-372. Rabin, E., DiZio, P., & Lackner, J. R. (2006). Time course of haptic stabilization of posture. Exp.Brain Res., 170, 122-126. Sozzi, S., Do, M. C., Monti, A., & Schieppati, M. (2012). Sensorimotor integration during stance: processing time of active or passive addition or withdrawal of visual or haptic information. Neuroscience, 212, 59-76.

O.11.3 Absence of transfer in postural adaptation to moving platform across voluntary sway and arm raising tasks

Masahiro Shinya[1], **Daichi Nozaki**[1], **Kimitaka Nakazawa**[1]

[1]The University of Tokyo

BACKGROUND AND AIM: For better training and rehabilitation, scientists and clinicians required to understand the mechanisms underlying various postural control tasks. Postural control can be performed consciously or unconsciously. Consciously performed motor commands are called focal movement, and voluntary sway is a good example. On the other hand, compensatory backward control of trunk and lower limbs before voluntary arm raise is known as anticipatory postural adjustments (APA), which is unconsciously performed. Here, we have conducted a preliminary experiment to investigate if voluntary sway and APA share neural representation or not. METHODS: In this study, we used a motor learning and transfer paradigm. Predictive motor commands to compensate for an external perturbation learned through one task will be transferred to another task if motor learning mechanism is shared between these two tasks. Hence we exposed subjects to a moving platform during voluntary sway trials and tested if learned motor commands were transferred to APA trials. Six healthy males stood on a platform were asked to move their center of pressure (CoP) in a forward or backward direction (voluntary sway task). Amplitude of the sway was set as 35% of his anteroposterior limit of stability (approx. 4.8 cm) for each subject. After 30 baseline trials on a stable support surface (10 trials for each of forward sway, backward sway and arm raise tasks), the platform was moved rightward or leftward (acceleration: 0.5 m/s2, peak velocity: 0.2 m/s, duration: 800 ms, amplitude: 8 cm) associated with forward sway or backward sway, respectively. Eighteen catch trials in which the platform was not moved (6 trials for each of forward and backward sway and arm raise tasks) were interleaved in 108 (54 trials for forward and backward sway) adaptation trials. RESULTS: Subjects learned to predictively shift the CoP in mediolateral directions to compensate for the platform movement associated with anteroposterior voluntary sway, which was confirmed by the presence of aftereffect in the catch trials (1.3 ± 0.7 cm rightward shift for forward sway and 1.2 ± 0.3 cm leftward shift for backward sway). If this predictive mediolateral shift of CoP transferred to APA during the arm

raise task, one could say that motor learning system for the postural tasks was overlapped between voluntary sway and APA. However, no mediolateral shift was observed during arm raise tasks (0.0 ± 0.1 cm). CONCLUSIONS: The absence of transfer in postural adaptation to moving platform across voluntary sway and APA tasks suggests that motor learning systems for these postural tasks are relatively independent.

O.11.4 The ability to recover balance with a single backward step in people after stroke is highly dependent on leg inclination angle at foot contact

Digna de Kam[1], **Jolanda MB Roelofs**[2], **Alexander CH Geurts**[2], **Vivian Weerdesteyn**[2]

[1]Radboud University Medical Center

BACKGROUND AND AIM: Falling is an important health problem after stroke [1]. A better understanding of critical determinants for successful balance recovery in this population is essential to develop more effective fall prevention programs. In healthy individuals the successfulness of backward balance recovery is highly dependent on the body configuration at foot contact of the first step [2, 3]. In this study we investigated the predictive ability of leg and trunk inclination angle on the ability to recover balance with a single backward step in people after stroke. METHODS: Twenty-five ambulatory people in the chronic phase (>6 months) after stroke were subjected to translational perturbations, at random in any of four directions (forward, backward, sideways left and right) on a moveable platform (240x174cm). The intensity of the perturbations was gradually increased for each direction until subjects were unable to recover with a single step. At four fixed acceleration intensities (1.5, 2.5, 3.5 and 4.45 m/s²) four trials were collected for further kinematic analyses. For backward perturbations we determined for each trial the leg and trunk inclination angles with the vertical at the moment of foot contact, as well as traditional step variables (step onset, length, duration and velocity). A trial was considered successful if balance was recovered with only one step. A stepwise logistic regression analysis was performed to determine the predictive ability of either body configuration or traditional step variables on the probability of success. Stepping leg and perturbation intensity were included as independent variables. RESULTS: The regression model with body configuration parameters correctly classified the successfulness in 82.9% of the 246 recovery attempts (r^2=0.646). The Odds Ratios (OR) for leg angle (degrees) and acceleration (m/s²) were 1.655 and 0.208, respectively. Stepping leg and trunk angle were not retained in the model. In the model with the spatiotemporal step variables, only step length (cm, OR = 1.256) and acceleration (OR=0.073) were retained. Its predictive ability, however, was significantly less (r^2=0.583) than the model with body configuration (÷² test, $p < 0.001$). CONCLUSIONS: Despite the heterogeneity of the stroke population, leg inclination angle alone can accurately predict the successfulness of backward balance recovery at a given perturbation intensity. The critical leg angles required for successful balance recovery were independent of the stepping leg. Apparently, the body configuration at foot contact is more critical for successful backward balance recovery than joint torques generated after foot contact. Therefore, improvement of leg inclination angles in backward stepping may be an important therapeutic target. REFERENCES: 1. Weerdesteyn et al. 2008. 2. Weerdesteyn et al. 2012. 3. Hsiao et al. 2001.

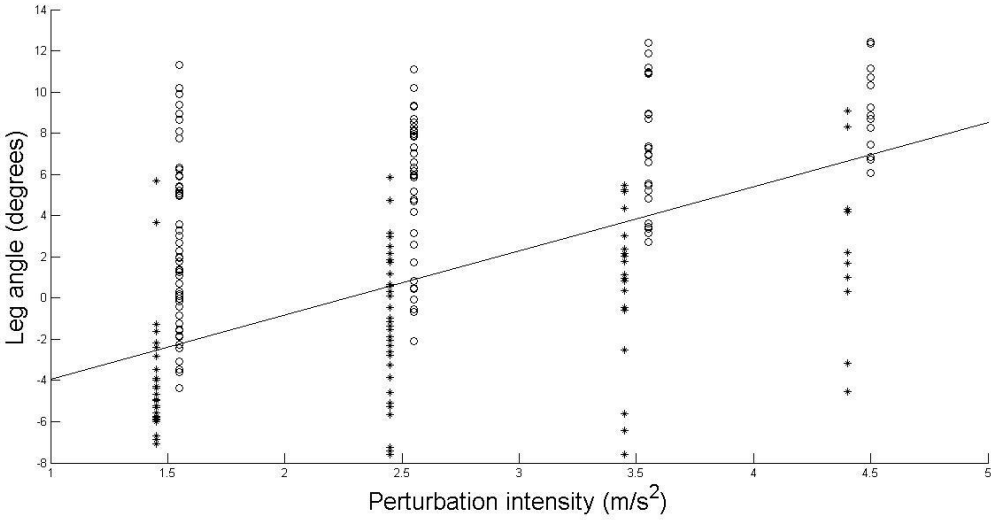

Figure 1. Leg inclination angles for successful (bullets) and failed (asterisks) recovery attempts at four perturbation intensities. The line represents the leg angles corresponding to 50% probability of success for each given intensity.

O.12 Falls and Falls Prevention II

O.12.1 Ankle dorsiflexor strength relates to the ability to restore balance during a backward support surface translation

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BACKGROUND AND AIM: Functional base of support (FBOS), the effective area for center of pressure (COP) movement, decreases with aging, which would reduce one's ability to restore balance during perturbed stance. Weakness in ankle muscles could contribute to a decreased FBOS and explain the increased incidence of stepping in the elderly when stance is perturbed. We investigated the relationship between ankle muscle strength, FBOS, and the ability to maintain balance, which was assessed as the threshold perturbation acceleration that required a heel-rise (HR) or step (STEP) response. METHODS: Standing posture of 16 healthy young and 16 healthy elderly adults was perturbed with a backward support surface translation with the speed ranging from 15 to 70cm/s. Whole body motion data with ground reaction forces were collected. Electromyographic data were also recorded to identify onset of muscle activities. Ankle joint moments were calculated based on a foot segment model. In addition, COP positions during sustained maximal leaning were calculated to determine forward, backward, and total FBOS. Ankle plantar- and dorsi-flexor strengths (PF and DF) were measured during maximum voluntary contraction. Linear regression analyses were performed to examine the relationship between ankle muscle strength and FBOS measures as well as threshold perturbation acceleration for STEP and HR (TAccSTEP and TAccHR). RESULTS: Elderly subjects demonstrated significantly smaller DF strength and FBOS measures than young subjects, but no significant group difference was detected in PF strength. DF strength was found to be significantly correlated with all the FBOS measures and threshold acceleration for HR (Table1). Significant correlations were also found between all FBOS measures and threshold

accelerations for HR and STEP, except for the backward FBOS and threshold acceleration for STEP. No significant differences between young and elderly subjects were detected in either muscle onset latency or ankle torque generation rate in response to perturbations. Most elderly subjects took a step once they raised their heels (74.0% of HR responses), while most young subjects were able to restore their balance after heel-rise (73.8% of HR responses). CONCLUSIONS: It was the dorsiflexor strength that significantly correlated with FBOS measures and threshold perturbation accelerations that required heel-rise responses. Individuals with weaker dorsiflexor strength showed smaller FBOS measures and raised their heels during backward perturbations with smaller accelerations. Elderly adults may not be able to control the COP and maintain balance while standing on their toes as effectively as young adults due to weakness in ankle dorsiflexors, which would limit their ability to restore balance from backward perturbations. FBOS measures and ankle dorsiflexor strength could be sensitive measures to detect individuals with reduced balance control.

Table 1
Results of linear regression analyses (PF and DF: Plantarflexor and Dorsiflexor strengths; FFBOS: Forward FBOS, BFBOS: Backward FBOS, TFBOS: Total FBOS; TAccSTEP and TAccHR: Threshold perturbation accelerations for STEP and HR responses).

	FFBOS [m]		BFBOS [m]		TFBOS [m]		TAccSTEP [m/s^2]		TAccHR [m/s^2]	
Variables	β	R^2	β	R^2	β	R^2	β	R^2	β	R^2
PF[Nm/kg]	0.009	0.02	-0.002	0.00	0.010	0.02	0.42	0.01	-0.31	0.01
DF[Nm/kg]	0.083*	0.24	-0.060*	0.29	0.143*	0.41	3.48	0.04	4.90*	0.29
FFBOS[m]							34.0*	0.23	19.1*	0.13
BFBOS[m]							-39.2	0.09	-29.3*	0.13
TFBOS[m]							35.0*	0.32	18.2*	0.20

*$p<.05$

O.12.2 Towards the automated detection of near falls in patients with Parkinson's disease and Idiopathic Elderly Fallers

Tal Freedman[1], **Eran Gazit**[1], **Ariea Tankus**[1], **Talia Herman**[1], **Marina Brozgol**[1], **Nir Giladi**[1], **Anat Mirelman**[1], **Jeffry Hausdorff**[1]

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BACKGROUND AND AIM: Much effort has been devoted to the development and evaluation of optimal measures of fall risk via self-report, however, the subjective nature and lack of sensitivity limits its utility. We propose an alternative approach to the assessment of fall risk: measuring near falls (NF). Several studies have found that self-report of NF frequency are related to fall risk and may occur before falls, enhancing its potential predictive value. Based on data collected with a "wearable" sensor, we aimed to develop a method for automatically detecting NF in the patient's routine activities of daily living. The aim of the present research is to develop an algorithm for automatic identification of near falls (NF) in patients with Parkinson's disease (PD), idiopathic fallers and older adults, under laboratory conditions. METHODS: A device located on the lower back measured acceleration and angular velocity in 40 patients with Parkinson's disease (age: 62.2±10 yrs, disease

duration: 5.3±3.5 yrs), 15 healthy older adults (age: 78.4±4.9 yrs) and 15 idiopathic fallers (age: 78.4±4.7 yrs). Subjects walked with a safety harness over an obstacle course designed to provoke NF. In addition to the obstacles course, the subject were in the laboratory for a battery of test to assess their motor and cognitive function. In total, each subject was in the lab for about 2 hours and at all time the acceleration data was recorded. An algorithm based on division of the data into windows of 5 seconds and features extraction from each window was developed. First only gait windows were extracted and then based on the features of a near fall we were able to detect the abnormalities that indicate NF event. Most of the features represent relationship between peaks inside each window, and the others are frequency-domain measurements. RESULTS: The algorithm was applied on the entire data collected from all the subjects. In total, 118 NF events were recorded among more than 100 hours of data. The algorithm achieved 89.83% Hit ratio and 98.94% specificity. CONCLUSION: In the lab environment, the developed algorithm identified NF events with good specificity and hit ratio. These results suggest that this automated approach can be used as an objective measure of fall risk; however, larger scale studies during community ambulation are needed to further validate this approach.

O.12.3 Does lack of arm movement after tripping cause falls in older adults?

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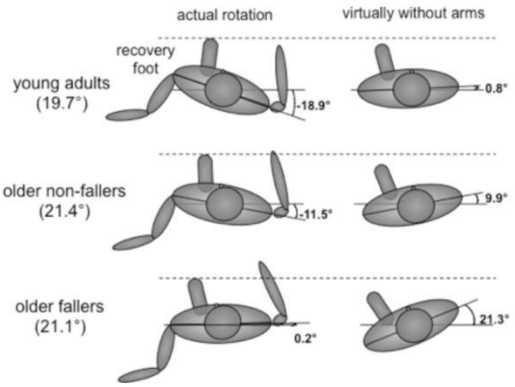
BACKGROUND AND AIM: Tripping over an obstacle induces a forward body rotation that must be counteracted to prevent a fall. Response reactions in the lower limbs have been shown to contribute to balance recovery, but also vigorous arm movements have been observed. In young adults, asymmetric arm movements substantially affected the body orientation in the transverse plane and thus contributed to balance recovery by facilitating a large step in the sagittal plane to brake the impending fall [1]. Since older adults in general, and particularly fallers, are generally less successful in their balance recovery after a perturbation, we aimed to investigate whether inadequate arm movements contribute to the decreased capacity to recovery balance in older people after tripping. METHODS: Fifteen healthy older adults (ranging from 65-74 years of age) were tripped at mid-swing over a suddenly appearing obstacle while walking over a platform. Full body kinematics were measured. A 3D model was used to calculate the angular momentum of both arms and of the whole body. To quantify the effects of arm movements, we numerically simulated how the body would rotate after tripping, if no angular momentum were transferred between the arms and trunk. We compared the actual orientation of the body at landing of the recovery foot with the orientation calculated by the numerical simulation of the armless body. The results of older adults were compared to those obtained in young adults. RESULTS: Preliminary results on 7 participants showed that the older adults showed less adequate balance recovery than the young adults in that their body was rotated more towards the tripped side at landing of the recovery foot. Four older adults needed full body support by a safety harness in their first tripping trial and were classified as fallers. At trip initiation, the axial body orientation of the older adults was significantly further towards the non-tripped side. After tripping, the older adults rotated slightly further forward in the sagittal plane and less towards the non-tripped side in the transverse plane, but this was not significantly different from the young (figure 1). Arm movements were similar between young and older adults, and the contribution of arm movements to balance recovery in the primary phase of recovery was therefore not different between age groups or between fallers and non-fallers. CONCLUSIONS: The less adequate body orientation at recovery foot landing in older adults is not due to inadequate arm movements, but rather to inadequate responses in the lower limbs and possibly to a less favorable angular momentum of the body in the transverse plane at trip initiation. [1] Pijnappels et al. Exp Brain Res. 201:689-99, 2010. Figure 1: Difference between actual rotation and virtually without arms in transverse plane body orientation at recovery foot landing.



O.12.4 Long-term changes of fall predictors: preliminary results from the FARSEEING project

Lorenzo Chiari[1], **Pierpaolo Palumbo**[1], **Marco Colpo**[2], **Stefania Bandinelli**[2]

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BACKGROUND AND AIM: Falls are prevalent and burdensome events in the elderly. Some clinical indicators differ significantly between prospective fallers and non-fallers. Many studies have been carried out to identify such indicators but little is known about the dynamic relationship between fall predictors and fall risk. Here we describe changes over time of two fall predictors and their ability to predict a fall after 3, 6 and 9 years. METHODS: Subjects from the InCHIANTI longitudinal study were assessed at baseline and at three 3 year-spaced follow-ups. Of the 1155 older adults recruited at baseline, 642 were present at follow up 3. Time to walk 4 meters at usual pace (WLK) and score on the CES-D (Centre for Epidemiologic Studies Depression) scale were chosen as low correlated fall predictors. Their change over time was individually studied by fitting linear growth curve (random slope) models, and marginal models with residuals constrained to have a correlation matrix with a Toeplitz pattern. The ability of WLK and CES-D assessed at baseline to discriminate between fallers and non-fallers at follow-ups 1, 2 and 3 was quantified with the area under the curve (AUC). RESULTS: The mean increase rate estimated in the linear growth curve model for WLK (CES-D) is significantly different from zero and equal to 0.74 s/3 yrs (0.82 points/3 yrs). The covariance between the random intercept and the random slope is positive (negative) and equal to 0.63 (-4.75). Coefficients of the within-subject Toeplitz correlation matrices are shown in table 1. AUCs of WLK and CES-D measured at baseline for falls reported at follow-up 1,2 and 3 are shown in table 2. CONCLUSIONS: Linear growth models show that mean WLK and CES-D worsen over time, though modestly. The negative correlation coefficient between the random slope and the random intercept signifies that CES-D increase is lower in subjects with higher CES-D at baseline. This "fanning-in" effect for CES-D may decrease the predictability of falls at subsequent follow-ups by CES-D score assessed at baseline, as the discrimination among subjects according to their fall risk obtained by the predictor at baseline tends to reduce. The coefficients r(i, i-Δt) of the residual correlation matrices are used as measures of self-similarity of the two indicators along time. These correlation coefficients are affected by both physiological changes along time and measurement errors. WLK is a more reliable and self-similar measure for time lags up to 6 years whereas CES-D proves to be more stable over long time scales. Estimated AUCs show WLK to be a good fall predictor at 3 years but its AUC loses statistical significance at follow-up 3. On the contrary CES-D is less strongly associated with fall risk but its AUC is still significant for falls that occur after 9 years. This work is a first step towards the characterization of the dynamic nature of the relationships between some clinical markers predictors of falls and fall risk.

AUC (95% CI)	Falls at follow-up 1	Falls at follow-up 2	Falls at follow-up 3
WLK	0.63 (0.58-0.67)	0.61 (0.56-0.65)	0.53 (0.48-0.59)
CES-D	0.60 (0.56-0.65)	0.61 (0.56-0.65)	0.59 (0.54-0.64)

Table 1

$r_{i, i-\Delta t}$ (95% CI)	Δt=0	Δt=1 follow-up	Δt=2 follow-ups	Δt=3 follow-ups
WLK	1	0.83 (0.81-0.85)	0.66 (0.61-0.70)	0.36 (0.28-0.44)
CES-D	1	0.51 (0.47-0.55)	0.45 (0.40-0.49)	0.49 (0.43-0.55)

Table 2. $r_{i, i-\Delta t}$ elements of the Toeplitz-shaped correlation matrices.

O.13 Tools and Methods IV

O.13.1 A proposal for a new definition of a near fall

Inbal Maidan[1], **Tal Freedman**[1], **Roy Tzemah**[1], **Nir Giladi**[1], **Anat Mirelman**[1], **Jeffery Hausdorff**[1]

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BACKGROUND AND AIM: A near fall (NF) has been defined as a stumble or loss of balance that would result in a fall if sufficient recovery mechanisms were not activated. Previous studies based on self-report demonstrated that NFs are related to fall risk, are more frequent than falls, and may occur before falls, potentially predicting the future risk of falls. Investigation of NFs might provide important information regarding an increased risk of falls. As a first step, we created a protocol to provoke NFs under safe conditions in a laboratory setting and video-taped the events. We applied the traditional definition of a NF and suggested a new defintion that includes 6 possible recovery mechanisms: unplanned movement of arms/legs, unplanned change in stride length, lowering COM, unplanned change in stride velocity, and tilting trunk forward. The presence of at least 2 is required to define event as a NF. This study aimed to assess intra and inter-rater reliability of the traditional definition of NF and to demonstrate potential utility of a new, more precise definition. METHODS:10 older adults, 10 idiopathic fallers, and 10 patients with Parkinson's disease walked in an obstacle course while wearing a safety harness. The examiner walked behind the subject, annotating events. The entire protocol was recorded using a video camera. 49 video segments were classified as obstacle negotiation, a fall or a NF according to annotations. The segments were used to create 2 movie clips each of 8.48 min, with the same segments in each, but in a different order. 4 raters: a senior physical therapist (PT), a PT, a neurologist, and a senior engineer were asked to rate each event as a fall, NF or no NF using the traditional definition. After 2 weeks, the raters were introduced to the modified definition of NF and were asked to rate the videos again. An intra-rater analysis using Kappa statistic (K) determined the consistency among raters. Inter-rater reliability was determined by calculating ICC between 4 raters for each clip separately, using the traditional definition of NF and the modified definition. RESULTS:Application of the traditional definition of a NF revealed poor intra-rater reliability for 3 raters

(K<0.054, p>0.137) and moderate intra-rater reliability for one rater (K=0.624, p<0.001). The inter-rater reliability between the 4 raters was moderate (ICC=0.667, p<0.001). The extended NF definition showed high intra-rater reliability for 4 raters (K>0.601, p<0.001) and high inter-rater reliability (ICC=0.781, p<0.001). CONCLUSIONS:It is, a priori, easy to distinguish falls from usual walking and NFs, but it is much more challenging to distinguish NFs from obstacle negotiation and usual walking. Therefore, a more precise definition of NF is required. This study shows that the modified definition increases intra and inter-rater reliability, a critical step for the potential utility of NFs in quantifying fall risk.

O.13.2 Portable fNIRS is a valid technique to study prefrontal cortical activation patterns during dual task walking in Parkinson's patients

Freek Nieuwhof[1], **Miriam Reelick**[1], **Anat Mirelman**[2], **Inbal Maidan**[2], **Jeffrey Hausdorff**[2], **Marcel Olde Rikkert**[1], **Bas Bloem**[1], **Jurgen Claassen** [1]

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Background: Walking, especially during dual task situations, requires executive (cognitive) functions. Functional near infrared spectroscopy (fNIRS) enables quantification of frontal lobe blood oxygenation levels, and thereby frontal activation, during walking. This study aims to investigate the feasibility and validity of an fNIRS protocol to assess frontal lobe activation during dual task walking (DTW) in patients with Parkinson disease (PD). Method: Prefrontal cortical activation, expressed as increased difference (HbDiff) between oxygenated (O2Hb) and deoxygenated (HHb) hemoglobin, was measured bilaterally in 12 PD patients using a new portable fNIRS technique. The participants (age 70.1 ± 5.4 years, Hoehn and Yahr stage II/III) walked under three conditions: simple walking (walking and counting), walking with serial subtractions and walking with digit span. Each task was repeated five times, with a duration of 40s and 20s of rest (standing quietly) before and after the tasks. Probes were placed on the forehead at a height of 15% of distance nasion-inion from nasion, and a width of 7% of circumference to the left and right to cover the (dorsolateral) prefrontal cortex. Continuous blood pressure and performance of both walking and cognitive (dual) task were recorded. Results: Between participants, different activation patterns were seen: (I) Simple walking: Stable O2Hb and HHb, DTW: increase in O2Hb, HHb unchanged (N=5) (II) Simple walking: decrease in O2Hb, HHb unchanged, DTW: reduction in decrease in O2Hb, HHb unchanged (N=2) (III) Initial increase in O2Hb and stable HHb during both walking and dual task walking (N=2). Two participants showed no change in signals, and one showed highly unstable signals, therefore these three participants were excluded from analysis. For the other participants (N=9), maximal HbDiff was significantly higher during walking with serial subtracting when compared to simple walking (t = 2.527; p = .035), while no significant differences were seen between walking with digit span and simple walking (t = -.240; p = .817). A significant decrease in gait speed was seen in walking with digit span when compared to simple walking (t=2.787, p=.024), while no significant difference was seen between walking with serial subtractions and simple walking (t = .913; p = .388). Conclusion: This study showed that, in PD patients, prefrontal activation during dual task walking can be detected by using portable fNIRS. The lack of increased activation during walking with digit span could be explained by the reduction in gait speed, which might have caused the dual task to be relatively easy and require no additional prefrontal activation compared to simple walking. Large between-subject differences in prefrontal activation patterns were found. These differences should be investigated and taken into account in fNIRS power calculations and analysis.

O.13.3 Using detrended fluctuation analysis to explain inter-limb coordination and toe clearance control during walking

Simon Taylor[1], **Daniel Lai**[1], **Russell Best**[1], **Rezaul Begg**[1]

[1]VICTORIA UNIVERSITY

BACKGROUND: Increased tripping frequency and the associated risk of falling is an international health problem in older adult populations. During leg-swing phase of walking there is a critical event where the toe reaches a minimum clearance height (i.e. the MTC event). Here, body posture is controlled by one supporting limb and the average distance between the swinging toe and the ground surface is approximately 1.5cm. At this instant in the gait cycle, the gait controller addresses two task-goals that appear simultaneously and the cooperation between the stance limb and swing limb is an outcome expression of the controller's executed plan. This study used detrended fluctuation analysis to investigate how ageing effects inter-limb cooperation in the context of the toe clearance task goal. METHODS: Two groups of 28 female participants with different mean age (25(±6) and 69(±3) yrs) walked on a treadmill for ten minutes under preferred walking conditions. Each participant's dominant and non-dominant limb was established. Three-dimensional lower limb segment kinematics captured from an OPTOTRAK motion capture system served as the input for a biomechanical model. Three vectors defined by the lower limb segments were created: a stance limb effector (vector spanning from the 'stance-foot' to the 'swing-hip'); a swing limb effector (vector spanning from the 'swing-hip' to the 'swing-toe'); and a combined effector (vector spanning the 'stance-foot' to the 'swing-toe'). Swing phase cycles (approx. N=600) were time-normalised and the effector-trajectory states of each swing cycle were time-aligned with the MTC event. For each effector trajectory, multiple time-series were then generated at time-slices that neighboured MTC. The level of control behaviour underlying the effector systems was investigated from the theory of persistence-likelihood using 'detrended fluctuation analysis' (DFA; [1-3]). RESULTS: For the non-dominant limb, the following results were found. At time slices neighbouring the MTC event, the DFA for the Elderly combined effector was significantly ($p<.05$) larger than the combined effector of the young group. In time series leading up to MTC, the DFA for the Elderly stance effector was significantly lower than the stance effector of the Young group ($p<.05$). For the DFA dependent variable, MANOVA planned contrasts showed a significant 'effector' x 'group' interaction when collapsing neighbouring time states and limbs (Figure 1C). CONCLUSIONS: The DFA results show differences between young and older adults in the way they organise their lower limbs to control toe clearance. Younger adults use both the stance and swing effectors to share the task-goal of toe clearance. In contrast, older adults are less likely to use redundant contributions of the stance and swing effectors to control toe clearance. Instead they focus on controlling the stance effector at mid-swing which appears to be the priority task-goal.

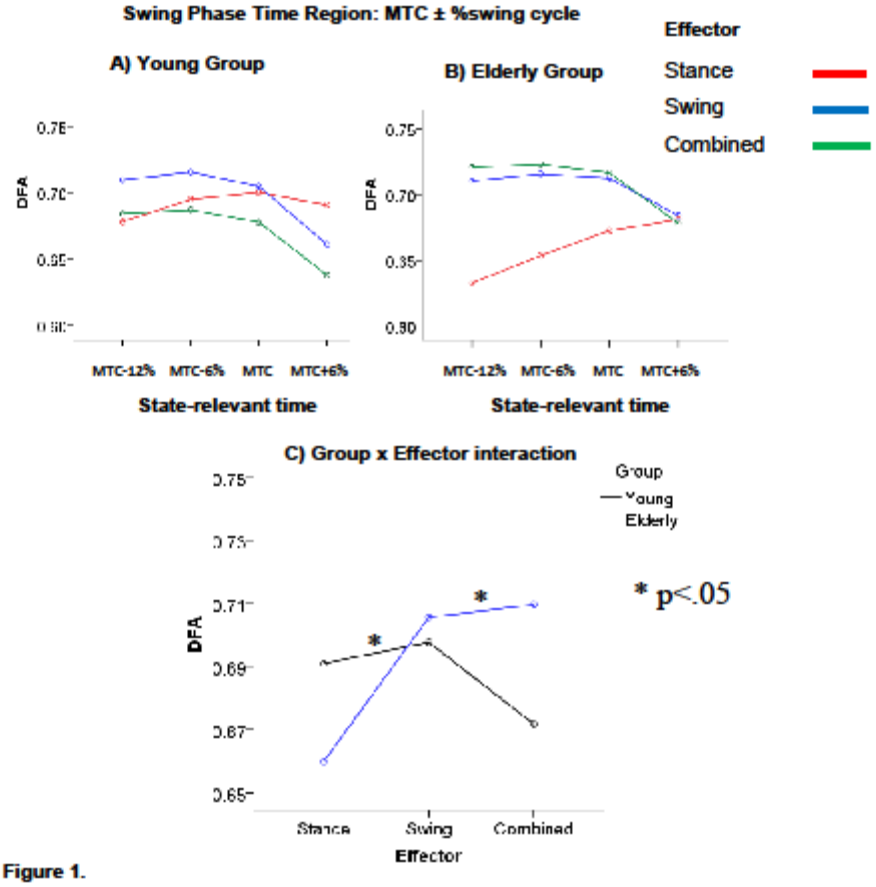

Figure 1.

Graphs of the vertical dimension of the mean DFA scaling exponent at the MTC region when collapsing dominant and non-dominant limbs. Graph A) demonstrates the interactions of effector and time state for the young group. Graph B) represents the elderly group. Graph C) illustrates group x effector interaction. Interactions effect of 'group' x 'effector' x 'state-time' was not significant. In plot C) significant 'group' x 'effector' contrasts are indicated by a black asterisk ($p<.05$).

O.13.4 Leg and Joint Stiffness in Children with Spastic Diplegia Cerebral Palsy During Walking

Hsing-Po Huang[1], **Ting-Ming Wang**[1], **Hsing-Po Huang Huang**[1], **Jia-Da Li**[1], **Shih-Wen Hung**[1], **Wei-Ching Lo**[1], **Tung-Wu Lu**[1]

[1]National Taiwan University

INTRODUCTION: Individual joint deviations are often identified in the analysis of cerebral palsy (CP) gait. However, knowledge is limited as to how these deviations affect the control of the locomotor system as a whole when striving to meet the demands of walking. The current study aimed to bridge the gap by describing the control of the locomotor system in children with diplegic CP, in terms of their leg stiffness (LS) and associated joint stiffness (JS) during level walking. METHODS: Seven children with spastic diplegia CP and 12 normal controls walked at self-selected pace while their kinematic and kinetic data were measured with a 7-camera motion analysis system (Vicon, U.K.) and 2 forceplates (AMTI, U.S.A.). The LS was calculated as the ratio of the

change of the ground reaction force with respect to body weight and the change in the leg length during a given period of time. The LS was decomposed into the skeletal and muscular components, reflecting the posture and load to the locomotor system [1]. The JS was defined as the ratio of the change of joint moment and the corresponding change in the joint angle. The LS, and JS for the lower limb joints were calculated during 4 sub-phases of stance, namely loading response (LR), mid-stance (MS), terminal stance (TS), and pre-swing (PS). Independent t-tests were performed for between-group comparisons of all the variables (α=0.05). RESULTS: The children with CP were found to have reduced LS ($p<0.01$) with increased JS at the hip, knee, and ankle joint during LR ($p=0.04$, 0.02, <0.01); reduced LS ($p=0.04$) with increased hip and ankle JS ($p=0.01$ & 0.01) but reduced knee JS ($p<0.01$) during MS; and reduced LS ($p=0.03$) with increased hip and knee JS ($p=0.01$ & <0.01) during PS. No between-group differences were found during TS except increased knee JS ($p=0.02$) in the CP group. The children with CP reduced the skeletal component of LS during the whole stance phase, especially during LR ($p=0.01$), MS ($p=0.03$) and PS ($p=0.02$). On the contrary, they increased the muscular component of LS during LR ($p=0.01$), MS ($p=0.04$) and TS ($p=0.02$). CONCLUSIONS: Reduced LS but increased JS in the CP group suggests that even with much effort to increase individual JS they were unable to produce appropriate leg stiffness necessary for normal gait. This appeared to be related to the more flexed limb posture, increasing the demand on the already weakened muscles to control the LS. The current findings suggested that LS and associated JS may help in the interpretation of clinical gait data in CP. REFERENCE 1. DeVita, P. and T. Hortobagyi. J Gerontol A Biol Sci Med Sci, 2000. 55(12): p. B593-600.

O.14 Tools and Methods V

O.14.1 Towards estimating fall risk from daily life measurements of trunk accelerations in older adults

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

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BACKGROUND AND AIM: Movement patterns obtained from inertial sensor data can be used to detect reduced dynamic stability and thus increased fall risk. To date, fall risk has been estimated under controlled conditions, providing large sets of steady-state data. Gait characteristics extracted from trunk accelerations during daily life may add to the quality of fall risk prediction - by construction they are complementary to questionnaire or laboratory based fall risk predictions. The aim of the current study was therefore to identify gait characteristics that are associated with self-reported fall history and can be reliably assessed. METHODS: Two weeks of trunk acceleration data (MoveMonitor) were collected in 48 older adults (age range: 67-97 years). After extracting locomotion episodes, various gait characteristics were determined, including local dynamic stability, inter-stride variability, and several spectral features. For all of these characteristics we computed the Pearson correlation with the participants' self-reported number of falls in the preceding year. Reliability of the gait characteristics was assessed by means of intra-class correlations (ICC), calculated across first and second measurement weeks. RESULTS: The local dynamic stability in medio-lateral direction ($R = 0.37$, $p = 0.01$, $ICC = 0.89$) correlated best with the number of falls in the preceding year, next to percentage of spectral power below 0.5 Hz along the medio-lateral direction ($R = 0.33$, $p = 0.02$, $ICC = 0.70$). CONCLUSIONS: This study shows that trunk accelerations measured during daily life contain reliable information that is significantly correlated with fall history.

O.14.2 Exergaming for balance training in elderly. part 1: usere requirements

Klaas Postema[1], **Mike van Diest**[2], **Claudine Lamoth**[3], **Jan Stegenga**[2], **Sabine Wildevuur**[4], **Gijsbertus Verkerke**[1]

[1]University Medical Center Groningen, [2]Innovation Centre for Advanced Sensors and Sensor Systems, INCAS3, [3]University of Groningen, [4]Waag Society

Background. Poor postural control is one of the major risk factors for falling and can be improved through training, yet current fall prevention programs suffer from low therapy adherence. Current exergames are not developed specifically with and for elderly. We aim to develop an exergame as a balance training tool for use in the home environment. Methods: A focus group of 10 elderly (aged 75.1 ± 5.6) was interviewed, concerning aspects about user requirements for an exergame device, the type of activities elderly are interested in, the user context and how exergaming would fit in, the willingness to invest in technology for balance training and the feedback and communication options. The interview method 'Users as designers' is described by the WAAG Society (Amsterdam, The Netherlands) and consists of semi-structured interviews and Visual Analog Scales (VAS). Next, in the practical part, 4 elderly played with 4 commercially available Kinect (Microsoft, USA) games for 15 min per week, over 7 weeks. The experience with the games was evaluated using a custom questionnaire evaluating after each session. Results Elderly prefer playing in a multiplayer mode with peers or grandchildren. The game should have a realistic look, be competitive and cooperation would be appreciated. The level of difficulty should be adapted during the game, but not be very challenging. Elderly would play on average almost 40 minutes per game session. The motivations for exergaming are to stay fit and to play a game as a social activity. The practical part showed that the games were found rather difficult to control, however, interesting to play and not very strenuous. The elderly prefer an in-game environment that is not too busy; the game should contain both cognitive and physical challenges; the difficulty should be adaptable; the progression should be monitored. The device should be easy to operate, install and store. Conclusion: The preliminary results from the studies showed that elderly are interested in playing exergames to improve or maintain their mobility. Important requirements include that the games should have a realistic look, adapt in difficulty, should take about half an hour to play and allow the user to monitor his progression. PARA Part 2 of this study concerns the development of reliable parameters to monitor balance during exergaming, and will be presented by Mike van Diest.

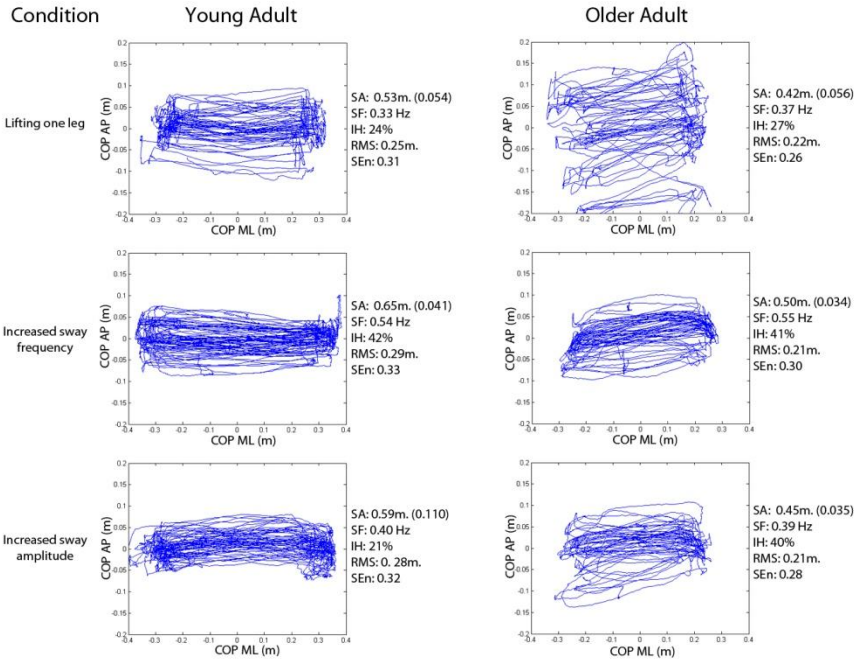
O.14.3 Exergaming for balance training in elderly. Part 2: Quantification of postural control in elderly during balance training using an exergame

Mike van Diest[1], **Claudine Lamoth**[2], **Jan Stegenga**[1], **Heinrich Wörtche**[1], **Klaas Postema**[2], **Gijsbertus Verkerke**[2]

[1]INCAS3, [2]University Medical Center Groningen

BACKGROUND AND AIM: Fall injuries are responsible for significant disability among elderly. Balance impairments with incorrect weight shifting is an important cause of falls[1], and can be improved through training[2]. We aim to develop a balance training tool consisting of an exergame in which the elderly perform task-embedded weight shifting movements. The objective of the study was to exam age-related differences in postural control during an exergaming task. As postural control decreases with aging and is associated with decreased sensory input and movement coordination, we hypothesized that age- and task-related differences can be quantified by analyzing the time-varying structure of the sway pattern. METHODS: Nine elderly (age 72.9 ±4.9) and five young adults (age 21.8 ±2.0) performed five different task-embedded weight-shifting exergame sessions in the frontal plane of about 1 min. while standing on a force plate. The conditions were: increased

dodge difficulty and game speed, lifting one leg and increased sway frequency (SF) and sway amplitude (SA). Ground reaction forces were recorded and analyzed. From lateral Center of Pressure (COP) displacements, SA, SF and root mean square (RMS) were calculated. Smoothness and predictability of the sway movement were quantified by the index of harmonicity (IH) and sample entropy (SEn) respectively [3,4,5]. RESULTS: RM ANOVA's showed age effects on SA, RMS and SEn ($p<0.05$) and a trend towards higher SF and IH in young adults. Additionally several significant condition effects were observed for each outcome measure. Results showed that outcome measures were lower in elderly indicating a smaller, slower, and more irregular movement then young adults. A selection of COP trajectories from two representative subjects is shown in fig 1, illustrating that the trajectory of the elderly is more irregular compared to the young adult when lifting a leg during sway exercises and that the SA of the young adult is larger when sway frequency is increased. Figure 1: Center op Pressure (COP) trajectories of a young and an older adult in 3 conditions. Axes represent the COP position in mediolateral (ML) and anteroposterior (AP) direction. SA = sway amplitude (standard deviation in parentheses), SF = sway frequency, IH = index of harmonicity, RMS = root mean square value, SEn = Sample Entropy. CONCLUSIONS: This study showed that during an exergame task, age and task-related differences in postural control can be quantified by analyzing the time varying structure of sway patterns. These measures can be used as feedback input in exergames for balance training, therewith adapting the training to the specific needs of the user. 1. Robinovitch SN, et al. The Lancet 2012:S014067361261263X. 2. Howe TE, et al. CDSR 2007:CD004963. 3. Lamoth CJC, et al. Gait & Posture 2009, 29:546-51. 4. Lamoth CJC, van Heuvelen MJG. Gait & Posture 2011, 35:489-93. 5. Kaptein R, Daffertshofer A. UPMOVE (version 0.2a) [software]



O.14.4 Effect of task order presentation on dual task interference on gait - Consequences and recommendations

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

[1]Newcastle University

Background: Dual task paradigms are increasingly adopted in gait research to examine the effects of age and disease on the ability to perform concurrent tasks whilst walking (dual task interference). Researchers often randomise or counter balance the order of single and dual task conditions during testing protocols to reduce task learning effects and minimise fatigue. However, little is known about the impact of task order on gait. Objective: To compare the impact of task order on dual task interference during gait in older adults. Methods: Gait was measured using a Gaitrite instrumented walkway during 2 minutes of walking in 188 community dwelling older adults (Mean (SD) Age 69 (7.6) years; 58% female). The gait and cognitive tasks (maximum forward digit span recall) were performed separately (single task) and concurrently (dual task). The order of single and dual task presentation was randomised. ANOVA, with task order (single task first, dual task first) as a between-person factor and dual task (single task, dual task) as a repeated measures factor, was conducted for each gait characteristic. Results: 86 participants performed the single task first and 102 performed the dual task first. Significant main effects for dual task showed that participants walked more slowly ($p < .001$), with a shorter step length ($p < .001$) and longer step time ($p < .001$), more variable step time ($p < .001$), length ($p < .001$) and width ($p = .001$), under dual task condition but measures of asymmetry did not change. Significant dual task x order interaction effects were also found for these variables. Post hoc tests showed dual task interference was greater for those who performed the dual task first, with task order affecting performance on dual task gait but not single task gait (for example, step velocity Fig 1-A). There was a strong correlation between the magnitude of the dual task main effect and order effect ($r^2 = .785$) (Fig1-B). Conclusions: Task order has a significant impact on dual task gait. The impact of task order is more pronounced for gait characteristics that are more susceptible to dual-task interference such as step velocity. Although randomisation or counterbalancing task order may reduce the impact of task order on estimating group means, it introduces greater within group variance that will reduce the power of statistical tests for both within- and between-group analysis. We recommend that dual task paradigms for gait either use a set task order or control for the task order as a covariate if a sufficiently large sample has been tested.

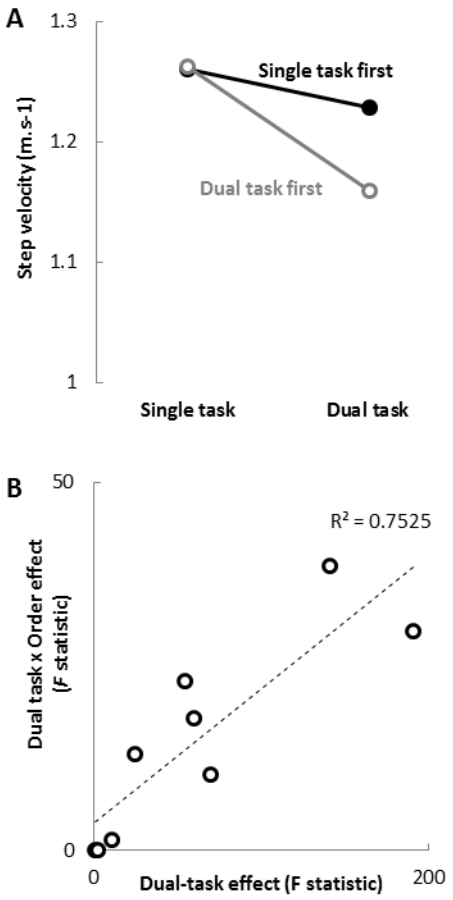


Figure 1. Step velocity under single and dual task condition in those who walked first under single task and dual task conditions first (Panel A). Relationship between magnitude of dual task effect and dual task x task order for 9 gait variables (Panel B).

O.15 Sensormotor Control II

O.15.1 Effects of aging on visual-vestibular interactions for maintaining stability while standing up from a sitting position.

Grace Kai Yan Lui[1], **Nandini Deshpande**[1]

[1]Queen's University

BACKGROUND AND AIM: Sit-to-stand (STS) is a biomechanically demanding task that requires the transition from a large 3-point base of support (BoS) to a small 2-point BoS while simultaneously controlling forward and vertical body acceleration. Vision is dominantly used for instantaneous feedback regarding body orientation with respect to the environment. Mourey et al. (2000) found older adults required visual feedback to precisely control movement during STS. During STS, the vestibular system could be highly stimulated due to linear acceleration of the head, first horizontally and then vertically. Age-related morphological changes in both the

visual and vestibular system could impair the ability to extract and interpret sensory information necessary for motor control in older adults, which can increase instability and risks of falls. We compared age-related changes in visual-vestibular interactions for maintaining stability during the STS task. METHODS: Fifteen young (YP, age=22.5±1.1) and 15 older (OP, age=73.9±5.2) healthy participants were asked to stand from a sitting position. Vestibular input was manipulated using percutaneous bipolar galvanic vestibular stimulation (GVS) where GVS threshold intensity was individually calculated for each participant during quiet stance with eyes closed. GVS was applied at both threshold and 2-times the participants' threshold intensity. Visual conditions included normal vision (eyes opened), sub-optimal vision using custom-made blurring goggles that simulate cataracts, or no vision (eyes closed). Outcome measures included transition phase duration (TPD), peak-to-peak trunk roll (T-roll) excursion, and peak braking force. Peak trunk center of mass velocity in the anteroposterior and vertical directions were used to delineate the start and end of the transition period, respectively. Data were analyzed using a 3-way mixed factor 2(Age-group)x3(GVS)x3(Vision) ANOVA. RESULTS: OP had a longer TPD than YP ($p<0.05$). Analysis for GVSxVision interaction indicated when vision was sub-optimal, OP had a greater T-roll irrespective of GVS ($p<0.05$). No effects of age were found in peak braking force between YP and OP ($p>0.05$). CONCLUSION: Overall longer TPD in OP could be because of slower generation of muscle forces or may be a possible cautious strategy. This strategy could be maladaptive as it prolongs time spent in the most unstable phase of STS. When vision was sub-optimal, but not when completely occluded, OP had lesser trunk stability independent of quality of vestibular input and despite availability of normal lower limb somatosensory information. This may indicate their tendency to depend on vision, when available, for axial control independent of the quality of visual information. PARA ACKNOWLEDGEMENTS: Thank you to Patricia Hewston and Mika Yoshikawa for their assistance. PARA REFERENCE: Mourey F, Grishin A, d'Athis P, Pozzo, T, & Stapley, P. The Journal of Gerontology. 2000; 55(9):B425-31.

O.15.2 Extracting self-motion information from visual motion to balance the body

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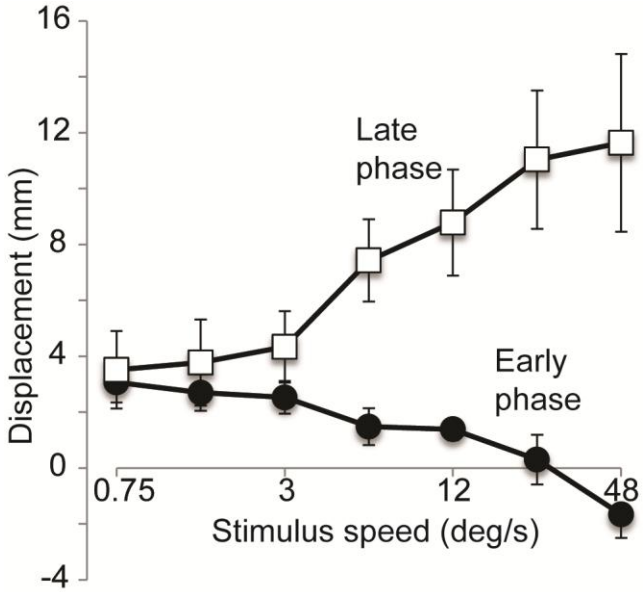
BACKGROUND AND AIM: Vision contributes to human balance control by providing information about how the body is moving in space. This requires that the brain distinguishes visual motion due to body movement from that due to movement of the environment. Here we hypothesise that the brain does this by assessing the likelihood that self-motion is the cause of the visual motion, for example by using non-visual sensory information and/or prior knowledge. This hypothesis predicts that the more rapidly a visual scene is made to move around a stationary standing subject the smaller the evoked response will be, even though the intensity of the visual motion stimulus is greater. METHODS: Healthy participants stood on a force plate (Kistler) in front of a large (2.4m x 2.0m) vertical screen in a darkened room. Markers were fixed to parts of the body and their movements were recorded in 3D (Coda). Multi-coloured dots (18mm dia) were rear-projected onto the screen. The dots had a uniform density (300 dots/m2) and were randomly distributed on a black background. The visual scene was set to rotate in the subject's frontal plane about a horizontal axis at ankle height. Typically, the scene would rotate clockwise or anticlockwise, or remain stationary. In one experiment, subjects were stimulated with ramp and hold angular velocity stimuli of different magnitudes. In a second experiment, constant angular acceleration and constant angular velocity stimuli were contrasted. RESULTS: In general, subjects responded by pushing themselves laterally in the direction of the visual stimulus. The response consisted of sequential actions that were differentially affected by changes in stimulus parameters. The first action was an initial acceleration in the direction of visual motion with a relatively fixed and short latency of ~220 ms. This was closely followed by a deceleration (second action) which occurred progressively earlier as the angular acceleration of the visual scene

increased. These two actions resulted in a body movement the size of which decreased with faster visual motion (figure), as predicted. However, this was followed by a third action that produced a second body movement in the direction of visual motion. In contrast, its size and speed increased with faster visual motion (figure). CONCLUSIONS: The whole-body balance response to a moving visual scene is surprisingly complex, consisting of two independent phases with different properties. The first phase is compatible with the hypothesised process that assesses the likelihood of the visual motion coming from self-motion. The second phase, however, appears to arise from a process that always attributes the visual motion, or at least a proportion of it, to self-motion. We suggest that visual motion evokes balance responses via two independent brain processes.



O.15.3 The relationships between eye movement and turning characteristics during on-the-spot turns

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BACKGROUND AND AIM: Large on-the-spot turns begin with a saccade towards the turn direction followed by additional saccades, which are driven by vestibular ocular reflex (VOR) induced nystagmus [1]. However, the characteristics of saccadic behaviour and how they relate to turning parameters (e.g. speed, amplitude and direction) has not been systematically described. Understanding these relationships is important as previous studies have shown that eye movement behaviour is altered in populations with turning problems (e.g. stroke and Parkinson's patients) and suggested a causal link between oculomotor dysfunction and turning deficits [2, 3]. Without knowing the relationships between turning and eye movement characteristics it is not possible to determine whether eye movement changes result from oculomotor dysfunction or as a by-product of altered body kinematics. This study aims to systematically investigate the effect of direction, amplitude and speed on eye movement characteristics during on-the-spot turns in healthy young adults. METHODS: Six young men (mean age 25.3 ±3.6) completed 5 trials of 180° on-the-spot turns for each of the following conditions; direction (right or left) and speed (moderate and fast). At the beginning of each trial an animation demonstrating the turn

conditions was shown on a video screen followed by a visual "go" signal. Kinematic data were recorded using a 10-camera Vicon system and horizontal eye rotations were recorded using a Bluegain EOG. Total saccade number, saccade and head rotation onset times, first saccade amplitude and velocity, and head peak velocities were determined. RESULTS: All turns were initiated with a saccadic eye movement in the turn direction. RM ANOVA showed a main effect of speed on all measured variables; most significantly on the number of saccades evoked (i.e. nystagmus fast phases) ($F(1,5) = 53.384$, $p<.05$). We found significant negative correlations between head velocity and number of saccades ($R2 = 0.63$, $P<0.01$) and first saccade amplitude and number of saccades ($R2 = 0.67$, $P<0.01$) and a significant positive correlation between head velocity and first saccade amplitude ($R2 = 0.40$, $P<0.01$). CONCLUSION: Our results demonstrate a significant effect of, and systematic relationship between, turning speed and eye movement characteristics during on-the-spot turns. The finding that the initial saccade characteristics were systematically related to subsequent head rotation speed supports the theory that a common mechanism operates to produce coordinated eye, head and body rotational movements and has implications for studies of turning behaviour in clinical populations. Further analysis of eye, head, body and feet kinematics should further elucidate the neural mechanisms that underlie this functionally important movement. REFERENCES: 1 Anastasopoulos, Ziavra, Hollands & Bronstein (2009) Exp Brain Res 193:232-336 2 Lohnes & Earhart (2011) JPD 1:109-118 3 Lohnes & Earhart (2012) Exp Neu

O.15.4 Gaze anticipation during human locomotion remains in darkness

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BACKGROUND AND AIM: Numerous experimental works showed anticipatory behaviors of the head and the gaze during curve driving [1] or human locomotion [2)]. This anticipatory strategy could correspond to an optimal selection of information in the optical flow field [3]. However, the head anticipation remains, even if the subject is immersed in the dark [4], suggesting that this behavior is not only elicited by vision. The present study aims at determining whether this gaze anticipation depends on trajectory planning processes or is a consequence of visual objectives. If gaze anticipation is a reflect of trajectory planning, it should remain so while in darkness. METHODS: Ten naive participants (six male) walked along two predefined complex trajectories ("limacon" and "eight"), without any visual cues indicating the trajectory to follow (shapes of the trajectories were beforehand presented to the subject on a sheet of paper). Two visual conditions were experimented: with and without vision (in a complete darkness with the eyes open). Head and trunk cinematic were recorded (VICON Motion System, 120Hz) as well as the movement of the participant right eye (Mocaplab video-based eye tracker, 50Hz). RESULTS: First of all, we confirm that the horizontal gaze orientation in space significantly anticipates the other segments orientation with vision (in advance of the head by 12.9±6.0° and of the current heading by 27.5±6.9°; Newman-Keuls post-hoc <0.01). We also show that this anticipation remains when participants walked in darkness. However, the anticipation amplitude decreases by a half without vision for both gaze and head (ANOVA, $F(1,9)=31.9$, $p<0.01$). CONCLUSIONS: The fact that the gaze always anticipates current heading and head direction shows that this behavior is not only visually induced. However, this anticipation is reduced without vision. These results support the idea that two mechanisms - visual and planning - collaborate for the execution of a locomotor trajectory. ACKNOWLEDGEMENTS: This research was partially supported by a European research project (RoboSoM, 248366). REFERENCES: [1] Land MF, Lee DN (1994) Where we look when we steer. Nature 369:742-744 [2] Grasso R, Glasauer S, Takei Y, Berthoz A (1996) The predictive brain: anticipatory control of head direction for the steering of locomotion. NeuroReport 7:1170-1174 [3] Authié CN, Mestre DR (2012) Path Curvature Discrimination: Dependence on Gaze Direction and Optical Flow Speed. PLoS

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O.16 Sensormotor Control III

O.16.1 Cataract surgery in older people improves gait speed in subdued lighting

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BACKGROUND: Cataract surgery improves vision and self-reported vision-dependent health and general health [1]. Cataract surgery on the first eye has also been found to reduce falls [2]. The effect of cataract on gait is sparsely reported. Gait is important for maintaining active life in older age, and thus the effect of cataract surgery on gait is important to investigate. Some few uncontrolled studies have found gait speed to increase shortly after cataract surgery [3, 4]. AIM: To assess changes in gait speed during walking in full light and subdued light in older persons undergoing cataract surgery on one or both eyes, in comparison to a group of age- and gender-matched persons with good vision for their age. METHODS: 182 older persons referred to unilateral or bilateral cataract surgery, and 168 age- and gender-matched references with uncorrected visual acuity > 0.5 logMAR, drawn from the national registry, were assessed at baseline and after a year. Assessments included tests of vision functions, medical examination and gait tests. Self-administered preferred and fast gait speed in full and subdued light (>250 lux and 5-15 lux at floor level, respectively) was measured by a 4.7 m long electronic gait mat, GaitRite. Mean walking speed over two trials was used as outcome. Analysis of differences in change between groups over a year was assessed by ANCOVA, controlling for differences in baseline gait speeds between groups. RESULTS: At baseline, persons referred to cataract surgery walked slower on all test conditions than the reference group (Table 1). We found differences in change in gait speed for gait in subdued light ($p<0.011$) but not in full light ($p<0.785$) between groups, in favour of those undergoing cataract surgery (Table 2). Change in gait speed during the year of follow-up was not different between those undergoing unilateral and cataract surgery. CONCLUSION: Cataract surgery improves gait speed under non optimal light conditions. Gait speed is an indicator of general functioning. The effect of cataract surgery on gait may be of relevance for functioning and for fall risk at high age should be further explored. 1.Helbostad J.L.; Odegaard, M.D., K.; Lamb, S.E.;, Lord, S.R.; Sletvold, O., Change in Vision, Visual Disability and Health Following Cataract Surgery. Optometry and vision science, 2013 (In press). 2.Harwood, R.H., et al., Falls and health status in elderly women following first eye cataract surgery: a randomised controlled trial. Br J Ophthalmol, 2005. 89(1): p. 53-9. 3.Ayaki, M., et al., Improvements in sleep quality and gait speed after cataract surgery. Rejuvenation Res, 2012. 4.Durmus, B., et al., Gain in visual acuity after cataract surgery improves postural stability and mobility. Bratisl Lek Listy, 2011. 112(12): p. 701-5.

Table 1. Baseline characteristics

	Cataract patients n=182	References n=168
Female gender	70%	66%
Age (years)	78.9 ±4.9	78.4±4.8
Body Mass Index	27.0±4.6	26.9±4.5
Mini Mental Status Examination(0-30)	27.1±2.4	27.2±2.5
Corrected visual acuity (logMAR)	0.64±0.21	0.91±0.34

Table 2. Gait speed at baseline and at one year follow-up.

	Cataract patients		References		Between-group changes
	Baseline	One year	Baseline	One year	p-value
Full light, preferred speed	0.75 (0.38)	0.91 (0.24)	0.96 (0.25)	0.98 (0.24)	0.785
Full light, fast speed	1.21 (0.34)	1.25 (0.33)	1.34 (0.34)	1.35 (0.34)	0.453
Subdued light, preferred speed	0.90 (0.24)	0.98 (0.20)	1.00 (0.24)	1.01 (0.22)	0.011
Subdued light, fast speed	1.17 (0.33)	1.26 (0.28)	1.33 (0.31)	1.29 (0.30)	<0.001

O.16.2 Increase in frontal brain activation during dual tasking in healthy young individuals: an fNIRS study

Hagar Bernad Elazari[1], **Inbal Maidan**[2], **Freek Nieuwhof**[3], **Miriam Reelick**[3], **Ariel Tankus**[3], **Yael Jacov**[3], **Nir Giladi**[3], **Anat Mirelman**[3], **Jeffrey Hausdorff** [1]

[1]Laboratory for Gait and Neurodynamics, Department of Neurology, [2]Tel-Aviv Sourasky Medical Center, [3]Radboud University Nijmegen

Background and aim: Accumulating evidence suggests that gait is influenced by higher order cognitive and cortical control mechanisms. The relationship between gait and executive function has been shown using behavioral testing, neuroimaging, and other indirect methods. Recently, several studies used functional near infrared spectroscopy (fNIRS) to examine functional brain activity during walking. Holtzer et al. (2011) reported an increase in oxygenated hemoglobin (HbO2) levels in frontal cortex during walking while talking. However, one cannot rule out the possibility that this increase was related to verbalization of words; further, it was not clear if the response was specific to gait or if it would also be observed during standing. Therefore, we aimed to investigate whether an increase in frontal activation is specific to dual tasking (DT) during walking. Methods: 10 healthy young adults (mean age 31.6±2.9 yrs) participated in the study. Gait was assessed using GaitRite while frontal brain activation was assessed using an fNIRS. The fNIRS consisted of two probes placed on the forehead at a height of 15% of the distance nasion-inition from nasion, and width of 7% of circumference to left and right. The subjects preformed 4 tasks: standing in place while subtracting 7s (S7), walking at a comfortable speed, walking while counting forward, and walking while S7. Each walking task consisted of 5 walks of 30 m. Quiet

standing of 20 sec was performed before and after each walk and served as a baseline. The standing task included five S7 intervals of 30 sec each, separated by 20 sec of quiet standing. After subtracting the baseline value, the HbO2 level for each task was determined by averaging 5 repetitions of the task. Results: HbO2 level was higher during walking with S7 compared to usual walking (increase of 0.22 µM, p=0.005), and compared to walking while counting forward (increase of 0.24 µM, p=0.002). No significant differences in HbO2 were found between comfortable walking and walking while counting forward (p=0.940), or between comfortable walking and standing while S7 (p=0.145). Gait speed during walk with S7 was significantly lower, compared to both comfortable walking and walking with forward counting (p=0.047). Conclusions: This study provides additional evidence that DT during walking is associated with frontal brain activation in healthy young adults. HbO2 differences were not observed between comfortable walking, walking with counting forward and standing while S7. The absence of a change in these conditions suggests that the increased activation in frontal brain areas during walking occurs only during a more challenging DT. The observed changes are apparently not a response to the verbalization of words and are specific to walking, as compared to standing. These findings suggest that a cognitively challenging DT increases frontal brain workload during gait which may be related to the resulting changes in gait speed.

O.16.3 Foot plantar vibration does not improve postural control in young healthy people after plantar ice immersion

Chich-Haung Richard Yang[1], **Chen-Kai Chien**[1], **Hsiao-Yuan Lee**[1], **Lan-Yuen Guo**[2]

[1]Tzu-Chi University, [2]Kaohsiung Medical University

BACKGROUND AND AIM: Postural control is a complex performance in human upright activities (e.g. standing and walking), which is an integration of optimal output of musculoskeletal, motor and sensory nervous system. Notably, somatosensory input in plantar area is an essential role in postural control in healthy people. The purpose of this study was to examine whether plantar vibration may improve postural control in people with plantar desensitization after ice immersion. METHODS: A total of six healthy collegiate students voluntarily participated in this study. A single-leg upright posture over a forceplate (Kistler Corp., USA) was selected to examine the capability of postural control under 3 conditions (pre-intervention, plantar desensitization after ice immersion, plantar vibration with plantar desensitization after ice immersion) with eyes open and eyes close. The procedure of ice immersion (12-15 Celsius) was applied over the plantar side in the dominant leg monitored by a real-time physiological recording system (MP 100, Biopac System, USA). Plantar desensitization in the dominant leg was confirmed over head of first metatarsal bone, head of fifth metatarsal bone and calcaneus through a set of monofilaments (Baseline Tactile Semmes-Weinstein Monofilaments, Patterson Medical, USA). Custom-made plantar vibration devices (input voltages, 1.5 volts) were used over the plantar area in third condition. RESULTS: The results have shown that significant reduced postural control in eyes open and eyes close conditions were found in people with plantar desensitization (after ice immersion), which indicating increased area, root mean square and mean velocity of center of pressure (COP) ($p < 0.05$). Meanwhile, plantar vibration intervention did not improve the parameters (Area, Root Mean Square (RMS) and Mean Velocity (MV) in anteroposterior and mediolateral directions) of COP in people after plantar desensitization. CONCLUSIONS: The findings confirm the role of plantar sensory input is a key role to mediate the postural control. In contrast, plantar vibration over the calcaneus provides adverse effect on the postural control in a single-leg upright standing posture.

O.16.4 Functional characteristics of spinal motoneurons in rat and monkey those acquired bipedal locomotor capability

Futoshi Mori [1], **Katsumi Nakajima**[2], **Naomi Wada**[1]

[1]Yamaguchi University, [2]Kinki University School of Medicine

BACKGROUND AND AIM: Motor behaviour including locomotion is finally made by the activity of the spinal cord (SC) motor neurons followed by the contraction of skeletal muscles. We have shown that the motor cortices including the primary motor cortex (M1) were significantly activated during bipedal (Bp) locomotion in Japanese monkey. This suggests that the cortical outputs play an important functional role for the execution of Bp locomotion. One of the targets of such output is the SC motor neurons. The H-reflex is the electric analogue of the spinal stretch reflex, which is mediated through monosynaptic pathways in the SC, so that this record is useful for assessing the excitability of SC motor neurons. In this study, we recorded the H-reflex to evaluate the functional characteristics of SC motor neurons in both recently established rat Bp walking model (RBWM) and monkey. METHODS: In rat study, the H-reflex was recorded using Ag-AgCl wire electrodes that were inserted under the skin of the hind paw plantar surface (interosseous muscles) after electrical stimulation (duration: 0.2 ms) of the lateral plantar nerve under anesthesia using ketamine-HCL. For monkey study, two adult male monkeys were the subject. One of the monkeys receives routine Bp walking task (3-5 times/week) for about 5 years, and the other have not been trained for more than 3 years. Under the right ketamine-HCL sedation, the H-reflex recorded at the soleus muscle was elicited by the tibial nerve magnetic stimulation. The recorded H-reflex and M-waves were amplified with an A/C-coupled differential amplifier and averaged, and the latency and amplitude of both waves were quantified in rat and monkey model. In rat, the further dorsal column lesion and total SC transection was made at T10-11 after recording of H reflex to evaluate the effect of spinal descending signals. RESULTS: H-reflex was induced by stimulating at a lower intensity than that required to produce M-wave in all rats. It is clearly observed that the H-reflex in RBWM was suppressed at the various stimulus intensities. Dorsal column region partially released the inhibition of H reflex. In monkey, both H reflex and M wave were observed after the magnetic stimulation. Similarly with the result obtained from RBWM, the amplitude of H-reflex was inhibited in a trained monkey. CONCLUSIONS: These results indicate that the threshold of the SC motor neurons in both RBWM and monkey model is raised after the acquisition of Bp walking capability. This high threshold may restrict the incoming signals from both supraspinal and/or peripheral nervous system and contribute for the stable execution of Bp locomotion.

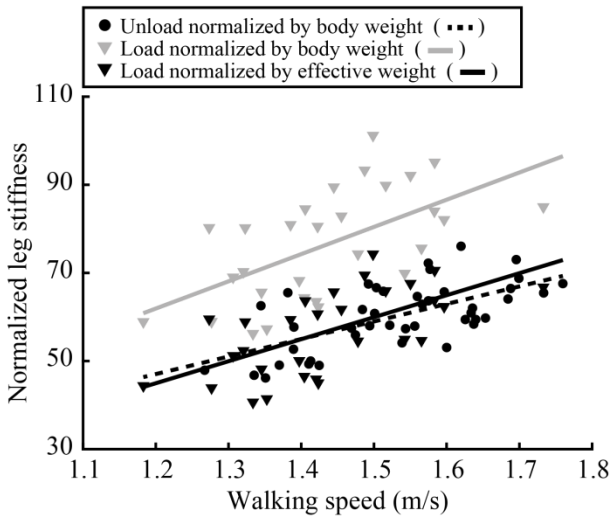
O.17 Modelling

O.17.1 Leg stiffness increased with load to achieve resonant gait dynamics

Sue Park[1], **Myunghyun Lee**[1], **Seyoung Kim**[1]

[1]KAIST

BACKGROUND AND AIM:Oscillatory behavior of the center of mass (CoM) in walking has been represented by a bipedal mass-spring model. One of possible benefits of leg stiffness increase with gait speed was reported as the close match between the resonant frequency of the CoM and the gait frequency. To confirm whether the leg stiffness is adjusted to achieve resonant gait dynamics gait, we examined the leg stiffness change with load, which is the other factor determining the resonance frequency of the mass-spring system. METHODS:Seven healthy young subjects participated and were instructed to walk over the ground with and without 25-kg load at three different walking speeds. Kinematic and kinetic data were measured by three force plates and six infrared motion capture cameras. Leg stiffness was estimated from the bipedal spring-damper model that best matched the empirical ground reaction force (GRF) data. To examine the hypothesis, the change of leg stiffness and corresponding natural frequency of the mass-spring model was compared. Elastic energy stored in a compliant leg at the end of single support phase was compared for various leg stiffness to check the energetic benefits of resonant gait. RESULTS:The results showed that leg stiffness increased with load to oscillate the CoM with natural frequency during single support phase. Estimated leg stiffness showed high correlation with the optimal stiffness that maximized the propulsion energy during the double support phase. CONCLUSIONS:The result implies that leg stiffness is adjusted to take an advantage of resonant gait dynamics.



O.17.2 Training teenagers with Cerebral Palsy on a split-belt treadmill: from kinetic adaptation to motor learning

Simona Bar-Haim[1]

[1]Ben-Gurion University

Training teenagers with Cerebral Palsy on a split-belt treadmill: from kinetic adaptation to motor learning
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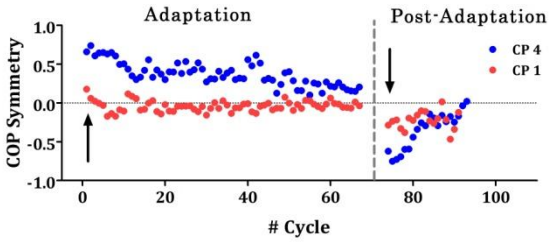
Introduction: Decades of neurorehabilitation research have proven that the damaged brain can learn, and that optimal recovery requires intensive task-specific practice. In the current study we have assessed the transition from adaptation to motor learning of teenagers with CP by analyzing the ground reaction forces (GRF) as well as the center of pressure (COP) during adaptation to speed perturbation, using a split-belt treadmill with integrated force plate. Methods: Ten healthy subjects (25.8±3.4 years) without a neurological history and without known disturbances in walking and 7 adolescents (18.3±1.8 years) with Cerebral Palsy (GMFCS II and III) participated in

this study. All subjects participated in one testing session that included baseline, adaptation and post adaptation periods. Subjects with CP then trained on the split-belt treadmill twice a week for 25 sessions. The teenagers with CP underwent functional performance tests (GMFM) to evaluate different aspects of their walking performance. Results: For the typically developed subjects, the test revealed that during adaptation to the split-belt force treadmill, the GRF of each leg at initial contact and the COP changed gradually and showed motor after-effects during early post-adaptation, suggesting the use of a feedforward predictive mechanism. However, adolescents with CP showed mixed results. We found that for four adolescents CP does not impair the ability to make predictive feedforward motor adaptations and they showed intact motor after-effects (Fig.1, blue points), whereas the predictive adaptation of three other CP subjects was significantly disrupted during splitbelt treadmill locomotion (Fig.1, red points). In addition, we found a significant correlation ($P<0.05$) between adaptation levels and GMFM functional test measures. Conclusions: For the adolescents with CP, we postulate that CP involving damage to cerebral structures did not impair adaptive predictive response and showed clear after-effect
during early post-adaptation. However, CP with diffusion and cerebellar deficits may disrupt predictive feedforward motor adaptations during walking on a split-belt treadmill. Furthermore, we found that adaptive response showed significant correlation with motor dysfunction tests. These findings demonstrate that diplegic teenagers with CP are able to adapt to speed perturbation whereas persons with moderate and severe CP are not able to use adaptive motor control. Fig 1: COP symmetry during adaptation and post-adaptation phases for two representative CP subjects



O.17.3 Hip-ankle synergy in human biped balancing resulting from multisensory integration in feedback control

Georg Hettich[1], **Lorenz Asslaender**[1], **Thomas Mergner**[1]

[1]University Freiburg

BACKGROUND AND AIM: Human stance control involves multisensory integration and sensory feedback when resisting unforeseen external disturbances such as support surface tilts. The control involves co-ordinations between hip and ankle joints, which provide functional synergies and cope with biomechanical interactions between the joints. Hypotheses on how the synergies may be explained vary in their emphasis of biomechanical constraints, neuromuscular synergies, eigen-synergies, or multisensory integration. Our study investigates the synergy of hip joint and ankle joint movements in keeping the trunk upright during moderate support surface tilts and asks whether it can be explained by the multisensory integration mechanisms in the hip and ankle joint feedback controls. METHODS: Seven healthy subjects balanced with eyes closed during support surface tilts in the sagittal plane (pseudo-random ternary sequences with frequency range of 0.017 to 2.2 Hz; peak-peak

amplitudes of 1, 2, 4, and 8°). Trunk, leg and body center of mass (COM) angular excursion with respect to the earth vertical as well as hip and ankle joint rotations were calculated from measured hip and shoulder displacements. Corresponding gain, phase and coherence plots were obtained using spectral analysis. The human data were implemented in a stance control model using control modules of the Disturbance Estimation and Compensation (DEC) concept of [1] and compared to computer as well as robot simulations. The robot data were obtained in the human experimental setup. RESULTS: The frequency characteristics of the human tilt responses were well reproduced in the robot and the computer simulations. There was one exception concerning an 'amplitude nonlinearity' (response gain decreasing with increasing tilt amplitude). In the human data, this was found only in the ankle responses and not in the hip responses, whereas in the simulations it was present in both, hip and ankle responses. This applied if the DEC modules for the hip and ankle joint controls were simply superimposed. However, when a DEC signal of foot-in-space rotation from the ankle joint DEC module was 'up-channeled' into the sensory integration of the hip joint DEC module, the simulation data matched the human data also with respect to the amplitude non-linearity. CONCLUSION: The human hip-ankle synergy during support surface tilts can be simulated in a computer model and a robot by using a superposition of two DEC modules for sensory feedback control in the hip and ankle joints, i.e. a modular rather than monolithic control architecture. Obtaining correspondence of the simulated data with the human data required us to link the modules with each other in the form that the estimation of foot-in-space rotation is passed from the lower module for the ankle joint to the superimposed hip joint module. Functional advantages of this 'up-channeling' will be discussed. [1] T. Mergner, Annual Reviews in Control, 34, 177-198, 2010.

O.17.4 Feedback control of balance muscle activity in individuals with Parkinson's disease before and after adapted tango rehabilitation

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BACKGROUND AND AIM: Adapted tango rehabilitation (AT) improves clinical measures of balance and mobility in individuals with Parkinson's Disease (PD) via unknown neural mechanisms. Muscular activity may provide a window into neural activity, potentially revealing neural mechanisms of motor dysfunction and recovery. In reactive balance in healthy young individuals, we have shown that muscles activate with timing and magnitude proportional to center of mass (CoM) motion to maintain the CoM above the base of support. However in individuals with PD, muscles activate with atypical timing and magnitude and high levels of antagonist co-contraction. Here we used a sensorimotor response model (SRM) to evaluate whether these differences in antagonist EMG reflect a degraded ability to achieve the task-level goal of stabilizing the CoM during reactive balance. We hypothesized that after successful AT, antagonist muscle activity in PD is more tightly coupled to the destabilization of the CoM due to perturbations during standing balance. METHODS: Individuals with PD (disease duration 6.0±3.9 years; n=9; H&Y stages 2 (n=5) 2.5 (n=1) and 3 (n=3); UPDRS 30.0±4.7) were assessed with the Berg Balance Scale (BBS) and for responses to forward and backward translation perturbations before and after AT (15, 1.5h lessons in 3 weeks). Kinematics and bilateral Tibialis Anterior (TA) and Medial Gastrocnemius (MG) EMG were recorded. Muscle activation timing and magnitude was characterized as the delayed and weighted sum of sensorimotor feedback signals of CoM acceleration, velocity, and position using the SRM. SRM parameters were identified through optimization. To identify significant changes in balance pre- and post-AT, we used paired t-tests (BBS, SRM parameters, R^2/variance accounted for (VAF)) and two-way ANOVA (peak CoM displacement, velocity, and EMG magnitude) at α=0.05. RESULTS: All participants completed AT and improved on BBS (50.3±6.5 to 53.6±3.6; p=0.03). After AT, participants exhibited decreased initial CoM velocity (backward perturbations, 0.5±1.0 cm/s, about 4%; p=0.04), decreased CoM excursion (0.4±0.7 cm,

about 10%; p<0.036) and decreased MG activity at the end of platform motion when the muscle acts as an antagonist (p=0.008). Muscle activation timing and magnitude were reconstructed by the SRM (VAF=0.73±0.11; R^2=0.36±0.24) before AT. After AT, SRM fits to TA activity, which is an agonist at the end of platform motion during backwards perturbations, improved (increase in R^2=0.124±0.117; p=0.047). CONCLUSIONS: AT decreased CoM motion and improved muscle activity at the end of perturbations to balance in individuals with PD. Specifically, deactivation of antagonist and activation of agonists were more precisely matched to CoM motion, suggesting improved control of task-level goals. SRM analysis may be a useful tool in the functional interpretation of changes in muscle activity associated with motor deficit and rehabilitation. Keywords: EMG, dance, exercise.

O.18 Vestibular Functions and Disorders

O.18.1 Gait impairment in downbeat nystagmus syndrome

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BACKGROUND AND AIM: Downbeat nystagmus (DBN) is the most common form of an acquired central ocular motor abnormality. DBN is based on cerebellar (flocculus) dysfunction and can be considered as an ocular motor or vestibular disorder in the vertical (pitch) plane. Gait disturbance is a key feature of the DBN syndrome. However, little is known about the characteristics of the gait pattern in DBN patients. METHODS: We measured overground locomotion of 50 patients with DBN and 50 healthy age matched controls using the GAITRite® sensor mat during walking with three different velocities, eyes open, and eyes closed. Analysis of Variance with a two-way ANOVA was performed. RESULTS: ANOVA revealed significant changes in gait velocity, stride length, swing phases, base of support, stride time, double support, and stance phase (p<0.001). Significantly altered coefficients of variation of stride time, stride length and base of support (all p<0.001) with a significant cofactor speed (p<0.001) were also observed. Intragroup analysis of DBN revealed that patients with concomitant limb ataxia have higher coefficients of variations of stride time than the other patients, but only during maximally fast walking. CONCLUSIONS: The results indicate that patients with DBN show abnormalities of spatial and temporal gait parameters in the sagittal and frontal planes characterized by an impaired dynamic balance control. Speed-dependent analysis of gait variability reveals a pattern of insufficient vestibular integration. However, the presence of limb ataxia in DBN patients alters the speed dependency of gait impairments, suggesting the flocculus has a distinct effect on gait control independent on the cerebellar hemispheres.

O.18.2 Recalibration of vestibular afference for orientation and navigation

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BACKGROUND AND AIM: Vestibular information is used for orientation and navigation, particularly in the absence of reliable visual cues [1]. This study examines how we can set the vestibular signal that represents zero rotation. METHODS: Subjects (n=5) were instructed to walk along a straight line for 40 m while they received bilateral, bipolar GVS with the head bent forward, maximising the body rotation signal [2]. In the first 20m,

subjects walked with sensory feedback (eyes open or touching a line). For the second 20m, feedback was eliminated and subjects were instructed to walk straight ahead. RESULTS: Baseline walking with GVS and eyes closed resulted in an average 5deg/m rotation and deviation in trajectory of 8m to the anodal side. With prior visual feedback, this rotation and deviation in trajectory was significantly reduced by half. A similar attenuation of rotation and deviation was seen with prior tactile feedback. However, there was no attenuation of the GVS effect on navigation following a passive (wheelchair) condition with verbal feedback regarding trajectory. Flipping the anodal direction in the second 20m resulted in a 3-times larger deviation in trajectory to the new anodal side. CONCLUSION: These results indicated that the vestibular signal, derived from semicircular canal afference, used to guide orientation during locomotion is continuously adjusted to bring it into line with sensory input obtained from visual and somatosensory input during locomotion. This adjustment is not achieved following passive motion and verbal feedback. This adjustment is through a process of "recalibrating" rather than "reweighting" the vestibular contribution to locomotion. REFERENCES: 1. Bent LR et al. Neurosci Lett 2000, 279, 157-60. 2. Fitzpatrick RC & Day BL. J Appl Physiol 2004, 96, 2301-16.

O.18.3 Contrived management for suspected autoimmune inner ear disease with abnormal eye movement.

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BACKGROUND AND AIM: Autoimmne inner ear disease (AIED) is a clinical syndrome of uncertain pathogenesis. We encountered 2 cases of bilateral hearing loss and vertigo with inner ear antibodies. These cases presented with very peculiar eye movement. The neuro- otological findings and the clinical course are presented. METHOD: The first patient (Case 1), a 34 year-old woman, came to our clinic on May 2001 complaining of right tinnitus. The second patient (Case2), a 22 year-old man who had right cochlear implant at the age 14, visited our clinic with dizziness on Dec 2005. RESULTS: In the case 1, the hearing progressively dropped despite of intensive treatments. She became deaf and underwent right cochlear implantation on June 2004. Dizziness and abnormal eye movement developed from August 2004. Bilateral vestibular function was reduced. The abnormal eye movement and dizziness improved by the left intratympanic injection of betamethasone. She had inner ear antibodies against 68 kDa etc and was treated with combination of steroid and immunosuppressive agents which was not effective. She underwent the left endolymphatic sac surgery with high dose steroid insertion in November 2007, but its effect was minimum. She further had gentamicin injection into the left ear which controlled the dizziness and eye movement. In 2 years, the dizziness and the abnormal eye movement recurred. Infusion of high dose steroid controlled these symptoms. She has stayed on low dose steroid and subsequently methotrexate up until now. The case 2 also showed bilaterally reduced vestibular function and abnormal eye movement from June 2006. He had the inner ear antibodies. Steroid combined with an immunosuppressive agent successfully controlled the dizziness and abnormal eye movement. CONCLUSIONS: Diagnosis of AIED is based on clinical picture and the laboratory tests for autoimmunity which are still supplemental. The pathogenesis and best treatment option should further be studied.

O.18.4 The association between impaired perception of verticality and cerebral white matter lesions in the elderly patients with orthostatic hypotension

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Background & Aim: The morbidity of orthostatic hypotension (OH) increases with age, and the elderly often complain of dizziness associated with OH. The pathogenesis of dizziness caused by aging is controversial. White matter lesions (WMLs) are frequently found on MRI in elderly patients with dizziness. However, little is known about the association between dizziness and white matter lesions in the elderly. We therefore evaluated the involvement of cerebral WMLs in the perception of verticality in the elderly with OH. Methods & Results: We analyzed 24 dizzy patients aged more than 65 years who met the criteria for OH proposed by the American Autonomic Society. The male patients aged more than 65 years with OH (Mean/SD 5.3/2.9 degree) showed a significantly higher magnitude of uncertainty in the subjective visual vertical (SVV), which indicates an impaired perception of subjective verticality, in comparison with the male patients aged less than 65 years without OH and the male patients aged < 65 years with OH (Mean/SD 2.8/1.2 degree, 2.6/1.3 degree, $p < 0.05$). Uncertainty in the SVV was found to be significantly correlated with the volume of WMLs in both sides on MRI in the male, but not female, patients ($p < 0.01$). Conclusions: Our results suggest that a disturbance of the cortico-subcortical neural vestibular network caused by the development of severe WMLs is involved in impaired perception of verticality, thus resulting in induced subjective dizziness.