

## Poster Session 2

Monday, June 24 between 15:30 and 17:30

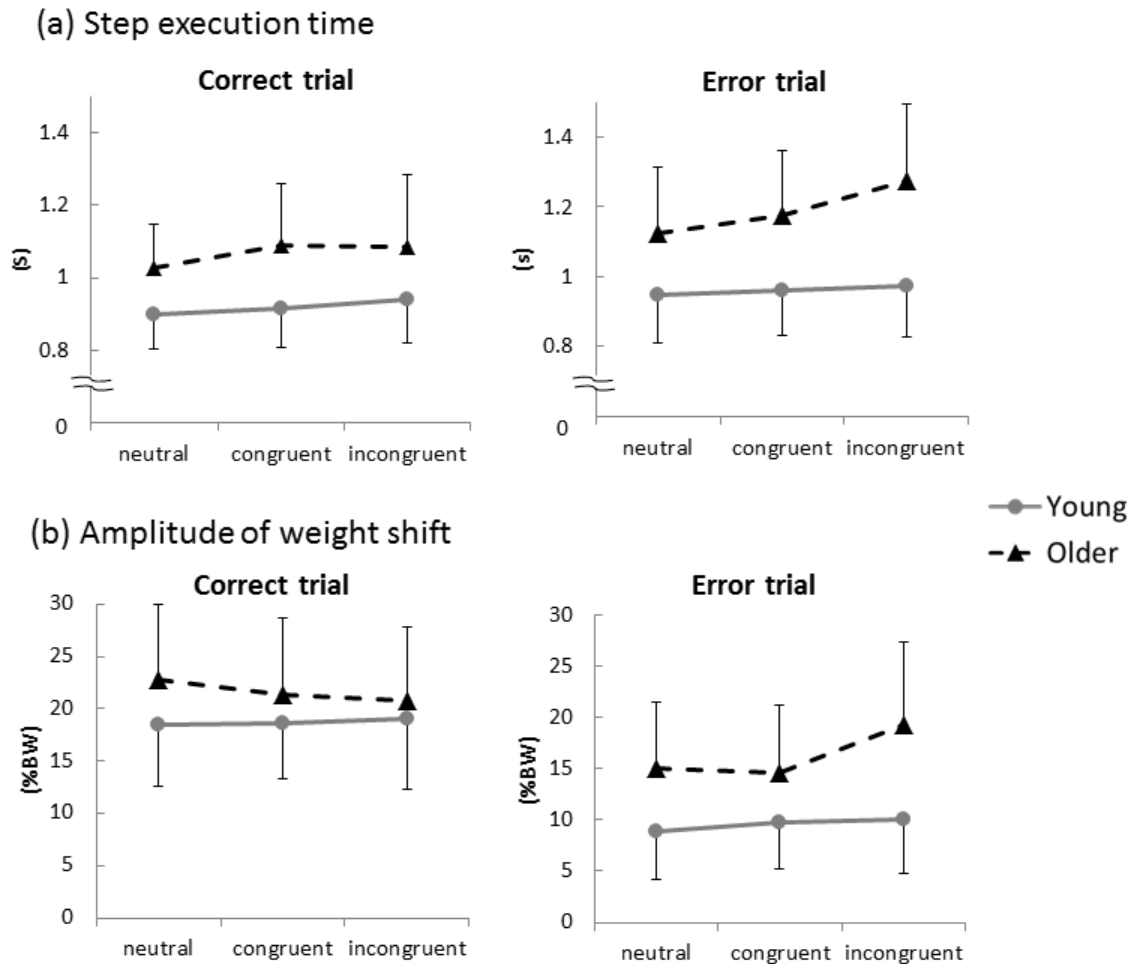
### L - Falls and falls prevention; Aging

#### **P2-L-151 Choice step reaction to a selective attention task is prolonged by errors of postural preparation in older adults**

**Kazuki Uemura<sup>1</sup>, Shuhei Takahashi<sup>1</sup>, Hiroki Togo<sup>1</sup>, Masato Kako<sup>1</sup>, Yasushi Uchiyama<sup>1</sup>**

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**BACKGROUND AND AIM:** Avoiding falls depends on a high level cognitive processing for selecting the correct motor and stepping response. We focused on the cognitive processing and judgment ability during movement initiation and previously reported that visual interference from a selective attention task increases potential errors in postural preparation and step execution times in young adults (Uemura K, Gait Posture 2012). This study aimed to determine whether older adults have specific deficits in initial judgment and step execution reacting to a selective attention task. **METHODS:** Twenty-two healthy young ( $21.9 \pm 1.4$  years) and 21 older participants ( $72.6 \pm 4.9$  years) were instructed to execute forward stepping as quickly and accurately as possible on the side indicated by a central arrow ( $\leftarrow$  left vs. right  $\rightarrow$ ) of a visual cue during a neutral condition. During a selective attention task condition, participants were additionally required to ignore flanker arrows on each side of the central arrow ( $\rightarrow \rightarrow \rightarrow \rightarrow$  congruent or incongruent  $\rightarrow \rightarrow \leftarrow \rightarrow$ ). Errors in the direction of the initial weight transfer (anticipatory postural adjustment errors; APA errors) and step execution times were measured from vertical force data. Amplitude of weight shift was also measured as the amount of force under the foot of initial APA onset at the peak of the APA, expressed as a percent of body weight. Amplitude of weight shift during a trial with an APA error indicates the degree of erroneous weight shift. A two-way ANOVA (condition  $\times$  age group) was used to assess step execution times. To determine the effects of condition and APA errors on step execution times and amplitude of weight shift, we employed a linear mixed model. **RESULTS:** Interaction effects between condition and group indicated that older adults showed increased step execution times as compared to young adults, particularly in the incongruent condition ( $p < .001$ ). In a linear mixed model, step execution times were prolonged for trials with APA errors relative to trials with correct APA in both groups. Only older adults showed interaction effect between APA errors and condition ( $p < .001$ ; Fig 1a), indicating that step execution times during trials with APA errors increased prominently in the incongruent condition as compared to the other conditions. In amplitude of weight shift, there was an interaction effect between APA errors and condition only for older adults ( $p < .001$ ; Fig 1b), indicating that the amplitude of initial weight transfer to the error side increased in the incongruent condition. **CONCLUSIONS:** Older adults need more time for choice step execution reacting to a selective attention task especially in trials with errors in postural preparation. Older adults might be vulnerable to potential motor program errors caused by an interference effect; this could increase the likelihood of falling. It may be important to address selective attention and judgment processes when assessing older adults' postural control.



### P2-L-153 Essential Concept of Fall-risk Classification and Formulae to Consider Fall-risk Scores

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**INTRODUCTION:** Today the holistic approach goes beyond professional sectors or disciplines and in order to prevent fall-related injuries. For establishing a rational systemic approach to fall-risk assessment, fall-risk factors and their interactions is definitively classified in this study. **METHODS:** Accurate estimation of fall-risk is often difficult, uncommon failures can be hard to estimate, and human activities are sometimes considered to be beyond estimation. But it is very important to assess personal risks for putting priorities on risks. Various assessment tools are used in this area, but most of them are not always practical and do not cover every risk. In this paper a fall-risk classification and essential formulae for considering fall-risk scores from major factors of falls are suggested conceptually. **RESULTS:** Fall-risk scores mainly for intrinsic factors for an individual person 'j'; (I<sub>j</sub>) could be obtained from past records of fall-experience, postural instability, physical fragility and daily activities in mobility. The following formula could be derived:  $\dot{y} @ \dot{y} @ I_j = p_j (x_j f_j) \dot{y} E a_j (1)$  where p<sub>j</sub>: score estimated by frequency of previous fall-experience or near accidents. x<sub>j</sub>: score for postural instability f<sub>j</sub>: score for physical fragility a<sub>j</sub>: probable frequency for daily activities in mobility If a<sub>j</sub> is nearly zero e.g. bedridden patients, the fall-risk (I<sub>j</sub>) for an individual person is almost nil. Elderly people with physical fragilities (f<sub>j</sub>) are highly accident-prone, even though daily activities in mobility (a<sub>j</sub>) is very low. The fall-risk scores for a certain site,"k"

and an individual person 'j' ;(Ejk) can be basically assessed by possible impact forces from falls, the likelihood of slipping, tripping and stumbling. The following formula could be derived:  $E_{jk} = H_k(f_j) \cdot L_k(x_j)$  (2) where  $H_k(f_j)$ : score for severities of injuries caused by falls at each site 'k' while walking as the function of  $f_j$ .  $L_k(x_j)$ : score for probabilities of slipping, tripping, stumbling and mis-stepping at each site 'k' as the function of  $x_j$ . If walkways and stairways are not used, no accidents occur at these sites. Therefore risk-scores of environments partially depend on the number of users and their physical factors. The theoretical fall-risk score of a certain site 'k'; ' $E_k$ ' can be obtained from the number of users; ' $n$ '.  $E_k = \sum_{j=1}^n H_k(f_j) \cdot L_k(x_j)$  (3) In design decision process, priority should be given to high traffic areas with a higher fall-risk score ( $E_k$ ). Specifically, in hospitals, nursing care homes, etc., fall-risk scores would be comparatively higher than at any other venues because of the physical fragilities of patients and the advanced ages of inhabitants. **CONCLUSIONS:** This paper introduces a novel concept of fall-risk classification and has derived essential formulae for considering fall-risk scores.

#### **P2-L-155 How fear of falling influences visual behaviours during adaptive gait.**

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<sup>1</sup>Brunel University, <sup>2</sup>Liverpool John Moores University

**Background and aim.** Older adults deemed to be at a high risk of falling transfer their gaze from a stepping target earlier than their low-risk counterparts. The extent of premature gaze transfer increases with task complexity and is associated with a decline in stepping accuracy. This study tests the hypothesis that increased anxiety about upcoming obstacles is associated with (a) premature transfers of gaze toward obstacles (i.e., looking away from a target box prior to completing the step on it in order to fixate future constraints in the walkway) and (b) reduced stepping accuracy on the target in older adults. **Methods.** High-risk (9) and low-risk (8) older adult participants walked a 10-m pathway containing a stepping target area followed by various arrangements of obstacles, which varied with each trial. Anxiety, eye movements, and movement kinematics were measured. **Results.** Progressively increasing task complexity resulted in associated statistically significant increases in measures of anxiety, extent of early gaze transfer, and stepping inaccuracies in the high-risk group. Importantly, high-risk older adults' gaze behaviour was characterised by a reduction in the frequency and duration of visual fixations on stepping constraints following the initial target. **Conclusions.** These results provide evidence that increased anxiety about environmental hazards is related to suboptimal visual sampling behavior which, in turn, negatively influences stepping performance, potentially contributing to increased falls risk in older adults.

#### **P2-L-157 Older adults perform worse than young in a dual task when response inhibition is required**

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**BACKGROUND AND AIM:** Motor inhibition plays an important role in adjusting ongoing steps and impairments are associated with falls in the elderly. Therefore it is of interest to assess the inhibitory abilities of older adults (OA) in situations resembling everyday circumstances of falling such as walking combined with a dual task. We compared the inhibitory abilities of OA to those of young adults (YA) when combining a motor and a cognitive (auditory Stroop) task [1] that both require response inhibition. We expected OA to perform worse on both tasks, in particular when incongruent Stroop stimuli are given, since those require inhibiting a response. In this abstract we focus on the results of the Stroop task and assess inhibitory abilities by the difference in performance between congruent and incongruent stimuli [2]. **METHODS:** Twelve healthy OA (age 66-78 years) and 9 YA (age 22-30 years) performed a task consisting of walking on virtual stepping stones and requiring sudden avoidance (response inhibition) of steps on stones that changed color. The walking task was performed at 4 difficulty levels. Simultaneously the subjects performed an auditory Stroop task that

consisted of the words 'high' and 'low' spoken in a congruent or incongruent high or a low pitch. Subjects had to correctly indicate the pitch used. Rates of incorrect responses to Stroop stimuli were analyzed using repeated measures ANOVA for congruent and incongruent stimuli separately. RESULTS: On average OA had 23.44% more incorrect responses to incongruent stimuli than YA (OA 34.92% and YA 11.48%,  $p = 0.01$ ) but only 1.05% more incorrect responses to congruent stimuli (OA 7.73% and YA 6.67%,  $p = 0.83$ ). Effect of walking task difficulty was significant only for rates of incorrect responses to incongruent stimuli ( $p = 0.02$ ). CONCLUSIONS: OA show clear deficits in dual tasking when response inhibition is required (incongruent Stroop stimuli) whereas they can perform as YA when inhibition is not involved (congruent Stroop stimuli). This difference persisted at all levels of difficulty of the walking task. REFERENCES: 1. Hegeman J, Weerdesteyn V, Van den Bemt B, Nienhuis B, Van Limbeek J, Duysens J. Dual-tasking interferes with obstacle avoidance reactions in healthy seniors. *Gait Posture* 2012 2. Redfern MS. Perceptual inhibition is associated with sensory integration in standing postural control among older adults. *J Gerontol B Psychol Sci Soc Sci* 2009; 64: 569-76

**P2-L-159 The Community Balance and Mobility Scale alleviates the ceiling effects observed in the currently used assessments for the higher-functioning community dwelling elderly**

**Chitra lakshmi K Balasubramanian<sup>1</sup>, Dawn Saracino<sup>1</sup>**

<sup>1</sup>University of North Florida

BACKGROUND AND AIM: Currently-used balance assessments show a ceiling effect in higher-functioning ambulatory older adults who live independently in the community. There is a lack of outcomes to evaluate balance abilities essential for community mobility in the elderly. The Community Balance and Mobility (CBM) scale was designed to evaluate functional balance and mobility in persons with traumatic brain injury and includes assessment of several challenging tasks suggested to be important for community mobility. The aim of this study was to validate use of the CBM scale in a high-functioning community-dwelling elderly population to alleviate the currently observed ceiling effects in gait and balance assessment in this cohort. METHODS: 40 older adults ( $73.4 \pm 6.9$  years) participated in this study. Inclusion criteria were age  $\geq 65$  years and ability to ambulate independently without assistive devices. Exclusion criteria were severe neurologic, orthopedic and cardiorespiratory impairments that limit balance and mobility. Previously standardized balance and mobility assessments were used to validate the CBM. Outcomes included: Timed Up and Go (TUG), Berg Balance Scale (BBS), Dynamic Gait Index (DGI), Functional Reach Test (FRT), Short Physical Performance Battery (SPPB), 6-minute walk test (6MWT), Activities specific Balance Confidence scale (ABC), and walking speed and variability (measured by an instrumented walkway). A falls questionnaire documented the history of falls. RESULTS: Rater reliability was high (ICC = .95) and the CBM showed high internal consistency ( $\alpha = .97$ ). The CBM scores demonstrated showed strong significant correlations with DGI, BBS, SPPB, 6MWT ( $p = .70 - .87$ ,  $p < .01$ ); moderate significant correlations with falls history, TUG, ABC, self-selected and fastest safe walking speeds ( $p = .44 - .65$ ,  $p < .01$ ); and low significant correlations with FRT, swing and stance time variability ( $p = .34 - .37$ ,  $p < .05$ ). Individual scores on the CBM showed the widest range compared to other assessments but did not demonstrate floor or ceiling effects. Contrarily, all other assessments demonstrated a ceiling effect (3% - 22%). Furthermore, CBM scores predicted falls history ( $\beta = -.40$ ,  $p < .05$ ). Specifically, 13/14 subjects with a history of falls  $\geq 2$  had CBM scores  $\leq 50$  (Fig 1). Mann-Whitney U tests showed that persons who scored  $\leq 50$  on CBM significantly differed in their balance abilities from those who scored  $> 50$  ( $p < .05$ ). CONCLUSIONS: Results indicate that the CBM scale is a valid and reliable tool to evaluate balance and mobility in community-dwelling elderly. A wider range of scores on the CBM scale suggests greater discriminatory ability of the CBM scale compared to other assessments. Unlike currently used balance and mobility assessments for the community-dwelling elderly, the CBM scale does not show a ceiling in detection of balance and mobility deficits. Preliminary analyses suggest a cut-off score of CBM  $\leq 50$  to indicate the risk for falls.

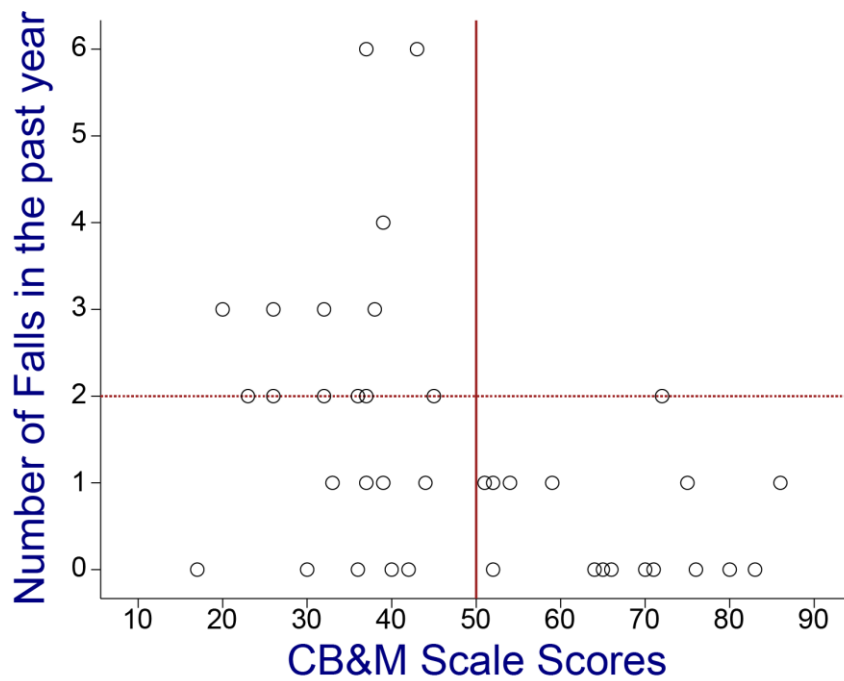


Figure 1. Relationship between CBM scale scores and number of falls in the past year.

**P2-L-161 Does arm swing emphasized deliberately increase the trunk stability during walking in the elderly adults?**

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**BACKGROUND AND AIM:**The reduction of arm swing is an age-related walking change, and there is a strong relationship between movements of trunk and arm during walking. However, no study to date has discussed the effects of arm swing on trunk stability while walking in elderly individuals. The purpose of this study was to determine whether trunk stability while walking changes when arm swing is deliberately altered in elderly individuals. **METHODS:**Participants included 21 community-dwelling elderly individuals (7 men and 14 women; age,  $81.8 \pm 5.0$  years). We measured trunk acceleration by using a wireless miniature sensor unit containing a tri-axial linear accelerometer under 3 walking conditions: normal walking (normal condition), deliberately walking without any arm swing (no swing condition), and walking with a deliberately emphasized arm swing (over swing condition). To evaluate trunk stability during walking, we calculated Harmonic Ratios (HRs) based on trunk tri-axial acceleration signals (anteroposterior: AP, vertical: VT, and mediolateral: ML). **RESULTS:**HR-AP and HR-VT were not significantly different across the 3 conditions, but HR-ML in the over swing condition was significantly higher than that in the other 2 conditions. An analysis performed using repeated measures analysis of covariance (ANCOVA) adjusted for walking speed also showed that HR-ML in the over swing condition was significantly higher than that in the other 2 conditions ( $p < 0.05$ ). **CONCLUSIONS:**These findings indicate that trunk stability in the ML direction increased when the elderly individuals walked with a deliberately emphasized arm swing.

**P2-L-163 The effects of route previewing on gaze behavior during adaptive locomotion**

**Benjamin Curzon-Jones<sup>1</sup>, Mark Hollands<sup>2</sup>**

<sup>1</sup>University of Birmingham, <sup>2</sup>Liverpool John Moores University,

Introduction: Effective visual sampling of our environment is crucial to safely navigate our surroundings without injury. Older adults, particularly those deemed to have a high risk of falling, look away earlier from imminent stepping targets

to view future stepping obstacles [1, 2]. The consequent lack of online visual guidance decreases stepping accuracy and increases the likelihood of a trip or fall. The aim of this study was to determine the effectiveness of training individuals to preview a route prior to initiation of walking in reducing the incidence and /or extent of early gaze transfer and improve associated stepping performance. Method: Five young adults ( $24.8 \pm 1.6$  years) completed six, walks with three task complexities over two sessions ( $6 \times 3 \times 2 = 36$  total trials). Each trial consisted of a stepping target box, followed by either 0 (Target Only - TO), 1 (One Obstacle - OO), or 2 (Both Obstacles - BO) 20cm raised wooden stepping obstacles. Participants started with their eyes closed, then on hearing a verbal signal, opened their eyes and set off (session 1), or stood previewing the route for 10 seconds before setting off (session 2). Body kinematics were recorded using a Vicon MX motion analysis system. Saccadic timings were recorded using vertical and horizontal EOG at 1000Hz, and gaze behaviour was recorded using a Dikablis eye tracker at 25Hz. Results: A RM ANOVA revealed that young adults fixated the nearest obstacle more frequently during walking when they had not previewed the route prior to setting off compared with when they had previewed the route ( $.13 \pm .03$  to  $.20 \pm .03$  times per sec,  $F(1, 4) = 10.18$ ,  $p = .033$ ).

Discussion: The results of these preliminary findings suggest that previewing the route prior to setting off does influence the gaze behaviour of young adults during adaptive locomotion. The increase in fixation frequency suggests participants spend more time scanning while walking when they have not had chance to preview the route. We are currently in the process of collecting more data from younger and older adults, and analyzing kinematic data to see if the changes to gaze behavior associated with route previewing are associated with improvements in stepping accuracy.

Acknowledgments: This work is supported by the Research into Ageing Fund, a fund set up and managed by Age UK.

References: [1] Chapman, G J & Hollands, M A (2007) *Gait & Posture* 26, 59-67 [2] Chapman, G J & Hollands, M A (2006) *Gait & Posture* 24, 288-294

## **P2-L-165 Mechanism underlying protective stepping response: Effect of light touch and age**

**Tippawan O-Phartkaruna<sup>1</sup>, Sopa Pichaiyongwongdee<sup>1</sup>, Jarugool Tretriluxana<sup>1</sup>, Roongtiwa Vachalathiti<sup>1</sup>**

<sup>1</sup>Mahidol University

BACKGROUND AND AIM: Falling is a serious problem facing elderly person causing of injury and disability. Stepping is always executed in daily situations to avoid, especially in the elder; it is initiated more often than necessary as pre-selected. Light touch (LT) has been reported to be important for controlling in both static and dynamic postural balance, however attentional demands associated with the use of it also have been observed. Here, we are interested to examine the effect of LT on induced protective stepping. METHODS: Thirty-two subjects (aged 60-80 and 20-30 years) were participated. Forward waist pull perturbation under two conditions of touch, no touch and LT, was applied. Vertical ground reaction force and Center of Pressure (COP) beneath both limbs were collected and analyzed to identify the mechanism underlying protective stepping. RESULTS: Compared between two touch conditions, both groups show significant lower in COP displacement and COP velocity in pre perturbation phase. After perturbation, the lower COP displacement and higher COP velocity with light touch are observed in both age groups. In addition, the anticipatory postural adjustment (APA) duration is lower in the elder and they take a step earlier than the young in both touch conditions. Across touch conditions, delayed in APA onset and shorter in APA duration are observed with light touch conditions. CONCLUSIONS: An additional lightly touching an external object enhances postural stability during quiet standing however it also requires higher functions of central nervous system and more attention. Applying LT with induced stepping results in decreased ability to recover postural balance after perturbation due to dual task effect in the young, but the elder seem to make a step as pre-selected strategy. This study suggests that the protective stepping is not only reflected by the state of balance stability, it also involves a pre-selection process.

**P2-L-167 Effect of task complexity on cognitive and motor prioritization during dual-task walking****Tanvi Bhatt<sup>1</sup> Prakruti Patel<sup>1</sup>**<sup>1</sup>University of Illinois

Background: Determining utilization, of which attention centers of the brain, most affects the dual-tasking cost, forms the crux for designing dual-task training paradigms. Although several studies have examined effects of different tasks on motor cost, these tasks are not exclusive and often target the same areas of the brain - further, the cognitive cost of dual tasking is seldom reported. To our best knowledge there is no reported literature exploring the interaction between utilization of explicitly different cognitive networks and gait. The aim of our study was thus to examine the effect of four different cognitive tasks on motor and cognitive prioritization during dual task (DT) walking. We hypothesized that under DT conditions, individuals would prioritize performance of cognitive tasks over the gait, with the motor cost increasing with the difficulty of the cognitive task. Further we hypothesized that the cognitive task sharing neural circuitry with the locomotor task would exhibit the greatest cognitive cost. Methods: Twenty healthy young adults were instructed to walk under five conditions: 1) Regular walking (single task-ST), and regular walking while performing 2) a visuomotor reaction time (VM) task, 3) serial subtraction (SS), 4) word-list generation (WLG), and 5) the Stroop test (STR). Gait velocity, step length, cadence, and double support time were recorded using GaitRite electronic walkway. The cognitive tasks were also performed in sitting (ST-cognition). The reaction time or numbers of errors were computed for cognitive tasks. The motor and cognitive costs of dual tasking for each of the tasks were computed using the formula  $[(ST-DT)/ST*100]$ . Results: Compared to the ST walking, DT resulted in marked reduction of gait performance. A significant effect of type of DT was observed wherein, velocity, step length and cadence were the least for the STR-task ( $p<0.001$ ) and double support time the greatest ( $p<0.01$  for all variables). In comparison, the VM-task demonstrated least difference between the single and dual-task conditions for the gait variables ( $p<0.01$ ). Thus the motor cost was least for the VM-task, and greatest for the STR-task ( $p<0.01$ ). The cognitive cost of DT walking was significantly greater for the VM-task (significant increase in reaction time) compared to the other three tasks. Although, cognitive error was significantly greater during DT compared to ST conditions for the WLG, SS and STR tasks, individually, there was no difference in the cognitive cost between these three tasks ( $p>0.05$ ). Conclusion: Motor and cognitive cost of dual task walking depends heavily on the type and complexity of cognitive task. With increasing task-complexity prioritization of cognitive tasks increased leading to decreased gait performance. The sharing of neural resources between visuomotor and locomotor tasks could create a bottle-neck for information processing leading to the increased cognitive costs during DT conditions.

**P2-L-169 Combining stepping and cognition: the ability of two tests to discriminate between fallers and non-fallers****Daniel Schoene<sup>1</sup>, Kim Delbaere<sup>1</sup>, Stuart Smith<sup>1</sup>, Stephen Lord<sup>1</sup>**<sup>1</sup>Neuroscience Research Australia

Background: Stepping is important for maintaining balance control and has been linked to falls in older people. Step responses are influenced by executive functioning (EF) that also have been associated with falls. We developed two tests that combine stepping with different EF and aimed to determine their ability to discriminate between fallers and non-fallers. Methods: Independent living people ( $n=103$ , mean age  $79.5\pm4.8$ ) without cognitive impairment (MMSE  $28.9\pm1.1$ ) underwent the step tasks. In both tests people stepped on a dance pad connected to a computer screen. In the Stroop stepping test (SST) participants were presented with an arrow pointing into one of four directions (left, right, front, back) that corresponded with the step directions. Inside the arrow was a written word pointing to an incongruent direction and participants were asked to step by the word as quickly as they could. Therefore a conflict had to be solved by selectively attending to one stimulus and inhibiting the other. In the Trail-stepping test (TST) participants were presented with a copy of the pad as a figure on the screen. Numerals/letters were allocated to each switch. Participants were asked to step on the numerals/letters in ascending alternating order as quickly as possible. This test therefore

included a set-shifting component. With each correct step, a trail connected the numerals/letters on the computer screen. For both tasks the time to completion and number of errors were recorded. In addition, participants underwent pen and paper-based tests of Stroop and Trail-making tests. Participants that reported  $\geq 1$  fall during the past 12 months were classified as fallers. Results: All participants completed the SST, 92% could complete the TST. Times required to complete the SST and TST correlated with the number of correct symbols in the Stroop test ( $r=-.367$ ,  $r=-.493$  respectively) and time required to complete the Trail-making test ( $r=.394$ ,  $r=.711$ , respectively). SST time also correlated with Stroop errors ( $rs=.326$ ) and TST time correlated with Trail-making errors ( $rs=.274$ ). SST errors correlated with Stroop scores ( $rs=-.232$ ) and time required to complete the Trail-making tests ( $rs=.281$ ). TST errors correlated with Trail-making time only ( $rs=.351$ ). Twenty-nine participants (28%) reported falling in the previous year. For SST performance, fallers took longer to complete the step sequence ( $63\pm 26s$  vs  $53\pm 14s$ ,  $p=.030$ ) and made more errors ( $1.7\pm 2.2$  vs  $0.6\pm 1.1$ ,  $p=.005$ ) than non-fallers. For TST performance, fallers showed a trend for longer complete time ( $170\pm 84$  vs  $141\pm 50$ ,  $p=.059$ ) and made more errors ( $2.9\pm 1.6$  vs  $1.9\pm 1.8$ ,  $p=.026$ ). No significant difference was observed in the pen and paper-based cognitive measures between the groups. Conclusions: Two tests combining stepping with different EF were able to discriminate between fallers and non-fallers showing the importance of imbedding cognition in task-specific tests of daily functioning.

#### **P2-L-171 Alcohol intoxication changes posture alignment strategies when standing with eyes open and closed**

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<sup>1</sup>Skane University Hospital, <sup>2</sup>Department of Otorhinolaryngology Head and Neck surgery

**BACKGROUND AND AIM:** Balance control when standing upright is a complex process and comprises contributions from several partly independent mechanisms such as coordination, feedback and feed forward control, and adaptation. Acute alcohol intoxication impairs these functions and is recognized as a major contributor to fall traumas. The aim of this study was to investigate whether acute moderate alcohol intoxication affected body alignment. **METHODS:** Mean angular positions of the head, shoulder, hip, and knee and ankles were measured with a 3D-Motion Analysis system in 25 healthy adults (13 women and 12 men, mean age 25 years) during quiet standing and during balance perturbations from pseudo-random pulses of calf muscle vibration over 200 s with eyes closed or open. Each subject performed the tests at the three different intended blood alcohol concentrations (BAC) of 0%, 0.06%, or 0.1 % in a randomized order. **RESULTS:** Alcohol intoxication had significant effects on body alignment during unperturbed stance, perturbed stance and on adaptation to perturbations. It induced a significantly less anterior, i.e. more posterior, position of the head and knees in both unperturbed and perturbed stance than when sober ( $p<0.05$ ). The impact was more apparent when visual information was available. In the anteroposterior direction, when intoxicated, visual information deteriorated adaptation to perturbations. In the lateral direction, alcohol intoxication had negligible influence on posture. **CONCLUSIONS:** Thus, acute alcohol intoxication resulted in inadequate balance control strategies with increased postural rigidity and poorer adaptation to perturbations. The results implicate that visual information provides a weaker contribution to postural control during alcohol intoxication. These factors probably contribute to the increased risk of falling when intoxicated with alcohol.

#### **P2-L-173 Uncontrolled Manifold Analysis of Obstacle-Crossing in Young Adults**

**Wei-Chun Tsai<sup>1</sup>, Jia-Da Li<sup>1</sup>, Tung-Wu Lu<sup>1</sup>**

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**INTRODUCTION:** A better understanding of motor control during obstacle crossing is helpful in preventing falls and related injuries. The presence of motor variability in movements could be explained by motor redundancy which employs more elements than necessary to complete a task. Uncontrolled manifold analysis (UCM analysis) [1] can be used to examine the redundancy. Variance projected onto the UCM would not affect task-level variables while variance orthogonal to the UCM would lead to deviations of the task variables. The purpose of this study was to use UCM analysis



to examine the stability of motor control in young adults when crossing obstacles of different heights. **METHODS:** Fifteen young adults crossed obstacles of heights respectively 10%, 20% and 30% of their leg length for fifteen times during level walking. Kinematic data were measured with a 7-camera, skin-marker based motion analysis system (Vicon, UK). The soft tissue artefacts of the kinematic data were minimized using the global optimization method[2] with a kinematic lower limb model, giving constant segmental lengths and accurate joint rotations necessary for the UCM analysis at the instances when the toe (end-point) was directly above the obstacle. The obtained variance of the joint configurations were divided into two components: one was to maintain the end-point position ( $\parallel$ UCM) and the other to deviate from the desired end-point position ( $\perp$ UCM). Variations of joint configurations affect toe position less if the ratio  $\parallel$ UCM /  $\perp$ UCM is greater than 1, hence the motion is more stable; if the ratio is less than 1, joint variations deviate the toe position more, resulting in more unstable motions. The smaller the ratio, the more joint variations would increase the toe deviation. All variables were analysed using independent t-test with a significance level of 0.05. **RESULTS:** The variations of joint angles and toe clearances ( $p=0.994$ ) were not significantly different between obstacle height conditions. With increasing obstacle height, the ratios of  $\parallel$ UCM /  $\perp$ UCM ( $p<0.05$ ) were found to decrease linearly (10%:0.49, 20%: 0.45, 30%: 0.44). **CONCLUSIONS:** Young adults were able to maintain statistically unaltered toe clearances when negotiating obstacles of different heights. However, the UCM analysis indicates that with increased obstacle height, variations of joint angles increase the possibility of endpoint deviations (instability), thus increasing the risk of falling during the task. **REFERENCES** 1. Scholz, J.P.et al. Experimental Brain Research 126(3): 289-3 2. Lu, T. W. et al. Journal of Biomechanics 32(2): 129-134.

#### **P2-L-175 Temporal response of human bipedal walking to a perturbation induced by a split-belt treadmill**

**Takaaki Oku<sup>1</sup>, Naomichi Ogihara<sup>1</sup>**

<sup>1</sup>Keio University

**BACKGROUND AND AIM:** Humans can walk without falling even though unexpected external perturbations are applied. In response to such external perturbation during human walking, adjustment of locomotor rhythm is considered as an effective strategy to maintain stable walking. In order to clarify the mechanism underlying generation of such adaptive response against external perturbations during bipedal walking, we investigated temporal response of human bipedal walking against external perturbations induced by a split-belt treadmill. The treadmill has two belts, one for each leg, and the speeds of the belts can be controlled independently by a computer to apply perturbations during walking. **METHODS:** Four adult male participants were asked to walk on the split-belt treadmill at 4.5 km/h. At this speed, all the participants declared that their walking was comfortable. After 5 minutes of normal gait (without perturbations), external perturbations were applied during walking by sudden decrease or increase in the speed of the right belt approximately once in 20 sec. The perturbations are applied randomly so that the perturbation can be applied at different instants of the gait cycle. The motion responses were measured using an eight camera motion capture system. A total of 12 reflexive markers were attached to joints of the participants. The sagittally-projected joint angles of the hip, knee and ankle and the trunk angle with respect to the inertial coordinate system were calculated from the 3D positions of the markers. Furthermore, to clarify how the locomotor rhythm is adjusted to the external perturbation, we plotted amount of phase-shift in walking cycle against the timing of the perturbation (Phase response curve). Human walking is a cyclic movement, cycle duration of which is approximately constant. However, when a perturbation applied, the cycle duration is either prolonged (delayed) or shortened (advanced). We quantified this change in the walking rhythm by means of phase response curve. **RESULTS:** The amount of phase shift was found to be always delayed for the decelerating perturbation during human walking, while that of the accelerating perturbation was always advanced. Furthermore, we found that the amount of phase-shift was phase-dependent, and it was large if the perturbation was applied in the early stance phase, but it tended to decrease as the timing of the perturbation was delayed.

**CONCLUSIONS:** Active adjustment of the walking rhythm in a phase-dependent manner may play an important role for generation of adaptive human walking.

**P2-L-177 Detecting freezing of gait and falls using motion recorder and home video in Parkinson's disease patients during everyday activities**

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**BACKGROUND AND AIM:** Freezing of gait (FOG) and recurrent falls are a disabling feature of Parkinson's disease (PD), and have a significant negative impact on the patients' quality of life [1]. Recently, we found that FOG is the most common cause of falls in advanced PD, particularly in the off-state and transition-state between on and off-state [2]. However, falls and FOGs were determined by patients' self-reports (fall diaries). The aim of the present study is to objectively detect and elucidate characteristics of FOG and falls in PD patients during everyday activities. **METHODS:** Patients were selected from 36 patients who participated in our previous prospective study on falls. We developed a motion recorder (body-fixed 3D accelerometer) with a long-lasting battery. First, healthy volunteers simulated FOG and falls, and acceleration signals were analyzed. Then movements of recurrent PD fallers were recorded during their everyday activities. Some falls were home videotaped. **RESULTS:** When healthy subjects simulated FOG and falls, the characteristic patterns of acceleration signals were recorded for forward falling. Falls were associated with impact acceleration and abrupt changes in trunk angle. Mimicked knee trembling was recorded as a rapid oscillation of acceleration. In PD patients, actual falls were detected by abrupt trunk angle changes with or without impact acceleration. Knee trembling was recorded when patients reported FOG-induced falls. These findings corresponded to videotaped features of actual fall events. **CONCLUSIONS:** Motion recording with our device is useful for detecting and analyzing FOG and falls in everyday life in PD fallers, and complements patients' self-reports. **REFERENCES:** 1. Okuma Y. and Yanagisawa N. *Mov Disord* 23 (Suppl. 2):426-430, 2008 2. Okuma Y, et al. *Mov Disord* 24 (Suppl. 1):S532-533, 2009

**P2-L-179 Physiopathology of freezing of gait (FOG) and falls in Parkinson's disease (PD) patients treated with subthalamic (STN) deep brain stimulation (DBS)**

**Florence Cormier-Dequaire<sup>1</sup>, Sara Fernandez Vidal<sup>1</sup>, Adele Demain<sup>1</sup>, Hayat Belaich<sup>1</sup>, Carine Karachi<sup>1</sup>, Marie Vidailhet<sup>1</sup>, David Grabli<sup>1</sup>, Marie-Laure Welter<sup>1</sup>**

<sup>1</sup>Pitie-Salpetriere Hospital

**BACKGROUND AND AIM:** FOG and falls represent a major disability in the course of PD. These symptoms have been reported to be less sensitive to dopaminergic replacement therapy and/or STN stimulation, with in some patients an apparent aggravation after surgery for STN stimulation. Our aim is to better understand the mechanisms of FOG and falls in PD patients and identify predictors of their occurrence with STN stimulation. **METHODS:** We analyzed clinical and anatomical factors related to the occurrence of falls and FOG in 309 PD patients operated for bilateral STN stimulation in the Pitie-Salpetriere Hospital, both before and one year after surgery. **RESULTS:** Before surgery, without drug treatment (Off), 81 and 40% of PD patients presented FOG or falls, respectively, with an improvement of these signs with dopaminergic agents in 63 and 54% of them, respectively. One year after surgery, under bilateral STN stimulation, 29 and 20% of patients showed an improvement in FOG or falls, respectively, whereas 52 and 29% showed a persistent and/or aggravation of these signs. Predictors of FOG one year after STN stimulation were the presence of a preoperative FOG without dopaminergic therapy (Off) and a rapid disease extension. The worsening of FOG under DBS was significantly associated to changes in the volumes of the putamen, orbitofrontal cortex and temporal gyrus. The presence of falls was significantly related to the severity of FOG and poorer cognitive performance, and volume changes

in the postcentral gyrus, uncus, cerebellum, but also in the midbrain and thalamus. The unresponsiveness of FOG and falls to dopaminergic agents was related to an eldest age. CONCLUSIONS: These results suggest that the risk of worsening of FOG and falls after STN stimulation was mainly dependent on the presence of these signs before surgery, in particular in the absence of drug treatment (Off). In PD patients, FOG was found to be related to brain changes in the limbic cortical areas and motor striatum, whereas falls were related to brain changes in the cortico-ponto-cerebellar-thalamic-cortical loop.

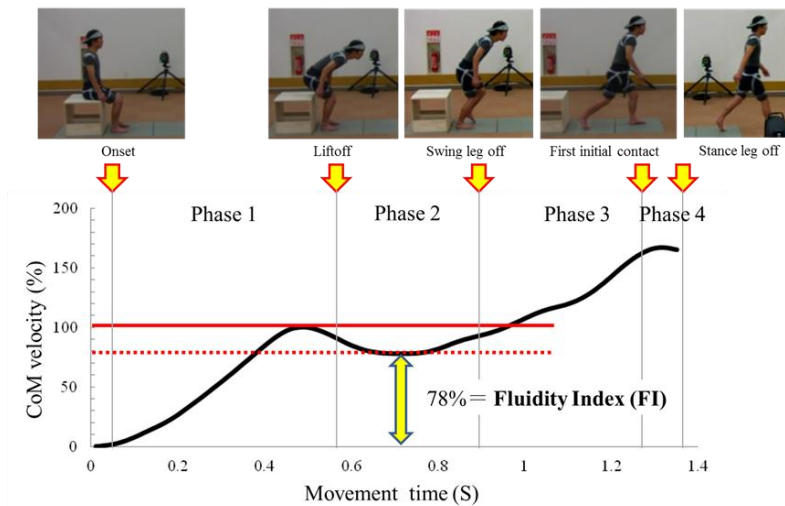
**P2-L-181 Does the Vitamin D multi-nutrient supplementation increase the fluidity of sit-to-walk motion in chronic stroke patients?**

**Yuji Osada<sup>1</sup>, Noriko Hagiwara<sup>1</sup>, Saori Tanabe<sup>1</sup>, Mizuho Ota<sup>1</sup>, Hirotaka Shimizu<sup>1</sup>, Hideyuki Nanri<sup>1</sup>, Masako Fuchi<sup>1</sup>, Setsuro Ibayashi<sup>1</sup>**

<sup>1</sup>Seiai Rehabilitation Hospital

INTRODUCTION: As many occasions require the stroke patient to start walking from the sitting position, getting fluidity and stability in sit-to-walk (STW) make decrease the falling risk. There are many studies suggesting that the Vitamin D supplementation improve muscle strength and decrease the fall risk. However, in previous studies, the effectiveness of the Vitamin D was only investigated for elderly and Parkinson disease. The purpose of this study is to examine the effect of Vitamin-D supplementation at the viewpoint of the STW fluidity in stroke patients. METHODS: Thirty five Chronic stroke patients (73.0±6.4yrs) were divided into Vitamin-D (25ig/week) supplementation group (group D) or control group (group C). The 5-m STW was measured using the VICON motion analysis system before and after three month intervention, and the degree of fluidity in STW was calculated using the Fluidity Index (FI) which corresponded to the percentage of change in the center of mass forward velocity. None of them were under resistance training at study entry, and no attempt was made to alter subject's daily activity or diet during the study. The difference of improvement rate in kinematic data between the two groups was compared using the Mann-Whitney U test. Then the relationships between FI and the indices of physical ability (blood Vitamin D level, SMI: skeletal muscle index, FRT: Functional Reach Test, FMA: Fugel Meyer Assessment, 10m maximum walking time) were analyzed using Spearman's rank correlation coefficients. RESULTS: The blood Vitamin-D level significantly increased in group D (p<0.05). There was no significance in other indices between the two groups, however, the skeletal muscle index (SMI) tended to decrease in group C. The score of Functional Reach Test (r=0.38) and 10m maximum walking time (r=-0.55) were significantly correlated with FI value. CONCLUSIONS: Although the retention of SMI in group D might support the hypothesis that Vitamin-D prevent the aging changes after stroke, there was no significant effectiveness of Vitamin-D supplementation in SMI or FI value. We consider it is not SMI or Vitamin-D to improve the adaptive locomotion but better balance control or walking ability which was affected in by rehabilitation.

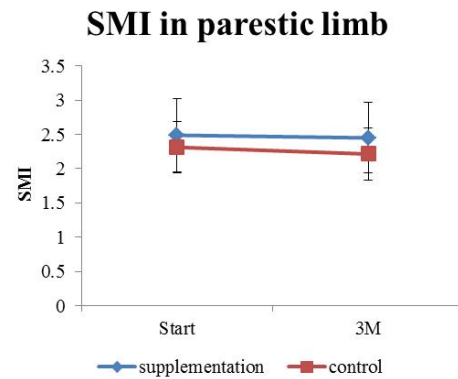
A)



A) This graph shows COM forward velocity changes in normal subject and calculation of FI. FI is calculated as the rate of decline from peak forward velocity before liftoff.

B) This graph shows the effect on SMI before and after intervention.

B)



## P2-L-183 Eye-foot coordination and lateral stability: protective stepping following balance perturbations versus voluntary stepping

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<sup>1</sup>University of Maryland School of Medicine

**BACKGROUND AND AIM:** Eye movement precedes foot placement in forward walking and stepping. However it is unknown if/how the eyes and feet are coupled during protective stepping reactions following external lateral perturbations of standing balance and for voluntary lateral stepping. This is an important area to investigate since poor lateral stability has been linked with age-related falls (Hilliard et al 2008). The aim of this study was to characterize the eye-foot coordination across two tasks: a perturbation task that involved protective stepping reactions following lateral waist-pull perturbations and a voluntary lateral stepping task. **METHODS:** Five young adults (4 females and 1 male, mean (SD) 28.6 (3.5) yr, 64.3 (12.4) kg, 1.71 (0.06) m) performed two tasks. In both tasks, subjects stood with their feet positioned on two separate force platforms while fixating on a visual target represented by a cross placed 4m in front of them at eye level. Initial foot placement was standardized across trials. In the perturbation task, subjects received 12 lateral waist-pull perturbations at 2 magnitudes (low: 4.5 cm at 8.6 cm/s with 180 cm/s<sup>2</sup> acceleration ; and high: 22.5 cm at 50.0 cm/s with 900 cm/s<sup>2</sup>) in randomized order. In the voluntary lateral stepping task, subjects performed 12 stepping trials where they were asked to step to the left or the right at their preferred speed in a randomized order. Step onset timing was determined by 3D motion kinematics and ground reaction force data. Saccade onset timing was identified by eye-in-head data collected with an eye tracking system. The saccade onset time relative to the step onset latency was calculated for all the stepping trials and compared with a paired t-test between the tasks. **RESULTS:** In both tasks, saccade onset occurred before step onset. For the perturbation trials, subjects stepped only with the high pull magnitude. For these perturbation trials, the saccade-step timing interval was longer (mean (SD) -172.7 (55.6) ms) than for the voluntary task (mean (SD) -81.9 (37.7) ms,  $p=0.066$ , Fig. 1). **CONCLUSIONS:** The preliminary results of this study show that younger adults use different strategies in the control of eye-foot coordination when they need to recover their lateral balance by stepping following an external perturbation compared to when they voluntarily make a side step. In the perturbation task, the longer eye-foot timing interval might indicate the need to scan the environment for online visual cues for balance recovery. In the voluntary stepping task, subjects may have relied mainly on stored visual

information about the environment. The timing interval of 172.7ms found in the perturbation task may argue in favor of the existence of a rapid sub-cortical visuo-motor process (Reynolds and Day 2005). Further investigation with older adults is warranted in order to understand the possible link between eye-foot coordination and fall risk.

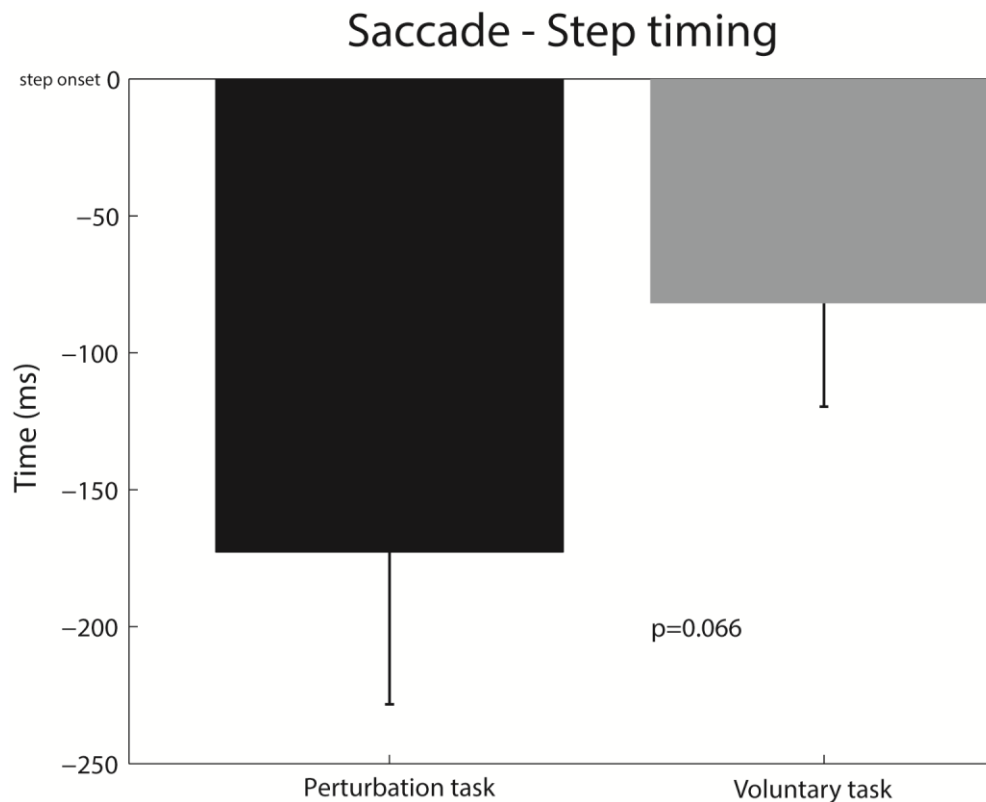


Fig.1 Mean (SD) of the saccade-step timing in the two tasks. Negative numbers represent the saccade occurring before the step.

## M - Neurological diseases; Aging

### P2-M -185 Cortical gray matter volume and gait functions in Parkinson disease

**Martijn Muller<sup>1</sup>, Roger Albin<sup>1</sup>, Kirk Frey<sup>1</sup>, Nicolaas Bohnen<sup>1</sup>**

<sup>1</sup>University of Michigan

**BACKGROUND AND AIM:** Control of gait involves several brain structures, including the brainstem, cerebellum, striatum, thalamus, and the cortex. Parkinson disease (PD) is characterized by striatal dopaminergic denervation. Although research in PD mobility has focused on subcortical, in particular dopaminergic functions, there is emerging evidence of cortical pathology in PD that may affect gait functions. The aim of this study was to explore the effect of selective gray matter volumes on gait functions in PD subjects while taking into account striatal dopaminergic denervation. **METHODS:** 110 PD subjects without symptoms of freezing upon clinical examination (29 F;  $65.7 \pm 7.8$  yrs old;  $5.7 \pm 4.1$  yrs motor disease duration; modified H&Y mean  $2.3 \pm 0.5$ , MDS-UPDRS part III motor score  $30.1 \pm 12.7$ ) underwent dopaminergic 11C-DTBZ vesicular monoaminergic transporter-2 (VMAT2) positron emission tomography (PET) and anatomic brain magnetic resonance imaging (MRI). Normal paced gait was assessed on a GAITrite<sup>®</sup> electronic walkway. All assessments were performed in the dopaminergic 'off' state. Striatal 11C-DTBZ distribution volume ratio (DVR), a measure of

dopamine availability, was estimated. Gray matter volumes of the brainstem, cerebellum, striatum, thalamus, and the cortex were estimated on the brain MR using FreeSurfer software. Primary gait parameters were gait velocity and cadence. Stepwise linear regression analyses were performed with separate models for gait velocity and cadence as dependent variables. Independent variables were the selective gray matter volumes, striatal 11C-DTBZ DVR, age, MDS-UPDRS part III motor score, and motor disease duration. RESULTS: There was an overall significant model for gait velocity ( $F=18.0$ ,  $p<0.0001$ ). Cortical gray matter volume ( $\beta=0.397$ ,  $t=4.7$ ,  $p<0.0001$ ) and MDS-UPDRS part III motor score ( $\beta=-0.245$ ,  $t=-2.9$ ,  $p=0.005$ ) were both independent predictors of gait velocity. There was no effect of striatal 11C-DTBZ DVR. None of the parameters could be entered in the gait cadence linear regression model. CONCLUSIONS: Decreased cortical gray matter volume is robustly associated with slowing of gait speed in PD subjects, independent of age, motor disease duration, overall motor impairment, or striatal dopaminergic denervation. These data indicate that cortical changes are a significant determinant of gait speed in PD independent from the degree of nigrostriatal denervation.

## **P2-M -187 Neuroanatomy of space, body and posture perception in brain-damaged patients**

**Arnaud Saj<sup>1</sup>, Jacques Honoré<sup>2</sup>, Patrik Vuilleumier<sup>1</sup>, Marc Rousseaux<sup>3</sup>**

<sup>1</sup>University Hospital of Geneva, <sup>2</sup>University of Lille Nord de France, <sup>3</sup>Lille University Medical Center

Objective: Hemispheric stroke frequently biases the representations of the gravitational vertical and body axis, as well as posture. These disorders are amplified in cases of spatial neglect, and are characterized by a contralesional tilt of the subjective vertical (SV), an ipsilesional bias of the subjective straight ahead (SSA) and a trunk imbalance. The aim of this study was to specify the neuroanatomical correlates of these pathological signs. Methods: The analysis focused on right hemisphere lesions in 21 neglect patients and 21 non-neglect patients (using MRIcro® software) and related performance in two experimental tasks (SV and SSA) and a clinical balance assessment. Voxel-based lesion-symptom mapping was used to highlight brain areas in which lesions best explained the severity of task biases. Results: The bias in the representation of body orientation was found to be strongly related to lesions of the anterior parietal cortex and the middle part of the superior temporal gyrus. The SV errors were associated with more widespread lesions of posterior parietal and temporal cortices. The imbalance was preferentially associated with lesions of the posterior insula and the adjacent temporo-parietal cortex. Conclusion: This constitutes the first report of cortical dissociation of biases of body-centered and gravitational vertical representations, which may reflect the differential involvement of these brain regions in spatial information processing. The lesions involved in representation biases (especially of the SV) and postural difficulties overlapped to some extent in the temporoparietal, superior temporal and posterior insular regions of the cortex.

## **P2-M -189 Feasibility of Using Inertial Sensors in the Clinic with DBS Patients to Assess Gait and Balance**

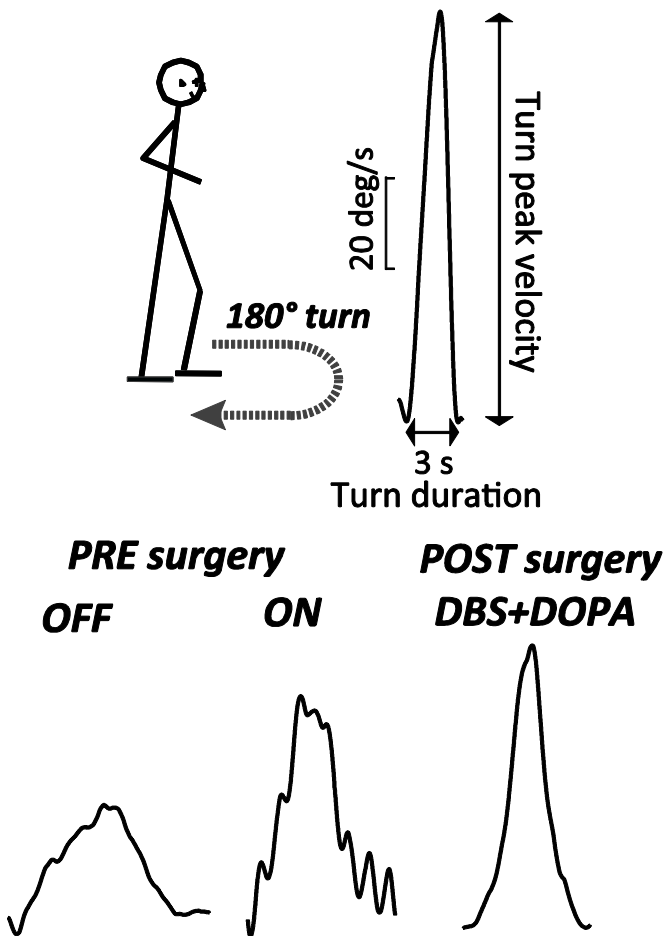
**Patricia Carlson-Kuhta<sup>1</sup>, Martina Mancini<sup>1</sup>, Shannon Donovan<sup>1</sup>, Matthew Brodsky<sup>1</sup>, Fay Horak<sup>1</sup>**

<sup>1</sup>Oregon Health & Science University

Background: Deep brain stimulation (DBS) for Parkinson's disease has become an increasingly common treatment for people with advanced Parkinson's disease who no longer have their symptoms readily managed by medication. DBS is effective in reducing bradykinesia, rigidity and tremor, but the effectiveness of DBS for gait and balance is less well defined. A fast, quantitative measurement of gait and balance could improve, over the currently used clinical scales and self-reports, clinicians' ability to optimize programming and track patient's progress following surgery. Aim: To improve clinical assessment of gait and balance in people with DBS for Parkinson's disease, using newly developed quantitative tests with wireless inertial sensors. Methods: Subjects were tested before DBS surgery (Off and On medication) and at several post-surgery times: Day 1 (On medication, Off DBS), Day 30 (Off medication, Off DBS and Off meds, On DBS), and Days 90 (Off and On medication). We have tested 35 subjects before DBS surgery and 16 subjects after surgery (9 GPi

## Turning 180° during Gait

### Healthy Control



Foundation and NIH grant AG006457.

and 7 STN). During each appointment subjects performed three instrumented stand and walk (iSAW) trials using an inertial sensor system (Mobility lab by APDM): the subject stands for 30s, walks 7m, turns 180°, walks back 7m. Quiet stance, step initiation, walking, and turning features were objectively characterized. Results: Preliminary results showed that 1) testing could be incorporated into regular clinic appointments, 2) differences could be detected before and after turning on the stimulator during a single appointment, 3) subjects could be tracked across appointments. The figure shows an example of pelvis rotation during a turn and identification of turn peak velocity and duration. The turn peak velocity increased pre-surgery from Off to On medication ( $110.7 \pm 14.9^\circ/\text{sec}$  to  $137.9 \pm 12.3^\circ/\text{sec}$ ) and from pre-surgery Off to post-surgery On medication DBS ( $137.7 \pm 9.7^\circ/\text{sec}$ ; Fig. 1). Similarly, turn duration decreased Off to On medication pre-surgery ( $4.8 \pm 0.9$  to  $3.2 \pm 0.6$  sec) and On medication DBS post-surgery was improved compared to pre-surgery Off ( $3.0 \pm 0.4$  sec). Conclusions: The short, quantitative gait and balance assessment with inertial sensors provided a feasible method to assess DBS patients during clinic appointments and has the potential to improve DBS programming of patients and to track their changes over time. Being able to quantify gait parameters, such as turn velocity, is valuable since turning ability is related to freezing of gait and falls in Parkinson's disease. Acknowledgements: This project was supported by The Parkinson Alliance, Kinetics

## P2-M -193 The effects of a concurrent motor task on walking in Alzheimers disease

Joanne Wittwer<sup>1</sup>, Kate Webster<sup>1</sup>, Keith Hill<sup>2</sup>

<sup>1</sup>La Trobe University, <sup>2</sup>Curtin University

**BACKGROUND AND AIM:** In people with Alzheimer's disease (AD), the addition of concurrent tasks has been used to investigate the effects of cognitive decline on walking. Studies have typically added cognitive tasks such as backward counting which are attention-demanding but lack ecological validity. The effect on spatiotemporal gait measures and gait variability of adding a motor task to walking has not previously been reported in people with AD, despite the fact that motor tasks are often concurrently performed with walking in everyday activities. The aim of this study was to evaluate the feasibility and effects on walking of carrying a tray and glasses in people with mild to severe AD and to determine whether effects differed with disease severity. **METHODS:** Thirty people ( $M=15$ ,  $80.2 \pm 5.8$  years) with AD (MMSE range 8-28) walked on an electronic walkway under two conditions: Baseline (self-selected comfortable speed); and Dual Motor Task (DMT - self-selected comfortable speed and carrying a tray with two long-stemmed empty plastic glasses). Gait measures were velocity (cm/s), stride length (cm) and stride time (s), and variability of stride length and stride time was calculated using coefficient of variation (CV). Baseline and DMT measures were compared using paired samples t-tests. Mann-Whitney U Tests were used to compare proportional change in each gait measure from baseline to the DMT condition between mild and moderate-severe subgroups. **RESULTS:** The dual motor task produced a

significant decrease in velocity (Baseline=111.5±26.5cm/s, DMT=96.8±25.7cm/s,  $p<0.001$ ) and stride length (Baseline=121.4±21.6cm, DMT=108.1±21.0cm,  $p<0.001$ ), and increased stride time (Baseline=1.11±0.11s, DMT=1.14±0.12s,  $p=0.001$ ). Effect sizes were medium for velocity and stride length and small for stride time. Measures of both spatial (Baseline=3.2±1.0%, DMT=3.9±1.5%,  $p=0.006$ ) and temporal (Baseline=2.4±0.8%, DMT=2.8±0.8%,  $p=0.008$ ) variability increased with the added motor task, each with medium effect sizes. A trend for DMT changes in gait spatiotemporal measures and variability to be greater with increased disease severity did not reach significance. **CONCLUSIONS:** Walking with a concurrent motor task produced significantly slower and more variable walking in this group of people with AD. The tray-carrying task had a greater effect on spatial than temporal measures. Effects on spatial and temporal variability were similar. Results are similar to previous findings using a similar task in other clinical groups. The tray carrying task was feasible, even for participants with severe cognitive decline. Future research should examine the potential for dual task effects on gait to be categorised according to factors such as the type of task and its demands on motor and sensory systems as well as its cognitive demands, and also determine the utility of DMTs as therapeutic interventions for gait decline in AD.

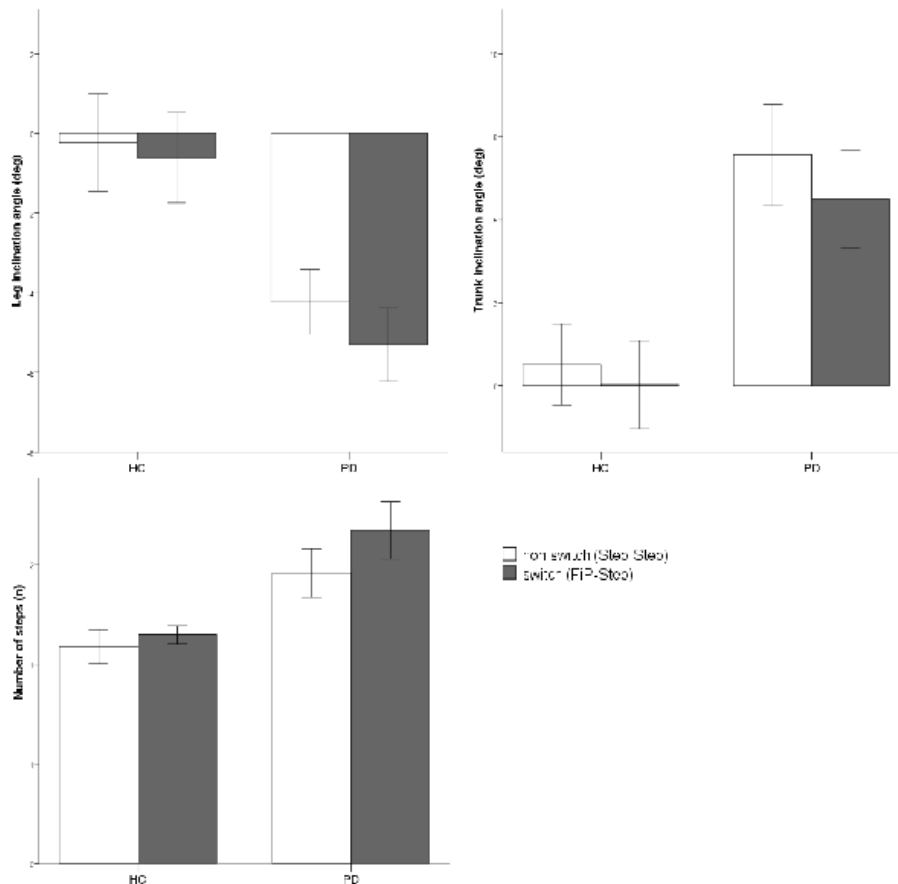
## **P2-M -195 Postural set rigidity in Parkinson's disease does not impair compensatory stepping**

**Katrijn Smulders<sup>1</sup>, Rianne Esselink<sup>1</sup>, Bert De Swart<sup>1</sup>, Alexander Geurts<sup>1</sup>, Bastiaan Bloem<sup>1</sup>, Vivian Weerdesteyn<sup>1</sup>**

<sup>1</sup>Radboud University Nijmegen Medical Centre

**BACKGROUND AND AIM:** Automatic postural responses to feet-in-place (FiP) perturbations can be adjusted based on expectation or instruction. Parkinson's disease (PD) patients demonstrate inflexibility to shape these postural responses to contextual factors, contributing to postural instability. However, it is unknown whether this rigidity in postural set is also present when a perturbation requires a compensatory step. Here, we compared compensatory stepping responses preceded by a series of FiP perturbations (inducing a switch in postural set), with stepping responses as part of a series of stepping responses (same postural set). **METHODS:** A total of 51 PD patients (59±7 yrs) and 22 healthy controls (60±6 yrs) participated in the study. Sixteen PD patients reported freezing of gait episodes in daily life (PD-FOG). To compare PD subgroups, patients without freezing (PD-noFOG) were matched to PD-FOG (age, gender, disease severity). Forward support surface translations were delivered at 1.25 m.s<sup>-2</sup> (inducing a step) and at 0.25 m.s<sup>-2</sup> (FiP response), resulting in backward balance perturbations. We compared non-switch steps (i.e. series of 8 expected step trials) with 4 switch steps (i.e. steps preceded by 8 FiP trials). Ground reaction forces were used to determine step onset and offset. 3D motion analysis was used to calculate the number of steps and step length. To assess the mechanical efficiency of the step, we also determined trunk and leg angles at the end of the step. (1) Trunk angle was calculated as the angle between the vertical and a line connecting the upper trunk and the pelvis. The leg angle was defined as the angle between the vertical and a line connecting the pelvis and the toe of the stepping leg. Higher leg and trunk angles reflect a higher efficiency of the step. **RESULTS:** In switch trials participants had smaller trunk (-1.2°,  $p<0.001$ ) and leg angles (-0.7°,  $p=.049$ ), and needed more steps to recover (0.1,  $p=.011$ ) than in non-switch trials. There were no significant differences between switch and non-switch trials with regard to step onset and step length. Crucially, the switch effects were similar between PD patients and controls, and between PD subgroups (no significant switch x group interaction effects for all parameters). Overall group comparisons showed that PD patients needed more steps to recover and had smaller leg angles and larger trunk angles compared to HC. PD-FOG had even smaller leg angles and larger trunk angles than PD-noFOG. **CONCLUSIONS:** A change in postural set led to a less beneficial body configuration. Possibly as a consequence of this, more steps were needed to recover from the perturbation in switch trials compared with non-switch trials. However, the ability to flexibly switch to a stepping response was not impaired in PD patients, which was true both for freezers and non-freezers. 1. Weerdesteyn V, Laing AC, Robinovitch SN. Gait Posture 2012;35:462-466



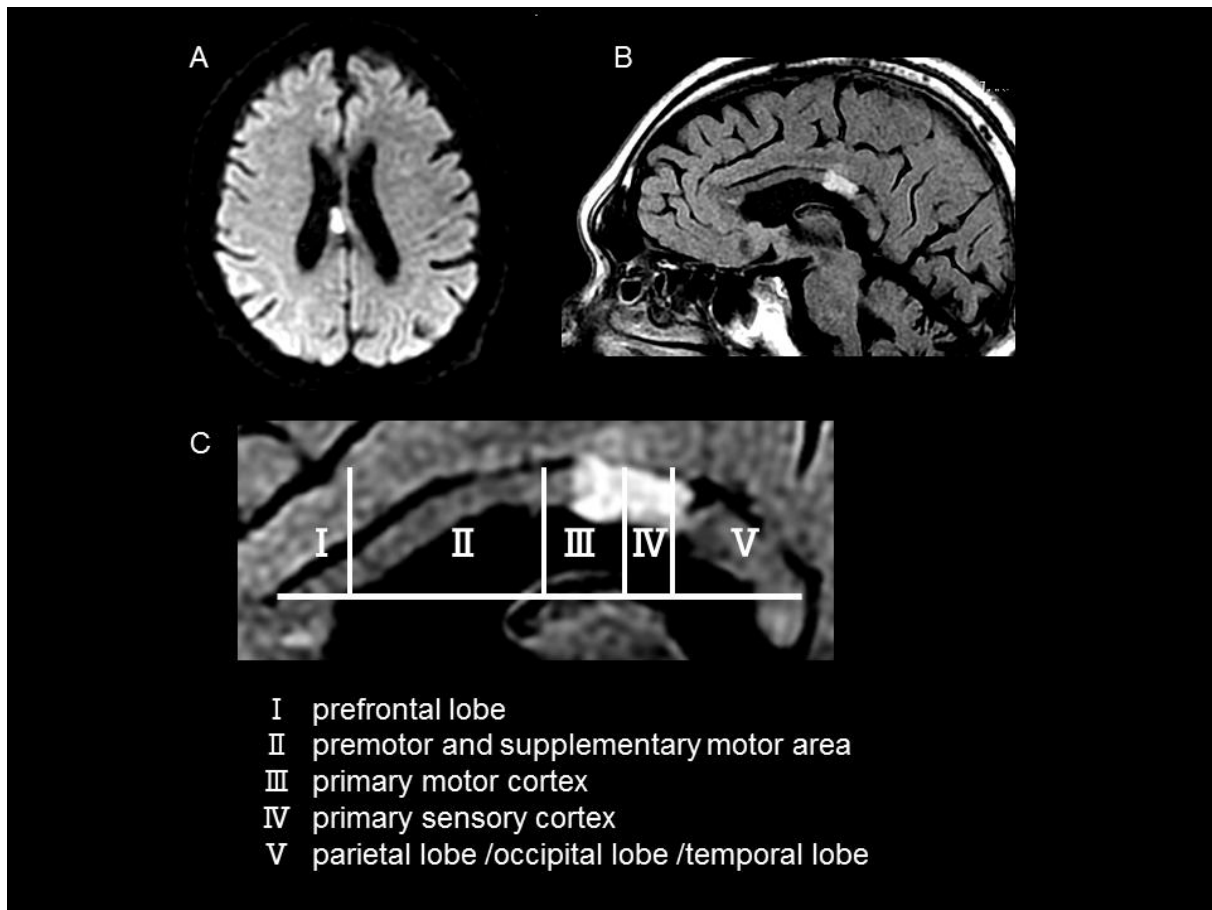


## P2-M -197 Reversible astasia-abasia syndrome caused by callosal infarction

**Sachiko Kamada<sup>1</sup>, Masashiro Sugawara<sup>1</sup>, Satoshi Ohkawa<sup>1</sup>, Akira Hanazono<sup>1</sup>, Masazumi Matsuda<sup>1</sup>, Fusako Takeda<sup>1</sup>, Hirohide Ohnishi<sup>1</sup>, Itaru Toyoshima<sup>1</sup>**

<sup>1</sup>Department of Neurology, Akita University School of Medicine

**BACKGROUND AND AIM:** There are considerable case reports of gait disturbances caused by callosal infarction. Most of those cases also associated so-called callosal disconnection syndrome. We experienced a very rare case presenting astasia-abasia caused by callosal infarction without any callosal disconnection syndrome. The corresponding lesion in corpus callosum causing astasia-abasia has not been well established. To detect the candidate lesion causing astasia-abasia, we analyzed the infarct lesion of the patient on MRI. **METHODS:** We analyzed the corresponding lesion in corpus callosum of a 77-year-old man presenting astasia-abasia without any callosal disconnection syndrome using his brain MRI and compared with topographical chart of the corpus callosum. We searched the past literatures describing about callosal infarction with gait disturbance and compared with our case. We investigated his clinical course and brain MRI. **RESULTS:** His brain MRI revealed a high-intensity area in back part of the right body of the corpus callosum on diffusion-weighted imaging. After anti-coagulant and anti-oxidative therapy, he could sit up on the 10th day and stand up on the 24th day, and walk unassisted on the 35th day of hospitalization. The topographic localization of communicating fibers between the premotor, the supplementary motor, the primary motor, and the primary sensory area was clarified by the studies using fiber tractography. The infarct area of our case was located on the communication of the primary sensory cortex and a part of communication of the primary motor cortex. **CONCLUSIONS:** Astasia-abasia should be caused mainly by the disconnection between bilateral primary motor cortex. The primary sensory cortex may also have a role in coordination of posture and gait.



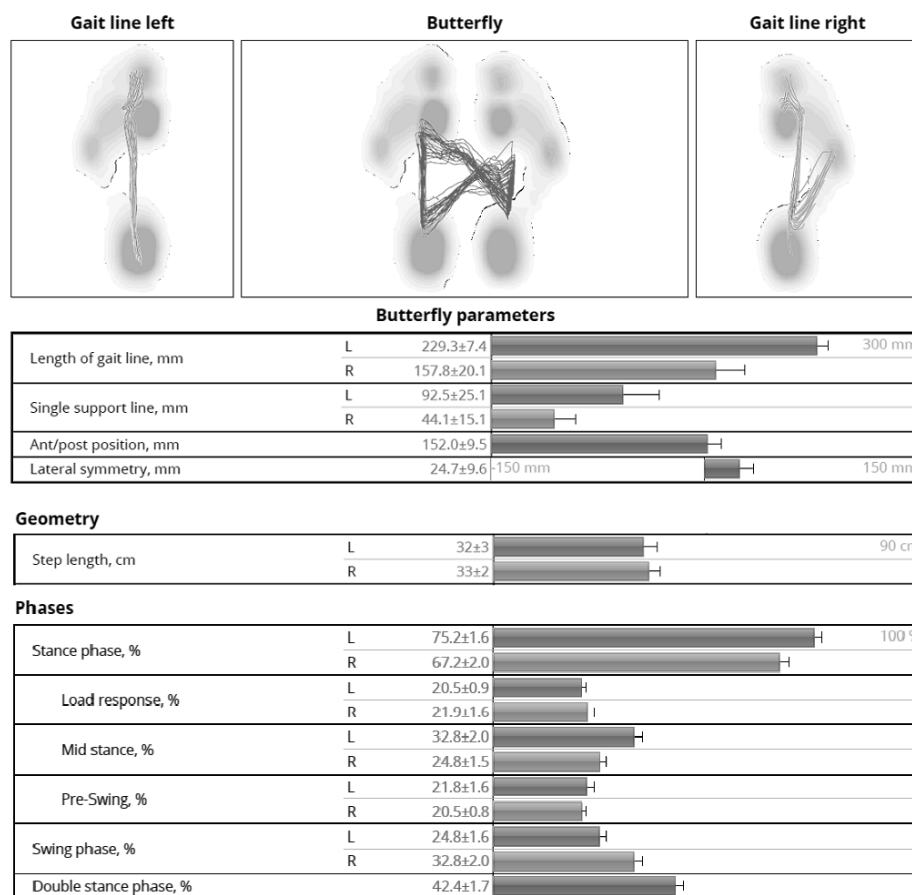
**P2-M -199 The efficiency of functional gait training by using virtual and augmented reality on symmetrization and speed of walking in postacute stroke patient**

**Zuzana Jurutkova<sup>1</sup>, Lucie Szmekova<sup>1</sup>, Petra Bastlova<sup>1</sup>, Barbora Kolarova<sup>1</sup>, Alois Krobot<sup>1</sup>**

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**BACKGROUND AND AIM:** The walking ability and symmetry of gait cycle are often reduced in stroke patients and they contribute to increase risk of falling. Functional treadmill training with visual feedback is common and task-specific intervention with positive influence on these parameters. Visual biofeedback can provide additional sensory information to supplement natural sensory information and improve human balance. However, it is unknown which additional sensory feedback (using virtual or augmented reality) is more effective and how can this kind of training change gait ability in daily life environment. The aim of our study was to analyse effect of treadmill gait training by using virtual and augmented reality on spatial and temporal gait characteristic and speed of walking in stroke patients. **METHODS:** 15 adult patients in postacute phase after stroke who were able to walk a minimum of 10m without physical assistance (FAC  $\geq 3$ , average age: 47  $\pm$  7 years, in avg 4,5 months after stroke) were assessed before and after 2 different interventions - gait training on treadmill with virtual reality (the tracks on the screen) and augmented reality (visual projection of foot placement on treadmill - stepping stones). Functional gait measures were 10-m Walk test (WT), Time up and go (TUG) test and physical analysis of gait symmetry through an instrumented treadmill with a pressure sensor. We focused on following outcomes: speed, geometry of gait cycle - step length symmetry and timing of stance phases (Figure 1). **RESULTS:** Our results showed obvious ability of stroke patients to change spatial and temporal gait parameters according visual context. The asymmetry of gait cycle was reduced more by using augmented reality. In Speed of walking, measured by TUG and 10m WT, was no significant difference between used interventions. More results will be present by graphs and reports of analysis. **CONCLUSION:** Treadmill training with augmented reality was

more successful intervention for improvement of gait asymmetry. Probably It can be caused by more task - specific orientation of training, which is more connected to real conditions. REFERENCES: Boonsinsukh, R., et al., Arch Phys Med Rehabil 2009;90:919-26. Fung, J., et al. Cyberpsychology & behavior, 2006; 9 (2), 157-162 Halicka, Z., et al. Act Ner Superior Rediviva, 2011; 53 (2), 67-71 Roerdink, M., et al. Human movement science. 2005;24, 379-402.



## P2-M -201 Relation between arm posture and gait instability in typically developing children and children with hemiplegia

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<sup>1</sup>KU Leuven

**BACKGROUND AND AIM:** Poor balance control is a major problem in children with Cerebral Palsy (CPc)[1]. CPc also show an altered posture of the upper limbs which was suggested to be related to instability during walking[2]. In a recent study, step width was used as a measure of gait instability. Step width itself is not a very good indicator of gait stability, as it does not take into account trunk movements. Therefore, in the current study, we calculated a measure of gait stability that takes into account the movements of the center of mass with respect to the feet. This allowed us to investigate the relation between an altered arm posture and gait instability in detail. **METHODS:** Participants included 11 children with hemiplegic CP (HEc) and 24 typically developing (TDC) children (4-12yr). Total body kinematics during comfortable and fast walking were recorded. The distance between the Foot Placement Estimator and touchdown of the most-affected/non-dominant foot in medio-lateral (FPE\_ML) and antero-posterior (FPE\_AP) directions, were used as measure of gait stability[3]. Three arm posture measures were examined in the sagittal plane; (1) mean vertical position of the hand (Zpos), (2) mean horizontal position of the hand (Xpos), (3) and mean angular displacement of the upper arm over the gait cycle (UAangle)[2]. Generalized Estimation equations were used with arm posture as dependent

variable, group as factor and speed and FPE measure as covariates. RESULTS: Both FPE\_AP and FPE\_ML were predictive for Zpos on both sides of the body (Most affected:  $p < 0.001$  and  $p = 0.001$ ; Least affected:  $p < 0.001$  and  $p = 0.003$ , respectively). Furthermore, for FPE\_AP, the 2 groups responded differently (FPE\_PE\*group interaction:  $p \leq 0.001$ ), indicating that, for HEc, being instable in AP-direction is related to higher hand positions than for TDc. FPE\_AP\*group was also predictive for least affected UAangle ( $p = 0.025$ ), meaning that, for HEc, increased AP instability was associated with a position of the least affected upper arm that was rotated more to the back than for TDc. Finally, FPE\_ML\*group\*speed was predictive for least affected Xpos ( $p = 0.019$ ). This suggests that Xpos is differentially related to instability for different speeds and for the 2 groups, i.e. for HEc, greater ML instability was associated with a more forward position of the least affected hand than for TDc, and in HEc the hand was brought less toward the back than in TDc when walking faster. CONCLUSIONS: The results indicate that arm posture is related to AP and ML instability during walking both in TDc and HEc. However, in HEc the arm posture is related differently to gait instability, possibly due to upper limb spasticity (most affected arm) and/or compensations (least affected arm). Acknowledgements: PM was supported by PDMK/12/180. SMB was supported by FWO (G.0901.11). References: [1]Woollacott Neural Plast 2005; [2]Meyns Eur J Paediatr Neurol 2012; [3]Millard J Comput Nonlinear Dynam 2012

**P2-M -203 Additional weight load increases the number of freezing of gait episodes in idiopathic Parkinson's disease**

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Background and aim: Freezing of gait (FOG) is an episodic gait disorder, characterized by inability to generate effective forward stepping movements, leading to falls. The pathophysiology underlying FOG remains insufficiently understood, and this hampers development of better treatment strategies. Preliminary evidence suggests that FOG may result from impaired force control during walking, thereby preventing correct unloading of the swing leg and initiation of the swing phase. Here we test the influence of load on FOG in Parkinson's disease (PD) patients. Methods: We manipulated loading responses of 12 PD patients with FOG, using contrasting conditions: (1) gait while wearing a belt loaded with lead weights (15% of body weight); (2) weight-supported gait while suspended from a parachute harness connected to a rigid metal cable running above the gait trajectory (15% of body weight) and (3) gait under normal gravity. Gait tasks were used that are known to provoke FOG: rapid 360 turns and walking with smaller steps compared to self-preferred step length. FOG episodes were quantified using blinded videotaped clinical assessment. Furthermore, ground reaction forces and full body kinematics were recorded. Results: Loading significantly increased the average number of FOG episodes per trial compared to the normal gravity condition ( $P < 0.05$ ). In contrast, weight-support did not affect FOG. We recorded a significant effect of gait task; loading further increased the number of FOG episodes during rapid 360o turns and when making rapid short steps (both known to provoke freezing of gait). Step length was significantly smaller during loading compared to normal gravity ( $P < 0.05$ ), whereas posture was not affected by load. Conclusions: The increased number of FOG episodes due to loading raises further questions on the underlying mechanism of freezing of gait. Movement adaptations, such as a smaller step length may require more precise gait timing and affect FOG. Furthermore, antigravity responses (Ib afferents and/or cutaneous afferents) may be impaired in PD patients, affecting somatosensory integration and underlying both the movement adaptations and FOG. Future studies should investigate if reduced sensitivity to changes in load contributes to FOG.

**P2-M -205 GBA-PD versus sporadic PD: Difference in postural control**

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**BACKGROUND AND AIM:** Patients with Parkinson's disease carrying a heterozygous mutation in the glucocerebrosidase (GBA) gene (GBA-PD) have the most common genetic risk for PD so far, and develop a basically comparable phenotype to sporadic PD (sPD). However, some doubts remain about whether GBA-PD really reflects sPD, as they show a more severe non-motor phenotype. Still, the motor phenotype is considered to be similar to sporadic PD. To test if motor abnormalities are indeed comparable between the above Parkinsonian disorders, we investigated static sway under challenging condition in GBA-PD, sPD and a matched control cohort. **METHODS:** Balance performance was assessed during quiet semitandem stance on foam with eyes open and closed in 11 GBA-PD patients, 19 sPD patients (matched to GBA-PD for disease duration and gender) and 19 healthy controls (matched to GBA-PD for age and gender). Study participants wore an accelerometer at the centre of mass at the lower spine (DynaPort Hybrid®, McRoberts, The Netherlands). **RESULTS:** Under the most challenging static sway condition (eyes closed on foam), GBA-PD patients had lower (i.e. control-like) values of area of sway (post-hoc  $p=0.003$ ), as well as acceleration of sway (post-hoc  $p=0.008$ ) and JERK (post-hoc  $p=0.03$ ) in the mediolateral direction, compared to sPD. These values did not relevantly correlate with motor (UPDRS III), cognitive (MMSE, MOCA) and behavioural (BDI) measures. **CONCLUSIONS:** This study suggests that postural control of GBA-PD patients is differently affected / compensated than in sPD.

**P2-M -207 Association between muscle coactivation and center of pressure movement during gait initiation in individuals with hemiplegia after stroke**

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<sup>1</sup>Kyoto University

**BACKGROUND AND AIM:** Muscle coactivation during gait is a compensation strategy related to postural control in individuals after stroke. Gait initiation (GI) was previously reported as high fall-risk task in hemiplegia after stroke. However, it is unclear the effects of muscle coactivation on GI. The aim of this study was to investigate the relationship between muscle coactivation measured using electromyography (EMG) and movement of COP during GI in individuals with hemiplegia after stroke. **METHODS:** Seventeen community-dwelling subjects with chronic hemiplegia participated in this study. The subjects stood on two force plates with one foot on each plate and were instructed to start walking on a 2-m walkway as quickly as possible after a visual LED light cue. The GI sequence was determined from the onset of visual cue to the trailing limb foot off event. Three trials were collected from each trailing limb condition. In each trial, the reaction time (RT) of COP movement from the onset of the visual cue (ms) and maximum posterior and mediolateral to the lead limb displacement of the COP (% foot length and % stance width, respectively) were determined from the force plate data (Figure 1). EMG signals were recorded at the tibialis anterior and lateral gastrocnemius muscles on the trailing limb in each condition. The coactivation index (Col) was calculated on the paretic and non-paretic sides during the GI sequence. Associations between Col values and COP variables in each condition were analyzed using Spearman's rank correlation coefficient. **RESULTS:** In the paretic trailing limb condition, high Col on the paretic side was associated with slow RT ( $r=0.50$ ,  $p<0.05$ ). A significant association was found between high Col on the non-paretic side and slow RT ( $r=0.66$ ,  $p<0.01$ ), less posterior displacement ( $r=-0.48$ ,  $p<0.05$ ), and less mediolateral displacement ( $r=-0.79$ ,  $p<0.01$ ) of the COP in the non-paretic trailing limb condition. **CONCLUSIONS:** The results of the present study suggested that high muscle coactivation may enhance fixation of the ankle joint to compensate for postural instability during GI, although antagonist muscle activity may inhibit smooth movement of the COP. Because less COP displacement previously reported to minimize forward momentum and induce postural instability during GI in individuals with hemiplegia.

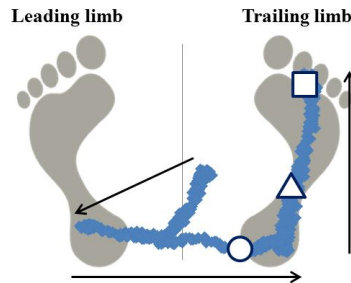


Figure 1. Center of pressure movement during GI sequence. Circle, triangle, and square symbols indicate the leading limb foot off, leading limb foot contact, and the trailing limb foot off events, respectively.

## P2-M -209 Factors affecting stiff-legged gait in Cerebral Palsy

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**BACKGROUND:** People with Cerebral Palsy (pwCP) commonly walk with a stiff-legged gait characterised by reduced knee flexion during swing phase. This gait pattern is inefficient, reduces the walking distance and increases the risk of trips and falls. A stiff-legged gait is commonly attributed to the presence of spasticity in the rectus femoris. However, modelling studies and findings in other patient groups suggest that factors such as changes in the passive muscle properties of the knee extensors, and weakness in the ankle plantarflexor and hip flexor muscles that initiate swing phase, may also contribute to this walking pattern. This study therefore aimed to investigate the relative impact of these multiple impairments on stiff-legged gait in pwCP. **METHODS:** Children with CP who were able to walk at least 100m and had not had any surgery or botulinum toxin injections in the last 3 months were recruited from local orthopaedic clinics and child development centres. They were compared to age and gender matched healthy controls. Knee kinematics and kinetics during walking were measured using 3D motion analysis (Codamotion, Charnwood Dynamics UK) and force plates (9286AA Kistler, Instruments Ltd, Hampshire, UK). Isometric ankle plantarflexor and hip flexor isometric strength was measured using a dynamometer (Biodex System 3, UK) and normalised by body mass. Stereotyped motor-driven 15° perturbations of the knee extensors were delivered at 50/s and 1750/s to assess the degree of passive and stretch-reflex related stiffness respectively. The torque, position, velocity and surface electromyography (EMG, MT8 Telemetry, MIE Leeds UK) were AD converted at 2KHz (Power 1401, Spike 2, Version 5, CED Electronics Cambridge, UK). Stiffness was defined as  $\ddot{A}position / \ddot{A}torque$ . Groups were compared using an unpaired t test. The relationship between the impairment measures (strength and stiffness) and the peak to peak range of knee motion and rate of knee flexion while walking was investigated using regression analysis. **RESULTS:** Sixteen pwCP (11 male 10.5 +/- 2.2 yrs; GMFCS median = II range I-IV) and 14 controls (9 males, 14.3 +/- 10.8) were recruited. In pwCP the ankle plantarflexor maximal isometric torque was  $44 \pm 27\%$  and hip flexor maximal isometric torque was  $63 \pm 16\%$  of that seen in the control group ( $p < 0.05$ ). Knee extensor passive stiffness was  $28 \pm 65\%$  and stretch-evoked stiffness was  $90 \pm 32\%$  higher in pwCP compared to

controls ( $p < 0.05$ ). In pwCP higher passive stiffness of the knee extensors was associated with a lower range of knee flexion in swing phase ( $R = 0.47$   $P = 0.05$ ) and slower speed of knee flexion ( $R = 0.52$   $R < 0.05$ ). The relationship with the other measures of impairment and knee kinematics were non-significant. **CONCLUSIONS:** pwCP present with Multiple Impairments that can affect walking. Passive Stiffness of the knee extensors can limit the amplitude and speed of knee motion and should be targeted with physical interventions.

## **P2-M -211 Resting state functional connectivity in the motor network in individuals with Parkinson disease**

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**BACKGROUND AND AIM:** PD commonly causes disordered motor behavior, with individuals frequently reporting gait and/or balance impairment. However, the underlying pathophysiology of these motor disturbances remains poorly understood. Freezing of gait may represent progression along the continuum of disordered motor control; however, movement constraints associated with MRI confound our ability to directly examine this motor symptom. Resting state functional connectivity (rs-fcMRI), which assesses activity at rest and therefore eliminates the need to evoke movement, allows for assessment of networks with a person at rest during scan acquisition. This removes confounds related to inability to perform a motor task. The aim of this study is to compare functional connectivity within the motor control network in individuals with PD to age-matched controls and individuals with PD FOG to individuals with PD-FOG.

**METHODS:** 19 healthy individuals (10 female, mean age 69.2 years, SD 7.2 yrs) and 17 individuals with PD (7 female, 66.7  $\pm$  8.7 years) completed a minimum of two 440s resting state functional connectivity blood oxygen level dependent MRI scans as well as T1 and T2 weighted images. Of these, 8 individuals with PD did not report FOG (-FOG; 5 female, 63.2  $\pm$  8.3 years), and 9 individuals with PD reported FOG ( FOG; 2 females, 69.9  $\pm$  8.3 years). All individuals with PD were assessed following a 12-hour withdrawal of their medication. During the scan participants were instructed to lie quietly, with their eyes closed, and remain awake. Data were examined for both gross movement during data collection as well as between-frame motion. Spurious correlations related to head motion were accounted for during BOLD preprocessing. Additionally, groups were matched for within-scan motion. Computation of correlation maps was completed using time series extracted from seed regions of interest with a minimum threshold of  $p \leq 0.05$  and two voxel clusters. **RESULTS:** Individuals with PD showed significant differences in functional connectivity as compared to controls using seed regions within the cerebellum and motor cortex. No significant differences were present between PD-FOG and PD FOG using the selected seed regions. Functional connectivity was altered between controls and PD FOG when seeds were placed in either the left or right motor cortex, but not in the cerebellum. No significant differences in connectivity were present between controls and the PD-FOG group. **CONCLUSIONS:** Individuals with PD show deficits in the motor control network as compared to controls. Resting state MRI may provide a means of assessing network connectivity changes in populations with movement disorders who have difficulty performing motor tasks in an MRI. However, due to the rigorous standards used to address movement related confounds a large sample size is necessary when comparing subpopulations within a cohort.

## **P2-M -213 Kinematic analysis of reaching movement with different height of obstacle in stroke patients.**

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**BACKGROUND AND AIM:** The feature of reaching patterns of patients following stroke is essential for the rehabilitative management of these patients [1]. Reaching performance could vary over different visual and space obstructions in the

workspace. Thus, the objective of the present study was to determine the association between reaching patterns and obstacle height in patients with stroke. **METHODS:** Ten highly functioning patients with hemiplegic stroke (Brunnstrom Stage VI) were seated and asked to cross an obstacle of different height and reach an object placed on the desk with each hand. The height of desk and distance of the objects were normalized to body height and upper limb length. The distance of the obstacle was 65% of upper limb length and the obstacle height was 0%, 10%, 20% and 30% of upper arm length. Hand movement kinematics was measured with a motion analysis system (Vicon, Oxford Metrics, U.K.). Difference between maximum and object grasping angle of the aperture (aperture excursion), movement time, peak speed of the wrist and the number of acceleration peaks were obtained. The vertical distances between the middle finger markers and the obstacle when the middle finger was directly above the obstacle, called mid-clearance, were calculated. A 2 by 4, 2-way mixed-model ANOVA (group x obstacle height) was performed for all variables ( $\alpha=0.05$ ). **RESULTS:** With increasing obstacle height the aperture excursion and mid-clearance were decreased linearly ( $p=0.04$ ,  $p<0.01$ ) and the movement time increased linearly ( $p<0.01$ ), but the peak speed of the wrist had no significant trend. Significantly more acceleration peaks were found in the condition with obstacles (10%, 20% and 30%,  $p=0.03$ ). There were no significant differences in all the variables between the affected and unaffected sides. **CONCLUSIONS:** Highly functioning patients with hemiplegic stroke showed a symmetric strategy with similar patterns between the affected and unaffected hands when reaching an object while crossing an obstacle of different height in the workspace. An obstacle placed before the targeting object appeared to reduce the smoothness of the reaching movement with more acceleration peaks. Increased movement time and decreased aperture excursion with increasing obstacle height may be a conservative strategy for reaching without hitting the obstacle. **REFERENCE 1.** Kamper DG. et al. Arch Phys Med Rehabil. 83(5):702-7, 2002.

## **N - Cognitive, attentional and emotional influences**

### **P2-N-215 Preclinical mobility disability in people with Parkinson's disease: a survey**

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**INTRODUCTION:** Difficulty walking is common in people with Parkinson's Disease (PD), resulting in loss of walking function and progressive onset of disability. In older adults, pre-clinical mobility disability has been identified, where people report that they have no difficulty when walking, but they modify what they do (Fried, 1996). In focus groups, some people with PD have identified that they have no difficulty walking but modify their walking under challenging conditions (Lamont, 2012). As walking in the community is challenging and important in maintaining independence, this study aimed to characterise how people with PD who modify their community walking differ from those who do not. **METHODS:** A cross-sectional survey was undertaken with people with PD in Australia. It was based on previous questionnaires and focus group findings, and included multiple choice questions and statements with Likert and visual analogue scales. It covered the frequency of their community walking, the environmental and personal challenges encountered, the strategies used to overcome challenges and their personal and disease characteristics. Respondents were categorised into one of four community walking categories: unable to walk in their community, requiring assistance, no difficulty but modified, or no difficulty and had not modified their walking. Differences in the distribution of responses across groups were assessed using Fisher's exact tests. **RESULTS:** Surveys were completed by 247 people with PD. Of these, 113 (44%) indicated they had modified their community walking, 78 (30%) had not modified their walking, and 46 (18%) could only walk in the community with assistance. The modified group had a higher proportion of freezers (50% vs. 23%) and a lower confidence level than those who had not modified their walking (70% vs. 100%).



Compared to those who had not modified their walking, the modified group took fewer outings within their neighbourhood, town, and outside their town; restricted where they walked; and their decision to go out was affected by whether the outing involved walking (all  $p < 0.001$ ). They found it difficult to walk in crowded places (74% modified vs. 36% unmodified), unfamiliar places (68% vs. 50%), when doing something else (70% vs. 22%), uneven surfaces (85% vs. 71%) in the dark (69% vs. 47%) and found walking difficult due to the unpredictability of others (54% vs. 25%) (all  $p < 0.001$ ). Personal barriers to walking that were more evident in the modified group included the severity and predictability of their symptoms, the variable effect of medications, anxiety, confidence and fatigue. **CONCLUSIONS:** People with PD who report no disability with their walking are likely to have modified their walking or outings to accommodate their symptoms. Understanding the challenging symptoms and situations will assist to develop appropriate, timely interventions.

#### **P2-N-217 The benefits of cognitive and physical training on dual-task walking**

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<sup>1</sup>Concordia University, <sup>2</sup>Centre de recherche institut universitaire de gériatrie de Montréal (CRIUGM)

**BACKGROUND AND AIM:** Recent non-pharmacological intervention studies of attentional/executive control training in older adults demonstrate promising improvements in gait and balance, and when motor performance is paired with concurrent cognitive activity (Li et al., 2010; Verghese et al., 2010). Other studies of aerobic fitness training in older adults also show significant improvements to attentional/executive control processes (Langlois et al., 1999), suggesting that a combined regimen of cognitive and aerobic training may lead to optimized gait and balance. Our aim was therefore to compare combinations of active and placebo training protocols to determine the relative efficacy of cognitive and fitness training. **METHODS:** Ninety-one older adults ( $M = 72.2$  yrs) were randomly assigned to one of four training conditions: (1) Aerobic Cog, (2) Aerobic Internet, (3) Stretch Cog, and (4) Stretch Internet. Participants completed 2 sessions of physical training and 1 session of cognitive training per week for 12 weeks. The pre- and post-training sessions included assessments of cognition, mobility, dual-task performance. Cognitive training involved a computerized dual-task with performance feedback. Placebo cognitive training involved learning how to use the internet. **RESULTS:** At baseline, the groups proved to be statistically comparable on background measures (age, education, gender ratio, Trailmaking Test, Digit-Symbol Substitution, medication, and cognitive status). Computerized dual-task performance was examined to quantify the degree of improvement in attentional/executive control due to training. Only the two groups receiving Cognitive training (1 & 3) showed significant reductions in dual-task costs after training ( $p \leq .031$ ). Walking speed (m/s) improved from pre- to post-training assessments across all groups (main effect of group,  $p = .23$ ) although the Stretch Internet group showed the least numeric improvement over time. Analysis of dual-task costs (walking speed alone minus walking speed and concurrent n-back working memory performance) revealed that costs were reduced significantly when the cognitive activity was demanding (1-back) but did not change when the cognitive task was easy (0-back). No pre-post improvements were observed for the n-back task. **CONCLUSIONS:** Computerized cognitive training combined with some physical training (aerobic / stretch) improved attentional/executive control processes, but the addition of aerobic training (Condition 1) did no better to improve cognitive control or walking speed. Furthermore, walking speed and dual-task costs in walking speed were improved by all training conditions although Condition 4 led to the weakest degree of improvement in walking, suggesting that some active intervention (either cognitive or aerobic training) must be present. Further research should examine individual differences in amenability to different training protocols (e.g., frailty, baseline cognitive status).

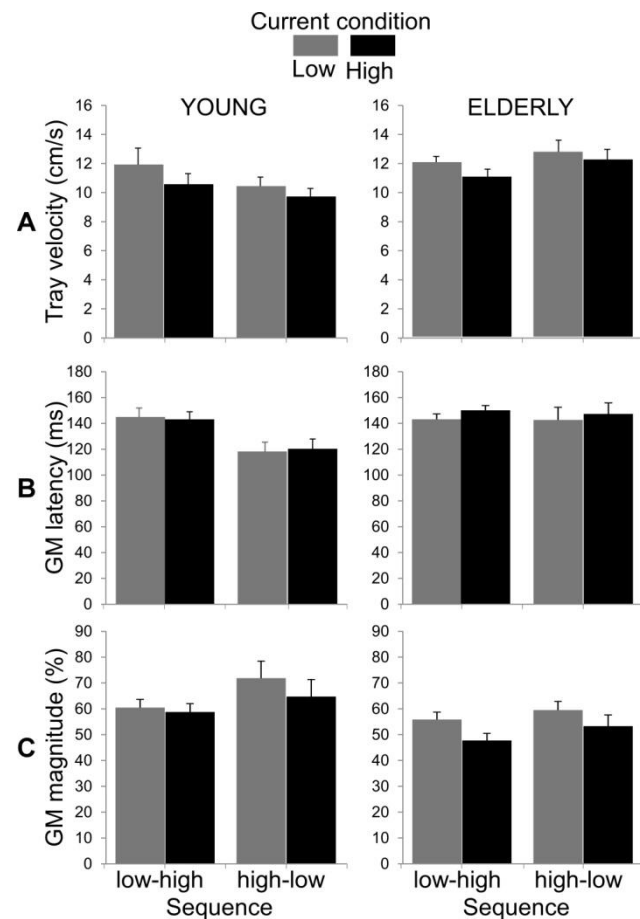
#### **P2-N-219 Adapting postural responses on the basis of constraints imposed by a voluntary task in the elderly**

**Andrea De Lima-Pardini<sup>1</sup>, Daniel Coelho<sup>1</sup>, Marina Silva<sup>1</sup>, Luis Teixeira<sup>1</sup>**

<sup>1</sup>University of Sao Paulo

**BACKGROUND AND AIM:** We recently found that a higher order level of motor control modulates automatic postural responses based on context set by the manual task in young individuals. However, it is not clear how postural responses

are modulated by the constraint posed by manual tasks in the elderly. Given that older individuals have higher incidence of falls during dual tasks, we hypothesize that the elderly have inefficient postural responses to the constraints from a voluntary task. **METHODS:** This study assessed in 16 elderly and 16 young participants the effects of stability constraints from a voluntary task on postural responses to an external perturbation. Participants stood upright and wore a harness attached to an electromagnetic plate fastened posteriorly at the level of the lumbar-sacral vertebrae. A steel cable, which was attached in the plate, passed through a pulley. A load corresponding to approximately 7% of the subject's weight was attached to the end of the steel cable. To counteract the body horizontal pull back force to maintain upright position, it was required activation of anterior postural muscles. Unpredictable load release required activation of posterior and inhibition of anterior muscles to respond appropriately to postural perturbation. Participants were analyzed under two versions of a voluntary task: holding a tray with a cylinder on it placed with the flat (low constraint, LC) or the round (high constraint, HC) side down. Participants aimed to keep stable upright body balance while preventing cylinder's motion following load release. Blocks of trials of low and high constraint were alternated during assessment.



**RESULTS:** Results showed that the elderly accomplished the manual task as well as controls, showing slower tray velocity in the high as compared with the low constraint condition. The elderly showed longer latency than young participants in the gastrocnemius medialis muscle. In addition, the high constraint condition induced longer latency and lower magnitude of muscle activation in the elderly but not in young participants. Initiating the experiment with the high constraint task induced shorter latency of muscular activation of the tibialis anterior muscle in both age groups. The current high constraint condition led to lower magnitude of tibialis anterior muscle in both groups. Kinematic analysis showed that the elderly had higher participation of the shoulder and hip joints than young participants, mainly in the high constraint condition.

**CONCLUSIONS:** These results suggest that the elderly are more likely to change their postural responses based on the constraint from a voluntary task than young individuals. However, the elderly seems to adopt a less efficient postural response in more challenging situations, which are featured by

late latency, low magnitude of agonist muscles and exaggerated joint movements to achieve the same level of success of young people to accomplish the voluntary task.

## P2-N-221 Precueing about kind and time of perturbation leads to improved postural responses in young and older individuals

**Marina Silva<sup>1</sup>, Daniel Coelho<sup>1</sup>, Thais Baptista<sup>1</sup>, Alessandra Martinelli<sup>1</sup>, Andrea Pardini<sup>1</sup>, Luis Teixeira<sup>1</sup>**  
<sup>1</sup>USP

**BACKGROUND AND AIM** Previous studies have shown that automatic postural responses can be influenced by cortical processing associated with learning, prior experience, and precueing. However, scarce behavioral evidence has been

provided about how postural responses are modulated by precueing in the elderly. Given that older individuals use cognitive processes more extensively than the young to regulate postural control, with less automatic responses, we hypothesized that the elderly are more benefited from precueing about an impending postural perturbation than the young. The present investigation aimed at comparing the effect of precueing about direction and/or time of platform rotation on postural responses in older ( $n=15$ , mean age=71) and young ( $n=16$ , mean age=22) participants. **METHODS** The task consisted of recovering stable upright body balance in response to rotation of the support basis, inducing dorsi or plantar flexion. Amplitude of rotation was  $10^\circ$  and velocity was  $50^\circ/\text{s}$  for both directions. Participants were analyzed under four conditions: (a) precue about direction of perturbation, (b) precue about time of perturbation, (c) precue about direction and time of perturbation, and (d) no precue. Precueing about direction of platform rotation was provided by vertical arrows presented on a monitor screen. Upward arrow indicated that the ensuing platform rotation would induce ankle dorsiflexion, while downward orientation indicated the opposite direction of rotation. Precueing about time of platform rotation was indicated through three consecutive 2-s-long auditory tones, with the third one coinciding with initiation of platform rotation. In the condition of no precueing about time of platform rotation a variable interval between 500 and 2000 ms preceded perturbation. Each experimental condition was evaluated in a block of 8 trials, with 4 trials for each direction of rotation. **RESULTS** Analysis of postural responses to dorsi and plantar flexion indicated decreased values of latency and center of pressure sway for the condition combining precueing about direction and time of platform rotation as compared to conditions of precueing about direction only and no precueing. No significant difference existed among elderly and young groups. **CONCLUSIONS** These results suggest that to be effective precueing must contain information about the kind of postural perturbation which will be suffered in combination with time in which it will occur. The benefit to postural responses seems to be similar to both age groups.

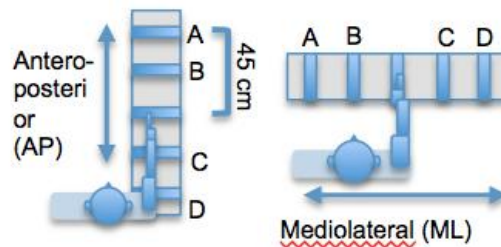
## **P2-N-223 Adaptive postural response to imagined arm movements in older people**

**Nicola Doherty<sup>1</sup>, Elizabeth Maylor<sup>1</sup>, Suvobrata Mitra<sup>1</sup>**

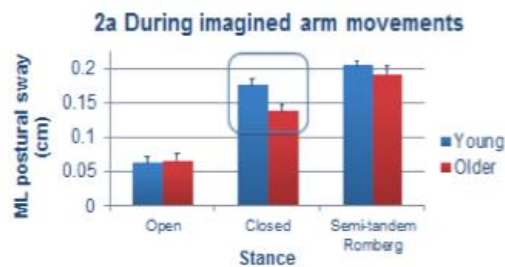
<sup>1</sup>University of Warwick

**INTRODUCTION:** Posture control and cognitive tasks can mutually interfere, especially in older adults [1]. Imagining arm movements (e.g. reaching) is a ubiquitous cognitive task but its effects on posture control are unknown. Imagined and actual arm movements are so similar that the former are considered simulations of the latter [2]. Since posture control not only maintains stance, but also adjusts it to support suprapostural tasks [3], imagined arm movements may evoke postural responses. We investigated the effect of physical and imagined arm movements on sway in young and older adults. Participants made actual and imagined arm movements to targets along the AP and ML directions, while standing in open, closed or semi-tandem Romberg stance. For physical movements, we expected greater postural compensation (i.e., sway restriction) in the challenging stances. For imagined movements, we predicted signs of the postural compensations expected in the corresponding physical movements. **METHODS:** 48 healthy young (18-25 yrs) and 48 older adults (65-80 yrs) stood in open, closed or semi-tandem Romberg (dominant foot forward) stance. Following practice, participants made physical (eyes open) and imagined (eyes closed) movements to targets located on a board at waist level in the AP or ML direction (Fig 1). We measured self-reported movement times and ML and AP body sway (RMS position drift across 1 s time windows [4]) during actual and imagined arm movements. **RESULTS:** Physical and imagined movement times increased with target distance; young and older participants did not differ. During physical arm movements, ML sway was least in closed stance and highest in open stance, with semi-tandem Romberg in between; young and older participants did not differ. During imagined arm movements, however, ML sway increased from open to closed to semi-tandem Romberg; older participants swayed significantly less than younger participants in closed stance (Fig 2). **CONCLUSIONS:** The increase in imagined movement time with target distance suggests similar constraints governing imagined and actual arm movements [2]. Older participants reduced ML sway relative to young participants when they imagined arm movements in closed stance. Since the least ML sway during physical arm

movements also occurred in closed stance (with its small support base), we suggest that older people tightened their ML sway during imagined movements to compensate for the destabilization they expected if the movements were actually carried out. This suggests that older people may be prone to generating postural compensations for imagined upper body movements. **ACKNOWLEDGEMENTS:** Supported by ESRC, UK. **REFERENCES** 1 Fraizer, EV, & Mitra, S (2008). *Exp Brain Res*, 185, 429-411. 2 Jeannerod, M (2006). *Motor cognition: What actions tell the self*. Oxford University Press: Oxford. 3 Stoffregen, TA, et al (2007). *J Mot Behav*, 39, 126-138. 4 Mitra, S (2003). *Hum Mov Sci*, 22, 253-270



**Fig 1. Manual pointing task**



**Fig 2. Experimental results**

#### **P2-N-225 The impacts of fear of falling on trunk variability during gait in community-dwelling elderly**

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**Introduction:** Fear of falling (FoF) is known to cause various changes on gait. Although successful locomotion is supported by reproductive motor behavior with maintenance of trunk equilibrium, the effects of FoF on trunk variability during gait are still unclear. The aim of this study was to explore whether FoF has impacts on trunk variability during gait in community-dwelling elderly. **Methods:** Ninety-three elderly people participated in this study. Each participant was categorized into either FoF or No-FoF group on the basis of having FoF. The participants walked 15m at their preferred speed. The wireless motion recording sensor units were attached to L3 spinous process and right posterior surface of heel during gait. Gait velocity, stride time and stride length were calculated. Trunk variability was represented by autocorrelation coefficients (AC) in three directions (vertical: VT, mediolateral: ML and anteroposterior: AP), respectively. Gait parameters were compared between groups, and generalized linear regression models were used to perform the analyses after adjusted for gait velocity, age, sex, height, weight and fall experience. The statistical level of significance was set at  $p < 0.05$ . **Results:** Gait velocity, stride time and stride length were not significantly different between groups. All ACs have worsened significantly in FoF group even after adjusted for variables (AC-VT:  $p = 0.011$ ,  $\beta = 0.053$ ; AC-ML:  $p = 0.044$ ,  $\beta = 0.075$ ; AC-AP:  $p = 0.002$ ,  $\beta = 0.078$ ). **Conclusion:** Our results suggest that having fear of falling would increase trunk variability during gait in community-dwelling elderly.

**P2-N-227 Interference of the Stroop test with concurrent postural sway****Yoshifumi Ikeda<sup>1</sup>, Hideyuki Okuzumi<sup>1</sup>, Mitsuru Kokubun<sup>1</sup>, Koichi Haishi<sup>2</sup>**<sup>1</sup>Tokyo Gakugei University, <sup>2</sup>Joetsu University of Education

**BACKGROUND AND AIM:** Earlier studies have demonstrated a link between control of postural sway and cognitive processing [1, 2]. This study was undertaken to examine features of postural sway when performing the Stroop test, particularly addressing response time (RT). **METHODS:** Ten adults (5 women, M age = 22.90±.99 years) participated. All participants were instructed to take a wide stance with feet shoulder-width apart (WS) and to balance on one foot (OF) as stably as possible while simultaneously performing cognitive tasks as rapidly and as accurately as possible. Cognitive tasks included 'no task', a probe response (Probe) task, and the Stroop test. The Stroop test consisted of a color-naming (CN) task and an incongruent color-naming (ICN) task. Four cognitive tasks and two postural tasks were randomized. For cognitive tasks, the number of errors and RT (ms) were calculated. As a center of pressure measure, RMS (mm) and sway length (mm) were calculated. **RESULTS:** The mean number of errors in CN and ICN tasks never exceeded one. Table 1 presents means and standard deviations of dual-task performances. Analysis of RT showed a main effect of cognitive task ( $F_{2, 18} = 241.10, p < .001$ ). No main effect of postural task or interaction was found. Analysis of RMS showed a main effect of the postural task ( $F_{1, 9} = 147.83, p < .001$ ). No main effect of cognitive task or interaction was found. Analysis of sway length showed main effects of postural task ( $F_{1, 9} = 213.16, p < .001$ ) and cognitive task ( $F_{3, 27} = 6.63, p < .01$ ). No interaction was found. Sway length was shorter for 'no task' than for Probe, CN, and ICN tasks in the WS postural task ( $p < .05$ ). In the OF postural task, sway length was shorter in 'no task' than in the ICN task ( $p < .05$ ). **CONCLUSIONS:** Results indicate that concurrent cognitive tasks, compared with 'no task', do not increase RMS but increase sway length, which might increase body stiffness. **REFERENCES** 1. Woollacott M. & Shumway-Cook A. Gait Posture. 16:1-14, 2002. 2. Barra J. et al. Exp Brain Res. 174:734-745, 2006.

Table 1 Dual-task Performances (M±SD)

		No task	Probe	CN	ICN
RT	WS	-	465±44	692±66	778±74
(ms)	OF	-	485±66	663±50	772±73
RMS	WS	0.37±0.16	0.34±0.09	0.38±0.10	0.33±0.07
(mm)	OF	0.82±0.08	0.83±0.14	0.77±0.12	0.85±0.17
Sway length	WS	38±6	50±10	49±12	49±10
(mm)	OF	172±38	187±29	185±40	197±37

**P2-N-229 The effect of divided attention on axial plane trunk kinematics during locomotion in healthy young adults and persons with a history of recurrent low back pain****Jo Armour Smith<sup>1</sup>, Kornelia Kulig<sup>1</sup>**<sup>1</sup>University of Southern California

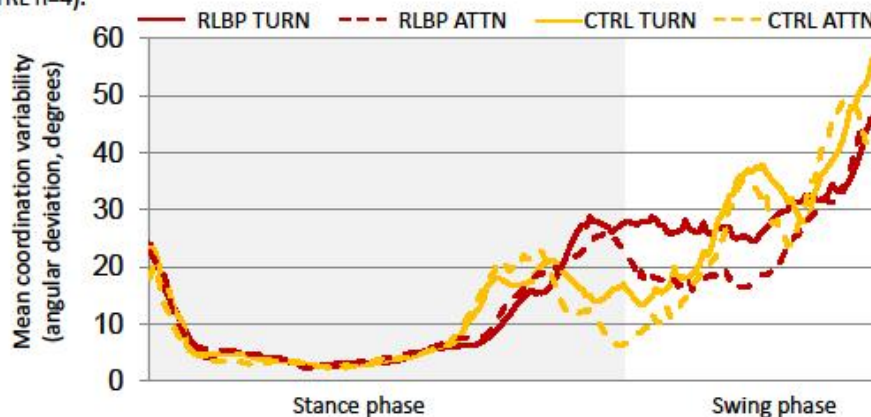
**BACKGROUND AND AIM:** It is unclear whether there are adaptations in locomotor variability in young adults when locomotion is performed simultaneously with an attention-demanding cognitive task. Limited treadmill evidence suggests decreased variability of relative motion (coordination) between the trunk and the pelvis in the axial plane under divided attention conditions. This adaptation may be more exaggerated in persons with a history of low back pain (LBP). Overground locomotor perturbations such as ipsilateral walking turns (spin turns) have greater mechanical

demand than straight locomotion and therefore may highlight adaptations associated with divided attention in young adults. The aims of this study were to investigate the effect of divided attention on axial plane trunk coordination during spin turns and to compare these adaptations between persons with a history of recurrent low back pain (RLBP) and healthy young controls (CTRL). **METHODS:** Nine subjects were recruited (mean age = 26.5 years: RLBP n=5, mean duration of LBP 5.7 years: CTRL n=4). RLBP subjects were symptom free at the time of testing. Axial plane 3-D kinematics of the trunk and pelvis were recorded during anticipated spin turns performed at 1.5m/s (TURN) and during turns performed simultaneously with a verbal 2-back task (ATTN). Subjects were instructed to prioritize the 2-back task but only trials with average locomotor speed of 1.5m/s were analyzed. Angular displacement of the trunk and pelvis in the axial plane was calculated. Coordination between the trunk and pelvis during the stride cycle of the turn was determined using the vector coding technique and the variability of the coordination was quantified as the angular deviation across a minimum of 15 trials for each condition. **RESULTS:** Average number of 2-back errors per trial at baseline was the same for both groups (RLBP 0.4, CTRL 0.4) and remained similar during ATTN trials. Peak to peak amplitude of trunk on pelvis motion did not systematically differ between conditions for either group (RLBP TURN 17.6° (3.5); ATTN 17.3° (3.1); CTRL TURN 18.0° (5.5); ATTN 17.1° (4.0)). There were no consistent changes in coordination pattern during the divided attention condition. Eight of the 9 subjects demonstrated decreased coordination variability during the swing phase of the turn in the ATTN condition (mean TURN 29.5° (9.8); mean ATTN 24.6° (8.7), Effect size = 0.53). The RLBP group had a greater decrement in coordination variability under the ATTN condition than the CTRL group (RLBP mean change - 5.7° (3.0); CTRL mean change -4.0° (4.4), ES = 0.44). **CONCLUSIONS:** Young adults modify trunk coordination variability during spin turns under a divided attention condition. Variability was adapted to a greater extent in the RLBP subjects than the controls. This suggests altered cognitive control of locomotor tasks in these subjects, even during periods of symptom remission.

Figure 1a) Stride cycle of a left spin turn (left foot initial contact to left foot initial contact)



Figure 1b) Time-series of trunk/pelvis mean coordination variability across the turn stride cycle during the TURN and ATTN conditions (TURN condition = controlled average speed, ATTN condition = controlled average speed + verbal 2-back task, RLBP n=5, CTRL n=4).



**P2-N-231 Spatial versus non-spatial cognitive task effects on walking stability in older adults****Jasmine Menant<sup>1</sup>, Daina Sturnieks<sup>1</sup>, Matthew Brodie<sup>1</sup>, Joanne Lo<sup>1</sup>, Stephen Lord<sup>1</sup>**<sup>1</sup>Neuroscience Research Australia

**BACKGROUND AND AIMS:** As demonstrated by gait and balance studies involving secondary cognitive tasks, balance control requires attentional resources. Previous research has suggested that visuo-spatial (VS) processing requiring working memory might be particularly important in balance control [1, 2]. However, the involvement of VS processing in the control of balance during locomotion has not been determined. This study examined the effects of a VS cognitive task versus an arithmetic task involving the phonological loop on gait stability and variability, while controlling for task difficulty, in older adults. **METHODS:** Thirty-six older adults (mean (SD) age: 81.4 (3.5) years, 18 women) walked at self-selected speed over the 15-middle metres of a 20 m-long unobstructed walkway. Participants performed three walking trials in each of four dual-task conditions presented in a block-randomised order. The four different cognitive tasks (2 types, 2 levels of difficulty) were delivered during the walking trials via a headphone set: (i) easy arithmetic; (ii) difficult arithmetic; (iii) easy VS; (iv) difficult VS. Temporo-spatial, variability (coefficient of variation of step time) and stability (harmonic ratios) parameters of gait were computed from a triaxial accelerometer attached to the sacrum. To objectively quantify cognitive task difficulty, the proportion of correct answers across three 30s seated trials was computed for each cognitive task. Non-parametric statistics and repeated-measures ANOVA (task type and difficulty level as within-subjects factors) were used to analyse the proportion of correct answers and gait data, respectively. **RESULTS:** When seated, participants showed the same proportion of correct responses for the arithmetic and VS tasks at both levels of difficulty ( $p>0.05$ ) and they also performed better in the easy tasks compared with the difficult tasks ( $p<0.05$ ). Compared with the arithmetic tasks, the VS tasks led to an increase in step time variability ( $p=0.023$ ) and reductions in gait speed ( $p=0.005$ ), step length ( $p=0.010$ ), and anterior-posterior and medio-lateral harmonic ratios ( $p=0.010$  and  $p=0.009$ , respectively). The differences in step time variability and medio-lateral harmonic ratios between the VS and arithmetic tasks remained statistically significant after normalising for gait speed ( $p=0.007$ , for both). **DISCUSSION:** At equal levels of difficulty, compared with arithmetic tasks, VS cognitive tasks led to a more variable and less stable gait pattern that was not compensated for by slower speed. These findings suggest that the VS sketchpad [1] might be involved in the control of balance during gait and imply that tasks requiring VS attention during locomotion present an additional challenge to balance control, particularly in older adults. **REFERENCES:** 1. Kerr B et al. J Exp Psychol Hum Percept Perform. 1985;11(5):617-22. 2. Sturnieks DL et al. J Gerontol A Biol Sci Med Sci. 2008;63(10):1063-8.

**P2-N-233 Rule for scaling shoulder rotation angles while walking through apertures****Takahiro Higuchi<sup>1</sup>**<sup>1</sup>Tokyo Metropolitan University

**INTRODUCTION** When an individual is trying to fit into a narrow aperture, the amplitude of shoulder rotations in the yaw dimension is well proportioned to the relative aperture width to body width (referred to as the critical ratio value). Based on this fact, it is generally considered that the amplitudes of shoulder rotations are determined in response to this ratio value. The present study was designed to determine whether the amplitude of rotations would be determined on the basis of another rule in which a minimal spatial margin is created at the aperture passage; this rule is beneficial particularly when spatial requirements for passage (i.e., the minimum passable width) become wider than the body with an external object. **METHODS/RESULTS** Eight young participants walked through narrow apertures of three widths (ratio value = 0.9, 1.0, and 1.1) while holding one of three horizontal bars (short, 1.5 and 2.5 times the body width). The results showed that the amplitude of rotation angles became smaller for the respective ratio value as the bar increased in length. This was clearly inconsistent with the general hypothesis that predicted the same rotation angles for the same ratio value. Instead, the results were better explained with a new hypothesis which predicted that a smaller rotation



angle was sufficient to produce a constant spatial margin as the bar-length increased in length. **CONCLUSION** The results show that, at least under safe circumstances, the amplitudes of shoulder rotations were determined to ensure the minimal spatial margin being created at one side of the body at the time of crossing. This was new in that the aperture width subtracted from the width of the body (plus object) was taken into account for the visuomotor control of locomotion through apertures.

**P2-N-235 Increasing internal focus of attention increases body sway and decreases cortical activities during quiet standing in young healthy adults**

**Kozo Ueta<sup>1</sup>, Hideki Nakano<sup>1</sup>, Michihiro Osumi<sup>1</sup>, Shu Morioka<sup>1</sup>**

<sup>1</sup>Kio University

**BACKGROUND AND AIM:** Recently, the relationship between focus of attention and postural control has been gaining interest. However, its effect on postural control during quiet standing remains controversial. While cortical areas of the brain are believed to be involved in this process, there is little experimental evidence to back it up. Thus, the purpose of this study was to investigate the influence of internal focus of attention on body sway, with the hope of identifying relating cortical activities. **METHODS:** Seven healthy individuals (mean age, 21.5 years; 6 men) participated in this study. They were subjected to a variety of conditions while either in a sitting or standing position. Electroencephalographic (EEG) data were continuously recorded from 64 scalp electrodes. "Relax" and "Cognitive" conditions were applied during the sitting task, while "Relax," "Still," and "Dual" conditions were applied during the standing task. During the standing task, subjects were asked to quietly stand upon a Stabilometer ; the subject stood with their feet close together and with their eyes open. During the "Cognitive" and "Dual" conditions, they were instructed to memorize a number. After completion of each trial, the participants were asked to provide subjective ratings regarding their degree of attention focus and their degree of active involvement in controlling body sway. The ratings were made using a 7-point numerical rating scale (NRS; 1: 'completely uninvolved, not trying hard at all' ? 7: 'extremely involved, trying as hard as possible'). One-way repeated-measures ANOVA was used to compare the  $\alpha$  ERD/ERS and body sway during the 3 standing conditions, while Friedman tests were used to compare the NRS. Moreover, the relationship between NRS, body sway, and the alpha power density was assessed using Pearson and Spearman correlations. A p value of <0.05 was considered significant. **RESULTS:** The NRS increased significantly during the "Still" condition compared to the other conditions while standing ( $p < 0.05$ ). Sway path length and mean COP velocity increased significantly during the "Still" condition compared to the other conditions ( $p < 0.05$ ). The high-frequency  $\alpha$  ERD/ERS was higher in amplitude in the "Dual" condition compared to the other conditions at C5, and in the "Relax" and "Dual" conditions compared to the "Still" condition at C4 (ANOVA  $p < 0.05$ ; post hoc  $p < 0.10$ ). The NRS correlated with sway path length and mean COP velocity ( $p < 0.05$ ,  $r = 0.36$  and  $0.49$ , respectively) and with the high alpha power density at C4 ( $p < 0.01$ ,  $r = 0.46$ ). The high alpha power density at C4 correlated with sway path length and mean COP velocity ( $p < 0.01$ ,  $r = 0.39$ ). **CONCLUSIONS:** These results demonstrate that subjects displayed a more active involvement in controlling body sway while increasing their focus of attention. In addition, the results indicate the possibility that increasing internal

**P2-N-237 Self-Immersion and Visual Angle Impact Temporal Gait Characteristics during Treadmill Walking**

**Chun-Kai Huang<sup>1</sup>, Ka-Chun Siu<sup>1</sup>**

<sup>1</sup>University of Nebraska Medical Center

**Background** Visual information affects gait characteristics during treadmill walking. Individual's self-perceived motion information such as optic flow generated through virtual environment (VE) has been shown to alter the spatial gait patterns, but the effect of visual angle on gait measures has not been investigated. Subject's self-immersion of VE is commonly evaluated by the Presence questionnaire. However, how the self-immersion of VE affects physiological



response during walking such as energy consumption is unknown. Therefore, this study investigated how the subject's self-immersion and visual angle of VE influence the oxygen intake ( $VO_2$ ) and the changes of gait characteristics during treadmill walking. **Methods** Ten healthy young adults walked on a treadmill with a virtual corridor projected in front of them. All subjects walked five minutes at their self-selected pace for familiarization followed by given the Presence questionnaire. They then walked on treadmill for five minutes in two VEs by presenting a virtual corridor either horizontally at their eye's level or at six-degree upward tilted. Two-way ANOVA with repeated measure was applied with one within-subject (horizontal or titled VE) and one between-subject factor (low or high level of self-immersion of VE) on  $VO_2$  and gait measures. Presence questionnaire scored above 16 out of 21 was determined as a high level of self-immersion of VE. Multiple comparisons were applied using Bonferroni's adjustment. Pearson's correlation was adopted to examine the relationship between the level of self-immersion and  $VO_2$ . The alpha level was set as 0.05. **Results** Only eight adults were analyzed due to technical issue. No significant main effect of self-immersion was found on gait measures and  $VO_2$ , but significant main effect of VE was found on the coefficient of variation (CV) of double support time ( $F_{1,7} = 8.3$ ;  $p = 0.02$ ). The CV of double support time was higher when subject walked with the tilted VE. Self-immersion significantly interacted with the change of VE on step time ( $F_{1,7} = 6.37$ ;  $p = 0.04$ ). A moderate positive correlation with marginal significant ( $r = 0.64$ ,  $p = 0.06$ ) between self-immersed level and oxygen intake was shown in the horizontal VE condition. **Conclusions** The level of self-immersion of VE impacts temporal gait measures, but not energy consumption. It is likely that the level of self-immersion is positive correlated to oxygen intake, which can infer more immersed into the VE, more energy consumed in the subject during treadmill walking. More samples are warranted to confirm this speculation in the future. The significant effect of VE on temporal gait variability could imply an increase of instability during treadmill walking in the tilted VE. The visual angle should be taken into account in the future VE-related studies

## O - Modeling, robotics and biomechanics and implantable neuroprosthesis

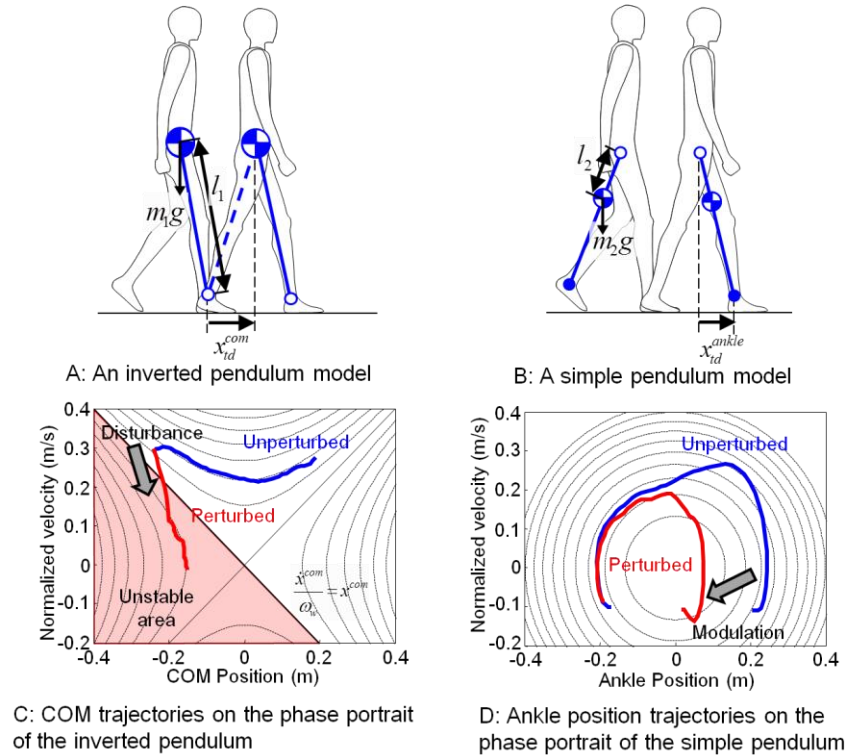
### P2-O-239 Coordination between the stance and swing leg in perturbed walking

**Takahiro Kagawa<sup>1</sup>, Yoji Uno<sup>1</sup>**

<sup>1</sup>Nagoya University

**BACKGROUND AND AIM:** A recovery of balance after a disturbance is crucial to maintain walking without falling. Reaction responses for backward balance losses have been investigated in previous studies. A common feature of the responses is a bilateral compensation for the stance and swing legs. In this study, we analyze the coordinated relationship between the stance leg exposed to the perturbation directly and the unperturbed swing leg using simplified walking models. **METHODS:** We hypothesize that the motion of the unperturbed swing leg is modulated so that a condition of backward balance is satisfied in the subsequent step and efficient recovery steps are performed. The condition of backward balance can be represented by a simple relationship using a linear inverted pendulum that simplifies the dynamics of the body center of mass supported by the stance leg. In addition, the movements of swing leg are analyzed by a simple pendulum model. According to the phase portraits of the inverted pendulum model and the simple pendulum model, an appropriate foot placement of swing leg depends on the position and velocity of body center of mass at toe-off, which is crucial to avoid backward falling and to recovery in efficient ways. Kinematics data while recovering for slip-related perturbations were analyzed on the phase portraits. **RESULTS:** The trajectories of swing leg corresponded to the perturbed COM trajectories. The modulated swing trajectories resulted in the appropriate foot placements and satisfied the condition for backward balance after the perturbations. Then, in the subsequent step, the COM trajectories moved along the ballistic trajectories of the inverted pendulum model. **CONCLUSIONS:** From these

results, we conclude that the recovery motion of swing leg is modulated to satisfy the condition of backward balance and to perform the subsequent steps efficiently



## P2-O-241 Adjustment of the angle of attack during human walking on sloped surfaces

Kei Tsunoda<sup>1</sup>, Naomichi Ogihara<sup>1</sup>

<sup>1</sup>Keio University

**BACKGROUND AND AIM:** Humans can walk on different slopes without tumbling by coordinated control of the complex musculoskeletal system. A simple spring-mass model of bipedal walking suggests that a proper adjustment of the angle of attack (defined as the angle between the limb axis and the horizontal line) is important for generation of stable walking. However, how humans adjust the angle of attack during walking on sloped surfaces remains unclear. In the present study, therefore, we kinematically investigated human slope walking to gain insights on adjustment of the angle of attack in uphill and downhill walking. **METHODS:** Five adult male participants were asked to walk on a treadmill at 4 km/h (1.1 m/s) at five grades (-9°, -6°, 0°, 6°, 9°), each for 4 minutes. This speed was declared to be comfortable for walking with all the participants. A total of 12 reflexive markers were attached to joints of the participants and the changes in the marker positions were measured using an eight camera motion capture system. The sagittally-projected joint angles of the hip, knee and ankle and the trunk angle with respect to the inertial coordinate system were calculated from the 3D positions of the markers. Furthermore, the angle of attack was calculated for each gait cycle. The limb axis, the axis connecting the center of mass (COM) of the body and the heel, was computed at every heel contact to calculate the angle of attack. The location of the COM was estimated based on the measured segment positions and published mass and COM fractions for each segment. **RESULTS AND CONCLUSIONS:** Our results showed that the angle of attack decreased in uphill walking and increased in downhill walking, respectively, as compared with level walking, demonstrating that the angle of attack was properly adjusted in human walking to adapt to the changes in the slope angle. We also noticed that variability of the angle of attack was very small during walking for each of the participants and for each of the slope conditions, possibly indicating that the angle of attack was actively controlled to certain

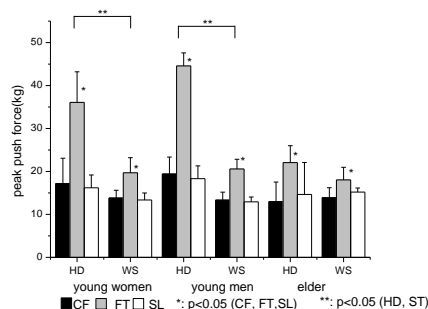
appropriate angles in human walking, in order to exploit a self-stability mechanism emerged due to the mechanical interaction between the body and the ground.

## P2-O-243 Motion analysis of hydraulic leg press machine for elder people

**Shu-Zon Lou<sup>1</sup>, Chiun-Ling Chen<sup>1</sup>, Jin-San Ho<sup>2</sup>, Ya-Yuan you<sup>3</sup>, Yu-Chi Chen<sup>4</sup>**

<sup>1</sup>Chung Shan Medical University, <sup>2</sup>National Taiwan Sport University, <sup>3</sup>I-Shou University, <sup>4</sup>China Medical University

**BACKGROUND AND AIM:** The leg press machine is built for training the lower extremity by simulating the crouch or squats. Compared these two movement, the leg press machine can be more efficiency in training muscle by adjustable loads control, but the personal trainer beside is needed for preventing the uncorrected posture or unsuitable external force that can damage the musculoskeletal system. Even though the resistant system progresses soon, the leg machine is designed for young healthy people. For the elder people, easy use, low force and high resistant force while occurring unsteadily, are main concerned. The hydraulic leg press machine seems to be suitable for these considerations. The aim of this study is to investigate effects of two types of leg press machines for elder people using motion analysis system. **METHODS:**Ten young healthy men and women, and ten elder with an average age of are recruited As many as 15 physically healthy male subjects with an average age of 24.2 (2.1), 23.6 (2.3) and 69.3 (3.2) year, an average height of 173.9 (2.72), 163.1 (5.42) and 160.4 (8.75) cm, and an average weight of 66.8 (7.39), 53.3 (5.5) and 56.8 (9.4) kg were studied. Each subject was asked to perform two different resistant types of leg machine, weight stack (WS) and hydraulic (HD) (fig 1), and three types of push speed, comfortable (CF), fast (FT) and slow (SL) (4 seconds). The Vicon Motion System (Vicon 460, Oxford, UK) with six 120 Hz cameras and four uniaxial load cells installed on foot-plate (Transducer Techniques, MLP200) with 1080Hz was used to measure relative joint positions and push force. The resistant force was adjusted to the same while knee was in full extension. The kinematics and push force were calculated and analyzed using laboratory-developed motion analysis procedures **RESULTS:**There is significant difference of peak push forces for young men, women and the elder between FT and SL but between CF and SL. The ratio of peak forces of FT to SL at hydraulic leg press machine for young men, women and the elder is 2.2, 2.4 and 1.5 respectively, and that at weight stack leg press machine is 1.47, 1.59 and 1.18 . There is significant difference peak push force between HD and WS for young men and women, but for elder people. **CONCLUSIONS:**The peak push force is significantly affected by types of leg press machine and push speeds, but the influence on young men and young women are higher than that on the elder.



Mean and SD of peak push forces at two types of leg press machine and three types of push speed

## P2-O-245 Effects of weight bearing on the kinematic change of the mid and hind foot

**Yasuhiko Hatanaka<sup>1</sup>, Takaaki Nakamata<sup>1</sup>, Koichi Saito<sup>1</sup>**

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**INTRODUCTION:** Knowledge of the foot kinematics is helpful for the analysis of pathological gait, understanding of the foot deformity mechanisms (i.e. hallux valgus) and development of the orthotics and shoes. But it is still not clear because of technical difficulties. Generally speaking, the role of the medial vault of the foot for distribution of body weight is well known. But we also know the motions of the foot joints are complicated and three dimensional. The aim of this study is to clarify the influence of the weight bearing on the three dimensional movement of the mid and hind foot. We also focused on the individual variation of the normal foot kinematics. In our previous studies, the individual variations in the movement of the mid and hind foot were greater than those of the movement themselves. We proposed that healthy subjects should be divided into three groups (high arched foot, normal foot and flat arched foot) according to Murley's method. Using this method, we could exclude the high and flat arched foot, and we could find the effects of the weight bearing on the kinematic change of the normal foot. **METHODS:** Twenty healthy male volunteers were included in this study. At first, we exclude the high and flat arched foot; Arch index was calculated using foot pressure measurement system (Nitta: Fscan), and normalized Navicular height was measured. Thus, we selected eleven normal foot subjects. An optoelectric motion capture system with ten infrared cameras (VICON612) and a ground reaction force platform (AMTI: OR6-6) were employed. Six [mm] diameter infrared reflective markers were attached on the eight bony landmarks of the right foot. Spatial coordinates of markers and ground reaction force were measured in the sitting position with additional weight (90 [kg]) on the knee. Then, antero-postero length of medial and lateral vault, navicular height, cuboid height, medial-lateral length of transverse arch, and the angle of Calcaneus (roll, pitch and yaw) were calculated. The data with no additional weight compared with those with 120 % weight bearing, which were analyzed statistically by paired t test, and the criterion for statistical significance was the 0.05 level. The university ethic committee approved the experimental protocol. All subjects signed the consent form before experiment. **RESULTS:** By weight bearing, the height of navicular and cuboid came down, but the change of the medial and lateral vault length were not significant. The change of the medial-lateral length of transverse arch was slight. Every markers but calcaneal tuberosity moved medially. Roll angle of Calcaneus was greater than those of pitch and yaw. **CONCLUSIONS:** In general, vertical loading to talus distribute to Calcaneus, medial and lateral vaults, then medial, lateral and transverse vault spread to absorb the impact. However the calcaneal movement and pronation of the hind foot were more distinct than the spreading of the vault in our experiment.

**P2-O-247 Pennation angles of ankle dorsiflexor and plantarflexor muscles depending on the muscle contraction intensity and ankle angles.**

**Seunghyeon Kim<sup>1</sup>, Jongsang Son<sup>1</sup>, Youngho Kim<sup>1</sup>**

<sup>1</sup>Yonsei University

**BACKGROUND AND AIM:** Determining muscle strength can be useful in understanding human body movement and normal and pathological locomotion. It is important for biomechanical engineers to understand the characteristics of the human neuromusculoskeletal system interface. However, there is currently no method for measuring individual muscle forces, and thus indirect methods which estimate muscle forces in vivo are used. The EMG-driven Hill model is one such way of estimating individual muscle forces and joint moments. The pennation angle varies with muscle contraction intensity (MCI), and has often been obtained via direct anatomical inspection of cadaveric specimens. However, values obtained from cadaveric specimens do not represent in vivo conditions and may be underestimated due to postmortem architectural changes. Real-time ultrasonography enables in vivo muscle scanning and offers promise as means of realistic determination of changes in muscle architecture. The purpose of this study was to determine in vivo pennation angles in the major ankle muscles tibialis anterior (TA), gastrocnemius medialis (GCM), gastrocnemius lateralis (GCL) and soleus (SOL) during isometric ankle dorsiflexion and plantarflexion. **METHODS:** Ten adult subjects with no history of musculoskeletal injury participated in this study. The ankle joint was fixed at 15° dorsiflexion (-15°) and 0°, 15° and 30°

plantarflexion. For each condition, the subject was required to perform 0, 30, 70 and 100% of their maximum voluntary isometric plantar and dorsiflexion. To measure the pennation angle of major ankle muscles, longitudinal sonography images were taken with a real-time ultrasonic apparatus. RESULTS: For all four major ankle muscles, TA, GCM, GCL and SOL, pennation angles increased with increases in MCI. In general, significant differences were found between 0 and 70% MVC and between 0 and 100% MVC ( $p < 0.05$ ). However, in most conditions, no significant difference was found between 70 and 100% MVC. The pennation angle of TA decreased as a result of on ankle angle plantarflexion, while the pennation angles of GCM, GCL and SOL increased. Significant differences were found between 0° and 15° dorsiflexion and between 15° plantarflexion and 15° dorsiflexion ( $p < 0.05$ ). CONCLUSIONS: In the existing muscle model, the pennation angle depends only on the fiber length under the assumption that muscle thickness is constant. However, the pennation angle would be a function of joint angle as well as MCI, since muscle thickness changes according to MCI. The main finding of the present study was that the pennation angle of major ankle muscles changed depending on MCI and ankle angles. This study suggests that it is necessary to measure pennation angle at different intensity of contraction and ankle angles to develop a more realistic muscle model. ACKNOWLEDGMENTS: This research was financially supported by MKE and KIAT through RDRI (70011192), and ISTDP (10032055) funded by the MKE.

#### **P2-O-249 Effects of an objective function on adjustment of muscle model parameters**

**Jongsang Son<sup>1</sup>, Seunghyeon Kim<sup>1</sup>, Youngho Kim<sup>1</sup>**

<sup>1</sup>Yonsei University

BACKGROUND AND AIM: Many researchers have tried to develop a subject-specific model which can predict well matched joint moments to measured moments. The general approach is to find model parameters related to individual differences with numerically minimizing the variance of the modeled and the measured moments, and its performance has been reported to be good. The lower value of the variance, however, might not always mean that the model predicted reliable muscle forces, since the combination of incorrect muscle forces could decrease the variance. This means that the general objective function is not sufficient to estimate reasonable muscle forces. The purpose of this study was to develop a new objective function which is proper to predict the well matched joint moments to the measured moments with the combination of reliable muscle forces. METHODS: The anatomical model was developed using the Stanford VA Upper Limb Model, which includes an elbow joint with six muscles, biceps brachii long head (BIClong), biceps brachii short head (BICshort), brachioradialis (BRD), triceps brachii lateralis (TRIlal), triceps brachii long head (TRIlong), and triceps brachii medialis (TRImed). The length and the moment arm of each muscle were determined from the anatomical model, and then the outputs were imported into our subject-specific model. The goal of the existing objective function (EOF) was to minimize the variance of the modeled and the measured joint moments. The new objective function (NOF) was designed to strengthen the linear relationship of (1) the modeled and the measured joint moments, and (2) the muscle activations and their corresponding muscle forces. One subject participated with the informed consent prior to commencing the experimental trials. During 30°/s isokinetic contraction, the moment and the angle of the elbow joint were acquired through Biodex System 3 Pro, and EMG data were simultaneously recorded at 1 kHz. BICshort and TRImed were assumed to have the same activation as the BIClong and TRIlong, respectively. RESULTS: Even though the modeled joint moments with EOF were well matched to the measured joint moments, it resulted from the combination of odd muscle forces, especially BIClong, BICshort, and TRIlong. However, the modeled joint moments with NOF were estimated from better combination of reliable muscle forces than with EOF. CONCLUSIONS: This study provided a promising result, implying that the developed objective function could potentially be used to estimate reliable muscle forces. In the future, this approach will be applied to a research to determine the reliability of muscle forces and to understand mechanisms from the reliable muscle forces. ACKNOWLEDGMENTS: This research was financially supported by MKE and KIAT through RDRI (70011192), and ISTDP (10032055) funded by the MKE.

**P2-O-251 A differential games approach to study spatial navigation in the presence of dynamic obstacles****Anuja Darekar<sup>1</sup>, Valery Goussev<sup>2</sup>, Bradford McFadyen<sup>3</sup>, Anouk Lamontagne<sup>1</sup>, Joyce Fung<sup>1</sup>**<sup>1</sup>McGill University, <sup>2</sup>Feil & Oberfeld CRIR Research Center, Jewish Rehabilitation Hospital, <sup>3</sup>Université Laval

**BACKGROUND AND AIM:** Spatial navigation in the presence of dynamic obstacles involves maintaining adequate clearance to avoid collisions while navigating towards a target. This can be influenced by personal space (PS: protective space around the body that guides clearance from the obstacle) and target position. Future clearance from the obstacle can be predicted using linear predictive properties and compared with PS to maintain safe clearance. The dynamic interaction between a moving person and a moving obstacle can be expressed using the classical differential games approach, specifically the "guard-evader" game whereby the guard or pursuer (obstacle) attempts to block the evader (subject) from reaching the target by affecting a collision. The purpose of this study is to investigate obstacle avoidance strategies in healthy and post stroke individuals using the differential game approach. **METHODS:** Linear predictive properties of clearance and a mathematical model based on differential games were developed using experimental data from 7 healthy subjects (age:  $18.25 \pm 0.46$  years) who walked in a virtual room towards a target placed 7 m from the initial position while avoiding collisions with obstacles that approached from 30° left or the right. Further, the model was used to evaluate data from 3 subjects post-stroke (age:  $54 \pm 7.21$  years; one year post-stroke) who walked in similar experimental conditions. **RESULTS:** An estimated minimal clearance from the obstacle at the intersection point of the subject-obstacle trajectory was first computed by the model. This estimated clearance was maintained constant by all subjects at about 2 m corresponding to the period between onset of obstacle motion and actual crossing of obstacle trajectory. Both the model and the behavioural data suggest that all subjects maintain similar intended clearance distances from the obstacle. The dynamic interaction between evader and pursuer described using the differential games model gives an optimal solution, ie. a locomotor strategy, expressed as a functional, which was influenced by the length of the trajectory towards the target, the weighted sum of inversed distances between the subject and the obstacle and the weighted sum of squared distances to the target. Further, it was observed that in all subjects, locomotor strategies were shaped by a combined influence of the obstacle and the target (with larger weight assigned to the obstacle) until a collision was successfully avoided, after which navigation was influenced only by the target. However, the weight assigned to the obstacle relative to the target during the avoidance was greater in the post-stroke subjects as compared to healthy individuals. Post-stroke subjects may employ increased caution in avoiding a moving obstacle for fear of collision. **CONCLUSIONS:** Both linear predictive properties and a differential game model can determine optimal locomotor circumvention strategies in the presence of moving obstacles.

**P2-O-253 Testing the natural-synergy control concept on a human-inspired biped robot****Georg Hettich<sup>1</sup>, Alexey Alexandrov<sup>2</sup>, Alexander Frolov<sup>2</sup>, Thomas Mergner<sup>1</sup>**<sup>1</sup>University Freiburg, <sup>2</sup>Inst. of Higher Nervous Activity and Neurophysiology

**BACKGROUND AND AIM:** Recent posture control research allowed several laboratories to mathematically model human reactive balancing responses to external disturbances such as support surface rotation or translation. However, there exist considerable differences among the models. Alexandrov and Frolov developed a 'natural synergies' concept for combining ankle and hip controls, where the neural interactions between the controls are thought to occur at the level of the controllers [1]. In contrast, the Freiburg group presented a model in which the interactions occur at the level of the sensory estimations of the external disturbances [2]. The latter group involved in their model simulation approach a human-inspired biped stance robot, which puts the model on a real world testing bench where it is facing 'complications' such as noise, inaccurate sensor signals, etc. The robot is meant as a testing bench that is open also to other researchers who want to test their stance control models. This led to the following implementation and simulation of the 'natural synergies' concept on the robot. **METHODS:** The 'natural synergies' concept was implemented in

Simulink/Matlab. The robot, called PostuRob II, is constructed with human-like anthropometric parameters for testing in the sagittal plane (see [2]). Its body consists of trunk, legs, and feet, interconnected by 'hip' and 'ankle' hinged joints (2 DOF). Signals from human-inspired mechatronic vestibular, joint angle, and joint torque sensor components are input to, and signals for the actuator control (pneumatic 'muscles') are output from a real time PC. There, the control model is executed as a compiled Simulink model. The robot is freely standing on a motion platform and the same experimental procedures as in the human subjects are applied, which include support surface rotations, translations, pushes against trunk or legs, and combinations thereof. RESULTS: After some adjustments of the 'natural synergies' model, PostuRob II was able to stand on the human motion platform and to balance the external disturbances, as well as to perform trunk and leg movements in response to the control signals for each synergy. This allowed us to measure and calculate joint angle and joint torque responses to the stimuli. These responses were small, demonstrating an almost ideal disturbance compensation. Post hoc comparison with corresponding human data revealed that the control needs to be modified somewhat to become more human-like compliant. CONCLUSION: We showed that PostuRob II represents a valuable simulation tool in this field of research, in that it makes the simulations more realistic and allows comparisons between model and human subjects within the same experimental testbed. (Acknowledgement - Grant RFBR 12-04-01718) [1] A.V. Alexandrov and A.A. Frolov, Biological Cybernetics 104: 425-438, 2011. [2] See Hettich et al. 2011 on [www.posturob.uniklinik-freiburg.de](http://www.posturob.uniklinik-freiburg.de)

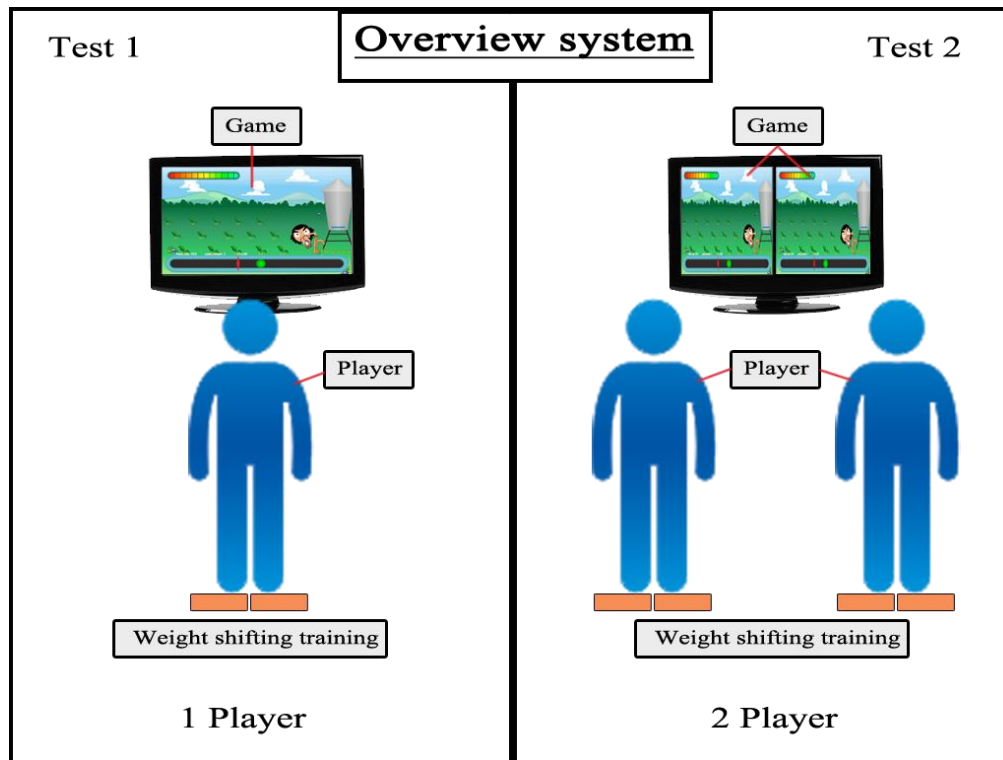
## **P - Habilitation and rehabilitation; Cognitive, attentional and emotional influences**

### **P2-P -255 Interpersonal Computer Game Enhance Performance and Motivation of Chronic Stroke Patients to Practice Balance Skill**

**Sanandunk Koonsiripiboon<sup>1</sup>, Prakarnkiat Youngkong<sup>1</sup>**

<sup>1</sup>King Mongkut's University of Technology Thonburi,

BACKGROUND AND AIM: Impaired balance, and walking ability are related to falling. Training can improve balance function, and motivation for training can be improved by social interactions. In this study, we aim to see if an interactive competition would enhance performance and efforts of elderly persons with balance problem or stroke patients who take part in a weight shifting training on a set of force sensor embedded mats in combination with custom designed games. Objective of the game is to quickly shift body weight on to left and right foot alternatively and continuously as fast as possible. Only the repetition which more than 80 % of weight would effects the score in the game. METHODS: Each player plays the game once alone, trying to maximize his or her score. In another attempt, the players play exactly the same game, but against other players. In this interactive situation, each player sees the score of oneself and also their opponents and must try to earn a higher score than the other player. An average frequency of the valid weight shifting, and an average magnitude of weight shifting of 10 elderly people and stroke patients with balance problem were calculated. A paired T- test showed significant difference between the two exercising situations. RESULTS: Interpersonal interaction increases motivation and performance during computer assisted balance training exercises. CONCLUSIONS: Further study should evaluate long-term effects of interpersonal game on training outcome.



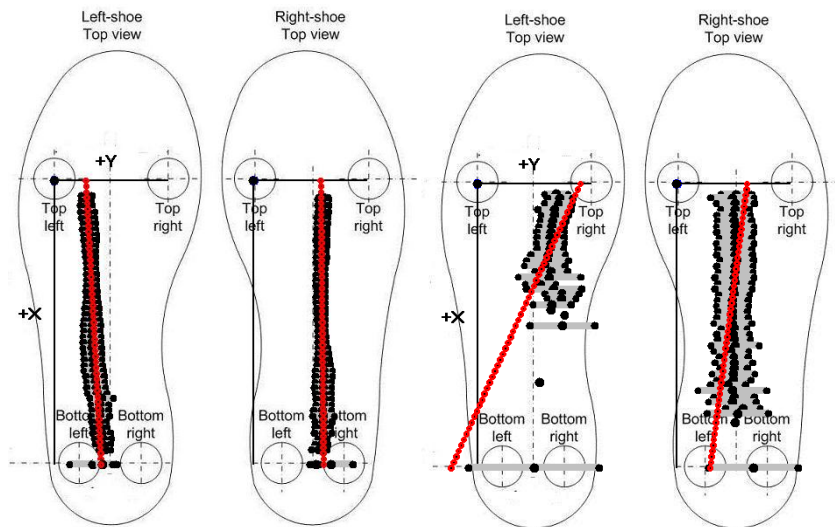
**P2-P -257 Training to walk amid uncertainty with Re-Step: measurements and changes with perturbation training for hemiparesis and cerebral palsy**

**Simona Bar-Haim**<sup>1</sup>

<sup>1</sup>Ben-Gurion University

Training to walk amid uncertainty with Re-Step?: measurements and changes with perturbation training for hemiparesis and cerebral palsy Simona Bar-Haim, Netta Harries, Yeshayahu Hutzler, Mark Belokopytov, Igor Dobrov Human Motion Analysis Laboratory, Assaf-Harofeh Medical Center, Zerifin, Israel Purpose: To describe Re-Step?, a novel mechatronic shoe system that measures center of pressure (COP) gait parameters and complexity of COP dispersion while walking, and to demonstrate these measurements in healthy controls and individuals with hemiparesis and cerebral palsy before and after perturbation training. Method: The Re-Step? was used to induce programmed chaotic perturbations to the feet while walking for 30 min for 36 sessions over 12-weeks of training in two subjects with hemiparesis and two with cerebral palsy. Results: Baseline measurements of complexity indices (fractal dimension and approximate entropy) tended to be higher in controls than in those with disabilities, while COP variability, mean and variability of step time and COP dispersion were lower(Fig.1). After training the disabled subjects these measurement values tended towards those of the controls, along with a decrease in double support time, 10 m walk time, average step time and the percentage of double support and increased Berg balance score. Conclusions: This pilot trial reveals the feasibility and applicability of this unique measurement and perturbation system for evaluating functional disabilities and changes with interventions to improve walking.





**Figure 1.** Prints of COP dispersion charted for a healthy control subject C while walking.

(left) (Note the linear pattern of the COP trajectory and low COP dispersion in both feet)

Prints of COP dispersion charted for subject G with diplegic CP while walking.

## P2-P -259 High muscle tone increases ipsilateral cortical excitability in healthy subjects

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<sup>1</sup>Daisen Rehabilitation Hospital, <sup>2</sup>Yamaguchi University

**BACKGROUND AND AIM:** We often observed the hemiplegic patients who showed continuous hyper muscle tone (hypertonia) in an unaffected side. This may express as a functional compensation of the affected side, and such compensatory physical response seems to be an impediment of the functional recovery. In this study, we investigated the effect of the weight load that mimics hyper muscle tone to the ipsilateral cortical activity in healthy subjects.

**METHODS:** Fourteen (mean body weight:  $61.6 \pm 13.0$  kg) right handed healthy subjects participated in this study after giving informed consent. Subjects were seated comfortably and lifted weight load of 10% of body weight upward by the right upper limb to make high muscle tone (weight task). No weight condition was control non-weight task. The contralateral left upper limb was on the table. First, we recorded motor evoked potentials (MEP) and motor threshold (MT) from left hand flexor carpi radialis (FCR) during "weight" and "non-weight" tasks. We then recorded H-reflex elicited by magnetic stimulation to the left median nerve to estimate the changes in the spinal motoneuronal excitability. To estimate functional effect (dexterity) during high muscle tone, subjects performed "purdue pegboard test" consisting of the examination of 30 seconds (peg-30) and an assembly examination of 60 seconds (peg-assembly). The left hand grip power was also measured and the power ratio (grip power / body weight) was calculated. Averaged values of each variable were submitted to paired t-test or Wilcoxon signed-rank test. The significant level was set at  $P < 0.05$ .

**RESULTS:** MEP amplitude increased significantly ( $P < 0.01$ ), and MT decreased significantly ( $P < 0.01$ ) in "weight" task. H-reflex were elicited in eight of fourteen subjects, however, there was no significant difference in its amplitude between the tasks ( $P = 0.95$ ). Although there was no significant difference between "weight" and "non-weight" task in

peg-30, peg-assembly decreased significantly ( $P < 0.001$ ) in "weight" task. The power ratio increased significantly in the "weight" task ( $P < 0.05$ ). **CONCLUSIONS:** The increased MEP amplitude, decreased MT and unchanged H reflex amplitude observed in the contralateral limb may be the results of increased ipsilateral motor cortical but not spinal motoneuronal excitability. The mimicked high muscle tone increased ipsilateral motor cortical activity and this excitability might be an impediment of the functional recovery in the paralyzed side. The lowered dexterity and increased power grip may support these hypotheses.

**P2-P -261 The effect of the biomechanical technique of gait correction for patients with central hemiparesis syndrome after stroke**

**Maria Abroskina<sup>1</sup>, Semen Prokopenko<sup>1</sup>, Vitaliy Lytnev<sup>1</sup>, Vera Ondar<sup>1</sup>, Elvira Gasymly<sup>1</sup>**

<sup>1</sup>Krasnoyarsk State Medical University

**BACKGROUND AND AIM:** 80% of patients underwent stroke have gait disorders that lead to decreased quality of life. The aim of our research is to create and evaluate the effectiveness of gait recovery biomechanical technique for the patients with central hemiparesis syndrome during recovery post-stroke period. **METHODS:** 20 patients with medium central hemiparesis syndrome during recovery post-stroke period were included into investigation. Treatment included only standard drug therapy and the suggested technique of gait correction. Patients wearied feet platforms based on springs during the treatment session. The task of exercises was to restore the stereotype of walk through mechanical stimulation a back impulse of foot. For assessment these technique we used the neurological status assessment, objective evaluation of balance by Computer Stabilometry (CS), objective evaluation of gait by method with the help of a laser range finder, balance clinical function - by Berg Balance Scale, walking function - by Dynamic Gait Index. **RESULTS:** Patients had significant improvement by the CS, method with the help of a laser range finder, functional scales (Wilcoxon nonparametric test:  $p < 0,05$ ) after the course of treatment. **CONCLUSIONS:** The suggested technique, to our mind, lets enhance patient's stability while walking, decreases the risk of falls during walking, and helps to create a new movement stereotype. The technique can be used as a part of the recovery comprehensive treatment of patients with central hemiparesis syndrome during recovery post-stroke period.

**P2-P -263 Effect of Transcranial Direct Current Stimulation (tDCS) on Protective Stepping Response in Parkinson's Disease**

**Pei-Yun Lee<sup>1</sup>, Kris Gadareh<sup>1</sup>, Adolfo Bronstein<sup>1</sup>**

<sup>1</sup>Imperial College London

**BACKGROUND AND AIM:** Falling is a major issue in Parkinson's disease (PD) patients, which responds less to medication. As transcranial direct current stimulation (tDCS) has shown positive results on motor recovery in stroke patients we examine here whether tDCS improves motor performance in PD patients as well. The purpose of the study is to examine the effect of tDCS, combined with exercise training, on protective stepping response in PD patients. **METHODS:** Seventeen moderate to severe idiopathic PD patients (mean age 66 years, Hoehn-Yahr scale 2-3) were recruited into the study. All participants received both real and sham tDCS conditions on the primary motor cortex for 15 minutes on separate days (at least five days apart to avoid carry-over effects) during exercise training. Before and after the intervention, subjects were instructed to stand on a platform which moves randomly forward and backward, thus requiring a protective step to maintain balance. Reaction time, step length, and angular velocity of the protective step were then measured. Number of steps taken during the perturbation was also recorded. Number of steps taken during the perturbation was also recorded. **RESULTS:** Forward and backward step length significantly increased after exercise training in both real and sham tDCS conditions ( $p = 0.007$ ). The number of steps taken during the perturbation was significantly decreased after exercise training ( $p = 0.041$ ). Step reaction time and angular velocity of the protective step

were unchanged. No additional effect on stepping response was found after tDCS. **CONCLUSIONS:** Exercise training exhibited an immediate effect on increasing the length of both forward and backward steps and decreasing the number of steps taken during the perturbation in PD. tDCS of the motor cortex did not show additional effect on performance of the stepping response. The lack of immediate efficacy of tDCS could be due to single and short intervention session, complexity of the task, or the motor fluctuations in PD. The effect of repetitive sessions or longer duration stimulation may require further investigation.

**P2-P -265 Attitudes and adherence to home-based dual task gait training using MP3 players in PD patients**

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<sup>1</sup>KULeuven, <sup>2</sup>Radboud University

**Background:** Dual task training (DT) is an evolving area in PD. MP3 devices lend themselves for at-home DT training. **Objective:** To investigate the feasibility of a personalized at home training program, aimed at improving gait and cognition, using MP3 players to deliver cognitive exercise during walking as part of the DUALITY trial. **Methods:** 16 PD patients (H&Y 1-3; age 68.06 CI95% 64.09 - 72.03) participated in a six-week DT training program at home. The program consisted of two exercise sessions supervised by a physiotherapist and two non-supervised sessions each week. Both gait and cognitive exercises were applied, either in a consecutive or an integrated way. After each supervised session cognitive exercises were put on a standard user-friendly MP3 player allowing patients to exercise independently. Patients' therapy adherence and attitudes towards the program were examined using questionnaires and a fall telephone call was conducted each week. We are reporting the unblinded results of patients' perspectives on such training. **Results:** All 16 patients were retained in the training program. The mean participation rate of the supervised and non-supervised sessions were respectively 97.4% (CI95% 94.7 - 100.1) and 87.5 % (CI 95% 78.5 - 96.5) (p=0.26). All participants were able to use the MP3 players. However, 3 patients experienced difficulties with the size of the on/off switch. All patients felt safe to practice without supervision and no falls were reported during practice. Most patients (15/16) reported to be motivated to practice independently when regularly supervised. 12 of the patients (75%) were interested in continuing the cognitive exercises after finishing the program. **Conclusion:** Patients with PD are able to practice safely with a simple electronic devices and show positive attitudes towards the use of cognitive exercises as part of a DT training program.

**P2-P -267 Gait abnormalities after stroke: beyond the hemiparesis**

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<sup>1</sup>Treatment and Rehabilitation Center

**BACKGROUND AND AIM:** Mobility is an important goal in post-stroke rehabilitation. However, the exact targets for rehabilitative interventions are not determined. **Aim of the study:** to determine biomechanics abnormalities leading to reduced mobility after stroke. **METHODS:** 30 post-stroke patients (26 male, 4 female aged 55.2±15.2 years) able to walk without assistance were recruited into the study. Examination included testing for muscle strength (6-grade paresis scale, mean 3.7±0.9), spasticity (Modified Ashworth Scale, mean 1.1±1.2), Rivermead Mobility Index (mean 11.8±2.9) and gait biomechanics measured by TRUST-M system with five sensors (sacrum, both hips, both chins) providing information on angles and accelerations. **RESULTS:** Beyond the hemiparesis grade and spasticity, the following predictors of Rivermead Mobility Index were identified: coxofemoral and knee walk range of motions at the paretic and also at non-paretic side, walk cycle asymmetry (time to second double support difference at paretic and non-paretic side). The discovered biomechanical abnormalities were relatively independent from paresis and spasticity grade (weak correlations). During ROC-analysis, the following cut-off values for a decrease of Rivermead Mobility Index below 13

were identified: paretic-side coxofemoral range below 32° (sensitivity 75%, specificity 86%, AUC=0.82), non-paretic-side coxofemoral range below 36° (sensitivity 68%, specificity 73%, AUC=0.88), paretic-side knee range below 44° (sensitivity 63%, specificity 79%, AUC=0.7), non-paretic-side knee range below 56° (sensitivity 63%, specificity 72%, AUC=0.72), time to second double support difference at paretic and non-paretic side modulus over 6% (sensitivity 57%, specificity 69%, AUC=0.63). CONCLUSIONS: Post-stroke decrease in mobility is caused not by hemiparesis per se but rather by a complex of biomechanical abnormalities. Thus, gait biomechanics should become a routine measure in rehabilitation.

**P2-P -269 A comparison of the kinematics and kinetics of overground walking and a functional mobility task in healthy subjects**

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**BACKGROUND AND AIM:**Task specific training is known to improve the walking ability of patients who have musculoskeletal disorders or who have suffered a stroke. An important aspect of therapies for improving walking ability is the use of functional mobility tasks (FMTs) that have features in common with overground walking (OGW). The purpose of this study was to identify similarities in both kinematics and kinetics between OGW and an FMT. **METHODS:**Twenty-two normal male volunteers who gave informed consent participated in this study. Each volunteer had spherical reflective markers (10 mm diameter) mounted on the left side of the following anatomical landmarks: the acromion, the greater trochanter, the lateral femoral epicondyle, the lateral malleolus, and the fifth metatarsal head. The OGW activity involved barefoot walking at a constant cadence. The FMT required the volunteer to adopt a left foot forward stance, with weight loaded onto the forward foot, and with both hip and knee extended. Each volunteer was monitored during 5 trials for both the OGW activity and the FMT. Two infrared cameras (MA-2000, Anima Co., Japan), sampling at 60 Hz, were used to record the movements of the volunteers. Ground reaction forces were recorded using a force plate (Anima Co., Japan) with sampling at 180 Hz. The motions of the hip, the knee and the ankle and each joint moment were calculated. Kinematic and kinetic data were low pass filtered with a 6 Hz cut-off frequency, and the averages for each parameter over five trials were calculated. Kinematic data were determined at four positions in the OGW activity, namely, initial contact (IC), the end of the loading response (LR), the end of the mid stance (MSt), and the end of the terminal stance (TSt). During the LR, MSt and TSt phases of the OGW activity and during the FMT, both maxima and minima of the kinetics parameters were obtained. We compared the kinematic and kinetic patterns of OGW and FMT for similarities in changes between each phase. Differences between each parameter in the three phases of OGW and FMT were analyzed using the Man-Wilcoxon test. **RESULTS:**Both the hip and the knee kinematic patterns during the FMT showed some similarity to those of the TSt phase of OGW. The ankle kinematic pattern during the FMT was similar to that in the MSt phase of OGW. However, there were significant differences in the three joint angles in the FMT compared to OGW. The three joint moment patterns of the FMT showed most similarity to the TSt phase of OGW. For the hip and knee joints, there were no significant differences between the maxima and minima of the parameters during the FMT and those during the TSt phase. **CONCLUSIONS:**The three joint moments of the TSt phase showed most similarity to those of the FMT. Therefore, it may be possible to treat problems during the TSt phase of OGW through training using the FMT we describe here.

**Q - Cognitive impairments; Aging**

**P2-Q-271 Cerebral correlates of gait impairment in mild cognitive impairment**

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**BACKGROUND AND AIM:** Over the last years abnormal gait has been recognized as an early and sensitive clinical feature of cognitive impairment. However, the pathophysiology of gait dysfunction in mild cognitive impairment (MCI) is not yet sufficiently understood. In the present study, we investigated the supraspinal locomotor network in patients with MCI in correlation to their gait performance. **METHODS:** Twelve patients with MCI and 12 age-matched healthy controls were included in the study. The neurocognitive status was tested by the CERAD-plus test. Gait was assessed using an electronic walkway under three different velocities and three dual-tasks conditions. All subjects underwent a [18F]-FDG-PET paradigm during single-task mean velocity real locomotion. **RESULTS:** Mean gait velocity was not significantly different between the groups under the single-task condition. By contrast, velocity decreased significantly under dual-task conditions in patients with MCI. In FDG-PET during locomotion, regional cerebral glucose metabolism (rCGM) was relatively increased in the dorsolateral prefrontal cortex and subthalamic nucleus bilaterally in the MCI group. Frontal cortex activation inversely correlated with gait performance during dual-task conditions. In the healthy control group rCGM during locomotion was relatively enhanced in hippocampus (right>left) and the superior vermis. **CONCLUSIONS:** The supraspinal locomotor control shows functional alterations already in mild cognitive impairment. For these patients a higher demand of prefrontal cortex activation is needed to maintain locomotion at single-task condition. Additional dual tasking during locomotion may induce decompensation of the gait pattern by requiring functional capacities of the frontal-basal-ganglia loops of motor and locomotor control.

#### **P2-Q-273 Effects of Dual-Task Training in Older Adults with Cognitive Impairment: A Case Series Study**

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<sup>1</sup>University of Nebraska Medical Center

**BACKGROUND AND AIM:** Several studies have found that dual-task (DT) training benefits healthy older adults. Although DT performance is worse for those with cognitive impairment (CI), DT training for this group is understudied. No DT training study has considered the effect of intensity. Based on motor learning theory, greater benefit with more difficult training is expected, but adults with CI may be incapable of DT training at high levels. Determining an ideal DT training intensity may help refining programs for older adults, particularly with CI. This case series examined the appropriateness of DT training with different intensities for adults with CI. **METHODS:** We recruited 5 individuals (mean age 72 years) with Mini Mental State Examination scores from 15 to 24. Two participants received an easy DT training program, and 3 received a hard one. Both consisted of 12 sessions over 4-6 weeks. Training included DT's with motor tasks constant between programs, while difficulty of cognitive tasks varied. Outcome measures were the Timed Up and Go and timed 6 m walk as single tasks (ST), and as 6 DT's by adding the following cognitive tasks to each: counting forward by 1's, counting backward by 3's, and carrying a cup of water. We compared pre- and post-training performance using dual task cost (DTC) calculated as follows:  $[(\text{Difference between DT and ST performance}) / \text{ST performance}] \times 100$ . **RESULTS:** Two of the 3 individuals who received the hard program showed reduced DTC on all 6 DT outcomes. One subject who received the hard program did not improve on any outcome. Individuals who received the easy program improved on only 2 and 3 outcomes, respectively, with less magnitude of improvement than those in the hard program. **CONCLUSION:** Change with training varied among participants and was somewhat related to training intensity. The better post-training performance shown by 2 individuals engaged in hard program suggests the training intensity was enough to produce positive change and did not exceed their capacity. Conversely, the lesser and variable results from those in easy training suggest that the training intensity was insufficient to yield consistent change. The individual who did not improve at all opposed the typical pattern of worse motor performance under DT conditions, making it difficult to see improvement with training. This individual's pre-training performance may signal some variability in people with CI, which could be

addressed with repeated measures. Also, we used only the MMSE to describe our participants' cognition. More specific information on this person's cognition may further explain his performance. In conclusion, the results of our case series suggest that older adults with CI could be trained at higher levels of intensity, a hypothesis that could be tested in a larger study.

**P2-Q-275 Association between performance on Timed Up and Go sub-tasks and Mild Cognitive Impairment: Further insights into the cognitive aspects of the TUG**

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**BACKGROUND AND AIMS:** The Timed Up and Go (TUG) was originally introduced as a test of mobility and fall risk that reflects motor impairments in older adults. A few studies that examined the time to complete the TUG suggested that it may also be related to cognitive abilities. The objective of the present study was threefold: 1) to investigate if the presence of MCI in older adults is associated with TUG time; 2) to evaluate if specific sub-tasks of the TUG are related to cognitive function; and 3) to identify which cognitive components are associated with performance on the TUG and its sub-tasks. **METHODS:** Data from 347 participants between the ages of 75-90 yrs ( $83.6 \pm 3.5$  yrs, 75% female) from the Rush Memory and Aging Project was analyzed. As part of their annual home testing, subjects performed two TUG trials while wearing a small, light-weight sensor on a belt. The sensor measures acceleration and angular velocity in 3 directions. Measures of overall TUG performance were derived from 4 different subtasks: transitions (sit-to-stand, stand-to-sit), walking, and turning. A series of logistic regression models were used to compare TUG sub-task performance in participants with no cognitive impairment (NCI) versus mild cognitive impairment (MCI). Global cognition and different cognitive abilities (e.g., working memory, visual spatial processing) were derived from 19 cognitive tests. **RESULTS:** 67 subjects were diagnosed as MCI. NCI and MCI did not differ in age, gender or years of education ( $p > 0.23$ ). Time to complete the TUG was not different (NCI:  $7.6 \pm 3.7$  sec vs. MCI:  $8.4 \pm 3.7$  sec;  $p = 0.12$ ), but TUG sub-task measures differed. Subjects with MCI had higher step frequency ( $13.49 \pm 5.43$  vs.  $12.13 \pm 5.00$ ;  $p = 0.05$ ), higher step irregularity (i.e., less consistency of gait) ( $0.50 \pm 0.12$  vs.  $0.45 \pm 0.13$   $g^2$ ;  $p = 0.01$ ), and limited AP translation of the COM when walking ( $0.45 \pm 0.25$  g vs.  $0.54 \pm 0.35$  g;  $p = 0.03$ ) as compared to NCI. Subjects with MCI also required more time to complete the turns ( $146.31 \pm 0.37$  vs.  $135.5 \pm 0.41$ ;  $p = 0.04$ ) and tended to have a higher pitch jerk during the transitions from sitting to standing ( $197.12 \pm 0.97$  deg/sec<sup>2</sup> vs.  $171.2 \pm 103.8$  deg/sec<sup>2</sup>;  $p = 0.06$ ), suggesting less consistency in getting up to standing. In a multivariate regression analysis, step regularity and pitch amplitude during sit-to-stand were identified as the main contributors to the observed group differences ( $p = 0.03$  and  $p = 0.04$  respectively). Interestingly, different cognitive abilities were associated with distinct TUG features: straight line walking with global cognition ( $p = 0.029$ ) and sit-to-stand transition with perceptual speed ( $p < 0.0001$ ). **CONCLUSIONS:** MCI is associated with impaired performance on TUG sub-tasks which cannot be identified when simply measuring the overall duration of TUG performance. Using a single body worn sensor to quantify gait performances may help to better understand and delineate the inter-relationship of late-life gait and cognitive impairments.

**P2-Q-277 Balance performance across three stages of cognitive impairment and Alzheimer's disease**

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**TITLE:** Balance performance across three stages of cognitive impairment and Alzheimer's disease. **BACKGROUND AND AIM:** Patients with Alzheimer's disease (AD) perform worse than healthy controls on global balance measures. Balance is often regarded as a complex construct with contribution of several underlying subsystems. Which of these systems that are affected in patients with AD, and at what stage of cognitive impairment is not examined. The aim of our study was to

explore differences in balance between patients with Subjective or Mild Cognitive Impairment (SCI/MCI), mild AD and moderate AD on both global performance as well as in the subsystems defined by the Balance Evaluation Systems Test (BESTest). METHODS: 175 patients were recruited from a memory clinic and through a local authority dementia team. Patients were included if they had probable SCI, MCI or AD, were home-dwelling and able to walk without walking device. The patients with AD were categorized with mild or moderate dementia based on the ICD-10 research criteria. Balance was evaluated with the BESTest, using the total score as a global measure and the scores for each of the six subsystems (Biomechanical constraints, Stability limits, Anticipatory postural adjustments, Postural responses, Sensory orientation and Stability in gait). Both total score and the subsystems are scored from 0-100, higher score indicates better performance. Two-way between groups ANOVAs with Bonferroni post hoc analyses were used to evaluate the differences between the three groups, and to check for the interaction with age. RESULTS: The total sample had a mean (SD) age of 72.4 (9.1) years, and 51.4 % were women. 34 had SCI or MCI (SCI/MCI), 99 had mild AD and 41 had moderate AD. There was no significant gender differences between the groups, but the group of moderate AD was older than the other groups ( $p < 0.001$ ). BESTest total scores, mean (SD), of the groups were; SCI/MCI 89.1 (6.6), mild AD 79.8 (11.4) and moderate AD 65.4 (12.4). Patients with mild AD performed worse than patients with SCI/MCI on total BESTest score and on 4 of 6 subsystems (Biomechanical constraints, Stability limits, Anticipatory postural adjustments and Stability in gait). Patients with moderate AD performed worse ( $p < 0.001$ ) than both the mild AD and the SCI/MCI group on all balance measures. For the total score, biomechanical constraints and anticipatory postural adjustments there was an interaction effect between age and the mild and moderate AD groups. CONCLUSIONS: In these independent walking patients with cognitive impairment we found that balance performances were worse in the group of moderate AD, however also mild AD differed negatively from the SCI/MCI group on most measures. Well aware of the limitations in the cross-sectional design of the study, we believe our findings indicate a decline in balance performance parallel to decline in cognitive function. These differences are enhanced by the impact of age on balance.

## **R - Development of posture and gait; Coordination of posture and gait**

### **P2-R-279 Visual Height Intolerance: Gaze Behavior at Upright Stance**

**Thomas Brandt<sup>1</sup>**

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**Introduction** Visual exposure to height generally causes instability (1). An epidemiological study (2) reports that height also evokes distress, called height intolerance; its prevalence is as high as 28%. According to the criteria of DSM-IV TR, the more severe acrophobia has a prevalence of about 4%. Do these divergent responses result from different strategies of visual exploration? We investigated gaze behavior during height exposure under natural conditions of locomotion and upright stance. **Methods** Eighteen participants with height intolerance and 19 without height intolerance were recruited from the German Alpine Association whose members participated in a survey on heights. The experiment took place on an escape balcony located on the 5th floor, i.e., 15 meters above ground level. The balcony had a thin balustrade providing safety while at the same time ensuring visual exposure to height. The participants stood upright looking into the vertical depth below for 30 seconds. They were instructed to stand close to the balustrade without touching it. In addition, participants had to perform a locomotion task (not investigated in the present work). The participants wore mobile binocular eye-tracking equipment with a head-fixed scene camera and integrated 6-degrees-of-freedom inertial sensors. In addition, locomotion and upright stance conditions were recorded with an external camera. **Results** During upright stance, visual exploration was spatially limited in the height intolerant group. In some height intolerant persons eye movements were restricted to horizontal exploration only; in extreme cases, gaze remained fixed most of the time.

Head movements were also reduced. The height intolerant persons moved their heads with a mean velocity of  $6^\circ/\text{s}$ , compared to  $11^\circ/\text{s}$  in the control group ( $p=0.003$ ). Conclusion The distress experienced by the height intolerant person affects oculomotor behavior and leads to less inspection of the surrounding environment. This can increase the risk of stumbling and ultimately of falling. Reduced head movements may imply tense muscles. Posturography should be used to quantify the impact of gaze behavior on body sway in height intolerant persons. References (1) Brandt, T., Arnold, F., Bles, W., & Kapteyn, T. S. (1980). The mechanism of physiological height vertigo. I. Theoretical approach and psychophysics. *Acta Oto-Laryngol* 89, 513-523. (2) Huppert, D., Grill, E., & Brandt, T. (2013). Down on heights? One in three has visual height intolerance. *J Neurol* 260, 597-604.

## **P2-R-281 Adjustments of the kinematic gait parameters during pregnancy**

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Pregnancy places a woman's body in a continual adaptive phase where hormonal and anatomical changes are constantly occurring. The purpose of this study was to examine adaptation of gait parameters during pregnancy and to evaluate gait in different physiological states. Kinematic data from 11 healthy women ( $29.2 \pm 3.5$  yrs) were collected during normal overground walking at a self-selected speed. Each woman participated in 3 sessions: before pregnancy (PRE state); during the last trimester of pregnancy (on average, after 33 weeks of gestation) (IN state); and half year after delivery (POST state). We analyzed only the trials performed at similar dynamically-equivalent walking speeds (Froude number 0.2-0.3). Spatio-temporal gait parameters and the mobility of the hip, pelvis and trunk were measured. No significant differences were found between the pregnant and non-pregnant conditions for general gait parameters (cadency, stride length, double support time) when comparing walking at the same Froude number. The percentage of mechanical energy recovery was also similar in all three states, though vertical oscillations of the center-of-mass in pregnancy were slightly smaller. Generally, the mobility of the pelvis and lower limb joints in the sagittal plane did not differ significantly. However, the 'stability' angle (related to the angular oscillation of the foot relative to the center-of-mass) slightly decreased. During gestation, the width of the base of support (measured as the distance between the ankles as well as between the fifth metatarso-phalangeal joints during the double support phase) increased. These observations suggest that pregnancy tends to provide maximally safe movements during walking.

## **P2-R-283 A functional approach to learning to walk: a longitudinal study**

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**BACKGROUND AND AIM:** In this research, learning to walk is approached from a functional point of view. To move forward, one must produce and control propulsive forces in order to create and tune a distance between the centre of mass (CoM) and the centre of pressure (CoP) along the antero-posterior axis. We hypothesize that learning to walk consists in learning to generate these propulsive forces to control such distance. **METHODS:** We present here a longitudinal study of six infants (3 girls, 3 boys) who participated in the experiment. Infants' gait was recorded weekly for the first 8 weeks after the onset of walking, and then biweekly until they had 14-16 weeks of walking experience. Walking kinematics were captured using two Northern Digital OPTOTRAK sensors (sampling at 60 Hz) and the propelling forces were recorded with a 40x60cm AMTI force plate. The OPTOTRAK and AMTI were synchronized. **RESULTS:** The results show that the distance between the CoM and the CoP along the antero-posterior axis increases during the first months of learning to walk, and that this increase is correlated with velocity. **CONCLUSIONS:** The very small values of (CoM-CoP) observed at onset of independent walking, coupled with a very small velocity are interpreted as the solution



adopted by the child to satisfy a compromise between the need to generate produce propulsive forces to move forward while simultaneously controlling the disequilibrium resulting from creating such distance between the CoP and CoM.

## **P2-R-285 Developmental change in variability of rolling over from supine to prone position in infants**

**Yoshio Kobayashi<sup>1</sup>, Hama Watanabe<sup>1</sup>, Gentaro Taga<sup>1</sup>**

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**BACKGROUND AND AIM:** Rolling over is a complex motion that requires coordination of movements of several body segments in a serial order, and variability of movement patterns can be generated by combinatorial diversity. Although classic studies have described the developmental processes of rolling over in infants, variability of the movement patterns is still not fully understood. The purpose of this study was to investigate developmental changes in the variability of rolling movement patterns with special emphasis on the serial order of limb movements in infants.

**METHODS:** Fifty-eight healthy infants including 30 younger infants (YI; 158-211 days old) and 28 older infants (OI; 249-297 days old) were enrolled in this study. Each infant was observed rolling over from supine to prone position 3 to 14 times. We measured displacement of markers on the trunk and on both wrists and ankles using a 3D motion capture system. We analyzed 448 movements. Depending on the direction of the rolling movements, the limbs were identified as ipsilateral arm (IA) and leg (IL) and contralateral arm (CA) and leg (CL). First, we determined the duration of rolling over using displacement of the trunk. We then identified the support limbs as those that maintained contact with the support surface. Next, we determined a time for the maximum velocity of each moving limb. Finally, the movement patterns of rolling over were classified on the basis of the number of support limb(s) and the serial order of moving limbs. Theoretically, there are 144 patterns. To quantify individual and group-level variability of patterns, we calculated entropy of frequency of movement patterns for each infant and for each age group, and performed statistical analysis. **Results:** This classification method revealed 17 movement patterns in the YI group and 26 movement patterns in the OI group. Twelve patterns were common between both groups, and the most frequently observed of these patterns were as follows: (1) IA and IL are support limbs, and CA and CL move synchronously; (2) IA is a support limb, and IL, CA, and CL move synchronously; (3) IA and IL are support limbs, and the movement of CA is followed by the movement of CL. All of the movement patterns that were observed only in OI included combinatorial diversity of the serial order of asynchronously moving limbs. The group entropy of the OI group was significantly higher than YI group ( $p < 0.05$ ). The group entropy of the OI group was significantly higher than that of the YI group ( $p < 0.05$ ), consistent with a larger repertoire of movement patterns in OI than in YI. **Conclusion:** While rolling movements were dominated by a few basic movement patterns in both YI and OI, OI showed more variation of movement patterns in terms of locus of supporting limbs and serial order of moving limbs. This suggests that the development of rolling over during the second half of the first year of life can be regarded as a divergent process rather than a convergent one.

## **P2-R-287 Postural control and visual information in children with cerebral palsy**

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<sup>1</sup>Universidade Cruzeiro do Sul

**BACKGROUND AND AIM:** Children with cerebral palsy (CP) present motor disorders that occur with perception, behavior disturbances, among others. This study investigated the influence of visual information manipulation on the postural control of children with CP. **METHODS:** Eleven children with spastic diplegic CP and 11 neurological normal (NN) children between 6 and 12 years old were requested to stand still inside a moving room that remained either stationary or oscillated at 0.2 or 0.5 Hz. When the room remained stationary, all children performed three trials with vision and three trials without vision. When the room oscillated (peak velocity of 0.6 cm/s), they performed three trials with vision at 0.2 Hz and three trials with vision at 0.5 Hz. In the vision conditions, children were instructed to look towards a target, and

in the no vision condition, they wore a blindfold to guarantee the absence of visual information. Mean sway amplitude (MSA) was calculated for all trials and gain, phase and variability of both position and velocity were calculated for those trials in which the room oscillated. RESULTS: All children presented larger MSA with no vision than with vision when the room remained stationary, and children with CP presented larger MSA than NN children either when the room remained stationary or oscillated. Gain was higher when the room oscillated at 0.5 Hz compared to 0.2 Hz for all children, with no lag at frequency of 0.2 Hz but with phase values around -100 degrees at frequency of 0.5 Hz. Children with CP presented higher position variability compared to NN children and all children presented higher velocity variability at frequency of 0.5 compared to 0.2 Hz. CONCLUSION: These results demonstrate that children with CP are influenced by manipulation of visual information similarly to NN children, however, children with CP show more variable control of postural sway suggesting that differences in performance might be due to how sensory information is integrated into motor activity.

## P2-R-289 Walking and running gait in children with Developmental Coordination Disorder

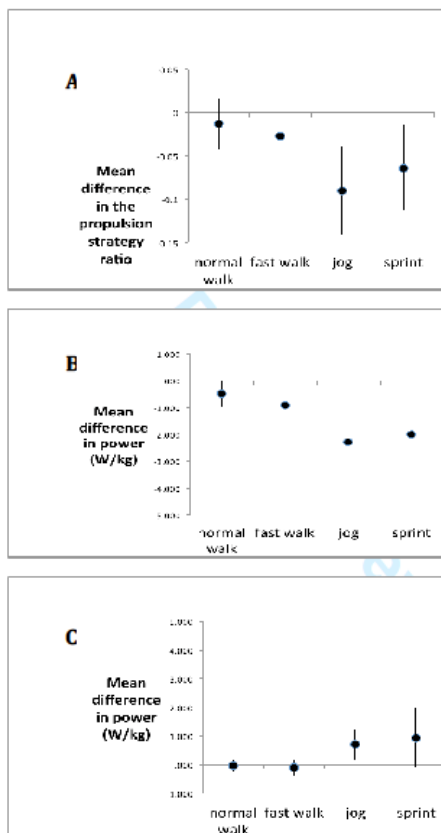
**Susan Morris<sup>1</sup>, Jenny Downs<sup>2</sup>, Nicola Diamond<sup>1</sup>**

<sup>1</sup>Curtin University, <sup>2</sup>Institute for Child Health Research

**BACKGROUND:** Children with Developmental Coordination Disorder (DCD) often have difficulties running. This study compared strategies of power generation at the ankle during walking and running in children with and without DCD. This

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**Figure 3.** Mean Difference (95% confidence interval) between typically developing children (TD) and children with Developmental Coordination type of Disorder (DCD) during each type of gait for a) propulsion strategy; b) peak A2 power c) peak H3 power.

aim of this study was to compare strategies of propulsion and power generation in children with DCD with TD children during late stance/early swing in both walking and running. METHODS: Eleven children (six male) aged nine to 12 years with DCD were matched by sex and age with 11 typically developing (TD) children. Gait kinematics and kinetics were measured during 4 gait types; normal walking, fast walking, jogging and sprinting using three-dimensional motion analysis. Propulsion strategy during gait was calculated as ankle power divided by the sum of ankle and hip power ( $A2/A2 + H3$ ). RESULTS: The children with DCD ran slower than the TD children (mean difference [MD] jog 0.3m/s; sprint 0.8m/s). Adjusting for speed, those with DCD had smaller propulsion strategy values during jogging ( $p = 0.001$ ) and sprinting ( $p=0.012$ ), explained by reduced ankle power generation at push off (A2) (jogging, MD 2.5W/kg,  $p<0.001$ ) and greater hip flexor power generation at pull off (H3) (jogging, MD 0.75W/kg,  $p=0.013$ ). Similar findings were observed during sprinting. CONCLUSIONS: Children with DCD ran with a slow and less efficient running style,

consistent with developmental immaturity. Physiotherapy targeting running-specific needs in relation to ankle muscle strength and coordination could enable more participation in running activities.

## **P2-R-291 Factors affecting performance of tray-carrying task in children with intellectual disabilities**

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**BACKGROUND AND AIM:** In this report, we investigate the factors affecting performance of a tray-carrying task in children with Intellectual disabilities (ID). The tray carrying task is a gross motor task, which can separately measure speed and carefulness. **METHODS:** The subjects were 78 children with ID (mean age  $14.0 \pm 2.2$  years, range 8-18 years. The mean IQ was  $44.7 \pm 12.6$ , range 13-71. Twenty-one children had Down syndrome (DS) and 19 children were autistic). For the tray-carrying task, subjects were given a tray with a glass (capacity 225 ml) of 200 ml water at the start line by an experimenter and instructed to carry it as fast as they could to the goal line 3 m away without spilling it. The time to reach the goal line was measured as an indicator of motor speed. The amount of water spilled was measured as an indicator of carefulness. The averages of two trials were used as representative subject variables. **RESULTS:** The amount of water spilled was not different among the clinical types of ID (DS, autism and residual) and very little across the groups ( $0.29 \pm 0.53$  ml). Multiple regression analysis was used to examine how the attributes of children with ID, such as chronological age (CA), IQ, and clinical type of disability, affect the tray-carrying performance. When the amount of water spilled was a dependent variable, the multiple correlation coefficient (R) was not significant ( $R=0.17$ ,  $p>.05$ ). In the case of the tray-carrying time, however, the R was significant. Standardized partial regression coefficient ( $\beta$ ) for the presence or absence of DS and CA were significant, i.e., children with DS tended to be relatively slower, and the higher a subject's CA, the faster the tray-carrying performance. **CONCLUSIONS:** In general, children with ID behave carefully in the tray-carrying task. Developmental change was found in motor speed. Although children with DS tended to take more time than the others, they did not lack carefulness as performers.

## **S - Effect of medication on posture and gait; Falls and falls prevention**

### **P2-S-293 Effect of pedunculopontine nucleus stimulation at low frequency on gait and balance disorders in advanced Parkinson's disease**

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<sup>1</sup>CR-ICM 1er étage CIC, <sup>2</sup>CR-ICM 5ème étage CIC

**Background:** Gait and balance disorders represent a major therapeutic challenge in advanced stages of Parkinson's disease as these signs are less sensitive to dopaminergic agents (DA) and deep brain stimulation. Recently, the low frequency stimulation of the pedunculopontine nucleus (PPN) has been proposed to improve these axial signs, but preliminary results were disappointing with heterogeneous data. In this study we aim to quantitatively examine the effects of bilateral PPN stimulation on both clinical and neurophysiological gait and balance capacities, in a double-blind cross-over study. **Methods:** Six patients (age:  $47 \pm 7$  yrs, disease duration:  $15 \pm 5$  yrs) with freezing of gait and falls were operated for bilateral PPN stimulation. Gait and balance clinical evaluation (Unified Parkinson's disease rating scale-UPDRS and Rating Scale Gait Evaluation-RSGE, quality of life-PDQ-39) and biomechanical recordings of gait initiation were performed before surgery (Off and On levodopa treatment) and after surgery with and without PPN stimulation (2 months, frequency: 20-40 Hz). Biomechanical parameters of gait initiation included: anticipation and execution phases durations, length and velocity of the first step, vertical velocity of the centre of gravity with the measure of the braking

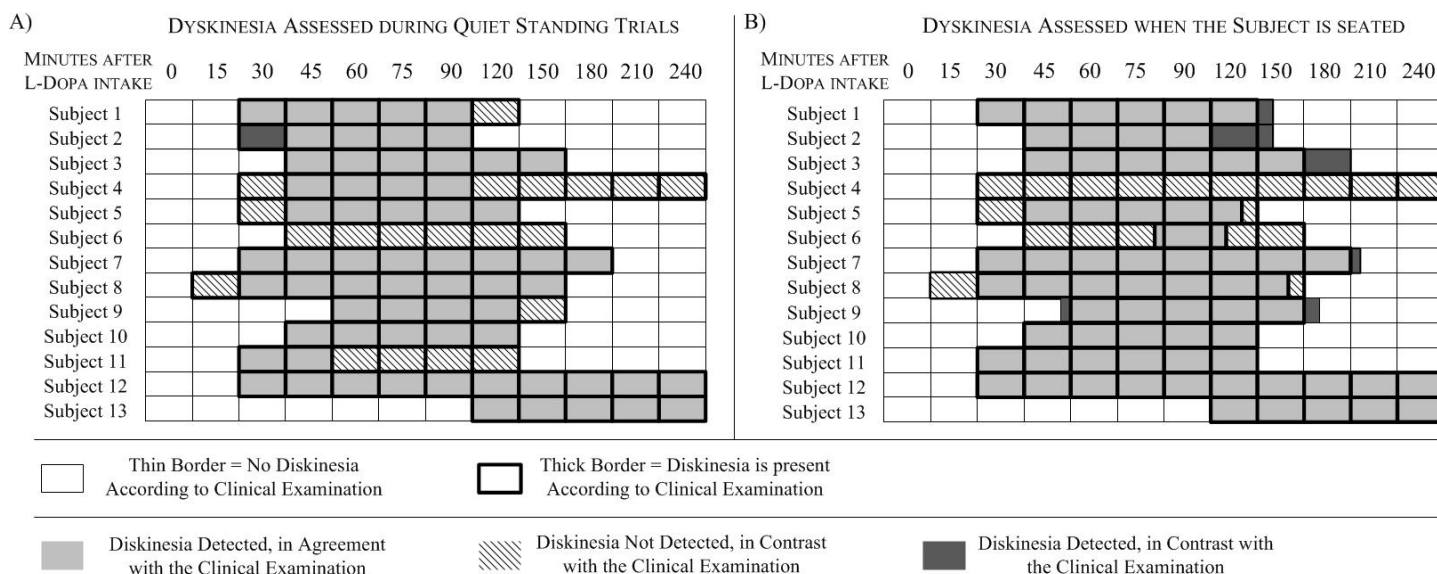
index (reflecting the postural control). Results: All PD patients showed a severe form of PD (UPDRS III Off:  $49 \pm 10$ ; DA dosage:  $1026 \pm 422$  mg/d) with axial signs poorly or unresponsive to levodopa treatment (axial score On:  $6 \pm 3$ ), with a residual freezing of gait in 5 and postural instability in 6. Four patients were included in the cross-over study. Two patients had severe adverse events that prevented stimulation (infection,  $n=1$ ; hematoma,  $n=1$ ). With PPN stimulation, there was no significant change in both the total and axial parkinsonian motor disabilities (Off and On drug conditions), the quality of life and dopaminergic agents daily dosage. However, in 2 patients, the combination of levodopa drug treatment and PPN stimulation was more efficient to improve gait and balance, with an increase in length and velocity of the first step but also on braking capacity, in comparison to levodopa or PPN stimulation alone. In the 2 others, PPN stimulation has no additional effect. Conclusion: This study suggests that bilateral PPN stimulation decrease gait and balance disorders in PD patients when combined to levodopa treatment, possibly acting as a permissive factor.

**P2-S-295 Dyskinesia detection and monitoring by means of a single inertial sensor in patients with Parkinson's Disease**

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**BACKGROUND AND AIM:** The development of Levodopa (LD)-induced dyskinesia (LID) is a known long-term drug adverse effect in Parkinson's disease (PD) patients. LID fluctuates markedly in relation to LD dosing during the day. In the current clinical practice its assessment is based on semi-quantitative scales administered by physicians. The aim of the present study was to verify if inertial sensors could reliably detect LID in a group of PD patients. **METHODS:** Forty-six PD patients (28 males;  $63 \pm 9$  yrs; Hoehn-Yahr 1-3) on chronic Levodopa therapy underwent kinetic-dynamic LD monitoring based on the intake of their usual morning drug dose followed by serial measurements of plasma LD concentration, motor and postural performances and dyskinesia rating (Clinical Dyskinesia Rating Scale-CDRS). The assessment was performed every 15 minutes for the first 90 minutes, then every 30 minutes up to a maximum of 4 hours. Eighteen de novo PD patients (13 males;  $59 \pm 9$  yrs; Hoehn-Yahr 1-2) and 18 healthy controls (CTRL; 9 males;  $60 \pm 11$  yrs) performed the same motor and posturography serial tests (5 repeated trials over 90 minutes). Posturography included Quiet Standing (QS) trials, with Eyes Open (EO), Eyes Closed (EC) and Eyes Open Dual Task (EODT). Functional tests were instrumented using an inertial sensor embedding a triaxial accelerometer and gyroscope (McRoberts Dynaport Hybrid) worn on the lower back. Postural sway in QS was quantified by a set of 120 parameters. A reliability analysis was performed (Intraclass Correlation Coefficients, ICC) on CTRL and de novo PD measures over 4 repetitions. The same method developed for QS sway quantification was applied while patients were sitting and free to perform any activity. The aim was to simulate a hypothetical monitoring protocol to be performed at home when the person is safely seated. **RESULTS:** No statistical differences were found about sex and age among patients' and control groups. Dyskinesia patterns obtained in 13 patients classified as dyskinetic according with CDRS are reported in the Figure. A subset of 10 instrumental parameters was selected for clinical applications ( $ICC \geq 0.7$  in EO, EC, and EODT condition). Best results in detecting dyskinesias during QS trials were obtained considering mean angular velocity in medio-lateral direction in EODT condition (Figure-A, 97.5% of overall accuracy). Time to onset and offset of dyskinesias as assessed by CDRS vs single inertial sensor is reported for each patient in QS (Figure-A) and in sitting position (Figure- B). Inpatient dyskinesia patterns overlapped in most cases. Instrumental dyskinesia detection was lacking when low-severity involuntary movements affected distal body segments (face, feet). **CONCLUSIONS:** Our preliminary results suggest that a wearable single inertial sensor may be a reliable and clinically applicable tool to detect and monitor dyskinesias in PD patients even in unsupervised settings.



**P2-S-297 Effect of chemodenervation of the rectus femoris muscle in adults with a Stiff Knee Gait due to Spastic paresis : A systematic review with a meta analysis in Stroke patients.**

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<sup>1</sup>Roessingh Research & Development

**BACKGROUND AND AIM:** To determine the effect of Motor Branch Block (MBB) or Neuro Muscular Block (NMB) of the rectus femoris on knee kinematics during swing, functional outcome, and energy cost in adults with spastic paresis presenting a stiff knee gait. **METHODS:** An electronic search was conducted in four databases Pubmed, Embase, Cinahl, and Cochrane library, followed by the examination of the reference lists of relevant papers. No restrictions were applied regarding study design. Patients were adults suffering from a central neurological disorder. Interventions had to include MBB or NMB. Outcome measures should include knee kinematics during swing phase. Study selection and scoring of methodological quality was independently performed by two reviewers. Data on kinematics, functional outcome, and energy cost from stroke patients were extracted from the total population and when possible pooled. **RESULTS:** In total eleven studies were included. Knee kinematics (peak knee flexion or knee range) during swing improved significantly in all included studies. The average increase in peak knee flexion varied from 1.9 to 15.4 degrees. Data pooling of peak knee flexion in stroke patients showed a significant improvement of 7.32 degrees ( $P < 0.001$  95% CI, 3.52-11.11) in the NMB studies and 9.35 degrees ( $P = 0.002$  95% CI 3.49-15.21) in the MBB studies. Data pooling of knee range of motion, knee flexion velocity at toe off, functional outcomes, and energy cost showed no significant difference. **CONCLUSION:** According to this review, chemodenervation of the rectus femoris shows a significant improvement on peak knee flexion during swing. The effect on functional outcomes and energy cost is still unclear.

**T - Ergonomics; Aging**

**P2-T-299 The effects of floor material, surface condition, and repetition on gait during walking**

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**BACKGROUND AND AIM:** Slips and falls are a major contributor to injuries, with substantial losses reported worldwide. Investigations of how individuals adjust their walking strategies to accommodate different walking conditions are essential in understanding the complexity of slips and falls. In this study, we investigated the gait adjustments made by participants when walking repeatedly on a walkway with various test floor materials and surface conditions. How the floor material, surface condition, and repeated trials altered individual's gait parameters were examined. **METHODS:** Thirty healthy participants (Ages  $28.5 \pm 10.8$  years) participated in the study. Five floor materials varying in visual cues to slipperiness and friction were selected based on previous pilot study findings and presented in a random order for the participants to walk on: A) standard quarry tile with raised-profiled tread line, (B) standard flat quarry tile, (C) vinyl composition, (D) marble tile and (E) glazed porcelain tile. Three surface conditions (dry, water, and oil) were applied to the entire floor for each test. Participants wore a safety harness and were provided with uniform footwear. They were asked to walk repeatedly five times on each test floor condition from one end to the other as if they were in a hurry. The lower extremity kinematic data and ground reaction forces at the heel strike landing phase when participants walked through the middle point of the test floor were analyzed and compared. **RESULTS:** Linear mixed model and pairwise comparison were used for statistical analyses (5 floor materials x 3 surface conditions x 5 trials). The results indicated that the floor materials, surface conditions, and trial/repetition all had significant effects ( $p < 0.01$ ) on peak normalized normal forces (PNNF) and utilized coefficient of friction (UCOF) values. The kinematic data such as step length and walking velocity were also affected by these factors. The dry surface had the highest averaged UCOF (0.2) and PNNF (1.26) values followed by the wet and oil conditions. The highest UCOF and PNNF values were observed for floor A (0.21, 1.26) in contrast to the lowest value for floor E (0.14, 1.12). Trial/repetition also had significant effects on the UCOF and PNNF. The averaged UCOF and PNNF values of participants' first walk had higher values (0.2, 1.23) which then reduced to lower values (0.18, 1.18) on the fifth repetition. This could imply that the participants were continuously adjusting their walking strategy until they were more familiar with the floor conditions. **CONCLUSIONS:** The findings suggest that individuals adjusted their gait in response to various floor materials and surface condition changes. Gait adaptation is a continuous process. Individuals may require more exposure to be able to make use of proprioceptive feedback in adjusting their gait for safer walking strategies.

## U - Psychiatric disorders; Vestibular function and disorders

### P2-U-301 Psychiatric comorbidity in patients with dizziness

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**BACKGROUND AND AIM:** We report herein psychogenic dizziness (PD) and psychiatric (Psy) comorbidity in Psy hospital with an otolaryngologist. **METHODS:** The subjects were 524 patients (159 male, 365 female) (age range, 7-95; mean age  $\pm$  SD 59.0  $\pm$  18.0 years) with dizziness. Patients were diagnosed as otolaryngologic (Otola) disorders (D) by a otolaryngologist and as Psy D by designated physicians of mental health or psychiatrists with more than 9 years clinical experience using ICD-10. **RESULTS:** PD in a narrow sense was revealed in 94 (17.9%) of 524 patients with dizziness. Psy comorbidity was revealed in 362 (69.1%). Of 362 patients with dizziness and Psy comorbidity, anxiety or panic D (F41) were revealed in 149 (55.2%), mood D (F3) in 36 (13.3%), adjustment D or post-traumatic stress D (F43) in 15 (5.5%), dissociative D (F44) in 5 (1.9%) somatoform D (F45) in 5 (1.9%) and other neurotic D (F48) in 14 (5.2%). But in addition organic mental D (F0) were also seen in 21 (7.8%) and schizophrenia (F2) in 15 (5.6%). Phobic Postural Vertigo was diagnosed in 30 (7.7%). Patients with dizziness of unknown cause (UC), otogenic vertigo and Meniere's disease, showed

higher prevalence of psychiatric comorbidity (Table). **CONCLUSIONS:** These patients were not only treated by otolaryngologists, but also received Psy therapy or 73% patients were prescribed psychotropic drugs. We believe that collaboration between psychiatrists and otolaryngologists in the hospital or doctors in local area can improve the mental condition and QoL of patients suffering from dizziness with Psy comorbidity.

Otola D	Psy Comorbidity
dizziness of unknown cause	<b>192/261 (73.6%)</b>
otogenic vertigo	<b>66/95 (69.5%)</b>
Meniere's disease	<b>54/77 (70.1%)</b>
chronic cerebral insufficiency	26/48 (54.2%)
BPPV	12/24 (50.0%)
other diseases	12/19 (63.2%)
total	362/524 (69.1%)