Poster Session 4

Tuesday, June 25 between 16:30 and 18:30

A - Tools and methods for posture and gait analysis

P4-A-2 Intrasession reliability for measures of variability in gait

Baard Bogen[1], **Mona Aaslund**[1], **Anette Ranhoff**[1], **Rolf Moe-Nilssen**[1]
[1]University of Bergen

Background It has been suggested that variability between gait cycles is an important feature of gait function, and a strong predictor of health-related outcomes. Measurement properties of variability measures have not been studied extensively. In this report, we investigated intrasession reliability of variability in step length, stride length, step width and step time, based on footfall analysis from an instrumented walkway (standard deviations), and regularity (autocorrelations) and smoothness of gait (harmonic ratios) based on acceleration data from a kinematic sensor. Method Participants were elderly community-dwelling people. They walked across an instrumented walkway (4.25 meters) six times, twice at slow, preferred and fast speed. Participants wore a kinematic sensor at their lumbar/sacral area, attached to a belt. The kinematic sensor registered data for a walking distance of 6.5 meters. Participants had a dynamic start/stop of 2 meters at each end. Data were detrended for speed to allow an analysis of reliability based upon only random error including all 6 walks. Intraclass correlation coefficients (ICC (1,6)) were estimated. Results Data from 43 participants were analyzed (mean age 75 years). 68 steps were registered with the kinematic sensor, 38 with the instrumented walkway. ICC (1,6) was relatively high (.919-.965) for the regularity measurements and somewhat lower for the smoothness of gait measurements and the step length/stride length/step time/stride time variability data from the electronic walkway (.700-.861). ICC (1,6) for step width variability was low (.517). Conclusion ICC (1,6) varied from low to high. Highest correlation was found for regularity measurements based upon autocorrelation procedures. Step width variability was found to have considerably lower ICC (1,6) than the other variables. This is in accordance previous findings. Participants walked fewer steps on the instrumented walkway, which may in part explain the lower ICC (1,6) values. Still, the number of steps is close to suggestions by other authors. As such, the number of steps alone does not fully explain the lower reliability. The method of detrending data chosen for this paper is not widespread in use, but allows reliability analysis of repeated measures with trend without organizing multiple test occasions. However, gait variability and regularity appear to be less speed-dependent than other gait parameters, such as cadence or step length. Therefore, a detrending procedure based on speed may not be warranted. Also, since all measurements were done in one session, comparison with the results of our study should be made with caution.

P4-A-4 Towards automated detection of freezing of gait during community ambulation? Further investigation of the FoG index

Eran Gazit[1], **Ariel Tankus**[1], **Tal Freedman**[1], **Talia Herman**[1], **Inbal Maidan**[1], **Nir Giladi**[1], **Anat Mirelman**[1], **Jeffrey Hausdorff**[1]
[1]Tel aviv sourasky medical center

BACKGROUND AND AIM: Freezing of gait (FoG) is a debilitating phenomenon that affects up to 60% of patients with Parkinson's disease (PD). To evaluate the burden and severity of FoG, there have been a number of attempts to detect

FoG in the lab and even efforts toward real-time detection. Data recorded in the lab that suffers from the so called reverse white coat syndrome; many patients report severe FoG at home, but do not experience these events when examined in the lab or clinic. To optimize disease management and quantitatively study this problem, it is, therefore, important to detect FoG episodes in data recorded in the patient's natural environment. METHODS: A device located on the lower back measured acceleration data from 108 patients with PD (mean age 65.1 +/- 9.2 years; Hoehn and Yahr 2.55+/-0.69) for 72 hours under routine daily living conditions. From the 108 patients, 32 suffered from FoG and had a score of 15.2+/-7.12 on the new Fog questionnaire (nFoG-Q). In addition, 10 PD patients completed a protocol designed to provoke FoG while wearing an accelerometer placed on the lower back. To perform detection, we attempted to utilize a commonly-used feature for FoG detection, i.e., the FoG Index (FI). The basic feature was defined as the power in the "freeze" frequency band (3.0-8.0 Hz) divided by the power in the gait band (0.5-3.0 Hz) in a running window. By applying a threshold, the window can be flagged as FoG or Non-FoG. An improved FI was later introduced adding a second threshold - the frequency border between the gait and FoG bands. We applied the improved FI to the laboratory data, once by searching for each patient's optimal threshold and once using a 2-fold cross-validation method. The basic FI was applied to the daily living data, using a fixed detection threshold of 2. Results of the daily living data were compared to scores on the nFoG-Q. RESULTS: In the lab, 175 FoG events were observed in the lab (mean duration: 9.02+/-15 sec). The improved FI on the lab data yielded optimal results of sensitivity 75.7% and specificity 72.2%. The 2-fold cross-validatation, however, yielded a significant drop in the ability to correctly detect events: sensitivity 56.7% and specificity 68.47%. When the FI was applied to the daily living settings, FoG duration did not differ significantly between subjects who reported FoG (n=31) (38.5+/-36.4 min), compared to those that did not (29.8+/-37.9 min), when normalized by total activity duration (p=0.49) or viewed as a raw score (p=0.14). The amount of FoG detected in the daily living settings was also not significantly correlated with the nFoG-Q scores (Spearman's correlation, p>0.23). CONCLUSIONS: Both the 2-fold cross-validation and optimal methods applied to the lab data are not adequate for detecting FoG detection in daily living settings. Before FoG can be detected in the daily living setting, adjustments and/or additions to the FI are needed.

P4-A-6 Trunk sway measurements during turning while walking in healthy adults

Naofumi Tanaka[1], **Ryushin Hashiba**[2], **Ryota Tobishima**[2], **Hiroko Saito**[2], **Asako Hirayama**[2], **Yoshihiro Muraoka**[3], **Shin-Ichi Izumi**[1]
[1]Tohoku University Graduate School of Medicine, [2]Medical Court Hachinohe West Hospital, [3]Faculty of Human Sciences, Waseda University

BACKGROUND AND AIMS: Turning while walking is an essential locomotor activity for everyday living. It is a complex task requiring postural adjustment and modification of the motor program during turning to change direction. Impaired turning is associated with a high risk of falls. However, previous studies have been limited to assessing gait parameters during turning. The aim of this study was to investigate the effect of turning while walking on dynamic body balance as measured by trunk sway angles compared to linear walking in healthy adults. METHODS: Ten healthy adults (mean age ± standard deviation; SD, 35.1±4.6, 5 women) participated in this study. They were instructed to walk straight ahead at their usual pace until, in response to an acoustic cue, they were to turn 90° to the right or left while continuing walking. Four different types of cues (no cue, cue to turn right, cue to turn left, cue to keep walking straight) were prepared. When no cue was delivered, the subjects were to keep walking straight. Two cues of each type, for eight cues in total, were delivered in random order. Trunk sway in roll (medio-lateral) and pitch (antero-posterior) directions was measured using an inertial sensor strapped to the lower back. We used one-way repeated-measures ANOVA to identify the effect of turning on balance. The level for statistical significance was set at $p<0.05$. RESULTS: Turning significantly increased the maximum ranges of roll ($F(3,27)=20.72$, $p<0.001$, partial eta squared=0.70) and pitch angles ($F(3,27)=7.62$, $p=0.005$, partial eta squared=0.46). Post hoc tests using the Bonferroni correction showed significant increases during both left and right turns compared to no-cue straight walking in the means (±SD) of the maximum ranges of roll angle (straight = 7.0±2.3, right turn = 10.8±3.3, left turn = 10.6±2.6) and pitch angle (straight = 4.2±0.9, right turn = 6.7±2.6, left turn = 7.1±2.2). The maximum ranges of roll and pitch angles with the cue to keep walking straight (7.4±1.5 for roll angle;

4.3±0.7 for pitch angle) did not differ significantly from the no-cue straight-walk condition. CONCLUSIONS: Trunk sway was increased during turning while walking in healthy adults under this task condition. This task could be useful for clinicians to evaluate fall risk in older adults.

P4-A-8 Correlation between Stabilometry and Electronystagmogram in Patients with Dizziness

***Hiroko Torii*[1], Mami Matsunaga[1], Kyoko Shimizu[1], Akiko Taura[1], Kazuo Funabiki[2], Juichi Ito[1]**
[1]Kyoto University, [2]Osaka Bioscience Institute

BACKGROUND AND AIM: Stabilometry is one of the frequently used equilibrium examination and some characteristic results are known in some disease, but the result which is specific to cervical vertigo has not yet to be known. Previously, we examined 10 patients with cervical vertigo by stabilometry with or without neck tilting torsion, or extension, and found that most of the patients with cervical vertigo displayed tottering in any neck position, and their tottering increased largely at their head-extended position. We examined their nystagmus in other time too, but most of them showed no nystagmus whereas some of patients with peripheral vestibular disorders showed nystagmus. So we hypothesized that the tottering in stabilometry, which is mainly related to vestibulo-spinal reflex, and the nystagmus, which is mainly related to vestibulo-ocular reflex, have weak correlation. In this study, we examined stabilometry and electronystagmogram simultaneously and further evaluated their correlation. METHODS:We assessed 50 patients with dizziness by stabilometry in the upright, head-extended position subsequent to the upright, front-faced position. We also assessed them by electronystagmogram. We analyzed the result of stabilometry and defined the patients who showed ≧6cm² area of statokinesigram as a tottering ones, and who showed ≧5cm² increasing of area of statokinesigram after head-extended loading as a tottering-increased ones. We counted the number of person who showed nystagmus on electronystagmogram in the upright, front-faced position and compared their ratio in tottering ones to non-tottering ones. We also counted the number of person who showed the increasing of nystagmus by head-extended loading, and compared their ratio in tottering-increased ones to non- tottering-increased ones. RESULTS:Twenty-two of 50 patients displayed tottering in upright position. Nystagmus was found in 12 of non-tottering ones, 8 of tottering ones, but statistically there was no significant difference. Fourteen of 50 patients displayed tottering-increasing in head-extended loading. Enhancement of nystagmus was found in 6 of non- tottering-increased ones, and 4 of tottering-increased ones, statistically no significant difference between those two groups. CONCLUSIONS:Above results indicate that the result of stabilometry with or without head extended loading can't be predicted with the findings of nystagmus. Thus, we should better examine stabilometry with head-extended loading in patient with dizziness, even if no nystagmus was observed.

P4-A-10 Quantitative Evaluation of Stroke Hemiplegic Gait Using Principle Component Analysis

***Yoshitaka Otani*[1], Osamu Aoki[2], Tomohiro Hirota[3], Masahito Murakami[1], Yuri Inoue[1], Masayuki Uesugi[1], Junichi Kato[4], Hiroshi Ando[5]**
[1]Faculty of Rehabilitation/Kobe International University, [2]Faculty of Rehabilitation/Shijonawate Gakuen University, [3]Department of Rehabilitation/Hyogo Prefectural Rehabilitation Hospital at Nishi-Harima, [4]Department of Internal Medicine/Hyogo Prefectural Rehabilitation Hospital at Nishi-Harima, [5]Faculty of Health Science/Kobe University Graduate School

BACKGROUND AND AIM: Post-stroke hemiplegic patients have difficulty walking independently even on a leveled surface because of gait instability and risk of falling. We postulate that this gait has the following characteristics: slow gait velocity (Mulroy, 2003), excessive perturbation (Menz, 2003), too little symmetry (Patterson, 2010) and regularity (Mizuike, 2009) of gait. Therefore, we used principal component analysis (PCA) to help better understand the role of these characteristics of gait instability in post-stroke hemiplegic patients. METHODS: Twenty-two post-stroke hemiplegic patients participated in this study (age, 65.3±10.0 years, stroke type, hemorrhage [10 patients] and infarction; [12

patients]; duration from onset, 116.0±41.0 days). A tri-axial accelerometer was fixed over the L3 spinous process using an elastic bandage. The subjects were instructed to walk two trials along a 10-m walkway at a comfortable speed. Gait ability indexes, i.e., gait velocity, root mean square (RMS, square of the gait velocity) and auto correlation coefficient of symmetry (ACC-S) and regularity (ACC-R), were calculated based on the acceleration data obtained by 3 gait cycles. The RMS, ACC-S, ACC-R were assessed using PCA. We selected a principle component (PC) with an eigenvalue of >1.0 to achieve >80% of cumulative contribution ratio. RESULTS: The first PC (eigenvalue, 2.22) consisted of the gait velocity (loading vector, -0.60) and RMS (loading vector, 0.55), which accounted for 55.7% of the variance. The second PC (eigenvalue, 1.00) consisted of the ACC-R (loading vector, 0.86) and ACC-S (loading vector, 0.46), which accounted for 24.0% of the variance. CONCLUSIONS: Our results suggested that hemiplegic gait instability could be quantitatively evaluated using PCA in post-stroke hemiplegic patients who cannot walk independently. The first PC showed the relation ability of fast walking and decreased perturbation and the second PC showed the relation rhythmic gait ability.

P4-A-12 Study of the stability in time of marksmen

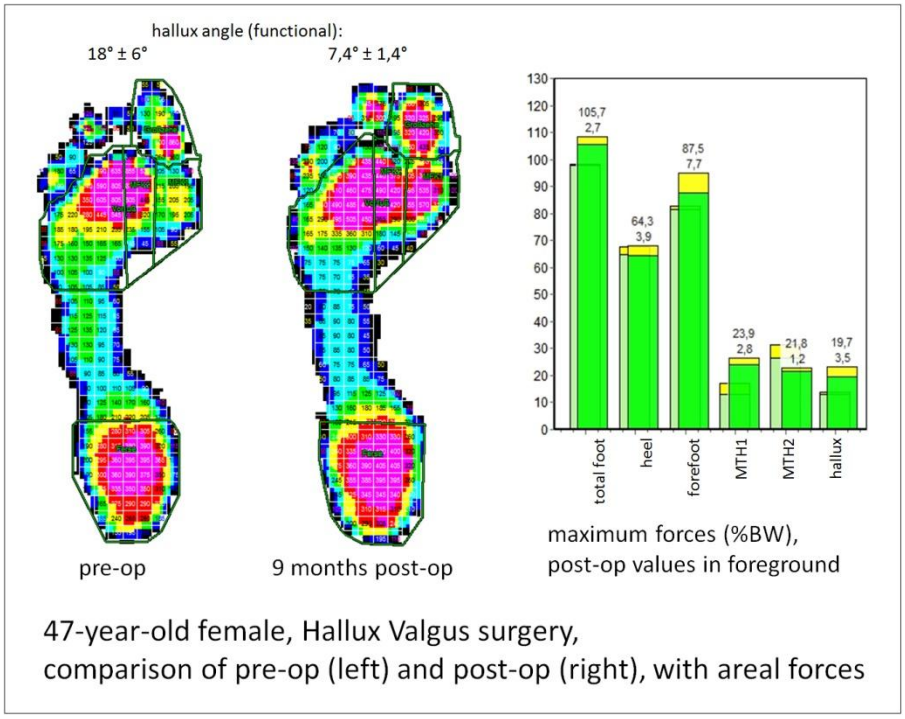
Pierre-Marie Gagey[1], **Raoul Dudde**[2], **Maurice Ouaknine**[3], **Bernard Weber**[1]
[1]Institut de Posturologie, Paris, [2]Fédération Française de Tir, [3]Université Méditerrannée

Study of the stability in time of marksmen Pierre-Marie GAGEY, Raoul DUDDE, Maurice OUAKNINE, Bernard WEBER BACKGROUND AND AIM: When shooting indoors with a rifle, 10 meters away from his target, in order to be successful, the marksman is required to push the trigger of his gun before his line of sight intersects the center of the target. The shooter must "anticipate" the "± 63ms" between the triggering of shooting and the arrival of the projectile on the target. As training improves performance of the shooter, it improves the accuracy of his anticipation, but by which strategies? We believe that postural control is concerned. The analysis of the stability of the rifleman in space cannot verify this, but if this hypothesis is correct the marksman's training should systematically modify the time constant of the upright postural control system. METHODS: The time constant of the upright postural control system was measured by stabilometry among shooters of different performance levels: 37 subjects at national level, 35 subjects at regional level and 40 control subjects. This time constant is measured by the abscissa of 0.5 crossing of the autocorrelation function of the acceleration vector of the center of gravity (Ouaknine et al, 2011). The modulus of this vector and its projections on the axes Ox and Oy were studied. The acceleration of the center of gravity was calculated by the analytical method from the successive positions of the center of pressure (Gagey et al, 2012). RESULTS: (Put table here) Time constants calculated from the modulus of the acceleration vector: Cm, and its projections on the axes Ox and Oy: Cx & Cy. CONCLUSIONS: Marksmen control their stability in time, better than the control subjects.

		Cx	Cy	Cm
Controls (C)		0.211 ± 0.04	0.186 ± 0.029	0.148 ± 0.03
Regionals (R)		0.243 ± 0.051	0.2 ± 0.026	0.159 ± 0.031
Nationals (N)		0.232 ± 0.043	0.204 ± 0.036	0.162 ± 0.035
C/R	Student's t	3.11	2.11	1.06
	p	0.01	0.05	ns
	ddl	75		
C/N	Student's t	2.21	2.237	1.91
	p	0.05	0.05	ns
	ddl	73		
R/N	Student's t	0.99	0.5	0.38
	p	ns	ns	ns
	ddl	70		

P4-A-14 Pedography - Dynamic Assessment of Foot Function

Holger Neumann[1]
[1]Novel GMBH



47-year-old female, Hallux Valgus surgery, comparison of pre-op (left) and post-op (right), with areal forces

BACKGROUND AND AIM: Pedography is a generic term for load distribution measurement under the foot. Recording is done with a sensor pad that is placed under the foot, measuring the local pressure and its distribution over the foot area. Pedography aims at assessing foot function when standing or walking in order to diagnose orthopaedic problems, to identify peak pressures carrying the risk for ulceration, or to support the biomechanical analysis of gait. METHODS: Since the human foot has a very complex structure, walking produces an inhomogeneous distribution of load on the foot's plantar side. Load distribution can be expressed by the time-dependent parameters pressure, force, and load-bearing area. While these parameters are linked by the formula "pressure=force/area", the specific application determines which parameter is in the focus of attention: If the precise load of the patient's tissue is of interest, the actual pressures are relevant; if a functional assessment of the foot structure is desired, the forces acting on the foot are analysed. PARA: In general, there are two methods of pedography. In the first scenario a person walks barefoot over a sensor platform, thus creating a pressure pattern of high spatial resolution. Since this is usually done under reproducible lab conditions, such assessments allow, for instance, pre- and post-operative comparisons. Due to the limited length of the sensor platform, a number of steps are recorded and then averaged before the data are evaluated. The second method of pedography, the measurement inside the shoe, allows for the recording of many successive steps, also outside the lab. As the shoe considerably influences the result, in-shoe pedography is not suitable for foot diagnosis but is the right choice to evaluate e.g. foot pressure reduction in diabetic patients, to assess complex movements in sports, or to develop functional footwear. RESULTS: In clinical applications, pedography can assist decisions regarding foot surgery and document the outcome. Below figure compares the pre-operative situation with the post-operative results of a Hallux Valgus surgery. The pre-op picture is characterised by a reduced load on the first ray and an elevated value for the functional hallux angle. Post-operatively, there is more load on the hallux and the first metatarsal head (MTH1), with the force diagram quantifying this improvement. CONCLUSIONS: Pedography is essential for the dynamic assessment of foot function. This method is applicable also to other parts of the human body whenever there is a physical interaction of the body with its environment. Thus, flexible and elastic sensors can measure for instance the grip force of the hand (manugraphy), the balance in standing (posturography), or the pressure exerted on skin when sitting in a wheelchair, lying on a mattress, walking with prostheses.

P4-A-16 The effect of overground walking protocols on the measurement of average gait and gait variability data

***Chitra lakshmi K Balasubramanian*[1], Robert Page**[1], **Joe Stoecklein**[1]
[1]University of North Florida

BACKGROUND AND AIM: While instrumented mats are increasingly being used in clinical gait research, there is little consensus in data collection procedures. Recent work suggests that the type of protocol chosen affects the measurement of gait variability (GV) data but similar reports on average gait (AG) data is lacking. It is also unclear if the type of protocol chosen would affect gait data measurement at different speeds. The aims of this study were to investigate the effects of different walking protocols on gait data collected at self-selected (SS) and fastest-safe speeds (FS) and to establish the number of trials required to accurately evaluate gait data. METHODOLOGY: 24 healthy subjects (22 ± 2.5 years) were recruited. Subjects were excluded if they have had any history of injuries within the last 6 months. Subjects completed four walking protocols (of 20 trials each) presented in a random order: 1) repeated at SS - REPSS; 2) repeated at FS - REPFS; 3) continuous at SS - CONTSS; 4) continuous at FS - CONTFS. All protocols were completed over a 20'instrumented mat (GAITRite). The repeated walking protocol involved subjects walking back and forth over a mat for each trial with short interruptions to the temporal rhythm of gait. Whereas in the continuous walking protocols, subjects walked continuously for the 20 trials along a curvilinear path. Average and step-by step spatiotemporal data were analyzed. RESULTS: 2x2 repeated measures ANOVAs revealed a significant ($p < .01$) interaction effect between protocols and speed for all AG measures except stride width. Post-hoc analyses showed that the REPFS was significantly different from CONTFS but there were no differences between the protocols at the SS speed. For stride width, only the main effect of speed was significant. 2x2 repeated measures ANOVA revealed significant ($p < .01$) main effects for speed for GV data. No differences were found between the two protocols. Data were sequentially truncated to 15 and then to 10 trials to establish the number of trials required to accurately evaluate gait data. When 15 trials were analyzed, the results were similar for AG data whereas for the GV data a significant interaction effect was found for all variables, except stride width. When 10 trials were analyzed, significant interaction was found for the AG data for all variables except stride width. Post-hoc analyses revealed significant differences across all four protocols.CONCLUSIONS: The type of overground walking protocol chosen might affect gait data measurement depending on the number of trials collected. For AG data, at least 15 trials at the SS speed and greater than 20 trials at FS speeds using the repeated walking protocols may be reflective of continuous gait. For GV data, 15 trials from repeated walking protocols may be accurate at both speeds. When using repeated walking protocols, stride width calculation may require lesser number of trials compared to other gait variables.

P4-A-18 Detecting not-wearing periods during activity monitoring in older adults

***Mirjam Pijnappels*[1], Martijn Niessen**[2], **Rob van Lummel**[2], **Jaap van Dieën**[1]
[1]VU University, [2]McRoberts

BACKGROUND AND AIM: Activity monitors can measure a subject's physical activity (PA), e.g. to quantify compliance with PA guidelines . Watz et al (2009) and Waschki et al (2012) stated that an activity monitor needs to be worn for at least 22-22.5 hours per day to obtain valid results on physical activity. Based on the wearing compliance and when a not-wearing period occurs (e.g. during day-time or night-time), a measurement can be either in- or excluded from analysis. This study was performed to determine wearing compliance of an activity monitor, during a period of 2-3 months in older adults. Also, the time of day (morning, afternoon, evening and night) of the not-wearing periods was determined. METHODS: A total of 43 participants, aged 83.1 ± 7.2 years, were asked to wear an activity monitor (MoveMonitor, McRoberts BV, The Hague) based on a tri-axial accelerometer (DynaPort) for 2-3 months. The subjects were instructed

to wear the accelerometer at all times, except during water activities (e.g. showering). Each week, the monitor was replaced in order to read out data and recharge batteries. To determine wearing compliance, we used an algorithm based on frequency analysis and threshold detection of the raw signal. This algorithm also allowed us to exactly determine the time of day (morning, afternoon, evening or night) of the not-worn periods. Only fully measured days (24 h) were used for analysis. RESULTS: Subjects wore the activity monitor on average for 6.8 ± 3.1 weeks. A total of 1747 days were used for analysis. On 1410 (80.7 %) days, the sensor was worn for more than 22 hours and on 1399 (80.1 %) for more than 22.5 hours (wearing compliance resp. 92 and 94%). Overall, wearing compliance was best in the afternoon. CONCLUSIONS: This study showed that older people, who have volunteered to wear an activity monitor, continue to wear it for longer periods of time with good wearing compliance. The time of day when a not-worn period occurs can be automatically detected and can be used for determining the validity of a measurement.

P4-A-20 The effect of sensory manipulations on mediolateral balance performance.

Luis Eduardo Cofré Lizama[1], **Mirjam Pijnappels**[1], **Jaap van Dieen**[1]
[1]VU University Amsterdam

BACKGROUND AND AIM: It has been proposed that decreased performance for daily-life activities, especially in the elderly, are related to detriment of balance control in mediolateral direction. To assess mediolateral balance control, we have developed a zero-order visual tracking task, using the centre of pressure (CoP) as feedback on performance in tracking a predictable and an unpredictable target with a frequency content ranging from 0.1 to 2.0 Hz. This method was shown to be reliable in determining frequencies at which phase shift and gain between the target and the CoP dropped below plateau values (PSX and GX, respectively). As the sensory systems can be affected by age, we aimed to explore the sensitivity of our method to small changes in different types of sensory information. METHODS: Manipulations of the vestibular system using a galvanic stimulator (GVS: 1 Hz at 1 mA) and foot sole somatosensory system using a transcutaneous nerve stimulator (TENS - 100 Hz at 18 mA, varying between feet at 0.17 Hz) were applied to 8 healthy young subjects when performing a visual tracking task. Each participant performed 3 trials for each target under three conditions: no-sensory manipulation, GVS and TENS. D-flow software 3.10.0 (Motek Medical, The Netherlands) was used to record raw data from a Kistler-9281B force plate (Kistler Instruments AG, Switzerland) in order to calculate CoP, produce targets and display visual feedback on performance at 60 Hz. RESULTS: Descriptive statistics and repeated measures ANOVAs for the measures of PS and G are summarized in table 1. Repeated measures ANOVAs showed significant ($p<0.01$) main effects of target for average phase and gain overall and within the bandwidth (PSY and GY, respectively). No main effects of condition were found. An interaction of target by condition was found for average gain, with a lower gain (worse performance) with GVS than in the other two conditions on the predictable task. CONCLUSIONS: These preliminary results appear to indicate a low overall sensitivity of the method, possibly due to the predictable nature of the sensory manipulations (fixed frequencies for GVS and TENS), but possibly also due to the subjects' ability to re-weight sensory inputs. Further investigations should explore whether these sensory manipulations affect the balance performance more in the elderly, especially in those at risk of falling.

	UNPREDICTABLE						PREDICTABLE						Target	Condition	Target * Condition
	No-Stim		GVS		TENS		No-Stim		GVS		TENS				
	m	sd	m	sd	m	sd	m	sd	m	sd	m	sd			
Phase Shift	-0.99	0.06	-0.99	0.06	-1.00	0.05	-0.43	0.04	-0.52	0.05	-0.47	0.04	**<0.01**	0.07	0.14
PSX	1.58	0.12	1.65	0.12	1.58	0.09	1.85	0.07	1.75	0.05	1.79	0.06	0.03	0.68	0.33
PSY	-0.72	0.12	-0.76	0.12	-0.76	0.09	-0.34	0.07	-0.36	0.05	-0.33	0.06	**<0.01**	0.68	0.57
Gain	0.56	0.02	0.61	0.02	0.60	0.02	0.93	0.02	0.89	0.02	0.91	0.02	**<0.01**	0.15	**<0.01**
GX	1.39	0.06	1.34	0.11	1.45	0.08	1.69	0.04	1.66	0.06	1.71	0.06	0.02	0.36	0.90
GY	0.62	0.05	0.66	0.05	0.67	0.06	0.99	0.03	0.94	0.03	0.97	0.03	**<0.01**	0.17	0.15

P4-A-22 Dual-task effects on smoothness of walking in patients with stroke using power spectrum entropy of trunk acceleration.

***Yu Inoue*[1], Shogo Hiragami**[2], **Kazuhiro Harada**[3], **Kojiro Kagawa**[4]
[1]Graduate School of Health and Welfare Science, Okayama Prefectural University, [2]Research Institute of Health and Welfare, KIBI International University , [3]School of Health Science and Social Welfare, KIBI International University, [4]Faculty of Health and Welfare Science, Okayama Prefectural University

BACKGROUND AND AIM Smoothness of walking is an integrated function of kinematics, kinetics and coordination of gait, and one of the important factors to determine recovery of walking capacity in clinical rehabilitation of cerebral vascular disease(i.e. stroke). Kojima, et al.[1] reported that a power spectrum entropy (PSEn) calculated from trunk acceleration is useful to evaluate the smoothness of walking, and the smoothness of walking increases with decreasing PSEn. In the previous study, it was reported that dual-task loads while walking could be a sensitive method for assessing higher levels of gait control. The purpose of this study was to investigate dual-task effects on smoothness of walking in patients with stroke using PSEn. METHOD Subjects were 17 patients with stroke (66.4±8.6 years, female: 7). To elicit surely greater cognitive-motor interference, participants walked a 12m walkway at fast walking speed under single- and dual-task conditions (walking with arithmetic task: addition, subtraction). Outcome measures were assessed under single- and dual-task conditions, and included time-distance parameter (walking velocity, stride length, cadence), root mean square(RMS) and PSEn calculated from trunk acceleration using tri-axial accelerometer (MVP-RF8, Microstone) attached to the L3 spinous process. Trunk accelerations were sampled at 200 Hz. The mathematical derivation of RMS and PSEn were based on the detailed description provided by Mizuike, et al[2] and Kojima, et al. [1]. To determine dual-task effects, all parameters were analyzed using repeated measures analysis of variance. Multiple comparisons with bonferroni adjustments were used to identify significant differences between tasks. Partial eta squared was used as a measure of effect size. Ethical approval was obtained from the local ethics committee. All the participants provided written informed consent after the purposes of this study were explained to them. RESULT Table 1 shows the results under different tasking conditions. The dual-task effects caused a decrease in all the values of time-distance parameters and RMS. A significant difference of PSEn was found only in the vertical component. PSEn in vertical component was the largest effect size in all parameters. CONCLUSION The results indicated that dual-task loads while walking cause significant changes in the vertical component, which involve decreasing motions of trunk and smoothness of the control. REFERENCE [1] Kojima M. et al., J Phys Ther Sci; 20:243-248, 2008. [2] Mizuike C. et al., Gait Posture; 30: 60-64, 2009.

P4-A-24 Gait Patterns of Ambulatory Hemiplegic Elderly

***Mi Jung Kim*[1], Junho Kim**[1], **Dohyun Yoon**[1], **Hyunpil Cho**[1], **Seunh Jun Seol**[1], **Sangwon Kong**[1], **Kyung Soo Lee**[1], **Seung young Choi**[1], **Boram Kang**[1], **Dong Hun Lee**[1], **Taikon Kim**[1]
[1]Hanyang University Medical Center

BACKGROUND AND AIM: To assess gait patterns of chronic ambulatory hemiplegic elderly (HE) compared with non-hemiplegic elderly (NHE), focusing on the temporal, spatial, and kinetic variables. METHODS: Twenty nine chronic ambulatory HE stroke patients (M:F=22:7) and thirty NHE volunteers (M:F=18:12) were recruited. Of HE, 17 patients had cerebral infarctions and 12 patents had cerebral hemorrhages. All subjects walked with self-selected comfortable gait speeds during motion capture. After sufficient practice trials for being well acquainted with Vicon® 512 motion analysis system (Oxford Metrics Ltd. USA), the three-dimensional trajectories of reflective markers on subject's skin were analyzed, and temporal, spatial, and kinetic variables were analyzed. All trials were normalized into a full (100%) gait cycle. RESULTS: HE showed significantly decreased walking speed, cadence, stride length, and step length compared

with NHE. And HE also showed increased stride time, step time, single limb support, and double limb support periods in comparison with NHE. When we compared the percentage of each gait event, initial and terminal double limb support of stance phase were significantly increased in HE. Affected limb single support was significantly decreased in HE. However, there was no meaningful difference in sound limb single support between HE and NHE. The affected side pelvic kinematics of HE showed marked upward elevation of pelvic obliquity from terminal stance to mid swing phase, and greater external pelvic rotation than the NHE within all gait cycle ($p<0.05$). The affected side hip kinematics of HE showed increased external hip rotation than NHE during entire gait cycle. The affected side knee kinematics of HE showed loss of the first and the second flexion wave, mild knee varus during stance phase, marked deficiency of knee valgus in swing phase. The affected side ankle kinematics of HE showed loss of the first rocker and the third rocker and marked outward foot progression angle compared to NHE throughout the gait cycle. CONCLUSIONS: Chronic hemiplegic elderly showed significantly impaired temporal and spatial parameters, and altered patterns of joint kinematics compared with age-matched normal elderly. Increasing of initial double limb support, which is the phase when the affected limb is accepting weight at initial loading, may indicate that the HE have difficulty in transferring body weight to the affected limb or that HE may have a balance problem. Increasing of terminal double limb support on the sound limb may indicate difficulty in executing a short sharp thrust at push off by the affected limb or a balance problem. However, when single support of sound limb in HE was not showed any difference compared with that of NHE. The implication of this study is that therapeutic goals may be focused for three abnormalities of stance phase in gait cycle.

P4-A-26 High-Pass-Filter Cut-Offs Determination of the Fatigue Index During Isotonic contractions

Jungyoon Kim[1], **Soonjae Ahn**[1], **Youngho Kim**[1]
[1]Yonsei University

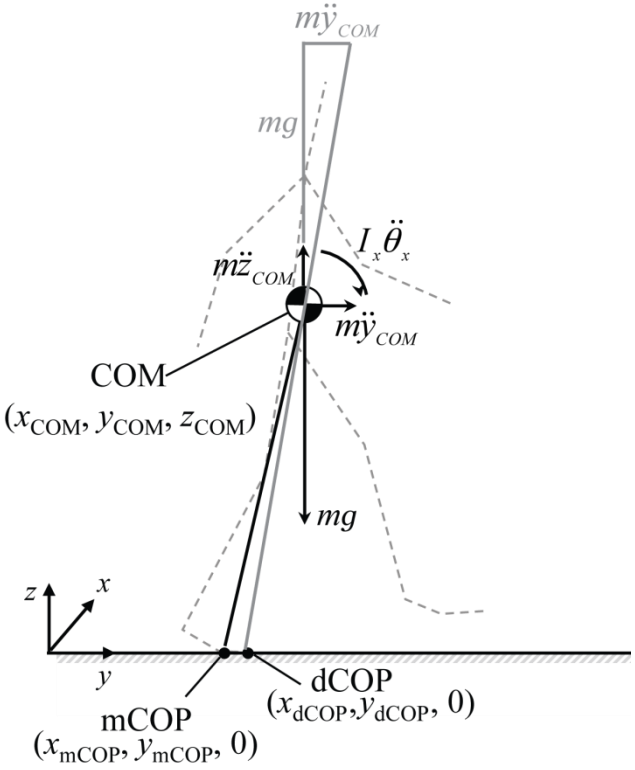
BACKGROUND AND AIM: The mean and median frequencies (Fmean and Fmed) are traditionally used to evaluate peripheral muscle fatigue. However, both Fmean and Fmed have a relatively low sensitivity under dynamic exercise conditions. In order to overcome this problem, various methods for the determination of muscle fatigue have been attempted. However, their methods required large amounts of computation and had limitations in time-frequency resolution. Kim et al. introduced the use of a filter-based fatigue index (FIhrlOPT), which the ratio of high-frequency to low-frequency components of EMG power. In this study, we optimized the cut-offs of the high-pass-filter (HPF) to maximize the correlation coefficient between the peak power and the FIhrlOPT in different muscles, and then to determine the frequency bandwidth of our fatigue index. METHODS: Forty-one healthy males were recruited for this study. Twenty-seven subjects performed knee extension/flexion exercises and fourteen subjects performed elbow flexion/extension exercises on an isokinetic dynamometer (Biodex System 3, Biodex Medical Systems, NY, USA). 10 repetition maximum was used for fatigue exercises. The experimental protocol was 5 sets of 10 knee extensions and elbow flexion with 2 minutes of rest between sets. EMG signals were obtained from rectus femoris (RF), vastus medialis (VM), vastus lateralis (VL) and biceps brachii (BB) muscles using the Noraxon EMG System (MyoSystem 1200, Noraxon Inc., AZ, USA). EMG signals, as well as biomechanical signals (angle, angular velocity and torque) were simultaneously recorded with a sampling rate of 1kHz. FIhrlOPT was calculated and cut-offs of HPF were optimized to maximize the correlation between the peak power and FIhrlOPT. RESULTS: Cut-offs of HPF of RF, VM, VL, BB showed in Table 1. Optimized cut-offs of RF, VM, VL and BB were similar (353.3± 49.5 Hz, 343.9± 34.2 Hz, 353.7± 36.1 Hz and 362.3± 28.2 Hz). RF, VM, VL and BB muscles showed good correlation with joint power (correlation coefficient was 0.81± 0.08, 0.56± 0.23, 0.52± 0.24 and 0.72± 0.08). CONCLUSIONS: Similar to previous study , cut-offs of HPF of muscles were about 350Hz (RF: 360Hz in previous study). Similar cut-offs of HPF in different muscles showed the possibility of general bandwidth to estimate muscle fatigue. Mills showed that the compound muscle action potential spectrum did not change during fatigue above 200Hz. Thus, the high frequency power decreased during fatigue because of the reduced motor unit activation. The low frequency power increased during fatigue because of the elevated motor unit action potential areas.

FIhrlOPT could reflect the decrease in the peak power during fatigue by these reasons. Acknowledgments: This research project was supported by the Sports Promotion Fund of Seoul Olympic Sports Promotion Foundation from MCST (s07201212022012). This research was also financially supported by the MKE and KIAT through the RDRI (70011192).

P4-A-28 Gait assessment using desired center of pressure: How robotics concept matches human gait

***Kei Masani*[1], Takeshi Yamaguchi**[2], **Hiroshi Onodera**[3]
[1]Toronto Rehabilitation Institute, [2]Tohoku University, [3]National Hospital Organization CREST lab

BACKGROUND AND AIM: In the control system of the Honda humanoid robot, the key for maintaining postural stability during walking is to control the center of pressure under the entire body (COP): The "desired COP" (dCOP) is defined as a virtual point on the ground, i.e., location where the moment around the body center of mass (COM) becomes zero when dCOP and the measured COP (mCOP) are at the same location (a modification of the Zero-Moment Point concept used in the Honda humanoid robot) (Figure); One of the key control strategies of such humanoid robots for maintaining postural stability is to control feet placement by aiming to place the mCOP on top of dCOP. The purpose of this study was to investigate whether this concept can be used for assessment of human gait. METHODS: Eleven male healthy subjects (18 - 24 yrs) participated in this study. Each subject was requested to walk on a 5m-long path ten times with his natural cadence and speed. Six force platforms, located in the middle of the path, were used to measure body kinetics including mCOP. Body kinematics were measured using a motion capture system, by which the center of mass (COM) behavior (displacement, velocity and acceleration) was estimated. The dCOP was calculated using COM behavior according to Eq. 1 in Figure. RESULTS: Eighteen to 38 steps were collected for each subject. The dCOP and mCOP trajectories appeared to follow closely, and the two measurements were highly correlated for each step (r = 0.527-0.827 and 0.894-0.957 for medio-lateral (ML) and anterio-postriro (AP) directions, respectively). Moreover, the distance between dCOP and mCOP (dCOP-mCOP) was small on average (RMS 2.1-3.4 cm and 3.6-7.1 cm for ML and AP directions, respectively). These results suggest that dCOP approximately follows mCOP during human gait. Further, dCOP-mCOP significantly correlated with its theoretical value (Eq. 2 in Figure) (60% and 93% of all steps for ML and AP directions, respectively), suggesting that dCOP can be accurately measured, especially regarding AP direction, despite expected measurement errors of COM behavior in most steps. We hypothesized that dCOP-mCOP caused the destabilizing moment and that its variability induced gait variability, which is an important measure for assessing gait stability. We found that the step interval was highly correlated with dCOP-mCOP in ML direction for 7 subjects (r = 0.373-0.841), suggesting that variability of dCOP-mCOP may cause gait variability. CONCLUSIONS: This is the first study where dCOP was calculated for human gait and we showed the feasibility using dCOP for assessing human gait stability. This method may be used to assess people with deteriorated gait such as neurological patients and the eldery. ACKNOWLEDGEMENT: This work was partially supported by Core Research for Evolutional Science and Technology (CREST) Program of Japan Science and Technology Agency (JST).



For y direction

Eq. 1 $$y_{dCOP} = y_{COM} - \frac{\ddot{y}_{COM}}{\ddot{z}_{COM} + g} z_{COM}$$

Eq. 2 $$y_{dCOP} - y_{mCOP} = -\frac{I_x \ddot{\theta}_x}{m(\ddot{z}_{COM} + g)}$$

Figure

P4-A-30 The Effect of Postural Stability by Foot Arch in Older People

Emi Anzai[1], **Kanako Nakajima**[1], **Yumi Iwakami**[2], **Shuichi Ino**[3], **Toru Ifukube**[4], **Kazuhiko Yamashita**[2], **Yuji Ohta**[1]
[1]Ochanomizu University, [2]Tokyo Healthcare University, [3]National Institute of Advanced Industrial Science and Technology, [4]Institute of Gerontology, University of Tokyo

BACKGROUND AND AIM: One of the fall factors in the elderly includes the decline of postural stability. The previous studies showed the association with the plantar intrinsic foot muscles and postural stability, and speculated that the arch of the foot contributed postural stability. However, the function of the arch remains unclear in postural stability. The aim of this study was to determine the relationship among arch of the foot, postural stability and fall. DEVELOPMENT: The Shoes Type Stabilometer was developed in this study. The device consists of a shoe insole with seven pressure-sensitive conductive rubber sensors and a wireless data transmission unit. The Shoes Type Stabilometer can measure center of pressure (COP) sway which had been employed as an evaluation of the postural sway. The device can mutually evaluate COP and the foot type. In the accuracy of the device, COP waveforms measured in Shoes Type Stabilometer were strongly correlated with in stationary type stabilometer(r=0.88~0.99). METHODS: 144 older adults (mean age 74.8, standard deviation 5.8 years) participated in this study. Plantar pressure distribution and postural stability were measured by using the Shoes Type Stabilometer. Postural stability was evaluated by COP sway for 45 seconds in the standing position. Fallers who have fallen at least once were investigated by the questionnaire. RESULTS: In the field test, all subjects could be measured. The ratio of midfoot pressure indicate arch of the foot, therefore subjects were classified into three groups by the ratio of midfoot pressure by using hierarchical cluster analysis; high arch group(low ratio of midfoot pressure), normal arch group (normal ratio of midfoot pressure) and low arch group(high ratio of midfoot pressure). As a result, the low arch group had a greater COP sway in total length, area, anterior-posterior (AP) and medial-lateral (ML) length than the normal arch group and high arch group. In addition, fallers (n=34) had a significantly higher ratio of midfoot pressure than non-fallers (n=109). CONCLUSIONS: Our results show that the low arch decrease postural stability. Therefore, the results mean that the arch of the foot affects postural stability in older people. In addition, fallers significantly decreased arch than non-fallers. Thus, the decrease of arch is associated with poor postural control and increased risk of fall in the elderly. This study indicated that the ratio of midfoot pressure contribute to one of the element of the fall factor.

P4-A-32 A new metric for upright balance

Mohammad Hadi Honarvar[1]**,** **Motomu Nakashima**[1]
[1]Tokyo Institute of Technology

BACKGROUND: Control of balance is a primary objective in most human movements. In many cases, research or practice, it is essential to quantitatively know how good the balance is at a body posture or at every moment during a task. Traditionally, the shortest distance of the vertical projection of the center of mass (CoM) to the base of support (BoS) was used to show how far from the balance a state is. Later, it has been brought to the attention that this criterion is not sufficient in dynamic situations, and the velocity of CoM should also be accounted for. The so called margin of stability (MoS) got suggested to represent the degree of stability of a state, which is now widely in use. However, MoS addresses the momentum still can be received without falling and is not well related to the "possibility" of maintaining the balance or "safety" at a state. It may be very small for a state while it is rather highly safe. The reverse is also true: high MoS is not necessarily highly stable. In this paper we suggest a new measure for postural upright stability which assigns a value to a body state based on the probability of avoiding a fall initiation from that state. METHODS: A bigger stability value should be granted to a state from which a smaller portion of the society will initiate a fall. Using the population's statistical characteristics and taking advantage of the concept of probability, the postural stability at a state may be defined as the probability of the balance to be recoverable over the entire population, and called the probability of recovery (PoR). For a perturbed body state solving the balance recovery problem for the population sample of 600 subjects estimates which portion of them have the possibility of regaining their stability. PoR takes values between zero (0%, no one) and one (100%, everyone). RESULTS: In order to illustrate the method we select a 3-segment mechanical model as a chassis in this

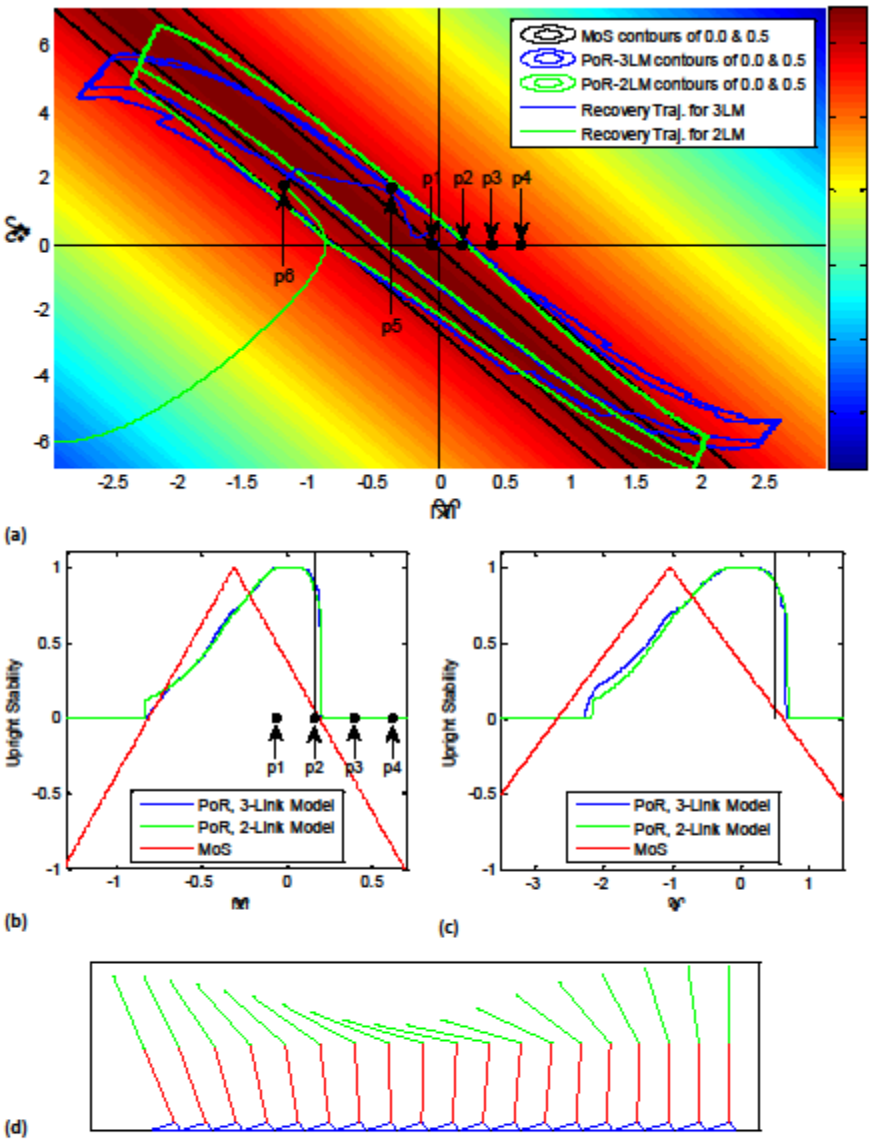


Fig. 6. (a) Margin of stability (MoS) for the $\hat{x} - \hat{v}$ plane, normalized to its maximum. Dark red corresponds to 1 (highest stability). Black curves are contours of 0 and 0.50 of MoS. Inner curve corresponds to 0.50. Green and blue curves are contours of 0 and 0.50 (inner) of the probability of recovery (PoR) for the 2-link model and 3-link model, respectively. Part of the 0.50 contours overlap with the 0 contours. Thick blue curve shows the recovery trajectory of the 3-link model from p6. Thick green curve shows the best try of the 2-link model from the same point. (b) cross section of PoR-2LM, PoR-3LM, and MoR at $\hat{v} = 0$, and (c) at $\hat{x} = 0$. Points p1~p4 are equally distanced. (d) A stick view of recovery trajectory from p5 by the 3-link model for 50ms intervals.

paper, although the methodology may be extended to other mechanical models. PoR for this model as well as for a 2-link model are calculated for all points on the plane of position-velocity of CoM, and compared to a conventional metric: the margin of stability (MoS). It is shown, for example, that MoS may be very low at a state from which most of the people will easily control their balance. CONCLUSIONS: The PoR as defined in this paper shows how probable avoiding a fall initiation is at a body state. It compares the states directly on the basis of success of the primitive balance control strategies, and hence, is capable to represent the stability at a body state by a single scalar quantifying how good the balance is, or its complementary, how likely the loss of balance is. A corollary, for example, is that a perturbation, no matter of what type or how complicated it is, may be transferred to the state space and replaced with a single scalar: PoR, as a function of the response delay.

P4-A-34 Assessing fall risk in Patients with Parkinson's Disease using an instrumented 3-day activity monitoring

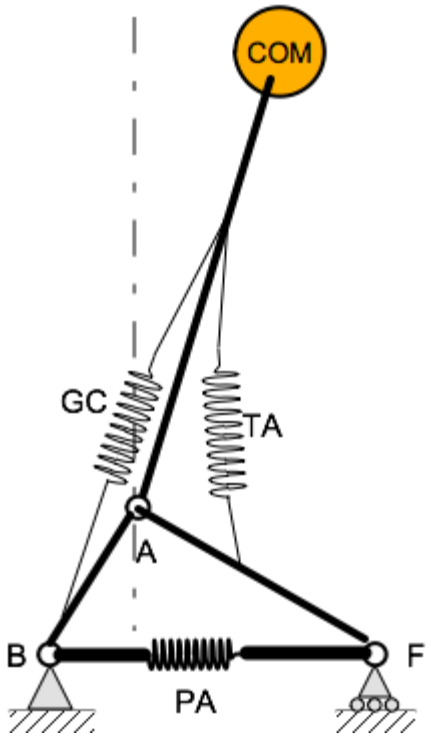
Aner Weiss[1]**,** **Talia Herman**[1], **Nir Giladi**[1], **Jeffrey Hausdorff**[1]
[1]Tel Aviv Sourasky Medical Center

BACKGROUND AND AIM: The evaluation of fall risk in patients with Parkinson's disease (PD) is generally based on self-report that may be affected by recall bias or a clinical test at one point in time. However, patients with PD typically suffer from motor response fluctuations, potentially limiting the utility of a test at one point in time. We recently proposed a method for quantifying activity in daily-living settings [1]. Here, we apply this method to assess fall risk. The aim of this study was to evaluate the possibility of using a single body-fixed sensor worn for 3 days to quantify and predict fall risk in PD patients as they carry out their routine activities. METHODS: 108 PD patients were studied (age: 65.1±9.2 yrs; Hoehn & Yahr "off": 2.57±0.69; 24.5% women). Falls status was assessed by fall-history in the year prior to the study and a follow-up for 12 months. Subjects wore a 3D accelerometer on the lower back for 3 days. Acceleration axes included: vertical (V), anterior-posterior (AP) and medio-lateral (ML). As previosly described [1], gait features were extracted that reflect the amount or quantity of walking (e.g., steps per day) and the quality of gait, e.g., step and stride regularity, harmonic ratio, and frequency-derived measures of gait variability (i.e., amplitude, width of the power spectral density). RESULTS: Based on fall-history, subjects were classified as PD fallers (n=42) or PD non-fallers (n=66). Both groups had similar values of quantity measures. However, the PD-fallers had higher gait variability in the V direction (V-Width non-fallers: 0.69±0.03 Hz; fallers: 0.73±0.06 Hz; p=0.001), and in the AP direction (AP-Width: non-fallers: 0.69 ±0.03 Hz; fallers: 0.73±0.07 Hz; p=0.0002). The PD-fallers had less consistency and smoothness in their V gait pattern, as depicted by the stride regularity and harmonic ratio. They also showed a less smooth ML gait pattern, reflected by the harmonic ratio (non-fallers: 0.59 ±0.13; fallers: 0.65±0.15; p=0.025). Fall history was significantly correlated with gait variability in all axes, and with consistency and smoothness measures ($r>0.19$, $p<0.044$). Prediction of future falls: We checked the discrimination between the patients who fell at least 2 times in the year following the study (n=25) and non-fallers (n=57) using binary logistic-regression. Fall history alone successfully classified 79.0% of the subjects (48.0% sensitivity, 92.9% specificity). However, when adding the acceleration measures, 86% of the subjects were correctly classified (75% sensitivity, 91.1% specificity). CONCLUSIONS: These initial findings suggest that a body-fixed sensor worn for 3 days can be used to predict and evaluate fall risk in patients with PD as they carry out their routine activities in their natural settings. Reference: [1] Weiss et al. Neurorehabil Neural Repair. 25:810-8, 2011.

P4-A-36 Role of the human foot in the erect posture

Okan Alkan[1], **Roshanak Akbarifar**[1], **Senih Gurses**[1]
[1]Middle East Technical University

BACKGROUND AND AIM: The human foot and ankle is a strong and complex mechanical structure containing more than 26 bones, 33 joints (20 of which are actively articulated), and more than a hundred of muscles, tendons, and ligaments.



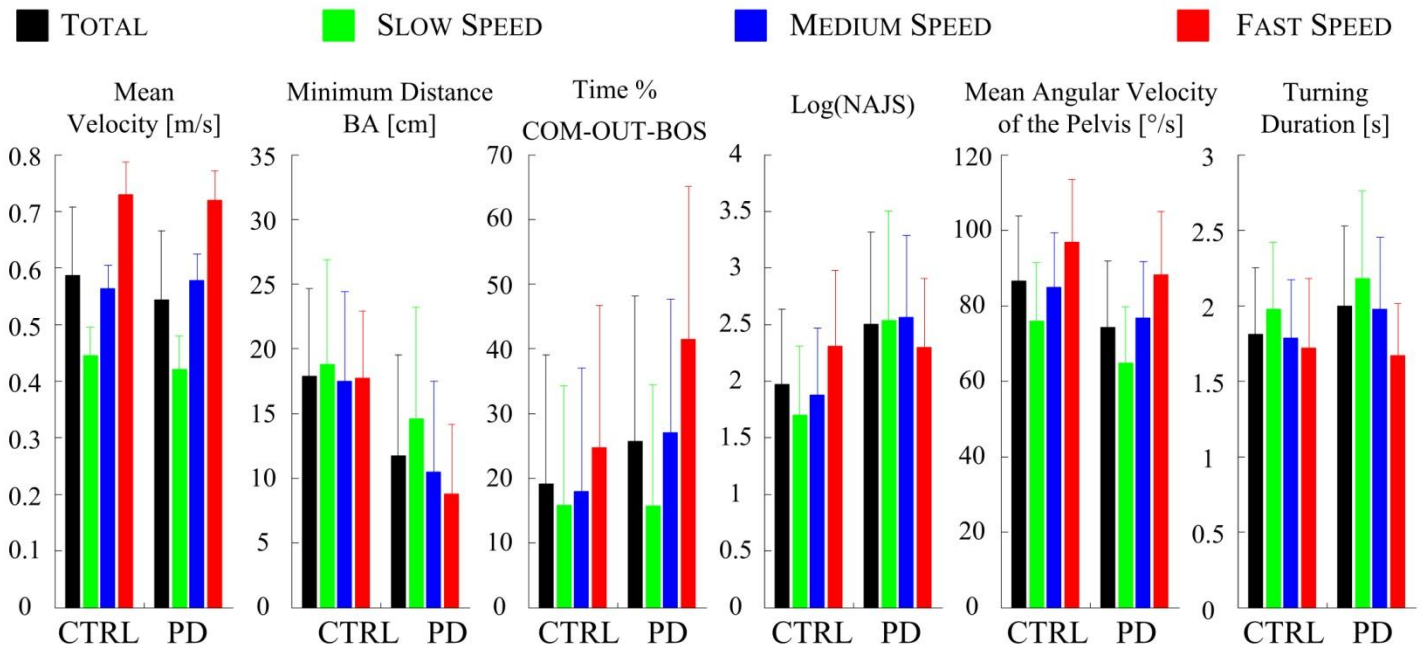
The foot can be subdivided into hindfoot, midfoot, and forefoot. Forefoot acts as an actuator, whereas hindfoot and midfoot function as load bearing elements. There exist also three arches (Medial longitudinal arch, lateral longitudinal arch, and transverse arch) of the foot which are formed by the tarsus and metatarsal bones and strengthened by ligaments and tendons allowing the foot to support the weight of the body in the erect posture. PARAAlthough, foot has great importance in load bearing and actuating function, in most of the human erect posture studies it has been treated as a rigid body with an ankle joint. However, during quiet stance when the foot is loaded, the greatest amount of motion occurs in the sagittal plane around the talonavicular joint (Wilson, 1994), which can also be described as the deformation of the medial longitudinal arch. The plantar aponeurosis (PA) has been shown to be the most important passive arch support during the stance phase, where it is also revealed that PA raises the longitudinal arch passively (without muscular contraction) when the toes are dorsiflexed, known as the windlass mechanism (WM) (Hicks, 1953). WM induces tension on PA resulting in a stiffened medial longitudinal arch through which the foot is transformed to behave like a rigid lever. There is also the reverse effect when the arch is flattened under the body weight so that the proximal phalanges become plantarflexed and the toes are firmly opposed to the ground. On the other hand, structural and functional foot abnormalities that cause clinical problems give rise to postural readjustments (Sakalauskaite, 2012). Difficulties in the implementation of the postural research studies into medical practice may arise, because of not considering the foot as an organ in human balance control. METHODS: We hypothesize that deformation of the medial-longitudinal arch, PA and WM altogether play an important role in maintaining erect posture in quiet stance. The Figure shows an inverted pendelum posture model (COM is center of mass) where the ankle joint (A) is not stationary, but is in motion due to the deformation in the medial longitudinal arch which is modeled as a tied arched structure consisting of truss members. Gastrocnemius (GC) and Tibialis Anterior (TA) muscles and PA are simply treated as springs. Point (B) is located at the plantar surface of calcaneus and is treated as a fixed support, while metatarsophalangeal joint and the sesamoid complex (point F at the forefoot) has been treated as a roller support. PARAMATLAB® and Simulink® models are under development. Human quiet stance experiments will be performed and compared with the model outputs.

P4-A-38 Stability and Dynamics of Turn During Walking in People With Parkinson's Disease

Martina Mancini[1], **Sabato Mellone**[2], **Fay Horak**[1], **Ryan Meyer**[1], **John Nutt**[1], **Lorenzo Chiari**[2]
[1]OHSU, [2]University of Bologna,

BACKGROUND AND AIMS: The ability to turn while walking is essential for daily living activities. Turning difficulties are a common symptom in Parkinson's disease (PD) which is also associated with freezing of gait [1]. In comparison with healthy subjects, turning is usually slower in PD and takes more steps; timing and coordination of the different body segments can also be altered [2]. All these disabling factors lead to a higher fall risk also with an increased risk of hip fracture [3]. We present the preliminary results of our study whose aim was to better understand turning dynamics in PD patients by means of stereophotogrammetry and inertial wearable sensors. METHODS: We examined 16 PD subjects (65±6 years, UPDRS III 24.5±7.5, 5 females) and 9 control (CTRL) subjects (68±8 years, 3 females) wearing a 9-axis inertial sensor on the lower back (Opal, APDM Inc., sample rate 128Hz) and a set of reflective markers (8-camera Motion

Analysis system, Santa Rosa, sample rate 60 Hz). Subjects were instructed to walk on a path composed of a mixed route with short straight paths interspersed with turns. Each subject performed 12 repetitions: 4 at preferred, 4 at faster, and 4 at slower speed. Several spatio-temporal turning features were extracted from both marker trajectories and signals. ANOVA has been used to identify significant differences ($p<0.05$) between groups. RESULTS: A subset of the results is reported in the Figure. Mean Velocity (MV) was significantly lower in PD. In order to limit the effect of the speed in the comparison, trials have been divided in three groups (Slow, Medium, Fast) depending on the measured MV rather than keeping the original groups. PD spend a higher percentage of the turn duration with their CoM outside their base of support at medium and fast speed, the percentage increases with speed but 1.5-1.7 times more in PD at medium and fast speed respectively. PD turns are jerkier (NAJS) at slow and medium speed and always slower (mean angular velocity of pelvis). Turning duration is also higher in PD at slow and medium speed. The Minimum Distance Between Ankles (MDBA) is always smaller in PD. All the features were correlated with MV for both PD and CTRL with the exception of the MDBA in CTRL. CONCLUSIONS: PD subjects show significant postural instability during turning compared to age-matched control subjects. The narrow distance between feet in subjects with PD resulted in more time with the body CoM outside their base of support, regardless of turning speed. The slower turning speed in subjects with PD may be to compensate for impaired postural stability. ACKNOWLEDGEMENTS: with the support of Italian Ministry for Foreign Affairs - Direzione Generale per la Promozione del Sistema Paese, NIA Merit Award (AG006457), and STRR grant from NINDS (R41 NS07608801) REFERENCES 1. H Bhatt et al. Parkinsonism Relat D; epub, Oct. 2012 2. M Hong et al. Neurorehabil Neural Repair, 23(2):166-76 3. O Johnell et al. Age Ageing; 21(1):32-8



Mean Value(Standard Deviation) = Bar(Whisker); Slow Speed = trials performed with a mean velocity < 0,5 m/s; Medium Speed = trials performed with a mean velocity between 0,5 and 0,65 m/s; Fast Speed = trial performed with a mean velocity > 0,65 m/s; CTRL = Control Group; PD = Parkinson Group; BA = Between Ankles; COM-OUT-BOS = Center Of Mass Out of the Base Of Support; NAJS = Normalised Angular Jerk Score;

P4-A-40 Heterogeneity of postural sensory integration functions in Parkinson disease

Martijn Muller[1], **Roger Albin**[1], **Kirk Frey**[1], **Nicolaas Bohnen**[1]
[1]University of Michigan

BACKGROUND AND AIM: Maintaining upright stability requires postural sensory integration functions. Postural instability symptoms present heterogeneously in Parkinson disease (PD). However, it is unclear whether postural sensory integration functions are uniformly affected in all PD patients or only in a subgroup. The aim was to compare

postural sensory integration functions in PD patients to healthy older adults and identify clinical correlates. METHODS: 110 PD (29F) subjects without symptoms of freezing upon clinical examination and 30 subjects (10F) without neurodegenerative disorder (NC) participated. There was no difference in age, gender distribution, BMI, height, and peripheral malleolar vibration sensitivity between PD and NC subjects. All subjects underwent the Sensory Organization Test (SOT) balance protocol on the NeuroCom® EquiTest® platform. For each of the 6 SOT conditions total center of pressure (COP) excursion (speed) and COP variability (root mean square; RMS) were calculated. Exploratory graphical presentation of speed and RMS for each SOT condition showed significant overlap between PD and NC subjects. PD subjects were categorized as 'normal-range' when both speed and RMS z-scores across all conditions were below 1.65 based on the normative data from the NC subjects. In addition, there should be no 'falls' in any of the SOT conditions. Subjects also underwent a clinical examination including MDS-UPDRS assessment. All assessments were performed in the dopaminergic "off" state for PD patients. RESULTS: 'Abnormal-range' postural sensory integration control functions was present in 45.5% of the PD subjects. Subjects with abnormal-range postural functions were older than normal-range PD subjects (68.1 ± 8.3 vs. 63.7 ± 6.38 yrs; t=-3.1, p=0.003), had longer motor disease duration (6.7 ± 4.3 vs. 4.8 ± 3.7 yrs; t=-2.4, p=0.018), and higher MDS-UPDRS part III motor score (35.3 ± 13.1 vs. 25.8 ± 10.6; t=-4.2, p<0.001). CONCLUSIONS: Abnormal postural sensory integration functions are not uniformly present in all PD subjects. PD subjects with abnormal postural sensory integration functions are generally older, have longer disease duration, and more severe motor impairment. These findings should be taken into consideration when studying postural sensory integration control functions in PD patients or designing clinical trials.

P4-A-42 Effects of Hallux Valgus on the Lower Limb Biomechanics During Walking

Kao-Shang Shih[1], **Hui-Lien Chien**[2], **Chu-Fen Chang**[2], **Tung-Wu Lu**[2]
[1]Shin Kong Wu Ho-Su Memorial Hospital, Taipei, Taiwan, [2]Institute of Biomedical Engineering, National Taiwan University

BACKGROUND AND AIM: Hallux valgus (HV) deformity is related to foot dysfunction and may lead to failure of basal support in the stance phase and load transmission during waling [1]. HV not only affects the foot alignment, but may also result in biomechanical changes of the ankle, knee and hip joints. However, no study has reported a complete description of the kinematic and kinetic alterations and associated compensatory changes in the lower limb joints. The study investigated the influence of hallux valgus deformity on the biomechanics of the lower limb joints during walking. METHODS: Eleven patients with bilateral HV and 11 healthy female controls participated in the current study. Each subject walked at a self-selected pace while their kinematic and kinetic data were measured with a 7-camera motion analysis system (Vicon, Oxford Metrics, U.K.) and two force plates (AMTI, U.S.A.). The ground reaction force (GRF), joint angles and moments at contralateral heel strike (CHS), contralateral toe-off (CTO) and ipsilateral toe-off (TO), as well as their peak values, were obtained for subsequent statistical analysis. The distance between the center of pressure (COP) and 1st metatarsal head as the COP passed the metatarsophalangeal joint line was also calculated. All the calculated variables were analyzed using independent t-test with a significance level of 0.05. RESULTS: No significant differences in gait speed, stride length, stride time and cadence were found between the groups. Compared with the controls, the HV group had smaller range of motion (ROM) at the knee in the frontal (p=0.048) and transverse (p=0.039) planes during stance phase, and at the hip in the transverse plane (p=0.025). The also had smaller knee abduction at TO (p=0.04) as well as peak ankle dorsiflexion (p=0.041) and toe-out angle during the gait cycle. Smaller medial (p=0.047) and greater anterior GRF (p=0.017) at CTO, as well as greater knee abductor moments during stance phase, were also found in the HV group. The distances between COP and 1st metatarsal head were greater in the HV group than the controls. CONCLUSIONS: Patients with HV were found to adopt compensatory strategies to unload the hallux and the 1st metatarsophalangeal joint. They successfully shifted the load (GRF) away from the hallux and 1st metatarsophalangeal joint via decreasing the toe-out angle and the ROM of the hip in the transverse plane. However, this strategy increased

the knee abductor moments, indicating that although HV is a forefoot deformity, it may increase the load at the knee as a result of compensation. REFERENCE 1. Kozakova. J. et al. Acta Univ. Palacki. Olomuc. 41(4) :49-54, 2011.

P4-A-44 The effect on gait asymmetry of treating older hip fracture patients in a geriatric ward as compared to usual care in an orthopedic ward ? The Trondheim Hip Fracture trial

Pernille Thingstad[1], **Kristin Taraldsen**[1], **Beatrix Vereijken**[1], **Rolf Moe-Nilssen**[2], **Olav Sletvold**[3], **Jorunn Helbostad**[1]
[1]NTNU, [2]University of Bergen, [3]St. Olav's University Hospital and NTNU

BACKGROUND AND AIM A hip fracture is a fall-related injury mostly affecting older persons. The majority of older hip fracture patients do not regain pre-fracture gait function and the risk of new falls and fractures is high. A hip fracture is a unilateral injury associated with pain, reduced weight-bearing, and reduced muscle strength in the affected leg. Consequently, asymmetry is an important aspect of gait to be targeted in rehabilitation. So far little is known about how different interventions affect asymmetry of gait after a hip fracture, and how asymmetry relates to other characteristics of gait. Gait speed has been regarded an overall indicator of health and function, while gait variability has been associated with fall risk. We have earlier shown positive effects for hip fracture patients of being treated in a geriatric ward compared to an orthopedic ward on gait speed and variability 4 and 12 months after the fracture. Based on these findings, we wanted to assess whether the same positive effect were found on gait asymmetry. Aim of the present study was to evaluate the effect on gait asymmetry 4 and 12 months post surgery of treating older hip fracture patients in a geriatric unit compared to usual care in an orthopedic ward. METHODS: The Trondheim Hip Fracture Trial is a two-armed randomized controlled trial, including hip fracture patients older than 70 who were home dwelling at the time of the fracture (Sletvold et al 2011). Patients who participated in both the 4 and the 12 months gait assessments were included in the present study. Gait characteristics were measured using an electronic gait mat (GAITRite). Patients walked back and forth the mat twice at preferred speed. Asymmetry was calculated for single support time and step length, using an asymmetry index: ? ln(affected/non affected)? x100. RESULTS: 196 patients of the initially randomized 397 hip fracture patients performed the gait assessments at both 4 and 12 months. This subsample had slightly better prefracture ADL scores than the total sample. There were no differences between groups for step length or single support time asymmetry at 4 or 12 months post-surgery. Both treatment arms demonstrated high asymmetry 4 months post surgery for single support (mean 13.0, SD 14.0) and step length (mean 12.7, SD 14.9). The entire sample demonstrated significant improvements in gait asymmetry from 4 to 12 months. CONCLUSION: The beneficial effect of being treated in a geriatric compared to an orthopedic ward found for gait speed and gait variability was not found for asymmetry. Gait asymmetry has earlier been suggested to be an independent domain of gait closely related to pathology (Lord 2012). This is supported by our findings. The intervention in this study was not targeted to improve gait asymmetry. Future studies are needed to assess whether a more targeted treatment can improve gait asymmetry after hip fracture.

	Single support asymmetry, mean(SD)				Step Length asymmetry, mean(SD)			
	geriatric ward		orthopedic ward	*p*	geriatric ward		orthopedic ward	*p*
4 mnth	13.1	(15.2)	12.8 (12.6)	0.9	12.8	(16.5)	12.6 (12.9)	0.2
12 mnth	7.9	(9.1)	9.5 (9.8)	0.9	8.6	(9.0)	10.4 (14.1)	0.3

P4-A-46 Gait performance abnormality in patients with vestibular disorders.

Yoshiaki Itasaka[1], **Kazuo Ishikawa**[1], **Eigo Omi**[1], **Koh Koizumi**[1]
[1]Akita University

BACKGROUND AND AIM: Many patients with vestibular disorders complain of equilibrium disturbance, including vertigo or dizziness. In our previous gait studies by using tactile sensors placed under both feet, we demonstrated that the presence of vestibular system disorders could cause unstable gait. Three dimensional motion analysis is a useful tool to investigate the whole body gait performance. The purpose of this study was to examine gait performance from the additional aspect such as spatiotemporal parameters obtained by three dimensional motion analysis in patients with vestibular disorders. METHODS: Twenty-nine patients (12 males, 17 females; mean age: 60.2 years old; mean height: 163.3 cm) with unilateral vestibular disorders were enrolled in this study. They were divided three groups: 5 patients with acute phase of vestibular neuritis, 17 patients with small acoustic neuroma (2 cm or under), and 7 patients with large acoustic neuroma (over 2 cm). Nine age and height matched healthy subjects (4 males, 5 females; mean age: 60.1 years old; mean height: 162.7 cm) served as controls. Subjects were asked to walk freely with comfortable pace at a distance of about 4 meters with eyes open or closed. Spatiotemporal components, including gait speed, stride length, stride duration, % stance phase, step width, head movements (vertical, yaw, pitch, and roll), gait shift, forefoot motion, and foot flexion angle during walking, were measured by three dimensional coordinates and compared among three groups. RESULTS: In vestibular neuritis group, slower gait speed, shorter stride length, and lesser foot flexion angle at heel strike were shown compared with those values in healthy subjects. Under gait with eyes closed, in addition to those changes, wider step width, greater gait shift, and lesser foot flexion angle at toe off were observed. In small acoustic neuroma group, shorter stride length, and lesser foot flexion angle at heel strike were found. In addition to those changes, the difference between highest and lowest toe position values during swing phase became smaller in large acoustic neuroma group. CONCLUSIONS: Those differences among the three groups might reflect a functional disorder of the gait control system caused by each disease. By using three dimensional motion analysis, we could delineate minor gait performance and its trait in patients with vestibular system disorders.

P4-A-48 Three-dimensional analysis of postural control during stepping in patients with unilateral vestibular dysfunction

Naoya Egami[1], **Shinichi Iwasaki**[1], **Chisato Fujimoto**[1], **Tatsuya Yamasoba**[1]
[1]University of Tokyo

INTRODUCTION: Detailed analysis of the dynamic stability during walking has recently become possible by means of three-dimensional (3D) motion analyzing system. In order to clarify the role of the vestibular function in human gait, we investigated the linear translation and angular rotation at the head and body segments during stepping in normal subjects and patients with unilateral vestibular dysfunction and compared them with those in normal subjects. METHODS: Eight patients with unilateral vestibular dysfunction (6 with vestibular neuritis and 2 with Ramsay Hunt syndrome patients) and 8 healthy subjects with no previous history of dizziness were included. Subjects were instructed to step according to the Unterberger-Fukuda's stepping test with the eyes open, and then with the eyes closed. The head, thorax, pelvis, knee and ankle joint movements were analyzed using 3D motion capture system (MA-2000S, Anima Inc., Tokyo). For data analysis, a peak to peak amplitude of translation for each walking cycle and rotation angle in the roll, pitch and yaw planes at the head, thorax and pelvis joints during each walking cycles were analyzed and compared between normal subjects and the patients. RESULTS: The width of lateral translation of all segments and head yaw rotation were significantly greater in patients with unilateral vestibular dysfunction compared to the normal controls, while there were no significant differences in the magnitude of vertical translation and the rotation angle of the other planes between the two groups. Rotation angles of the head, trunk and pelvis rotation in the yaw plane and head roll were significantly greater in the patients compared to normal controls. CONCLUSION: We demonstrated that horizontal linear translation and angular rotation at the head and body segments during stepping were greater in patients with unilateral vestibular dysfunction compared to healthy subjects. These findings suggest that vestibular system

contributes to the regulation of horizontal linear translation and angular roll rotation at the head and yaw rotation at the head and body segments during stepping.

B - Sensorimotor control

P4-B-50 Altered proprioceptive weighting impairs postural balance in individuals with chronic obstructive pulmonary disease

Lotte Janssens[1], **Simon Brumagne**[1], **Alison McConnell**[2], **Kurt Claeys**[1], **Madelon Pijnenburg**[1], **Nina Goossens**[1], **Jonas Raymaekers**[1], **Chris Burtin**[1], **Wim Janssens**[1], **Marc Decramer**[1], **Thierry Troosters**[1]
[1]KU Leuven, [2]Brunel University

BACKGROUND AND AIM: Postural control deficits are identified as important risk factors for falling in individuals with chronic obstructive pulmonary disease (COPD). However, the specific use of proprioception, which is of primary importance during postural control, has not been studied in individuals with COPD. The objective was to determine the specific proprioceptive control strategy during standing postural balance in individuals with COPD and healthy controls, and to assess whether this was related to inspiratory muscle weakness. METHODS: Center of pressure displacement was determined in 20 individuals with COPD and 20 age/gender-matched controls during upright standing on an unstable support surface without vision. Ankle and back muscle vibration were applied to evaluate the relative contribution of different proprioceptive signals used in postural control. Root Mean Square (RMS) values and mean values (directional effect of muscle vibration) were used for analysis of postural robustness and proprioceptive postural control, respectively. RESULTS: Compared to healthy controls (RMS: 4.5±1.5cm), individuals with COPD (RMS: 6.5±3.0cm) showed an increased anterior-posterior body sway during upright stance (p=0.037). Individuals with COPD showed an increased reliance on ankle proprioception during postural control as shown by a larger posterior body sway (-10.4±4.1cm) during ankle muscle vibration compared to controls (-7.6±4.4cm) (p=0.047). This was supported by the finding that the COPD group showed a lower reliance on back muscle signals, as anterior body sway (3.0±2.4cm) during back muscle vibration was reduced compared to controls (6.2±2.2cm) (p=0.025). Simultaneous ankle-back muscle vibration elicited significantly larger posterior body sways in individuals with COPD (-7.6±3.7cm) compared to controls (-3.8±3.2cm) (p= 0.002), indicative of a dominant use of ankle proprioceptive signals during postural control. Individuals with COPD with the weakest inspiratory muscles showed the greatest reliance on ankle proprioception when compared to the stronger individuals with COPD (p=0.037). CONCLUSIONS: Individuals with COPD, especially those with inspiratory muscle weakness, increased their reliance on ankle proprioceptive signals and decreased their reliance on back proprioceptive signals during postural control, resulting in a decreased postural robustness compared to healthy controls. This proprioceptive reweighting may be explained by an impaired postural contribution of the inspiratory muscles to trunk stability. Further research is required to determine whether interventions such as proprioceptive training and inspiratory muscle training improve postural control and reduce the fall risk in individuals with COPD.

P4-B-52 Undershooting of target angles in a joint position matching task derives from passive movement in the position memory phase

Yuki Sato[1], **Kazuhiro Yasuda**[1], **Hiroyasu Iwata**[1]
[1]Waseda University

BACKGROUND AND AIM: Increasing emphasis has been placed on tests of ankle joint position sense in both the clinic and the laboratory because of its significance in rehabilitation and coordination of posture. One method used to assess proprioception is the ipsilateral joint position matching task. In this test, participants memorize a target angle position

(i.e., memory phase) and reproduce the target angle (i.e., reproduction phase) by using active or passive movement in the absence of vision. Previous studies have indicated that participants undershoot the target ankle joint position when using passive movement. However, no clear consensus exists as to whether such undershooting depends on passive movement in the memory phase or the reproduction phase. This study sought to clarify which phase (i.e., memory or reproduction phase) more profoundly affects undershooting in the joint position matching task. METHODS: Fourteen healthy young adults participated. Participants performed an ipsilateral ankle position matching task. Each blindfolded participant performed four movement conditions in which they memorized and reproduced target angles: (1) active, active (memory and reproduction phase=active); (2) active, passive (memory phase=active, reproduction phase=passive); (3) passive, active (memory phase=passive, reproduction phase=active); and (4) passive, passive (memory and reproduction phase=passive). Joint reproduction errors (i.e., AE: Absolute Error, CE: Constant Error, and VE: Variable Error) were analyzed using a two-way ANOVA, 2 movements in the memory phase (active, passive) × 2 movements in the reproduction phase (active, passive), which indicated significance at the 0.05 level. RESULTS: The significant main effect of movements in the memory phase indicated that the participants showed a smaller CE in the passive movement condition than those in the active movement condition. No additional significant main effects or interactions were detected among the other measurements. These results suggest that the undershooting of target positions depends on passive movement in the memory phase rather than movement in the reproduction phase. CONCLUSIONS: This study revealed that the undershooting of target angles in the ankle joint position matching task derive from passive movement in the memory phase rather than in the reproduction phase. Researcher and clinician should take into consideration that the CE might be predetermined by passive movement in the memory phase.

P4-B-54 Soleus H-reflex is suppressed during unilateral hip and/or knee passive movements in human

Yohei Masugi[1], **Taku Kitamura**[2], **Tetsuya Ogawa**[3], **Noritaka Kawashima**[3], **Kimitaka Nakazawa**[1]
[1]University of Tokyo, [2]Shibaura Institute of Technology, [3]Research Institute of the National Rehabilitation Center for Persons with Disabilities

BACKGROUND AND AIM: It has been well established that spinal stretch reflex excitability is modulated in a phase-dependent manner during human walking. Our previous studies showed that somatosensory inputs associated with robot-assisted stepping had an inhibitory effect on the soleus (Sol) H-reflex amplitude. In the present study, to elucidate the underlying neural mechanism further, effects of sensory input induced from each of ipsilateral and contralateral hip and/or knee movements were investigated. METHODS: Ten healthy males participated in two different experiments performed on separate days. The experiments were designed to test the H-reflex elicited in the right-side soleus (SOL) muscle during robot-assisted lower limb movements in Lokomat. In experiment 1 ipsilateral leg movement was tested, and in experiment 2 the contralateral leg movement was tested. Each experiment consists of hip and knee-motion condition (H+K), single hip-motion condition (H), knee-motion condition (K), and air-standing condition (ST). In each condition the Sol H-reflex was elicited by electrical stimulation to the posterior tibial nerve. The peak to peak amplitude of M-wave and H-reflex was measured, and normalized to the M-max amplitude. RESULTS: The results showed that in all ipsilateral conditions H-reflex was drastically suppressed compared to the H-reflex size in the ST condition (45% of ST H-reflex), while in the contralateral movement conditions the suppression was not as large (87%) . In the exp 1 (ipsilateral leg movement), there was no significant difference in H-reflex sizes among conditions. However, the contralateral H+K condition and H condition had significantly greater inhibitory effects on the H-reflex than K condition. In all experimental conditions, background EMG activity was less than 1% maximal voluntary contraction. As to phase-dependent modulation no marked differences were observed in all conditions, although in the contralateral condition (exp 2) a significant difference ($p<0.05$) was found between phase 4 and 3 in the K-condition. CONCLUSIONS: The present results revealed that the motion related sensory inputs significantly suppressed the Sol H-reflex amplitude in both ipsilateral and contralateral conditions. In the ipsilateral condition, Sol H-reflexes as a whole were lower than those in the

contralateral condition, indicating that sensory inputs from ipsilateral leg have the stronger inhibitory effect. In the ipsilateral leg movements, the observed inhibition sizes of H-reflex in both H and K conditions were comparable, suggesting that sensory inputs associated with both hip and knee movements have primary roles in the Sol H-reflex inhibition. Phase-dependent modulation was not observed in unilateral passive leg movements, indicating that phase-dependent modulation during walking might be attributed to not only sensory inputs but also interaction with central motor commands at spinal level.

P4-B-56 Sensory and cognitive challenge to postural control in older and young adults

Kimberly Dockx[1], **Veerle Van den Bergh**[1], **Bart Malfait**[1], **Sabine Verschueren**[1], **Alice Nieuwboer**[1]
[1]KU Leuven

BACKGROUND AND AIM: Previous research has shown that postural stability is influenced by cognitive, sensory and motor aspects, particularly in the context of ageing. Not much is known about the effect of ageing on postural control when cognitive load is added to conditions of sensory disruption. The aim of the present study was to investigate whether adding a cognitive task during situations when sensory information is compromised, would differentially impact on postural control in young and healthy older adults. METHODS: Postural stability of 9 young (22,8 ± 1,86yrs) and 5 healthy older subjects (70,8 ± 8,61yrs) was investigated during quiet stance in four different sensory conditions: 1) normal, 2) eyes closed, 3) proprioceptive disruption using muscle tendon vibration to the Achilles tendon and 4) combining visual and somatosensory disruption. Each subject performed all conditions both in single and in dual task. The individualized digit span backwards (DSB) was used as a cognitive task to increase cognitive demands during quiet stance. Force plates integrated in the CAREN platform were used to determine the mean centre of pressure displacement (CoPD) in both anteroposterior (AP) and mediolateral (ML) direction. All subjects completed the MMSE and Mini-BESTest. RESULTS: No significant differences were found between young and healthy older adults in performance on the MMSE (> 24, p=.38), Mini-BESTest (p=.69) or level of the DSB (p=.39). The effect of sensory disturbance on postural control was not significantly different between young and healthy older adults. However, a significant group effect was found in AP (p=.01) but not in ML direction (p=.19), with healthy older adults having greater CoPD compared to young adults. Postural stability was also significantly influenced by sensory condition in both AP (p<.01) and ML direction (p<.01). Postural displacement was the greatest when both visual and somatosensory information were removed (p<.01) and easiest when only visual information was compromised (p<.01). Surprisingly, the addition of a cognitive task did not significantly affect sway when sensory information was disrupted (AP: p=.96; ML: p=.41) and the effects were the same in both young and old. CONCLUSION: Despite equal motor and cognitive performance on clinical tests, older people had significantly more postural sway than young adults in all conditions. The effect of sensory manipulation and adding a cognitive task on postural control was not significantly different between old and young, which may be related to the modest group sizes. Further study is needed to confirm whether sensory context is a more decisive parameter than cognition for postural stability in both young and healthy older adults.

P4-B-58 Age-associated differences in global and segmental adaptive locomotor responses: effects of dual-task and suboptimal sensory conditions

Patricia Hewston[1], **Nandini Deshpande**[1]
[1]Queen's University

BACKGROUND AND AIM: The ability to safely navigate through the natural environment is critical for functional independence of older adults. However, the environment is complex and often presents cognitive and sensory challenges that require adaptive locomotor responses to maintain stability. Age-associated declines in cognitive and sensory systems independently have been documented to increase postural instability and risk of falls in older adults.

The purpose of this study was to investigate age-associated differences in global and segmental adaptive locomotor responses while walking during dual-task under suboptimal sensory conditions. METHODS: Fourteen young (YA, age: 25.0±2.6 years) and 14 older (OA, age: 73.0±5.2 years) healthy adults walked at a self-selected pace along a 6-meter path with serial subtraction by 3's (walking-while-talking, WT) or no additional cognitive challenge (no-WT). Somatosensory information was manipulated using either a normal surface (Hard) or compliant surface of medium-density polyurethane foam (Foam). Vestibular information was either perturbed using galvanic vestibular stimulation (GVS) at the participant's threshold intensity or intact (no-GVS). Global, segmental and cognitive performance measures were obtained in each experimental condition. Data were analyzed with a 4-way mixed factor 2(Age-group)x2(Dual-task)x2(Surface)x2(GVS) ANOVA. RESULTS: Gait speed increased in YA within WT and Foam, concurrently ($p<0.001$). Trunk roll increased with GVS in no-WT conditions ($p<0.05$), however, not in WT conditions ($p>0.05$). Head roll decreased with GVS on Hard surface ($p<0.05$), however, not on Foam ($p>0.05$). Head roll decreased in OA in WT conditions ($p<0.05$). No age-associated differences were found in dual-task performance ($p>0.05$). CONCLUSIONS: Within global responses, YA increased gait speed possibly, to utilize forward momentum during WT on the foam surface; a strategy that may not have been safe for OA. Within segmental responses, GVS is known to induce lateral trunk movement. However, during WT a stiffening strategy of the trunk was possibly evoked to overcome GVS effects. With normal visual and somatosensory information (Hard), head position may have been overcompensated to counteract GVS effects. However, with unreliable somatosensory information (Foam) overcompensation effect was not seen in YA or OA despite normal vision. OA also decreased head roll in response to divided attention (WT). Our results suggest that OA employ a more cautious strategy compared to YA under dual-task conditions with decreased somatosensory inputs despite normal vision. ACKNOWLEDGEMENTS: This project was funded by the Senate Advisory and Research Committee (SARC) to Dr.Deshpande. Thank you to Alison Novak, Mika Yoshikawa and Fang Zhang for their assistance.

P4-B-60 Effects of mismatch of visual and vestibular input to standing and stepping state. - A study using artificially moved 3D visual image triggered with head movement.

***Tatsuhiko Harada*[1], Yasuaki Ito**[1], **Tsunemi Kitagawa**[1]
[1]International University of Health and Welfare Atami Hospital

BACKGROUND AND AIM: Mismatch of sensory inputs is a major cause of dizzy feeling and loss of balance. However, the details of how sensory mismatch effects on balance and body movement are still uncovered. In this study, the effect on head and body positioning to artificially changed visual field image triggered with head movement are measured. METHODS: Subjects wore a head-mount display (Z800, eMagin, USA) in front of the eyes and 12 pieces of reflecting markers for infra-red light around head, thorax, and pelvis. In the head-mount display, 6 axis accelerometer and gyroscope with magnetometer were built-in. Two types of 3D computer graphic (vertical poles and random dots) were made and moved with detected head movement, and displayed in the head-mount display. The graphic moved with 4 different patterns, normally moved as head movement, fixed, exaggerated the head motion, and reversely moved to head motion. The tasks were composed of combinations of head movement (still, pitch movement, roll movement), movement of lower extremities (standing or stepping), type or floor surface (stand directly on the force plate, or on elastic pad; Balance Pad Elite, Airex, Swiss), graphic patterns (vertical pole or dots), and the type of graphic movements (as written above). Period of movements of head and stepping were both around 2 second. During this task, head, thorax, and pelvis movement as well as floor reaction force were detected with VICON 3D motion analysis system. RESULTS: At present, single subject had been measured. In this subject, no obvious difference with movement of the graphic when standing on the plate, but greater perturbation was seen with exaggerated or reversed view to the head motion when standing on the pad or stepping. Results of detailed analysis with more subjects are planned to be presented. CONCLUSIONS: Head movement leads to center of body mass movement and visual field movement simultaneously. Maintaining proper visual field image during head movement is important especially when support

surface is unsteady. Findings in this study can be applied to direct adequate head and body movement so as not to lead loss of balance in the patients who have vestibular or other sensorineural impairments.

P4-B-62 Backward Obstacle Avoidance In Young Healthy Adults

Jeanet Wichards[1], **Duysens Jaak**[2], **Bradford McFadyen**[3]
[1]Radboud University, [2]KU-Leuven, [3]CIRRIS-U. LAVAL

Background and aim: Backward walking (BW) with different constraints can be useful in rehabilitation training and testing. Yet, while kinematic patterns are remarkably similar but reversed from forward walking (FW), Carpenter et al. (1998), have suggested that BW is not a simple reversal of FW when avoiding obstacles. They did not, however, include an approach phase when dynamically gathered vision is effective, or manipulate exproprioception of the lower limb and obstacle known to be important for FW obstacle avoidance (Rietdyk and Rhea, 2006). The main objectives of this study were to better understand BW patterns over obstacles and how visual information about the obstacle and lower limbs influences it. Methods: Ten young healthy subjects (25.3 ± 4.2 years; 5 male) were recruited to walk forwards and backwards over a low (1,5 cm) and high (10% of leg length) obstacle, with full (FV) and partial (PV; blocking the lower visual field and thus exproprioception of legs and obstacle) vision and with natural or forced cadence (metronome). The subjects initiated gait four steps from the obstacle. 3D kinematics (100 Hz; Optotrak) of the lower limbs, trunk and head and bilateral electromyography (1000 Hz; Noraxon; not reported here) were recorded. Dependent variables for this presentation include toe clearance margin, foot proximity before and after clearance, body centre of mass (COM) displacement and velocity, and angular head movement. Descriptive statistics were combined with a four-way ANOVA with a Tukey post hoc test as well as T-tests for differences between limbs. Significance level was p ? 0.05. Results: BW during FV resulted in the trail foot being placed farther in front of and closer behind the obstacles than for FW. In PV, both distances in foot proximity respectively increased and decreased for both directions of walking. However, this was much more pronounced for FW resulting in the trail foot to be placed closer to the obstacle for BW as compared to FW during PV. Clearance margin was greatest for lead clearance for both directions and BW showed higher clearance margins than FW for both limbs and all conditions. Clearance was increased for both limbs during PV in FW, but in BW the already greater clearance was maintained regardless of the limb. Clearance margin was greater for the low compared to the high obstacle. Finally the only effect of a forced cadence was to cause the head to be turned away from the obstacle earlier during approach in BW. Conclusions: These results support the notion that foot trajectory control during obstructed BW is not similar to FW. They also show that while exproprioception information about the lower limb and obstacle is important for FW, it may be less so for BW. This in part could be because of an already cautious high stepping behaviour combined with a possible higher cognitive control of the unseen trajectory during BW (Pham et al., 2011).

P4-B-64 Control of COP and COG in anticipatory postural adjustments during multi-directional gait initiation

Tomonori Sawada[1], **Masaki Yukimune**[1], **Nobuhiro Kito**[1]
[1]Hiroshima International University

BACKGROUND AND AIM: Gait initiation (GI) is a complex motor task that entails the transition from a quiet standing posture in double-limb support. Older adults and individuals with central nervous system (CNS) disorder exhibit impaired performance during multi-directional GI. GI involves a preparatory phase and a stepping phase, and the former involves anticipatory postural adjustments (APAs) in which center of pressure (COP) shifts toward the swing limb, to move center of gravity (COG) over the stance limb. It is known that APAs play an important role in GI. We hypothesized that the control of step direction during GI is performed in APAs. We studied displacement of COP and COG in APAs during multi-direction GI. METHODS: Kinetic and kinematic variables were collected on 20 healthy young adults (10 male, 10 female.

age: 21.4±0.7) during GI in five conditions: forward, left 30°, right 30°, right 90°, backward. The subject started multi-directional GI from right lower Limb at a self-selected speed and stride length. APAs phase was defined from the point moving COP toward the right to the most lateral point. We measured following values: Medial-lateral (M-L) and anterior-posterior (A-P) displacement of COP and COG in APAs, M-L and A-P acceleration of COG at the most lateral point of COP. M-L displacement of COP and COG were normalized to distance between anterior superior iliac spine (/mm), and A-P displacement of COP and COG were normalized to foot length (/mm). These variables were measured using a 8-camera Vicon motion system (VICON MX; Oxford, UK) and 8 force platforms (AMTI; Watertown, MA, USA) and were performed using the processing software "BodyBuilder (Vicon Motion Systems; Oxford, UK)". All data were analyzed using repeated one-way ANOVA. Statistical significance was set at $P<0.05$. RESULTS: M-L and A-P displacement of COP and COG and acceleration of the COG were significantly different depending on the direction of GI. Especially, M-L displacement of COP was located on the right at left 30° and A-P displacement of COP was located on the front at backward. Additionally medial acceleration of the COG was significantly increased at left 30° and posterior acceleration of the COG was significantly increased at backward. M-L displacement of COG was located on the left at left 30° and A-P displacement of COG was located on the back at backward, but these values seemed much less than those of COP. CONCLUSIONS: These results suggest that displacement of both COP and COG in APAs were important for control of step direction. Especially, we found that the acceleration of COG was determined due to the displacement of COP in APSs. The outcome of this study could be used while developing rehabilitation strategies focused on fall prevention in older adults and individuals with CNS disorder.

P4-B-66 Early rate of split-belt adaptation is correlated to somatosensory perception

***Wouter Hoogkamer*[1], Zrinka Potocanac**[1], **Daria Uniszkiewicz**[1], **Steve Dierckxsens**[1], **Stephan Swinnen**[1], **Jacques Duysens**[1]
[1]KULeuven

BACKGROUND AND AIM: Gait adaptation is essential for humans to be able to walk or run easily over different terrains in various conditions and is often studied using a split-belt treadmill [1]. A split-belt treadmill consists of two belts that can run at separate speeds. Within several minutes of split-belt walking, healthy participants adapt their initial asymmetric step lengths towards a symmetric pattern [1]. Somatosensory perception can be expected to play an important role in this gait adaptation, but this has not yet been established. Thus, we evaluated the relation between the rate of gait adaptation and two somatosensory perception measures: 1) How well can one perceive differences between belt speeds? 2) How well can one reproduce knee angles? METHODS: Ten healthy volunteers participated in 2 sessions in which 3D kinematics of the lower body were recorded. In the 'split-belt session' the participants walked with one belt at 0.5 m/s and the other belt at 1.0 m/s for 5 minutes. The early rate of adaptation was calculated as 'step symmetry[step 11-13] - step symmetry[step 1-3]' and the total adaptation was calculated as 'step symmetry[step 191-193] - step symmetry[step 1-3]'. The perception threshold was established in a separate session. In 8 different trials one of the belt speeds was slowly changed and the participants had to indicate when they perceived the belt speeds to be different [2]. The perception threshold was defined as relative difference between belt speeds at the time of response (mean of all 8 trials). Additionally, participants bilaterally performed two knee angle reproduction trials in supine position. First the experimenter raised the participant's leg to a position with a knee angle of about 70 degrees; secondly the participants actively reproduced this knee angle. Outcome was the deviation from the target angle. RESULTS: The perception threshold (mean=12.0%, SD=3.6%) and the outcome of the knee angle reproduction tests were significantly correlated ($r=0.69$, $p=0.029$). Both these measures were correlated to the early rate of adaptation ($r=-0.79$, $p=0.019$ for the perception threshold; $r=-0.75$, $p=0.011$ for the knee angle reproduction tests). CONCLUSIONS: The results suggest that proprioceptive abilities are important in determining the speed of gait adaptation, specifically for early changes in the gait pattern. REFERENCES: 1. Torres-Oviedo G, et al. Prog Brain Res 191: 65-74, 2011 2. Lauzière S, et al. Proc. of ISPGR / Gait & Mental Function, abstract J18, 2012.

P4-B-68 Phase modulation of corticospinal excitability for forearm muscle during voluntary leg stepping

Taku Kitamura[1], **Yohei Masugi**[2], **Shin-ichiro Yamamoto**[1], **Kimitaka Nakazawa**[2]
[1]Shibaura Institute of Technology, [2]University of Tokyo

INTRODUCTION: In treadmill walking, the arm swing enhances the leg muscle activities and shapes the muscle activation pattern in healthy parson and patient with spinal cord injury. This implicates the existence of interlimb interaction between arms and legs, but the neural mechanism for those interlimb interactions are rarely investigated. In this study, we investigated the corticospinal excitability of forearm muscle during voluntary leg stepping with hypothesis that corticospinal excitability is modulated with change of voluntary command for leg movement. METHODS: Nine neurologically intact male subjects participated in this study. Subjects wore the driven gait orthosis (Lokomat) on the legs, and performed voluntary leg stepping (treadmill speed was set to 2.0km/h) according with the movement of Lokomat orthosis. Electromyography were recorded from right flexor carpi radialis (FCR), extensor carpi radialis (ECR), rectus femoris (RF), biceps femoris (BF), tibial anterior (TA), and soleus (SOL) muscle. Motor evoked potentials (MEPs) in resting FCR were elicited by the transcranial magnetic stimulation (TMS) to left motor cortex. TMS were applied at six different phases of the stepping cycle (360, 720, 1080, 1440, 1800, and 2150 ms after right heel contact) and standing condition. To keep precision and accuracy of stimulus coil location during stepping, custom made coil navigation system, utilizing the three-dimensional motion capture cameras (OptiTrack), was used. For all muscle, the root mean square during 50 ms before TMS was measured as the background EMG. RESULTS: MEP amplitudes in resting FCR muscle during leg stepping were facilitated in late stance and late swing phase, while amplitude was not changed in early stance and early swing phase. As investigating the cross correlation between the FCR MEP amplitude and background EMG of leg muscles, there was significant correlation for BF activity during swing phase, whereas there was no correlation during stance phase. CONCLUSIONS: Results of this study suggest that the corticospinal excitability for FCR muscle were modulated according with the change of voluntary command to the leg muscle, especially BF muscle.

P4-B-72 Role of the feet during a complex curved path

Laura Marazzato[1], **Cecilia Laschi**[1], **Paolo Dario**[1], **Alain Berthoz**[2], **Colas Authie**[2]
[1]The Biorobotics Institute, [2]lppa,Umr7152, Cnrs-Collège De France

BACKGROUND AND AIM: During locomotion continuous changes in path direction occur and they require a coordinated reorientation of the body segments toward the new travel direction. It has recently been proposed these changes follow a top-down strategy in which the hierarchical sequence of the body segments is based on the anticipatory role of gaze [1]. However, it has been also shown that foot orientation contributes to the control of the direction in the top-down strategy [2] or, as in studies on the podokinetic system [3], the top-down strategy is upset in favour to a bottom-up and to an end-point control strategy in which feet are the first rotated. In the present work a detailed sequence of the body segments has been analyzed for the first time to underline the role of feet in the relation between the top-down and bottom-up strategies used during a continuous curved path. METHODS: Ten healthy subjects (29.2±3.7 years) volunteered to participate in the study. Full body 3-dimensional kinematic data were collected using an 12-cameras Vicon system, and 46 reflective markers were placed on the strategic anatomical body landmarks. Participants performed Limacon and Cloverleaf shapes clockwise and counter-clockwise naturally and at a preferred velocity. Three trials were performed in each condition. The variable of interest were the relative horizontal orientation of head, trunk, pelvis and feet, referred to the horizontal orientation of gaze at the heel strike events. RESULTS: In this case of a trajectory in which the curvature did not change sign, the foot placement strategy was always of the spin turn. Gaze direction maintains its anticipatory role in the hierarchical sequence and is followed by head and feet reorientation. Some small differences were observed for either left or right turning. However the changes of the horizontal orientation of the head, the trunk and feet respect to the horizontal orientation of gaze are not statistically different for left and

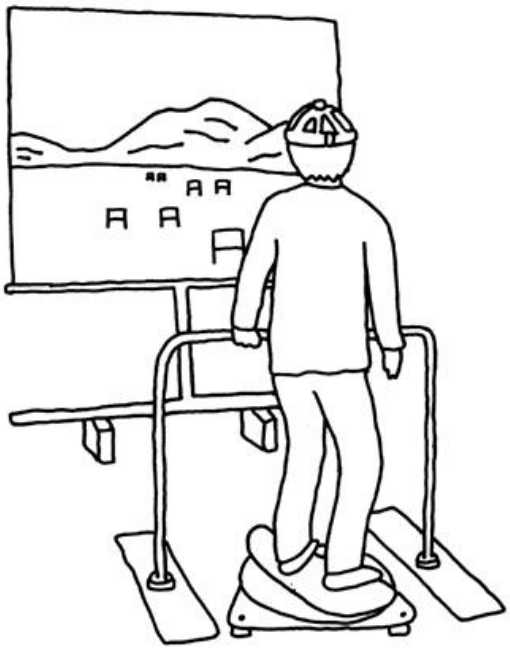
right turning (p>0.05, for both feet). We observed that during right turn for example, the inside foot anticipates trajectory direction at the time of heel strike but is still delayed with respect to gaze. At heel strike, gaze, head and inside foot direction anticipate pelvis and trunk. The outer foot swings towards the trajectory direction but is never in advance with respect to trajectory direction. CONCLUSIONS: The findings suggest that feet participate with an anticipatory role on the trunk and the pelvis orientation. In this way the strategy used by the brain is not purely top-down or bottom-up but these strategies seem to be combined together. ACKNOWLEDGEMENTS: This research is partially supported by a European research project RoboSoM. REFERENCES: 1.Bernardin D, Kadone H. EBR 223(1): 65-78, 2012. 2.Melvill Jones G, Fletcher WA. EBR 167(4): 649-653, 2005. 3.Weber KD, Fletcher WA. EBR 120(3): 377-385, 1998.

C - Exercise and physical activity; Habilitation and rehabilitation

P4-C-74 Repeated snowboard exercise with conflict between body rotation and delayed visual feedback in the virtual reality world enhances head stability and slalom run performance in the real world in normal young subjects

Yoshiro Wada[1], **Noriaki Takeda**[2], **Kazuyoshi Tsukamoto**[3]
[1]Nara Medical University, [2]University of Tokushima, [3]Kagawa University

BACKGROUND AND AIM: In the present study, we developed a snowboard exercise system using virtual reality (VR) technology and examined the effects of conflict between body rotation and delayed visual feedback on the head stability and the slalom run performance in normal young subjects. METHODS: Forty-two normal young subjects participated in the study. The subject stood on a simulated snowboard attached to a turntable in front of a screen presenting a downhill course. At each trial, they were asked to run through a total of 20 slalom gates which were approaching every 2.85 sec for 60 sec with turning the snowboard with body rotation. During each trial, the computer of the VR system provided the new direction of gaze and the scene from the new point of view on the screen. The visual scene minimally delayed after the body rotation at trail #1, #2 and #9 without time lag. Additional time lag to the inherent delay of the visual scene that the computer recreates behind the snowboard rotation was applied. The duration of time lag was 0.1, 0.2, 0.3, 0.4, 0.5 and 0.6 sec at trials #3-8, respectively. At each trial, head linear acceleration was recorded with a motion tracking system (Flock of Birds, USA) and its standard deviation was used as an index of head stability. The subjective performance of slalom run was also scored from 0-100 at each trial. RESULTS: The standard deviation of interaural, but not naso-occipital and vertical, head linear acceleration increased with an increment of the duration of time lag applied in trails #3-8 and reached a maximum at trial #8 with time lag of 0.6 sec. This finding indicates that the motion-visual feedback conflict in the VR world disturbed the head stability in normal young subjects. But, at trail #9 without time delay, the standard deviation of interaural head linear acceleration was significantly ($p<0.006$, paired t test) decreased and the subjective performance score of slalom run was also significantly ($p<10\text{-}10$) enhanced in comparison with that at trial #1 without time delay. These findings indicate that after repeated snowboard exercise with motion-visual feedback conflict in the VR world, the head motion was stabilized and



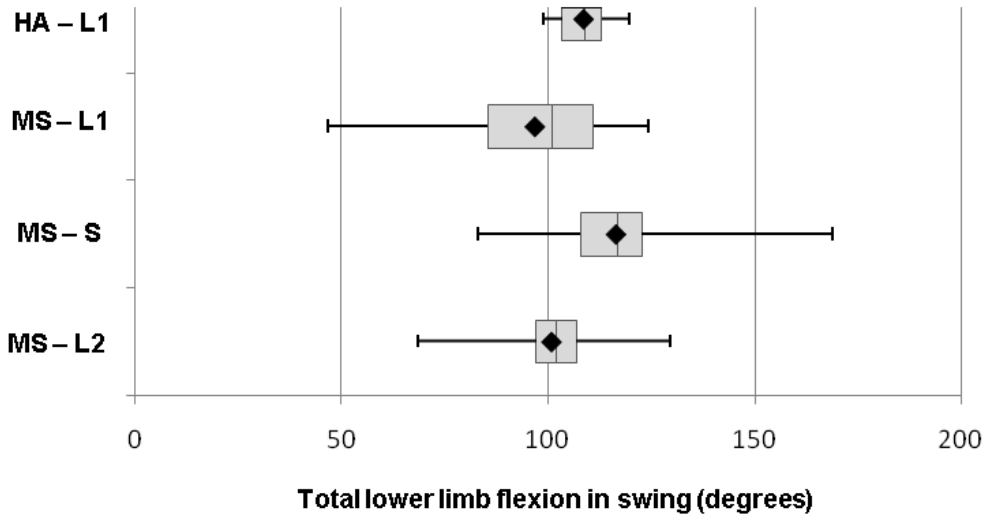
the motor performance was enhanced in the real world. McCabe et al (2005) stated that the conflict between the prediction and actual sensory feedback is fed back to motor system to update the state variables and thereby inform future efferent copy. Blakemore et al (2001) also indicated that the cerebellum is involved in signaling the conflict between the prediction and actual sensory feedback using PET. Thus, it is suggested that snowboard exercise under various time delay conditions improves the ability to adjust the prediction (i.e. exercise image) to visual feedback with or without time delay mainly by learning in the cerebellum. CONCLUSION: The motion-visual feedback conflict in the VR world will be a promising exercise tool for motor performance enhancement.

P4-C-76 Life's a Beach! Benefits of walking on sand on gait kinematics in individuals with MS

Maayken van den Berg[1], **Ben Patritti**[2], **Chris Barr**[1], **James McLoughlin**[1], **Maria Crotty**[1]
[1]Flinders University, [2]Repatriation General Hospital

BACKGROUND AND AIM: It is common for patients with multiple sclerosis (MS) to display gait deviations related to deficiencies in overall flexion of the lower limb during swing, impairing foot clearance. Understanding how patients adapt to walking on varying surfaces may provide useful insight into paradigms that could be used to force them to adopt improved locomotor patterns. The aim of this study was to characterise gait adaptations made by individuals with MS when walking on sand and to examine whether there was any carry-over effect of the observed adaptations when walking on level ground. We hypothesised that individuals would adapt to walking on sand by increasing overall flexion of the lower limb during swing to facilitate foot clearance. METHODS: The gait of 13 adults with MS (11 females, mean age 51.4±5.5, 12-Item MS Walking Scale 35.1±11.5, Disease Steps 2.4±1.0), and 10 healthy age-and gender matched adults (HA) were captured using an 8-camera Vicon motion capture system (Oxford, UK). Each subject completed 10 walking trials on each surface in the following order: level ground (L1: baseline), sand (S: gait adaptation response), and level ground (L2: carry-over), while perceived fatigue and exertion were monitored. Gait patterns were characterised by hip, knee and ankle kinematics. The sum of peak hip and knee flexion and ankle dorsiflexion during swing was used to describe total lower limb flexion. Non-parametric statistics were used for analysis. RESULTS: During L1 adults with MS showed significantly less total lower limb flexion ($p<0.05$) compared to the HA group (Fig 1). Like the HA, adults with MS adapted to walking on sand by significantly increasing hip and knee flexion and ankle dorsiflexion ($p<0.05$) during swing, resulting in an overall 20 greater total lower limb flexion ($p<0.05$). There was a non-significant carry-over effect of 2d flexion at the knee and 4d at the ankle. During S mean total lower limb flexion reached was within normal range (ref values L1 in HA) with a non-significant residual effect of 4d greater total lower limb flexion maintained during L2. Walking on sand did not increase scores of perceived fatigue or exertion. CONCLUSIONS: Adults with MS adapted to walking on sand by increasing hip and knee flexion and ankle dorsiflexion during swing without any detrimental effect on perceived fatigue and exertion. Preliminary data shows that for adults with MS even a short bout of walking on sand may lead to a positive carry-over effect when returning to walk on level ground. Although the carry-over effect was statistically non-significant, clinically it is of great importance as the cumulative effect resulted

Fig 1 Total lower limb flexion across groups and surface



in lower limb flexion within the normal range, and likely contributed to improved foot clearance. This forced-used paradigm of gait retraining shows promise as a therapy approach. Increasing the training dose may result in a larger post-adaptation carry-over effect and warrants further investigation.

P4-C-78 Effects of the oriental breathing technique on the center of pressure trajectory while standing

Atsushi Itaya[1], **Tomohiro Kizuka**[1], **Takuro Endo**[1]
[1]University of Tsukuba

BACKGROUND AND AIM: We empirically know that intentional breathing, for example deep breathing, is an efficient way to relax the body and mind when they become tense under pressure. Additionally, intentional breathing is one of the most important and fundamental techniques in oriental bodyworks (e.g., Qigong, Tai Chi and Yoga). However, there is little scientific evidence to demonstrate its beneficial effects. On the other hand, previous studies have shown that control of upright postures sensitively reflects states of body and mind such as fear of falling, anxiety, and strain under dual task situations. The results of such studies have suggested that unusual states of body and mind under pressure lead to impaired automaticity in postural control. The purpose of this study was to examine the effects of a simple oriental breathing technique on the center of pressure trajectory while standing. METHODS: Sixteen healthy young adults (nine male) were instructed to stand at ease on a force platform in bare feet, and completed three 300 s trials in each of two conditions: natural breathing (NB) and intentional breathing (IB). Each standing trial consisted of five time sections: 0 - 30 s with eyes open, 30 - 60 s with eyes closed, 60 - 240 s applying NB or IB with eyes closed, 240 - 270 s with eyes closed and 270 - 300 s with eyes open. For IB, the participants were asked to take each breath while following three simple instructions extracted from various oriental bodywork techniques: inspire through the nose and expire through the mouth; feel the air flow through the body while both inspiring and expiring; inspire and expire comfortably. The center of pressure (COP) displacement was measured. Thoracic movement associated with breathing was measured with a respiration transducer. NB and IB sections were divided equally into three time periods for data analysis. For COP data, areas of 90% confidence ellipse (sway area) and anterior-posterior (AP) and medial-lateral (ML) sample entropies (SEns) were calculated for each period. RESULTS: With IB, breathing frequency significantly decreased relative to NB. Also, the sway area was smaller, and both SEns were greater than with NB only during the 1st time period (Fig. 1). CONCLUSIONS: In general, greater tidal volume leads to greater postural sway. However, our results demonstrate that sway area is smaller with IB. SEns have been regarded as markers for automaticity in postural control; greater SEns indicate greater automaticity. Thus, our results suggest that the IB technique enhances the automaticity of postural control and decreases postural sway. It seems that the breathing technique instantaneously affects postural control. However, the effect also diminishes quickly, probably due to fatigue as our results revealed this effect only during the 1st time period. This is the first report that provides scientific evidence to prove the beneficial effects of oriental breathing techniques for postural control.

P4-C-80 Evaluation of dual task training on gait and cognitive parameters in elderly idiopathic faller

Moran Dorfman[1], **Talia Herman**[1], **Marina Brozgol**[1], **Shirley Shema**[1], **Aner Weiss**[1], **Anat Mirelman**[1], **Jeffrey Hausdorff**[1]
[1]Movement Disorder Unit, Tel Aviv Sourasky medical center

BACKGROUND AND AIM: About one-third of older adults over 65 years fall every year.Most falls occur during walking, however, the cause often extends beyond what was traditionally viewed as balance and gait impairments. Indeed, agrowing body of literature highlights the relationship between falls and cognitive impairments. Everyday walking often takes place during dual task (DT) conditions when cognitive resources are relied upon to maximize performance and safe ambulation. Aim:To assess whether a treadmill (TM) training program while performing DT can improve cognitive and

motor performances and reduce the incidence of falls in older adults who experience multiple fall for no apparent reason. METHODS: A repeated measure design (pre training, post training, and follow up at 4 weeks and 6 months) was used to evaluate the effects of the training program in 10 idiopathic fallers (mean age: 5.81 ±78.1yrs, 7 women) with a history of at least two falls during the half year prior to the intervention. The training program consisted of walking on a TM while practicing a variety of DT: phoneme monitoring, verbal fluency and arithmetic tasks, 3 times a week for 6 weeks. During the six months follow upfalls were tracked by monthly calendars. RESULTS: Immediately after the intervention, significant improvement was demonstrated in performance based measures of balance and mobility: Berg Balance Scale (pre: 49.6±4.5 post: 52.2±3.3, P=0.02), Dynamic Gait Index (pre: 19.5±3.6 post: 21.7±2.1, P=0.03), usual gait speed (cm/sec) (pre: 55.3±14.0; post: 60.2± 14.1, P=0.05) and while performing DT (pre:52.8±12.9 post: 57.5±14.1,P=0.04). Step length during usual walking and DT also improved (P<0.05). In terms of cognitive function, the number of serial 3s subtracted while sitting and walking increased (P<0.05) and the Trails Making Test Bdecreased (sec)(pre: 148.0±65.3 post: 129.0± 54.8,P=0.02).In addition quality of life, as measured by the SF36, improved (pre: 55.7 ±14.2 post: 68.9± 10.4, P=0.01) as did physical activity, as measured by PASE(pre: 90.5 ±58.1 post: 126.0± 56.5,P=0.02). Four weeks after training, improvements were sustained only as trends, however, the gains were no longer observed after 6 months. During 6 months follow up a significant decrease at falls frequency was demonstrated (P= 0.02). CONCLUSIONS: These results highlight the potential of training DT abilities in idiopathic fallers and the carryover from trained to non-trained tasks. An intensive, 6 weeks long DT training program improved motor and cognitive performances, both immediately after the intervention and after 4 weeks later. This kind of training is applicable in clinics and can be an easily accessible tool for therapists to achieve functional improvements. However the small sample size of this study and the return to baseline values 6 months after the completion of the intervention warrants further research.

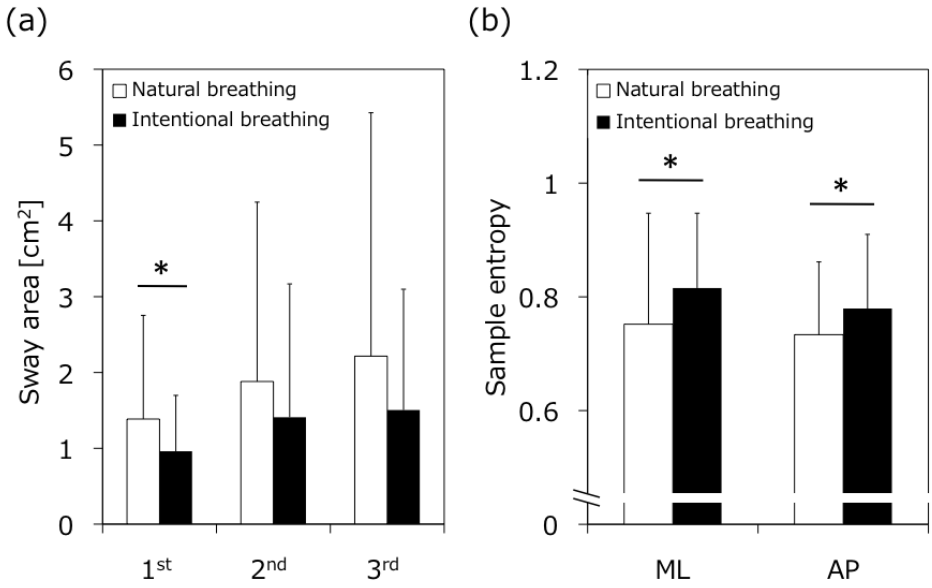


Fig. 1 Mean value (+ SD) of sway area (a) and sample entropy in 1st period (b). *: $p < 0.05$

P4-C-84 Clinical experience using a 5 week training program that combines a treadmill with virtual reality to enhance gait

Shirley Shema[1], **Pablo Bezalel**[1], **Ziv Sebrelo**[1], **Moran Dorfman**[1], **Orly Wechsler-Yannai**[1], **Nir Giladi**[1], **Jeffrey Hausdorff**[1], **Anat Mirelman**[1]

[1]Tel Aviv Sourasky Medical Center

BACKGROUND AND AIM: In previous work (Mirelman, JGMS, 2011), we developed a virtual reality (VR) system simulating virtual obstacle negotiation while walking on a treadmill. This approach presents challenging motor-cognitive training. The training is customized to allow for individual progression, fitting different subjects' abilities and needs by adjusting progressive levels of difficulty (i.e., obstacle size and frequency) according to the subject's performance, while providing immediate feedback and knowledge of results. Preliminary studies have shown that VR augmented gait training may be useful for patients with Parkinson's disease. The aim of this study was to assess the efficacy of VR gait training applied in a clinical setting to improve gait and mobility in subjects with a history of falls, problems with mobility, or complaints of gait instability. METHODS: We retrospectively examined outcomes measured before and after subjects completed a progressive intensive treadmill training, incorporating the VR simulation. Subjects came to the clinic 3 times per week for 5 weeks. Outcome measures included gait speed, Timed Up & Go (TUG) and the Two Minute Walk Test (2MWT). A subset of patients were also evaluated using the Four Square Step Test (FSST). RESULTS: Sixty two subjects (age 72.24±10.28, 51.6% men) completed 15 sessions and evaluation. The cohort was heterogeneous and included subjects with extrapyramidal disease, high level gait disorders, post stroke and idiopathic fallers. Training parameters were gradually increased from week 1 to week 5 in treadmill speed, walking time, hands support, virtual obstacle size and frequency of appearance. Post training, TUG decreased from 15.18±6.0 seconds to 13.3±4.87 seconds ($p<0.001$) and distance walked in the 2MWT increased from 114.8±28.7 meters to 125.38±28.39 meters ($p<0.001$). Improvement was also observed during the FSST (17.46±8.82 to 15.18±6.78 sec, $p=0.031$). CONCLUSIONS: Treadmill training with VR appears to be a feasible and effective clinical tool that can be used for gait training of subjects sustaining motor difficulties and gait instability. Further study may help to extend our knowledge on the clinical utility of the current training with respect to motor learning, additional motor-cognitive tasks, and fall risk, and to identify unique aspects of the training that relate to different pathologies.

P4-C-86 Changes to ankle joint motor patterns after gait exercise: immediate and after effects

Koichi Saito[1], **Ryouta Maegawa**[2], **Kazuhiro Ito**[2], **Takaaki Nakamata**[1], **Yasuhiko Hatanaka**[1]
[1]Suzuka University of Medical Science, [2]Oumionsen Hospital

Background: Optimal performance of complex motor behaviors involves learning through repetitive exercise. Exercise induces motor learning changes in the brain through formation of motor memory and consolidation into long-term memory. Once a motor skill is consolidated into long-term memory, then it becomes available throughout the lifetime of the individual. The cerebellum is acknowledged as a critical site for motor learning because of the plasticity of synaptic transmission in the neural circuit of the cerebellar cortex. The important role of the cerebellum has been demonstrated in experiments using prism adaptation tasks and adaptation of horizontal optokinetic responses. Yin et al (2001) investigated rapid reaching movements in monkeys adapted to a visual displacement. They found that no aftereffects could be identified at 24 hours after 250 trials; however, significant after effects could be identified at 24 hours and 72 hours after 500 trials. Brashers-Krug et al (1996) investigated whether consolidation of a motor skill was disrupted if a second motor task was learned immediately after the first. There is a fragile period for consolidation of motor memory after completion of the repetitive exercise.? The effectiveness of motor learning for motor skill acquisition depends on the number of repetitions, the interval and other motor tasks in subsequent exercises.? Purpose: The aim of this study was to examine the immediate and after effects of changes to ankle joint motor patterns after gait exercise with respect to the number of repetitions, the interval and motor tasks in subsequent exercises. Method: Seventeen healthy male volunteers participated in this study. The men were fitted with an orthotic device to restrict dorsal flexion of the ankle joint. They were then instructed to walk continuously for 1000 steps (500 steps for each leg) and their gait was measured using a 3D motion analysis system and a force platform. Measurements were made before gait exercise (pre-

test), immediately after gait exercise (post-test), and at 1 hour after gait exercise (1 h test) Gait speeds and ankle joint angles were calculated using the inverse-dynamics method. This study was approved by the Institutional Review Board of Suzuka University of Medical Science. Results: At the post-test and 1 h test, a significant reduction in gait speed was found compared to the pre-test ($p < 0.01$). Additionally, the ankle joint angle at the initial contact and the maximum planter flexion angle at the loading response caused a significant change in the direction of planter flexion compared to pre-test ($p < 0.01$). Maximum dorsal flexion angles in the stance and swing phases were also significantly smaller than in the pre-test ($p < 0.01$). Conclusion: We suggest that there are both immediate and after effect changes to ankle joint motor patterns after gait exercise with respect to the number of repetitions, the interval and other motor tasks in subsequent exercises.

P4-C-88 Effectiveness of Resistance Training on Muscle Strength and Physical Function In People With Parkinson's Disease: A Systematic Review And Meta-Analysis

Chloe, Lau Ha Chung [1], **Thilarajah Shamala**[2], **Dawn Tan**[2]
[1]TanTock Seng Hospital , [2]Singapore General Hopsital

Background: Muscle strength is reduced in people with Parkinson's disease (PD) and may be associated with activity limitations and falls. Little is known of the efficacy of resistance training (RT) in PD where muscle weakness may be centrally mediated. Aims: 1) To systematically review the evidence investigating the effectiveness of RT in people with PD 2) To provide evidence-based recommendations for an optimal resistance programme for this population.Methods: Only randomized controlled trials which investigated the effects of RT on muscle strength and physical function in people with PD were considered. A targeted search to identify full-text English language studies published between 1966 and Aug 2012 was conducted across 7 electronic databases. The methodological quality of selected studies was assessed using the PEDro scale. Relevant information was extracted using a standardized form. Studies with similar outcomes were pooled by calculating standardized mean differences (SMD) using fixed or random effects model, depending on study heterogeneity. Results: Three studies (of 779 screened), comprising of 51 participants with early to moderate disease (Hoehn and Yahr stage 1 to 3), were included. The median quality score was 4/10. The meta-analyses demonstrated significant SMD in favour of RT compared to non-RT or no intervention controls for muscle strength (1.06; 95% CI, 0.28 to 1.83; $p = 0.007$) and balance (0.59; 95% CI, 0.02 to 1.16; $p = 0.04$) but not for gait (0.17; 95% CI,-0.49 to 0.85, $p=0.61$). Conclusion: High intensity resistance training, 2-3 times per week over 8-10 weeks can result in significant gains in strength and balance in people with early to moderate PD. However, these results need to be interpreted carefully due to the presence of biases in existing studies, highlighting the need for high quality research in this area. Based on the current literature, the beneficial effect on people with moderate to late stage of PD and fall prevention is still inconclusive. Further research is needed to evaluate the long term effect of RT and to determine the optimal dose for both acute intervention phase and maintenance phase.

P4-C-90 Strength- versus balance-training to improve postural control in patients with Parkinson's Disease: a randomized rater-blinded trial - preliminary results

Christian Schlenstedt[1], **Jan Raethjen**[1], **Burkhard Weisser**[1], **Günther Deuschl**[1]
[1]Christian-Albrechts-University of Kiel, Germany

BACKROUND AND AIM: Postural Instability is one of the major symptoms of patients with Parkinson's Disease (PD) and can hardly be improved by medication or Deep Brain Stimulation (Visser et al. 2008). It has been shown that strength- and balance-training can both be effective (Falvo et al. 2008; Smania et al. 2010). The aim of this study is to compare both training types and to answer the question which exercise is more effective to improve postural control in PD. METHODS: 24 patients (4 drop-outs) with idiopathic PD participated until now and were randomized into two groups,

one received strength- (SG, n=8) and the other balance training (BG, n=12) twice per week over 7 weeks. The general mobility and postural control of the patients were assessed by a blinded rater using the Unified Parkinson's Disease Rating Scale (UPDRS) and Fullerton Advanced Balance Scale (FABS). Gait was analyzed on a treadmill to assess gait variability, bilateral coordination and gait asymmetry. Maximal leg strength and rate of force development was assessed due to isometric contractions in a leg press. PDQ-39 and BDI was used to assess quality of life and degree of depression. All tests were performed PRE, directly (POST) and 4-weeks (FOLLOW UP) after the end of the training period. RESULTS: SG and BG both improved significantly from PRE to POST in UPDRS, UPDRS-motor score and FABS. The improvement in the FABS of the SG (+4,63; 95%CI: 1,28 to 7,97) was higher (p=0,079) than of the BG (+1,50; 95%CI: 0,43 to 2,57). SG improved significantly in the PDQ-39 (-3,93; 95%CI: -7,09 to -0,77), whereas BG did not. In contrast to BG, SG also improved (not significantly) in gait velocity. CONCLUSIONS: These preliminary data show a tendency towards strength training being more effective than balance training to improve postural control and quality of life in PD patients. More patients will be included to draw final conclusions as to which is the best physiotherapeutical approach in PD patients with postural disturbances. Falvo, M. J., Schilling, B. K.,Earhart, G. M. (2008). Parkinson's disease and resistive exercise: rationale, review, and recommendations. Mov Disord 23(1): 1-11. Smania, N., Corato, E., Tinazzi, M., Stanzani, C., Fiaschi, A., Girardi, P.,Gandolfi, M. (2010). Effect of balance training on postural instability in patients with idiopathic Parkinson's disease. Neurorehabil Neural Repair 24(9): 826-834. Visser, J. E., Allum, J. H., Carpenter, M. G., Esselink, R. A., Speelman, J. D., Borm, G. F.,Bloem, B. R. (2008). Subthalamic nucleus stimulation and levodopa-resistant postural instability in Parkinson's disease. J Neurol 255(2): 205-210

P4-C-92 Functional ability and health in patients with cervical disc disease compared with patients with chronic whiplash associated disorder and healthy people.

Anneli Peolsson[1]
[1]Linköping University

Functional ability and health in patients with cervical disc disease compared with patients with chronic whiplash associated disorder and healthy people. Anneli Peolsson1, 2, Maria Landén Ludvigsson1, Johanna Wibault1, Åsa Dedering3, Gunnel Peterson1 1Dep. Medical and Health Sciences, Physiotherapy, Faculty of Health Sciences, Linköping University, Linköping, Sweden; 2 NHMRC CCRE (Spinal Pain, Injury and Health), The University of Queensland, Brisbane, Australia, 3Department of Physical Therapy, Karolinska University Hospital, Stockholm, Sweden Background and aim Physical function is scarce evaluated in patients with cervical disc disease (CDD) as well as those with chronic whiplash (WAD) associated disorders.The general aim of the study was to examine whether any differences in function and health related quality of life appeared between patients with MRI-verified CDD with cervical radiculopathy scheduled for surgery and patients with chronic WAD and to compare measures of patients´ physical function with those obtained from healthy controls. Methods Physical measures of Active range of motion of the neck (AROM), neck muscle endurance (NME), hand grip strength and self-rated neck and arm pain intensity, Neck Disability Index (NDI), self-efficacy (SES) and health related quality of life (EQ-5D) was measured in 198 patients with CDD and 214 with chronic WAD. NME was measured in 116 healthy people and AROM and hand strength in 101. Results The patient groups had significantly lower performance in all physical measures than the healthy group ($p<0.0005$), except for NME in flexion for women ($p>0.09$). The patient groups mostly had results of the physical measures of about 60-80% of the healthy group, except for men in NME in flexion were they had about 40% and for NME in extension were men and women had about 25% and 20%, respectively. Except for NDI were the WAD group rated a significantly higher disability ($p<0.0001$) than the CDD group, there was a general trend with worse values in the measures as well as in the ratings in the CDD group compared with the WAD group. Significant differences were seen in neck AROM, hand strength left for women, pain intensity, EQ-5D and SES ($p<0.0001$). Conclusion One can conclude that physical function and especially NME in extension needs to be taken into account when designing rehabilitation programs both for patients with CDD and chronic WAD.

Biography of Anneli Peolsson

–University Certificate in Physiotherapy 1989

–Master of Medical Science in Physiotherapy 1996

–Exam in orthopaedic manual therapy 1996

–Specialist in Physiotherapy in Orthopaedics 1999

–PhD in physiotherapy 2002

–Associate Professor 2008

D - Vestibular function and disorders

P4-D-94 Standing balance tests to screen for vestibular disorders

Helen Cohen[1], **Ajitkumar Mulavara**[2], **Brian Peters**[3], **Haleh Sangi-Haghpeykar**[1], **Jacob Bloomberg**[4]
[1]Baylor College of Medicine, [2]Universities Space Research Association, [3]Wyle Science, Technology and Engineering Group, [4]NASA/ Johnson Space Center

BACKGROUND: The Romberg test of standing has a long history of use for screening people for vestibular and balance disorders although the paradigms for Romberg testing have changed over time. Current computerized versions, with either stable or unstable platform testing usually utilize the basic Sensory Organization Test (SOT) strategy used in the well-known Equitest. In clinical environments where expensive equipment and/ or space is not available clinicians continue to use the inexpensive screening version developed by Shumway-Cook and Horak, the Clinical Test of Sensory Integration and Balance (CTSIB). AIM: The aim of this set of experiments was to determine if sharpened versions of CTSIB would be useful to screen people for vestibular disorders. METHODS: We have updated the CTSIB, using modern technology (Inertial Motion Units) to measure kinematic variables as well as using behavioral measures that are more readily available. We compared a large cohort of normals to patients with several vestibular disorders, and we compared some patients to normals on the SOT. RESULTS: Results suggest that normals and patients can perform the conditions with eyes open easily, even on unstable surfaces. The more challenging conditions, on unstable surfaces with eyes closed, are difficult for everyone. Sharpening the test with head movements made the tests more sensitive and specific to patients and normals, respectively. Cutting the age ranges where the data differ significantly, rather than at arbitrarily selected divisions also improved the test. CONCLUSIONS: The sharpened test is better that the standard version of the tests but is not yet idea for screening.

P4-D-96 Dizziness, Postural control and Quality of life in patients with Benign Paroxysmal Positional Vertigo (BPPV): A retrospective cohort study

Dawn Tan[1], **Grace Koh**[1], **Geetha Kunasaigaran**[1]
[1]Singapore General Hospital

BACKGROUND AND AIM: Benign Paroxysmal Positional Vertigo (BPPV) is a common cause of vertigo in the general population and can be distressing and disabling. This study aims to investigate: 1) the impact of BPPV on postural control, dizziness, motion sensitivity and quality of life (QOL) in a Singapore cohort, and 2) the effects of physiotherapy

in these patients. METHODS: A retrospective cohort design was utilized where data of patients with BPPV were extracted from a registry of patients attending an outpatient physiotherapy vestibular clinic between September 2010 and February 2012. Information on patient demographics; BPPV characteristics and symptoms; and outcomes of physiotherapy were extracted. Severity of dizziness, motion sensitivity, and impact of dizziness on QOL were quantified by the Vestibular Rehabilitation Benefit Questionnaire (VRBQ) subsection scores. Balance impairments were quantified by the Activities Balance Confidence (ABC) scale and the Neurocom posturography results. The differences between initial and discharge scores were analyzed using the Wilcoxon signed rank test. Significance was set at $p<0.05$. RESULTS: Data on 58 adults (mean age 58.0±14.5 years, 78% women, and 79% Chinese) were extracted. 95% were canalithiasis BPPV while 5% were cupulolithiasis. The posterior semi-circular canal was most commonly affected (80%), followed by horizontal (7%); anterior (4%); and multiple canals (9%). At baseline, the mean posturography scores were 66±14.1; ABC scores were 79.6±27.4%; dizziness scores were 48.0±11.5%; motion sensitivity scores were 52.2±19.7%; QOL scores were 19±28%. Although there were statistically significant improvements in balance confidence ($z=-2.52$, $p=0.01$, effect size, $r=0.5$); severity of vestibular symptoms ($z=-3.89$, $p<0.001$, $r=0.6$) and quality of life ($z=-1.79$, $p=.001$, $r=0.3$), 50% of the patients continued to experience impaired postural control (Figure 1) and reduced levels of balance confidence. CONCLUSIONS: BPPV resulted in moderately severe dizziness, motion sensitivity, impaired postural control and reduced QOL. Physiotherapy strategies such as canalith repositioning techniques are effective in alleviating these symptoms and resulted in improved QOL. However, considerations should be given to addressing impairments in postural control after resolution of BPPV.

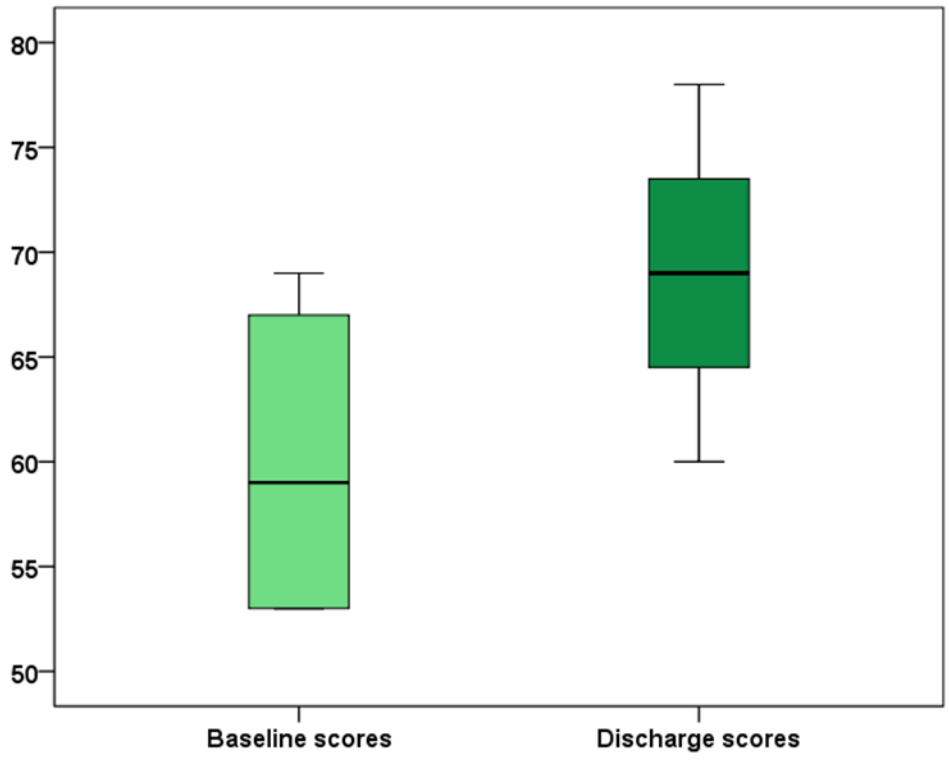


Figure 1: Graph showing posturography scores at baseline and discharge

P4-D-98 New Three-Dimensional Head Movement Video Image Analysis Technique Using Personal Computer and Public Domain Software

Makoto Hashimoto[1], **Takuo Ikeda**[1], **Hironori Fuji**[1], **Hiroshi Yamashita**[1]
[1]Yamaguchi University

INTRODUCTION: Usually motion analysis is performed using several cameras or sensors. On the other hand, we previously have developed a three-dimensional eye movement image analysis technique using commercialized infrared CCD camera, personal computer and public domain software. In this study, we devised a three-dimensional head movement video image analysis technique using one camera, personal computer and public domain software. METHODS: Head movement video image from the top of the head was captured directly to the personal computer at 30 frames per second. Image analysis was performed automatically using public domain software ImageJ. For analysis of forward-backward and right-left direction, the XY center of the head was calculated. For analysis of rotation of the head, the shape and hair pattern of the head, which was rotated each 0.1 degrees, was overlaid with the same area of the next head image and the angle that both area matches most was calculated. RESULTS: Using this technique, it is possible to perform inexpensively the three-dimensional head movement analysis from video image recorded by one camera. In addition, this technique does not require any equipment attached to the subject and is easy to prepare. CONCLUSIONS: We conclude that this new head movement image analysis technique is useful for clinical examinations and research into vestibular function.

P4-D-100 Animal study of vestibular-evoked myogenic potentials

Yi-Ho Young[1]
[1]National Taiwan University Hospital

Aim: The otolithic organs, utricle and saccule, respond to linear acceleration and gravity, serving as a functional role in maintaining postural stability. Recently emerging ocular and cervical vestibular evoked myogenic potential (oVEMP and cVEMP) tests expand the test battery for clinicians to assess the dynamic utricular and saccular functions, respectively. This study applied the oVEMP and cVEMP tests to guinea pigs coupled with morphological examination to study the pathophysiology of otolithic disorders in guinea pigs. Method: Ten healthy and 10 gentamicin-treated guinea pigs were enrolled. An amount of 0.05 mL of gentamicin (40 mg/mL) was directly dropped onto the round window membrane of the left ear. After two weeks, all animals underwent oVEMP and cVEMP tests. The oVEMP test was elicited via a hand-held bone-conducted vibrator placed on the animal's forehead at the stimulus intensity of 139 dB force level (FL). The cVEMP test was conducted using click stimuli (120dBSPL) generated by an earphone connected via a short tube inserted into the ear canal. Having finished the VEMP testing, all the animals were sacrificed for morphological study. Results: All 10 healthy guinea pigs exhibited clear oVEMPs, with the mean nI latency, pI latency and nI-pI amplitude of oVEMPs were 3.21±0.39 ms, 4.80±0.29 ms, and 67.3 ±47.8 ìV, respectively. Similarly, all healthy animals showed clear cVEMPs, with the mean positive peak I latency, negative peak II latency, and amplitude I-II of cVEMPs of 6.41±0.78 ms, 7.42±0.52 ms, and 5.75±1.95ìV, respectively. In contrast, none of the gentamicin-treated ears showed clear oVEMPs and cVEMPs. Morphological study of animals with absent oVEMPs and cVEMPs identified substantial damage to the utricular and saccular macula. Conclusion: The animal models of oVEMP and cVEMP in guinea pigs set the stage for studying the pathophysiology of otolithic disorders.

P4-D-102 New concept of BPPV pathology ""cristolithiasis"" -Otoconia attached on the crista ampullaris-

Koji Otsuka[1], **Mamoru Suzuki**[1], **Miho Negishi**[1], **Taro Inagaki**[1], **Masanori Yatomi**[1], **Ujimoto Konomi**[1], **Takahito Kondo**[1], **Yasuo Ogawa**[1]
[1]Tokyo Medical University

BACKGROUND AND AIM: Nystagmus of BPPV canalolithiasis gradually decreases by repeating positional change. On occasion, the nystagmus disappears suddenly by positional change and appears again. We suspect this phenomenon being induced by the otoconia attached to and detached from the base of the crista. We arbitrarily call this "cristolithiasis". The validity of this theory was investigated by experimental and clinical studies. METHODS: The labyrinths of the bullfrog were used. A tiny opening was created in the membranous labyrinth of the crus commune. A small piece of otoconia removed from the sacculus was introduced through this opening into the canal (canalolithiasis model). The position of the preparation was adjusted so that the otoconia were attached to the cupula (cupulolithiasis model). In other preparations, the otoconia were allowed to attach to the base of the crista (cristolithiasis model). We compared cupulolithiasis and cristolithiasis by adding two kinds of stimuli, gravity and vibration. Experiment 1 (Gravity): The labyrinth preparation was placed so that the cupula-to-crista axis was in the horizontal plane with the canal side in downward position for 30 minutes. Experiment 2 (Vibration): Mechanical vibration was applied to the surface of the bony labyrinthine capsule using a surgical drill. We also performed a clinical study on the posterior semicircular canal BPPV patients. At first, we made a diagnosis of BPPV by observing nystagmus in supine and sitting positions. Next, the patients were asked to put the head down for 30 seconds in sitting position. Then, they were placed in supine position with the head hanging down. The nystagmus observed in the sitting and the head hanging positions were compared. RESULTS: Experiment 1 (Gravity): In cupulolithiasis models, the otoconial mass was detached within 30 minutes in 2 out of 10 (20%) labyrinth preparations. In cristolithiasis models, the otoconial mass was detached within 30 minutes in 4 out of 5 (80%) labyrinth preparations. Experiment 2 (Vibration): In cupulolithiasis models, the average detachment time was 140.3 seconds. In cristolithiasis models, the average detachment time was 17.5 seconds. The otoconia of cristolithiasis were detached easily than cupulolithiasis. In 2 out of 6 patients no nystagmus was evoked in supine position after putting the head down in sitting position. DISCUSSION: The inner wall of the semicircular canal is covered by wall cells with smooth surface. The otoconia of canalolithiasis move along the canal smoothly. On the other hand, the basal portion near the crista has transitional cells, the planum semilunatum, and dark cells. The epithelia have microvilli and secretory activity to which the otoconia easily become attached. The attachment is weaker than cupulolithiasis. It is assumed that this attachment and detachment of the otoconia lead to disappearance and return of the nystagmus.

P4-D-104 Characteristics of verticality in the hemiplegic patients after stroke

Atsushi Manji[1], **Kazu Amimoto**[1], **Osamu Moromochi**[2], **Ryota Uchida**[2], **Mana Okochi**[2]
[1]Tokyo Metropolitan University, [2]Saitama Misato General Rehabilitation Hospital

BACKGROUND AND AIM:The earth vertical cognition of the human is mainly supported by vestibular and equilibrium systems. The earth vertical cognition is constructed by Subjective Visual Vertical (SVV) and Subjective Postural Vertical (SPV). There are some reports about the interrelationship between the earth vertical and the postural control disorders after stroke (e.g. Pusher syndromes). It is important to investigate that the cognitive disorders of the verticality will affect on therapeutic intervention for postural control dysfunction (e.g. lateral tilting, bending etc.).The purpose of this research was to clarify the characteristics of the verticality in hemiplegic patients by comparing with healthy subjects. METHODS:The SVV and SPV on a frontal plane was measured for 10 normal young subjects (5 female and 5 males, 20-35 years old: NY), 10 normal elderly subjects (4 females and 6males, 45-75 years old: NE) and 10 hemiplegic patients (6 females and 5 males, 48-72 years old: HP) in the rehabilitation hospital. All subjects gave written informed consent for their participation. The Vertical board (VB) with semicircle rail under the seat was used in the measurements. After the subject sat on the VB, we rotated the VB in 2 degree per second from 15 degrees tilted to the right or left position. When a subject judged their body was upright, we recorded the angle deviation of the VB. The measurement conditions were SVV (with eyes open) and SPV (with eyes closed), were repeated 4 times respectively. Differences for groups were

tested using two-factor ANOVA with Tukey test as post hoc analysis. RESULTS:Two-factor ANOVA showed a group effect and condition effect. As for the result of Tukey test, SVV and SPV of HP (3.3(2.1), 4.3(2.4): average (SD)) showed significantly larger deviation compared with those of Normal subjects (NY: 1.5(0.4), 1.6(0.8), NE: 1.5(0.7), 1.7(0.7)), respectively ($p<0.05$). CONCLUSIONS:In hemiplegic patients, SVV and SPV were deviated from the earth vertical. It could be consider that the cause of large error in SVV and SPV seems to be influenced by equilibrium obstacle and muscle tone unbalance due to brain damage. On the other side, in elderly subjects, SVV and SPV were as accurate as young subjects. It means that SVV and SPV system are robust in the subjects without brain damage. The serious obstacle is caused in hemiplegic patients and it is important to consider the evaluation to such an obstacle and treatment. The understanding of the characteristics of SVV and SPV will give more useful information for rehabilitation in hemiplegic patients.

P4-D-106 Sleep medicine may cure the Meniere's disease

***Meiho Nakayama*[1], Shinichi Kuriyama[1], Kayoko Kabaya[1], Keiji Takemura[1], Shingo Murakami[1]**
[1]Nagoya City University

It is well known that insomnia is associated with increased psychological symptomatology and perceived stress, higher predisposition to arousal, and more impairment of health quality. The relationship between Ménière's disease and stress is well documented, but that between Ménière's disease and insomnia is unclear. Physicians often encounter Ménière's disease patients who also suffer from insomnia, but there are no reported studies on the quality of sleep in Ménière's patients. Objective: To evaluate the quality of sleep in Ménière's disease patients with the use of polysomnography. Study Design: Prospective study using polysomnography administered in patients diagnosed as "certain Ménière's disease cases" according to the guidelines of the American Academy of Otolaryngology--Head and Neck Surgery. Methods: Fifteen patients aged 31 to 71 years with active, unilateral, cochleovestibular Ménière's disease refractory to medical management underwent polysomnography. The results were compared with fifteen healthy controls matched for age, sex, and BMI. All participants underwent full-night polysomnography, and a sleep medicine physician interpreted the results. Results: Two severe cases of obstructive sleep apnea syndrome (OSAS) and three cases of periodic limb movement disorder (PLMD) were found in the Ménière's group. Ten of the Ménière's disease patients (67%) had stage 3 and 4 sleep of less than 1%, versus four (27%) of the controls. Quality of sleep, especially deep sleep, was significantly lower in the Ménière's patients. Conclusions: Poor quality of sleep may cause additional stress and lead Ménière's disease patients to a negative spiral of symptoms, resulting in them becoming refractory to medical management. This may indicate a possibility by using sleep medicine will cure the Ménière's disease.

P4-D-108 Body image relies on a vestibular sense of the gravito-inertial force field

***Richard Fitzpatrick*[1], Brian Day[2]**
[1]Neuroscience Research Australia, [2]University College London

Deficits of body representation and proprioception are prominent in neurological and psychiatric conditions and impair voluntary movement, locomotor, postural and balance control. Here we investigate the somatic and vestibular contributions to the sense of whole-body motion and body image. We use galvanic vestibular stimulation (GVS) to create a false signal of head rotation and the gravito-inertial force field, and superimpose this on a stimulus of real body tilt in ten subjects who sat blindfolded on the platform of a rigid swing that had an axis of rotation through the sagittal axis of the head. Sinusoidally varying bipolar GVS (4mA) at 0.3Hz was synchronised with the swing motion. With the real and galvanic signals in phase, perceptions of rotation were greater than that of the real rotation alone (5.8º vs 4.4º; P=0.002). When out of phase the perception of rotation was abolished (0.5º) and replaced by a sense of whole-body translation with the head and bottom moved linearly and in phase by similar amounts. Each subject identified a straight posture at a central point but at the peaks of the perceived rotation each subject reported a bending of the body.

Profound distortions of body image were reported when the GVS lagged the real motion by 90º. Subjects described these sensations as shearing and/or sliding of the top of the body over the bottom with the shear plane somewhere in the mid-lower thoracic region. We conclude that altered vestibular input distorts perceived body image in addition to its orientation in gravity.

E - Orthopedic diseases and injuries

P4-E-110 Effect of Kinesio Taping on EMG Onset in Patellofemoral Pain Syndrome

Yi-Wen Chang[1], **Shr-Ming Li**[1], **Hong-Wen Wu**[1]
[1]National Taiwan University of Physical Education & Sport

BACKGROUNG AND AIM: Patellofemoral pain syndrome is a common sport injury at knee, which is resulting from the abnormal tracking of the patella on the trochlear groove of the femur. Patellar malalignment occurs when the vastus medialis oblique (VMO) is weaker or has a delayed onset of activation than vastus lateralis (VL). Kinesio taping has been clinically used for correcting the patellar tilt. However, little is known about the effect of the kinesio taping on muscle activation timing in the patellofemoral pain syndrome. Therefore, the purpose of this study was to investigate the effect of kinesio taping on the electromyographic (EMG) characteristics in the subjects with patellofemoral pain syndrome. METHODS: Fourteen subjects with patellofemoral pain symdrome participated in this study (10 females and 4 males; age: 25.4±6.6 years; length: 162.3±8.7 cm; weight: 61.3±11.2 kg). Stair ascent and descent were performed for each subject. Two taping conditions were used (no tape and kinesio tape around patella). The surface EMG system was used (MA300, Motion Lab Systems Inc., USA) and two surface EMG electrodes were placed on the VMO and VL. The onset time differences between these two muscles were calculated. Positive value denoted an earlier onset of the VMO than the VL. Paired t test was used for comparing the difference between no tape and kinesio tape. RESULTS: Kinesio tape (1.1±7.4 ms) showed a significantly earlier onset of the VMO than no tape (-5.6±3.5 ms) during stair ascent ($p<0.005$). Kinesio tape (-4.0±6.5 ms) showed a significantly lesser onset time difference than no tape (-8.4±5.2 ms) during stair descent ($p<0.005$). CONCLUSIONS: Kinesio taping could be used to elicit an early contraction of the VMO for the people with patellofemoral pain syndrome. Kinesio taping might help improve the patellar stability in knee extension during stair ascent and descent.

P4-E-112 The effect of hip chondropathy on single-leg balance performance in adults

Anna Hatton[1], **Joanne Kemp**[1], **Sandy Brauer**[1], **Ross Clark**[2], **Kay Crossley**[1]
[1]The University of Queensland, [2]The University of Melbourne

BACKGROUND AND AIM: Impaired balance control has been reported in the elderly with advanced hip osteoarthritis (OA), yet this relationship has not been explored in young adults with hip chondropathy, or early hip joint degeneration. It is also unclear whether limitations in hip joint mobility and hip muscle strength are associated with balance performance in adults with hip chondropathy. This study aimed to determine whether people with hip chondropathy demonstrate impaired balance ability during a dynamic single-leg squat with eyes open (SquatEO) and single-leg standing task with eyes closed (StandEC), relative to controls. A secondary aim was to explore whether hip range of motion (ROM) and muscle strength were correlated to balance measures in the hip chondropathy group. METHODS: 63 adults (36 female, mean [SD] age: 37.6 [11.6] years) with hip chondropathy (diagnosed arthroscopically in the previous 12-24 months using the Outerbridge classification system for chondral damage) and 60 healthy controls (41 female, mean [SD] age: 35.7 [9.7] years) performed two single-leg balance tasks: SquatEO and StandEC while standing on a Nintendo Wii balance board. All tests were performed with the participant barefoot, on the surgical leg of hip

chondropathy participants and the dominant leg of controls. Centre of pressure (CoP) total path velocity, and the range and standard deviation (SD) of CoP movement in the mediolateral (ML range and MLSD) and anterior-posterior direction (AP range and APSD) were extracted. Hip ROM and hip muscle strength were measured with an inclinometer and hand-held dynamometer. Reliability of all measures was established. Data were analysed using a one-way analysis of variance and stepwise linear multiple regression. The alpha level was set to 0.05. RESULTS: During the SquatEO, greater CoP ML range (P=0.001) and APSD (P=0.030) was observed in those with hip chondropathy compared to controls. No significant between-group differences were observed for any of the balance measures during the StandEC (P>0.05) task. Hip external rotation ROM was significantly associated with ML range during the SquatEO (P=0.005), accounting for 11% of the variance in CoP ML range. No hip measurements were associated with APSD during SquatEO. CONCLUSIONS: Dynamic single-leg balance squat performance is reduced in young adults with hip chondropathy compared to healthy adults, but single-leg standing balance is not. This may reflect reduced control of dynamic movements. The current study suggests that early hip joint degeneration may be associated with impaired postural control mechanisms, in particular during dynamic tasks that incorporate an internal perturbation. Those with greater hip joint external rotation ROM appear to have worse single-leg squat balance performance. Further investigation into balance deficits associated with hip disease is necessary to establish early-identification strategies and a more tailored-approach to rehabilitation.

P4-E-114 The contribution of ankle strategy in balance control for people with ankle fracture

***Fang-Ching Lin*[1], Yun Chen Yeh[1], Shuya Chen[1], Ying-Hao Chen [1], Hsiu-Chen Lin[1], Horng-Chaung Hsu[1]**
[1]China Medical University, Taiwan,

BACKGROUND AND AIM: "Ankle strategy" is used to keep one's balance when encountering external disturbance, such as unilateral standing. Unilateral standing is commonly used to evaluate balance control for various pathology populations. Ankle fractures result in broken bone and torn ligaments, leading to unstable ankles, and thus poor balance control. Therefore, the purpose of this study was to examine the contribution of ankle strategy in balance control using people with ankle fracture as a study model. METHODS: Fifteen participants with ankle fracture after surgery reconstruction (AF) and fifteen health participants (HP) matched with age and gender were recruited and tested with Balance Master (NeuroCom® Inc, USA). Unilateral standing (US) was conducted with eyes open (EO) and eyes closed (EC) for the right and left legs, respectively. Each trial was ten seconds.The trajectory of center of pressure was used to calculate sway velocity (SV) and loss of balance (LOB). RESULTS: Significant differences of SV and LOB between the AF and HP groups were found (SV: AF-3.18, HP-0.65 degree/sec; LOB: AF-9.42 sec, HP-10 sec; $p<0.05$). When looking at the affected legs of the AF group, there was a tendency of higher sway velocity and less test duration. The significant higher sway velocity was found in the EO condition (sound-0.92; affected-3.18 degree/sec; $p<0.05$) and the significant less test time was found in the EC condition (sound-8.48; affected-5.55 sec; $p<0.05$). CONCLUSIONS: The findings suggest that the ankle strategy did not fully recover in people with ankle fracture after surgery reconstruction. The balance training should emphasize ankle strategy accommodation to further improve functional capability.

P4-E-116 Neuromuscular screening for ACL injury in elite female athletes during a single-leg drop vertical jump

***Bart Malfait*[1], Bart Dingenen[1], Jos Vanrenterghem[2], Filip Staes[1], Sabine Verschueren[1]**
[1]Catholic University Leuven, [2]John Moores University

BACKGROUND AND AIM:Anterior cruciate ligament (ACL) injuries are common in dynamic sports. Few biomechanical and neuromuscular parameters have been found to be predictive for an ACL injury. In addition to the biomechanical parameters, high knee abduction angle and moment, one neuromuscular parameter has been found to be predictive. Females who showed high activity of vastus lateralis (VL) versus activity of semitendinosus (ST), expressed as difference in preparatory (10ms) activity between VL and ST (ΔVL-ST) during sidestepping, had 50% increased probability of

sustaining an ACL injury. (Zebis et al. 2009) In another study, females demonstrated decreased vastus medials (VM) to VL activity ratio compared to males during side-stepping tasks. This low VM/VL activity ratio might result in worse control of the medial knee joint compartment which may increase ACL load. (Myer et al. 2005) PARAThe aim of the present study was to assess the association between the ΔVL-ST activity and VM/VL activity ratio during single-leg drop vertical jump tasks (SLDVJ). Additionally, associations between these neuromuscular and biomechanical parameters predictive for ACL injury were assessed. METHODS:Forty-eight injury-free female athletes volunteered to participate (mean age=21.1±3.4yrs). All subjects performed 3 SLDVJ from a box of 10 cm. EMG data, kinematics and kinetics were recorded in Nexus (Vicon) at 1000 Hz. The root mean square (RMS) EMG amplitude was calculated for VM, VL and ST during a time period 10 ms before initial contact (Fig.1). RESULTS:Pearson correlation analyses showed significant negative associations between ΔVL-ST and the VM/VL activity ratio in both the dominant (r=-0.35;P=0.015) and the non-dominant leg (r=-0.42;P=0.003). No significant associations were found between the neuromuscular parameters and the biomechanical parameters, knee abduction angles and external knee abduction moments during SLDVJ. CONCLUSIONS:The present findings indicate that a large ΔVL-ST is significantly associated with a low VM/VL activity ratio. A large ΔVL-ST suggests that there is a decreased activity of the ST, an important agonist of the ACL, relative to the VL and a low VM/VL ratio indicates low activity of the VM relative to the VL. Literature assumed that both neuromuscular control parameters may potentially lead to medial knee joint gapping and subsequently increase ACL load and ACL injury risk. The not significant relations between these neuromuscular predictive parameters and knee abduction angles and/or moments suggest that the medial knee joint gapping phenomenon due to maladaptive neuromuscular control is not visible in these biomechanical parameters. Based on these current findings, we suggest including both the biomechanical and neuromuscular predictive parameters in screening programs. Future prospective research is necessary to confirm the importance of pre-activity of the VM and ST as a target point in neuromuscular prevention programs.

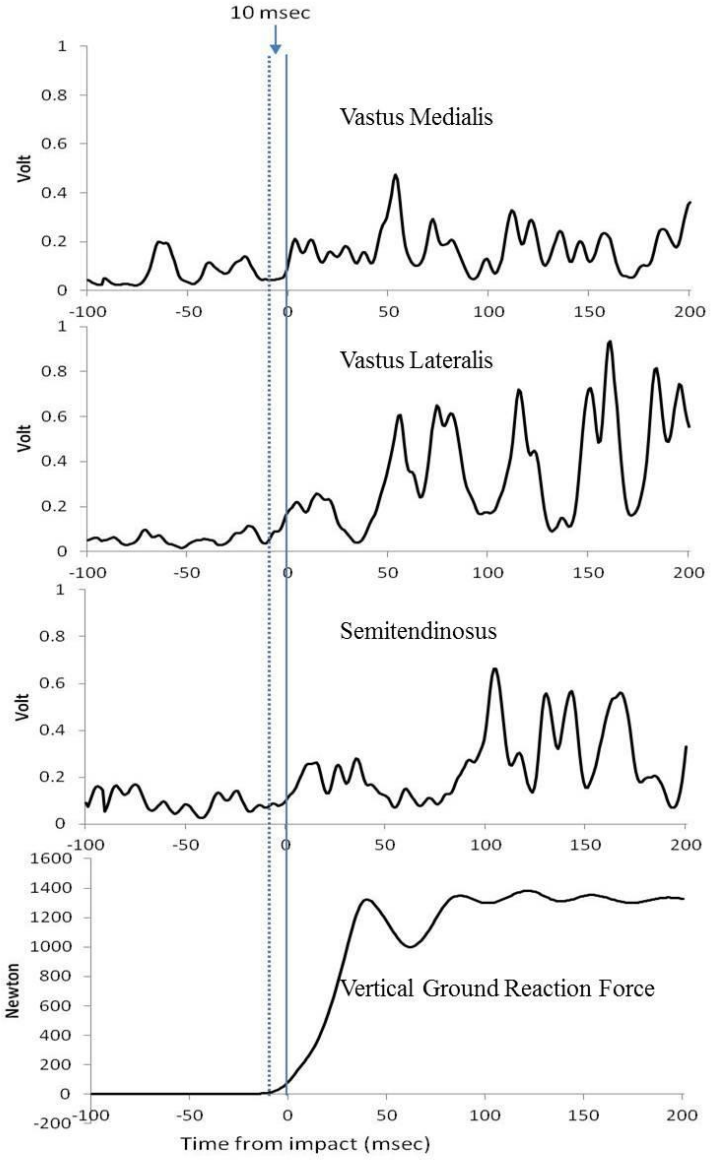


Figure1: Example of processed EMG activity (VL, VM and ST) and vertical ground reaction force during SLDVJ task in 1 representative subject. The solid line represents initial contact. The interval between the dotted line and the solid line represent the 10-milliseconds interval before initial contact (10 ms pre-activity).

P4-E-118 Pain intensity is correlated with postural strategies in patients with severe knee osteoarthritis under different sensory conditions.

***Rogerio Hirata*[1], Tanja Jørgensen** [1], **Sara Rosager Mortensen**[2], **Lars Arendt-Nielsen**[1], **Henning Bliddal**[2], **Marius Henriksen** [2], **Thomas Graven-Nielsen**[1]
[1]Aalborg University, [2]Copenhagen University Hospital,

INTRODUCTION: Knee osteoarthritis (KOA) is a progressive joint disease associated with pain in and around the knees, balance impairment, and increased risk of falling. However the relationship between pain and balance (sway) impairments in this population is still unclear. AIM: To investigate the correlation between pain and quiet standing sway parameters during different sensory conditions in patients with various structural severities of KOA. METHODS: A group of 45 patients with KOA was included. Structural disease severity was assessed from standard semiflexed standing radiographs and the disease severity in the medial tibiofemoral compartment was graded from 0 (normal) to 4 (end stage KOA) by the Kellgren and Lawrence (KL) score from the radiographs. Only patients with KL > 0 were included. Quiet balance was assessed using a force platform. Each participant was tested during 4 different sensory conditions, applied 3 times each randomly: (i) eyes open (EO) and firm surface (FS), (ii) eyes closed (EC) and FS, (iii) EO and soft surface (SS), and (iv) EC and SS. During the SS condition a foam cushion was placed on top of the force platform. Each of the 12 trials lasted for 1 minute while 3 dimensional ground reaction forces were recorded. The centre of pressure (CoP) was calculated from the force platform data, and the mean position in anterior-posterior (AP) and medial-lateral (ML) directions were extracted. Spearman's correlation analysis was performed between pain intensity (numeric rating scale), and the CoP mean position. RESULTS: Pain intensity was significantly correlated ($P<0.05$) with the mean AP CoP position during both conditions on FS (EO, $r=0.34$; EC, $r=0.31$) and during EO-SS condition ($r=0.31$) on EO (FS, $r=0.34$; SS, $r=0.31$) and EC-FS (FS, $r=0.31$). CONCLUSION: Postural strategies adopted by KOA patients relates to pain intensity, unless visual and proprioceptive input from the feet are altered simultaneously (EC-SS). Severe patients decrease the distance between the body Center of Mass (CoM) and the anterior boundaries of the base of support, which increases the likelihood of reactive strategies to restore balance when the body is perturbed forward. This may indicate the necessity of the severe patients to prioritize stability against the most challenging perturbation (body perturbed backwards). Therefore, rehabilitation procedures aiming to decrease pain, may lead to improvements in balance and reduce risk of falls in KOA patients. ACKNOWLEDGEMENT: The Danish Ministry of Health and Prevention and The Oak Foundation.

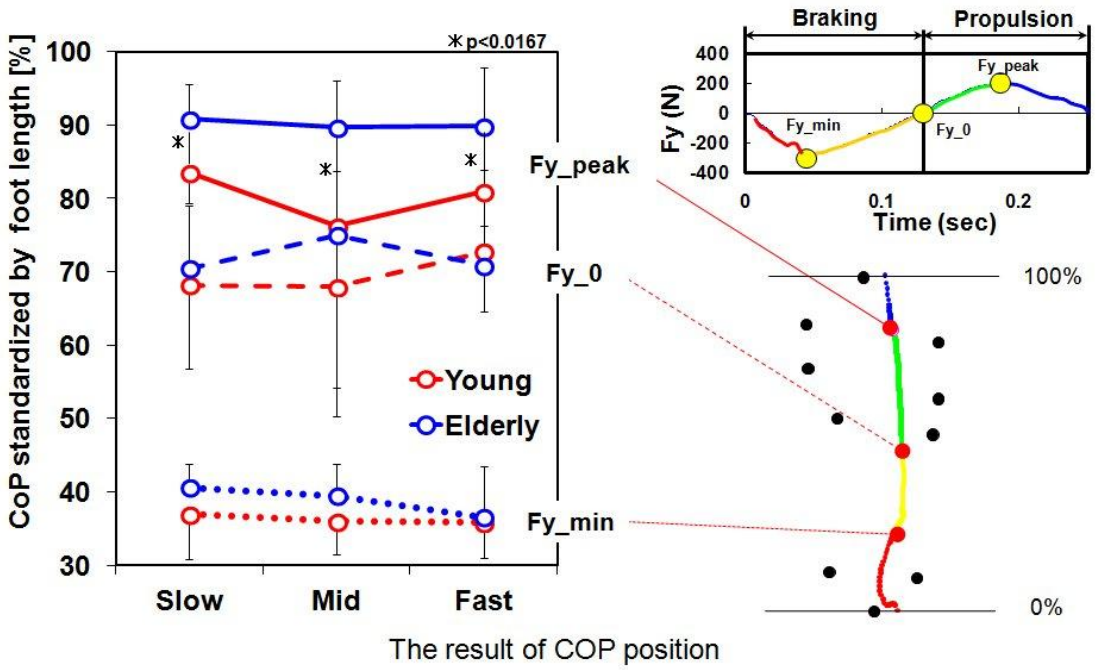
F - Aging

P4-F-120 Relationship between hip extension and COP forward progression during gait in the elderly

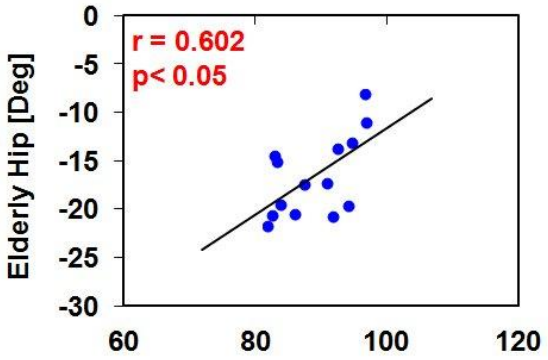
***Shingo Takashima*[1], Takehiro Tagawa**[1], **Yusuke Torii**[1], **Masaru Ichikawa**[1], **Tsuyoshi Nishiwaki**[1]
[1]ASICS Corporation

BACKGROUND AND AIM: Hip muscle function is considered to be important for the elderly in terms of life space and postural control. On the other hand, hip impairments, such as decreased hip angle, moment and power during gait, have been reported in the elderly. It was also known that hip muscle function in gait is linked with ankle muscle function like decreased ankle pushoff contributes to the increase of ROM, moment and power in the hip joint. These findings suggest that hip kinetics and kinematics could be altered by foot kinetics and kinematics because ankle pushoff is affected by MP dorsiflexion and the trajectory of COP. However the relationship between hip action and foot action in gait has been unclear. The purpose of this study is to investigate the relationship between hip and foot functions during gait in the

elderly and to figure out the possibility of compensatory hip action by foot action. METHODS:11 young (aged 28.4±4.8) and 14 community-dwelling elderly (aged 69.6±4.7) volunteers participated in this study. All subjects were healthy with no acute musculoskeletal symptoms and no history of neurological problems. Ground Reaction Forces and lower extremity kinematics data were measured by a force plate and a motion capture system in gaits with 3 different speed (Slow: 60 - 80m/min, Mid: 80 - 100m/min, Fast: 100 - 120m/min), respectively. The angles of maximum hip extension, maximum ankle plantarflexion and maximum MP dorsiflexion were calculated. The positions of COP forward progression were also calculated at appearances of the maximum braking force, the transition from braking to propulsion force and the maximum propulsion force appeared. RESULTS:Multiple comparisons showed that the hip extension angle and the MP dorsiflexion in the elderly during fast gait were significantly smaller than those in the young ($p<0.05$). On the other hand, there was no significant difference of ankle plantarflexion angle between the elderly and the young during fast gait. The COP position at the maximum propulsion phase in the elderly was also significantly forward compared with that in the young ($p<0.05$), however there were no significant differences at the maximum braking and conversion from braking to propulsion phase. The above results suggested that the elderly had different strategy to increase gait speed. In addition, a significant correlation between hip extension angle and COP forward progression within the elderly was observed($r=0.602$, $p<0.05$). CONCLUSIONS: The relationship between hip and foot muscle functions in gait was investigated by comparing the elderly and young. Compensatory ankle action was observed during fast gait and the COP position at the maximum propulsion force had a significant correlation with maximum hip extension angle in the elderly. These results suggest that hip kinematics can be increased by controlling COP forward progression from heel rise phase to toe off phase.



The result of COP position

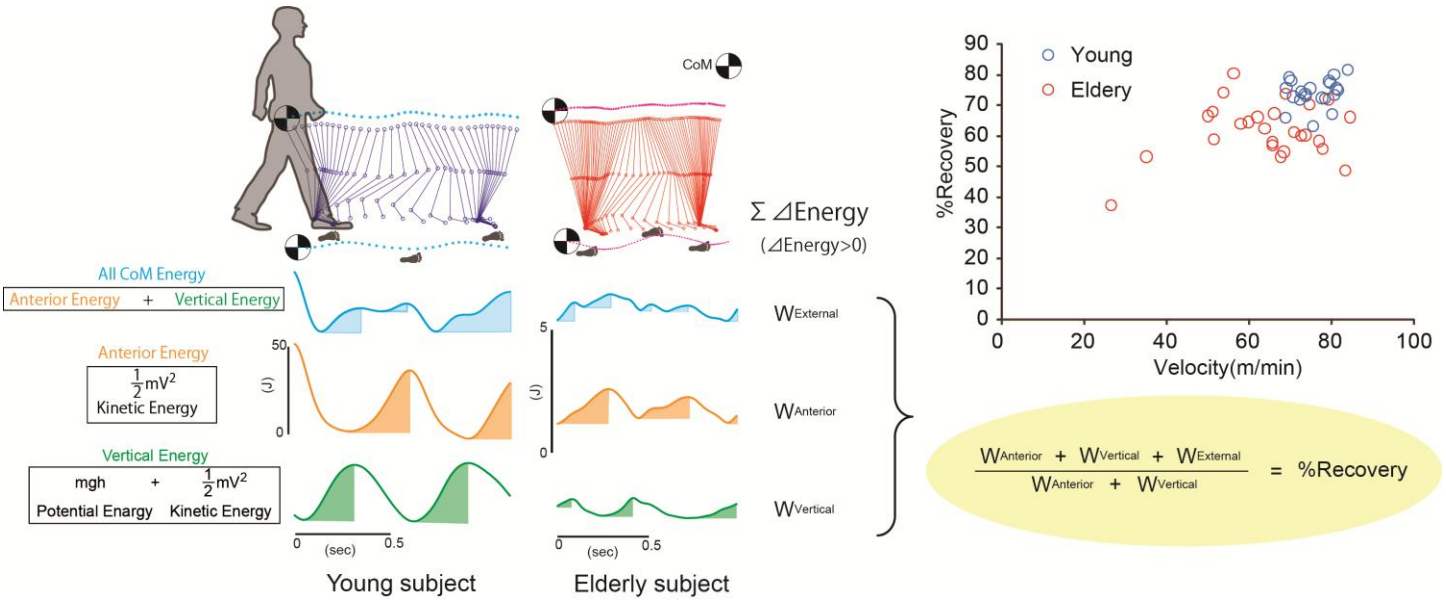


Relationship between hip extension angle and COP position

P4-F-122 Age-related difference of Center of Body Mass Motion during Walking

Takaharu Hosoda[1]**,** **Tomohiro Takahashi**[1], **Shin-ichiro Yamamoto**[1], **Noritaka Kawashima**[2]
[1]Shibaura Institute of Technology, [2]Research Institute of NRCD, Japan

BACKGROUND AND AIM: While there are many attempts to examine age-related alteration of the bipedal gait behavior, it is not easy to characterize it because of larger extent of inter-individual variability in elderly persons. We here observed characteristics of center of body mass behavior, specifically from the aspect of how the gait motion is effectively conducted. METHODS: 28 elderly adults (69±7y) and 21 younger adults (24±4y) participated in this study. Participants walk on force plates at comfortable speed. We acquired CoM position from the result of 3D motion analysis, and the mechanical energy and workload of CoM was measured as Energy = mgh (potential energy) + mV2/2 (kinetic energy) and Work load = Σ⊿Energy (⊿Energy>0). In addition the conversion efficiency of energy (% Recovery) was measured as (WAnterior+WVertical-WExternal) / (WAnterior+WVertical) using the formula of Cavagna (1976). RESULTS: In the younger group, workload for maintaining velocity in anterior direction and workload against gravitation are almost equal. On the other hand, in elderly group, workload against gravitational force was significantly smaller than that in younger group. As clearly shown in the figure, elderly subjects tended to show inefficient movement. CONCLUSIONS: Our results suggest that elderly persons tended to show worth energy costs even under the case of comfortable speed walking.



G - Aging; Coordination of posture and gait

P4-G-124 Impacts of Muscle Strength and Balance Control on the Component Tasks of the Timed up And Go Test

Tzurei Chen[1]**,** **Li-Shan Chou**[2]
[1]University of Evansville, [2]University of Oregon

BACKGROUND AND AIM: The Timed Up and Go test is a commonly used clinical assessment for screening mobility impairment and fall risk. Previous studies have shown that elderly fallers need more time in the sit-to-stand and turning components in the Timed Up and Go test when compared to young subjects. However, no further data have been collected to demonstrate what factors cause differences between the two groups. Therefore, in this study we examined

the association between two age-related functional declines (muscle strength and balance control) and the amount of time taken to perform sit-to-walk or the turning component of the TUG. METHODS: Sixty elderly adults over the age of 70 years were recruited in the study. Muscle strength was quantified by peak joint moments during the isometric maximal voluntary contraction test for bilateral hip abductors, knee extensors, and ankle plantar flexors. The balance control was measured by two clinical balance tests: Berg Balance Scale and Fullerton Advanced Balance Scale as well as a biomechanical measurement, COM-Ankle inclination angle, which can reflect postural alignment and quantify balance control during gait. We constructed a series of multiple regression models to examine the combined contribution of strength and balance variables to predict each TUG component time after controlling for potential confounding factors (age, cognitive impairment, ADL, and past fall history). RESULTS: When strength variables were included in the regression model, the explained variance was increased by 8.9% for STW duration and 1.8% for turning duration. Significant F change was detected when strength variables were included for STW duration prediction ($p=0.03$). When balance variables were added to the regression model, the explained variance was significantly increased by 18.7% for STW duration and 7.4% for turning duration. The regression model that included strength and balance variables explained a statistically significant portion of variance in STW and turning durations ($p = 0.005$, $p = 0.049$, respectively). After controlling for demographics, cognition, fall history, and ADL function, balance control was significantly related to STW ($p=0.001$) and turning durations ($p= 0.038$) whereas muscle strength was not. CONCLUSION: Our findings suggest that balance control is an important factor that contributes to longer STW and turning durations on the TUG. Furthermore, strength has a higher association with STW than turning duration.

P4-G-126 Effects of aging on relationship between standing balance and two-point discrimination sensation in the plantar area

Kazuhiro Chidori[1], **Keisuke Takeda**[2], **Yuji Yamamoto**[1]
[1]Nagoya University, [2]Hara Neurosurgery Clinic

BACKGROUND AND AIM: The ability to balance while standing on one leg is an important indicator of falling in the elderly. However, it is still not clear why this ability declines in the elderly. One possibility is a decline in the sensitivity of the plantar surface of the foot. Menz and Lord found that subjects with a history of multiple falls had a significantly greater foot problem than did those who had not fallen or who had fallen only once [1]. Therefore, we investigated the relationship between the duration of one-leg standing and age-related changes in two-point discrimination (TPD) sensation involved in moving the center of pressure (COP) of the plantar surface of the foot. METHODS: Thirty-nine healthy elderly (age 76.3 ± 5.5 years) and 30 younger (age 23.0 ± 2.1 years) subjects participated in this study. Static TPD testing was performed bilaterally on the toe, hallux, fifth metatarsal head, and heel to evaluate the threshold of the leg sensation using calipers. When the subject felt both points in at least two out of three trials, the distance was noted in mm [2]. The duration of static one-leg standing with the eyes open for up to 60 seconds was measured. RESULTS: The elderly had a higher threshold of TPD than the younger subjects in the plantar region ($p<0.01$). In addition, there were significant differences between the toe and heel and toe and hallux in the elderly group only. The TPD and one-leg standing time had a significant negative correlation (Figure 1). CONCLUSIONS: Melzer et al. speculated that impaired plantar cutaneous sensation in older people would delay a compensatory step or grasp reaction times when a fall is initiated owing to impaired ability to sense the COP movement under the feet [2]. The reduction in plantar sensation in the elderly, especially at the heel, was correlated with a decline in the duration of one-leg standing, which caused falling. REFERENCES 1. Menz HB, et al. J Am Geriatr Soc. 49: 1651-1656, 2001. 2. Melzer N, et al. Age and Aging. 33:602-607, 2004.

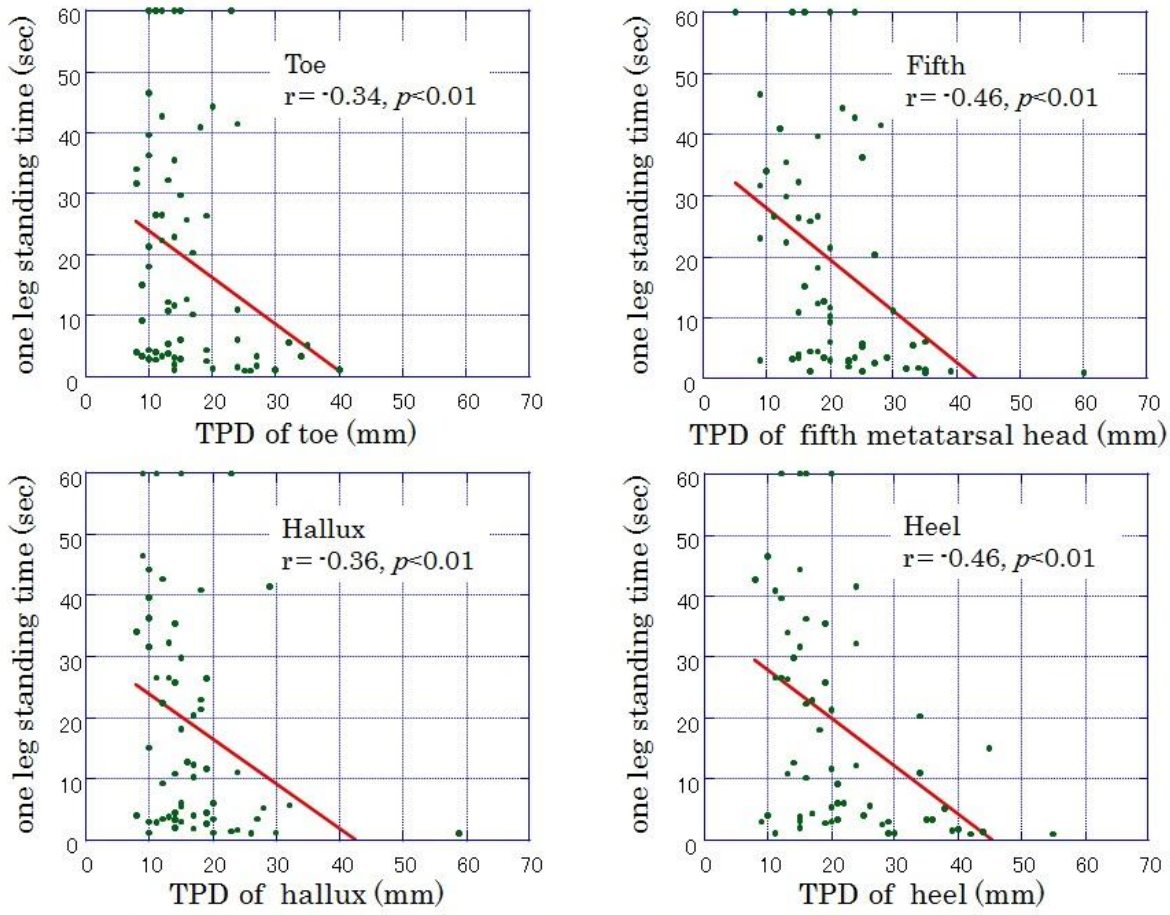


Fig1. Correlation between TPD of plantar region and one leg standing time

H - Coordination of posture and gait

P4-H-128 Mechanisms underlying four-limb coordination of human walking - preliminary report on a split belt treadmill study

Meir Plotnik[1], **Yotam Bahat**[1], **Vadim Neder**[2], **Yoav Gimmon**[1]
[1]Sheba Medical Center, [2]Holon Institute of Technology

BACKGROUND & AIM: The mechanisms regulating four-limb coordination during human gait are not fully known. Aim: to better understand the inter relations between four-limb rhythmic movements while walking. METHODS: 6 healthy young adults (30.9¡À2.8 yrs; 3 women) walked on split belt treadmill (VGAIT, Motek Medical, NL) in three scenarios (randomly presented): A- 5 conditions were presented in continuum (1) 2 min self-selected speed (as determined form 4X 10 m walk trials) - tied belts; (2) Incremental speed increase (over 2 min) of the left belt to 150% of the baseline speed value (but ¡Ü 2 m/s); (3) 4 min walk with uneven belt speeds (left 150%, right 100% of baseline); (4) Similar incremental speed increase as in condition #2 of the right belt; and (5) 2 min walking in maximal speed (tied belts). Scenarios B and C (not presented here) controlled for laterality aspects, and for the isolated effect of speed increase. Gait analysis was performed on data recorded by three-dimensional optoelectronic analysis system (Vicon Motion systems, UK). Outcome masseurs: left and right stride time and length (RS_T, LS_T, RS_L LS_L, respectively), arm swing cycle time (L/R_AS_T), amplitude (L/R_AS_A; i.e., total anterior posterior displacement of the elbow relative to the shoulder in each cycle) and arm swing asymmetry (AS-A). Bilateral coordination of stepping and arm swinging was

assessed using the phase coordination index (PCI), a metric that quantifies the consistency and accuracy of the anti-phase pattern, with lower values indicating better coordination. Modified PCI (mPCI; quantitatively compatible with the PCI) was used to quantify ipsi-lateral arm-leg coordination. RESULTS: Here we present results from stages (1), (3) and (5) of scenario A. During the maximal difference in belts' speeds LS_L increased by 24.1 ¡À 3.3% (SEM; p<0.001) and RS_L decreased by 8.6 ¡À 2.1% (p<0.001) as compared to condition #1. In the final fast speed tied belt condition LS_L and RS_L stabilized on about 19% increase compared to baseline, with the LS_L showing significant decrease as compared to the maximal split belt condition (p=0.005). Arm swing amplitude was decreased significantly during the maximal split belt condition (e.g., R_AS_A = 49 ¡À 1cm) as compared to baseline (55 ¡À 2 cm; p=0.002). This difference was preserved in the fast tied belt condition. AS-A increased in condition #3 and remained increased in condition #5. L/R_AS_T and L/RS_T variability as well as PCI and mPCI values did not change significantly throughout the experimental conditions. E.g., AS PCI values were 16.7 ¡À 3.4%, 14.4 ¡À 1.2% and 12.2 ¡À 1.9%, in conditions #1,3 and 5, respectively (p>0.2). CONCLUSIONS: Despite the limited number of subjects, it is suggested that movement rhythmicity and inter limb coordination are the primary control features which are preserved during locomotion modulation, while movement scaling is differentially controlled, most likely to accommodate this preservation.

P4-H-130 Common muscle synergies for balance and walking

Lena Ting[1]**, Stacie Chvatal**[1]
[1]Emory University and Georgia Tech

BACKGROUND AND AIM: Understanding how balance and locomotor functions are integrated is important for developing clinical assessments of motor ability that are generalizable across activities. We have proposed that muscle synergies reflect a modular structure for motor control outputs, specifying a library of motor actions. As such, muscle synergy analysis may provide a way to identify common neural strategies for coordinating muscles in walking and balance control. Previously, muscle synergies underlying reactive balance control and overground walking have been identified. However, it is unknown whether muscle synergies from these two task reflect distinct or overlapping patterns of muscle coordination. Here, we hypothesized that a common set of lower-limb muscle synergies mediate muscle activity for reactive balance control across movement contexts and during overground walking. METHODS: We recorded electromyograms (EMGs) of 16 muscles in the right leg and trunk during postural responses to ramp and hold translations of the support surface during standing balance, as well during perturbed walking at both self-selected (1.2-1.5 m/s) and slow walking speeds (0.6-0.7m/s) and during unperturbed walking in 7 subjects (4 male, 3 female, age 22.7±2.4 years). Perturbations in twelve directions in the horizontal plane were delivered in random order. Using non-negative matrix factorization, muscle synergies were extracted from the reactive balance response during standing and perturbed walking, as well as from the entire timecourse of unperturbed walking trials. Muscle synergy composition and recruitment were compared across conditions. RESULTS: Most muscle synergies used in perturbation responses during standing were also used in perturbation responses during walking, suggesting common neural mechanisms for balance across different contexts. In each subject we identified 4-6 muscle synergies during perturbation responses during standing balance and during walking, 2-4 of which were similar across perturbation conditions. Furthermore, during unperturbed walking we identified 6-8 muscle synergies in each subject, most of which (4-6) were also used in reactive balance responses. Differences in the composition and recruitment of muscle synergies across conditions reflected differences in the biomechanical demands of each condition. CONCLUSIONS: Our results suggest that neural circuits mediating locomotion and reactive balance recruit a common set of muscle synergies. We propose that muscle synergies are organized based on the biomechanical subtasks required for a given motor task. As such, muscle synergies can be recruited by parallel motor pathways across different movement contexts. Therefore, muscle synergy analysis may be helpful in providing a more generalizable assessment of how motor function is impaired, potentially providing more specific neural pathways that should be targeted in rehabilitation.

P4-H-132 Gait characteristics of mild to moderate disabled Parkinson patients

***Chang-Hwan Kim*[1], Bee-Oh Lim**[2], **Mi-Young Kim**[1], **Kyu-Sung Kim** [1]
[1]School of Medicine, Inha University, [2]ChungAng University

BACKGROUND AND AIM: Very few studies have examined the gait characteristics from mild to moderate disabled patients with Parkinson disease. Understanding of gait deviations could be beneficial for treatment and rehabilitation planning. The purpose of this study was to compare gait characteristics for people with Parkinson disease. METHODS: Thirty-three (n=11 per group) people with Parkinson disease (Hoehn and Yahr stage 1-3, mean age=61.4 years) participated in the study. The participants walked 3 times across the walkway of the GAITRite system at a self-selected speed. Dependent variables were statistically analyzed using one-way ANOVA with Bonferroni adjustments. RESULTS: Significant differences between Hoehn and Yahr stage 1, 2 and 3 were found for velocity, functional ambulation profile (FAP) score, and step extremity ratio. Significant differences between Hoehn and Yahr stage 1 and 3 were found for stride length and toe out angle. Significant differences between Hoehn and Yahr stage 2 and 3 were found for cycle time and HH base support (step width). CONCLUSIONS: This study has identified several gait characteristics that were significantly different between Hoehn and Yahr stage 1 and/or 2 and 3 group walkers.

P4-H-134 Locomotor-respiratory entrainment is more constrained in low back pain

***Paul Hodges*[1], Steven Saunders**[1]
[1]The University of Queensland

BACKGROUND AND AIMS: Locomotion and respiration are coordinated (entrained) in healthy humans. This avoids foot contact at times in the respiratory cycle when trunk muscle activity is reduced. People with low back pain (LBP) walk more slowly, and have decreased transverse plane thoraco-pelvic rotation and changes in trunk muscle activity. This study investigated whether these differences impact entrainment in recurrent LBP. METHODS: Nine people with recurrent LBP (LBP episodes over 18 months sufficient to restrict activity/seek care; pain-free or pain <2/10 during testing)(age: 18-41) and 13 people with no LBP history (age: 23-41) participated. Foot switches fixed to the plantar aspect of the right and left calcaneous recorded foot strikes while participants walked over ground at a self-selected natural speed for 2 minutes. Respiratory movement of the chest wall was recorded with a pressure cuff strapped to the chest. Times of peak inspiration and expiration were identified and inspiratory and expiratory periods were divided into ten epochs of equal duration. The frequency of foot strikes in each ten-percentile epoch of inspiration (i1-10) and expiration (e1-10) was identified. Frequency of foot contacts, step rate, respiratory rate and locomotion-respiration ratio (LRR) were compared between groups with analysis of variance (ANOVA). RESULTS: Step rate (LBP: 62(10) vs. control: 58(5) steps/min), respiratory rate (25(7) vs. 21(4) breaths/min) or LRR (2.5(0.5) vs. 3(0.6)) did not differ between groups ($P<0.001$). Few foot strikes occurred at the transition from inspiration to expiration (i10, e1) and more than average occurred at the transition from expiration to inspiration (e10). The frequency of foot strikes during inspiratory epoch 4 and 8 and expiratory epoch 2, 6 and 10 was increased compared to controls ($P<0.0001$). CONCLUSION: Entrainment in both groups avoided foot contact at the transition from inspiration to expiration when abdominal muscles are expected to be least active, and increased the likelihood of foot contact at the transition from expiration to inspiration when the abdominal muscles are most active. Although foot strikes were relatively evenly distributed across the remaining epochs for controls, those with recurring LBP maintained tight coupling throughout the respiratory cycle with more frequent foot strikes in every fourth tenth-percentile epoch. One interpretation of this observation is that foot strikes are more tightly coordinated with breathing in LBP to reduce the potential for errors in entrainment. This may be an adaptation to reduce the risk to the spine of a poorly timed foot contact (and the associated reactive force at the spine) at a time when spinal protection may be reduced.

I - Learning, plasticity and compensation; Coordination of posture and gait

P4-I-136 The effect of age on the adaptation process of gait termination under the repeated optic flow stimulation

***Suzuyo Okazaki*[1], Suetaka Nishiike[1], Hiroshi Watanabe[2], Takao Imai[1], Atsuhiko Uno[1], Tadashi Kitahara[1], Arata Horii[3], Takefumi Kamakra[1], Yasumitsu Takimoto[1], Noriaki Takeda[4], Hidenori Inohara[1]**
[1]Osaka University Graduate School of Medicine/Japan, [2]National Institute of Advanced Industrial Science and Technology, [3]Osaka National Hospital, [4]University of Tokushima Faculty of Medicine

BACKGROUND AND AIM: We reported that even under the optic flow, youth terminated their gait stably. On the other hand, the walking velocity at the start of the termination process dynamically changed through the experiment (Okazaki et al., 2012). In this study, we compared the effects of optic flow on head deviation and walking velocity of youth during gait termination with that of elderly. METHODS: Twenty-three healthy young and nineteen older subjects completed the study. Subjects started walking as an acoustic cue and stopped immediately after recognizing scenery change in VR system (CAVE). After the eight-time control trials without optic flow, experimental trials consisting of two conditions were performed. During horizontal movement condition, the front screen constructed with random-dot pattern started moving horizontally to the right, and during rotational movement condition, it started rotating clockwise as soon as subjects walked more than 0.9 m in length. Two conditions were repeated four times each in mixed random order as the first set. The second and the third set were respectively resumed after three-minute rest. We defined the gait termination as the period between the times when visual stimulation started and when subjects stopped walking. Because there was no significantly different effect between horizontal and rotational optic flows on head deviation or walking velocity, we analyzed the average effect of both kinds of optic flows. RESULTS: In anteroposterior direction, the head deviation of youth by optic flow during gait termination did not change, but that of elderly decreased. In mediolateral direction, there was no significant change of the head deviation compared with control in both groups, but it was significantly large and did not decease in elderly unlike youth. The walking velocity dynamically changed through the experiment in youth. Walking velocity of elderly, however, was significantly slow and did not change with time unlike youth. The time course of gait termination did not change throughout the experiment. Optokinetic nystagmus was always observed in all subjects throughout the HM trials, and it was also observed in all subjects in 79.7% of the RM trials. CONCLUSIONS: Elderly were more influenced by repeated optic flow during gait termination in anteroposterior direction, and swayed larger in mediolateral direction than youth. The basic strategies to stop walking which we observed in youth were seemed to weaken in elderly. We observed short-tem (adaptation) and long-term (habituation) flexible changes of walking velocity in youth. It is suggested that these flexible changes of the walking velocity subserve the stable process of gait termination under variable circumstantial changes such as optic flow. On the other hand, the walking velocity of elderly did not change flexibly unlike youth. This may be one of the reasons why elderly tend to fall.

P4-I-138 Role of the cerebellum and supplementary motor cortex in postural control during gait initiation in healthy adults: a pilot study

***Alienor Richard*[1], Amine El Helou[2], Sabine Meunier[1], Marie-Laure Welter[2]**
[1]CR-ICM, UMRS 7225, Groupe Hospitalier Pitié-Salpêtrière, [2]ICM Fundation, Groupe Hospitalier Pitié-Salpêtrière

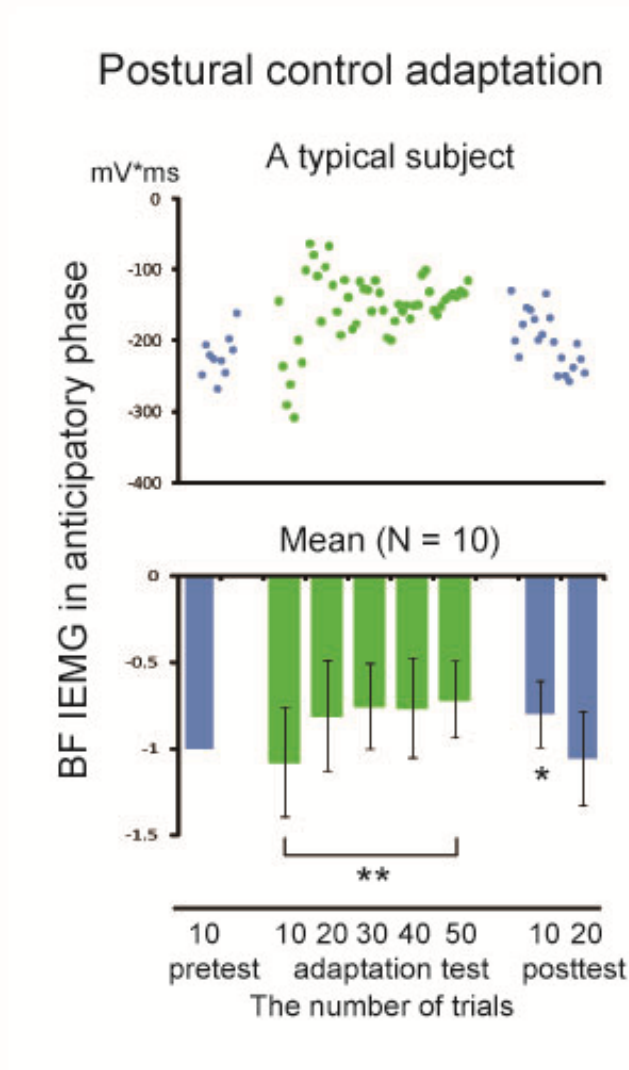
BACKGROUND AND AIM: In human, physiology of gait and balance is not clearly established. By using functional imaging and electrophysiological techniques, various brain regions from the cortex to the midbrain area, including the cerebellum, have been identified as involved in such control. Yet their specific roles in the capacity to go forward (locomotion) and to stand upright (balance), respectively, but also in the different phases of the gait initiation process, are still unknown. In this study, we aimed to assess the specific role of both the supplementary motor area (SMA) and

the cerebellum in postural control during the initiation of gait. METHODS: Gait initiation was studied in 10 healthy subjects before and after functional inactivation (using inhibitory repetitive transcranial magnetic stimulation, rTMS) of the cerebellum or SMA. Biomechanical, kinematic and electromyographic parameters of the gait initiation were recorded using a force platform, reflective markers with infrared cameras (VICON system) and lower limbs surface EMG electrodes. From a biomechanical point of view, during the anticipatory postural adjustment phase (APAs), the duration and posterior and lateral displacements of the centre of foot pressure (CP) were measured. During the step execution phase, the length and width of the first step, anteroposterior (AP) and vertical velocities of the centre of gravity, and phase duration were measured. The vertical CG velocity allowed us to estimate the CG fall and the capacity to actively reverse this fall (braking index). Two conditions of gait - spontaneous and fast- were examined before and after functional inactivation of the cerebellum or the SMA by rTMS. The rTMS was delivered as a theta burst stimulation protocol in a randomized design: cerebellum (bilateral), SMA or sham stimulation (applied either on the SMA or on the cerebellum). RESULTS: The functional inactivation of the SMA induced a significant increase in the APAs duration (0.47 ± 0.06 sec vs 0.51 ± 0.05 sec, $p<0.02$, spontaneous condition). The functional inactivation of the cerebellum resulted in a significant increase in the step length (69.3 ± 10.5 cm vs 72.3 ± 11.2 cm, $p<0.03$), execution velocity (0.61 ± 0.12 vs 0.70 ± 0.12 m/s, $p<0.05$) and the CG fall (-0.25 ± 0.08 m/s vs -0.29 ± 0.08 m/s, $p<0.04$)(fast condition). Conversely, the lateral CP displacement during the APAs (6.3 ± 3.3 cm vs 5.5 ± 2.4 cm, $p<0.01$) and the step width (21.0 ± 7.6 cm vs 19.8 ± 6.1 cm, $p< 0.02$) were significantly reduced. CONCLUSIONS The preliminary data obtained in our study suggest that the SMA and the cerebellum play different roles in the initiation of gait, with a predominant control of the preparatory phase for the SMA and motor coordination in the execution phase for the cerebellum.

P4-I-140 Postural control adaptation during a repeated load release task

Hiroshi Saito[1], **Masanori Yamanaka**[1], **Satoshi Kasahara**[1]
[1]Faculty of Health Sciences, Hokkaido University

BACKGROUND AND AIM: The central nervous system controls postural muscles in three different phases during voluntary arm movement in standing and maintains postural stability to perform focal movement appropriately. The time course on postural control is divided into three phases, such as anticipatory phase (-100 ms to 50 ms), automatic phase (50 ms to 200 ms), and voluntary phase (200 ms to 350 ms) from the focal movement onset (Latash 2008). It is known that repetitive training of arm movement while standing leads to improvement in motor performance such as accuracy and velocity. However, the effects of movement repetition on postural control are unknown, although the changes in postural control must contribute to improvement in motor performance. We examined whether repeated load release movements induced postural control adaptation in lower limb muscles, and if so, in which phase adaptation of postural control was induced. METHODS: Ten healthy subjects (21 ± 1 years) were required to stand, holding a load bar (3 % body weight) with both hands at shoulder level, and to release it 10 times in self-paced manner (pretest). In adaptation test, external perturbation force (6 % body weight) was applied to trunk for bending forward simultaneously with load release, which was repeated 50 times. Then, posttest similar to the pretest was repeated 20 times. The surface electromyograms (EMG) of tibialis anterior (TA), gastrocnemius (GAS), rectus femoris (RF), and biceps femoris (BF) were recorded. The integrated EMG was calculated in each phase. The infrared cameras measured displacement of head and hand. RESULTS: In pretest, robust inhibitions of activity in GAS and BF were observed for maintaining postural stability. During the last ten trials in adaptation test, the inhibitions of muscle activities were significantly decreased. The changes



in postural muscle responses were observed clearly in anticipatory phase. In addition, the backward displacement of the head significantly increased and occurred earlier. During only ten trials in posttest, robust inhibitions of muscle activities and postural stability recovered again. CONCLUSIONS: These results suggest that repetitive arm movement training during standing induces postural control adaptation in anticipatory phase prior to the onset of focal movement and the adapted postural responses could recover rapidly.

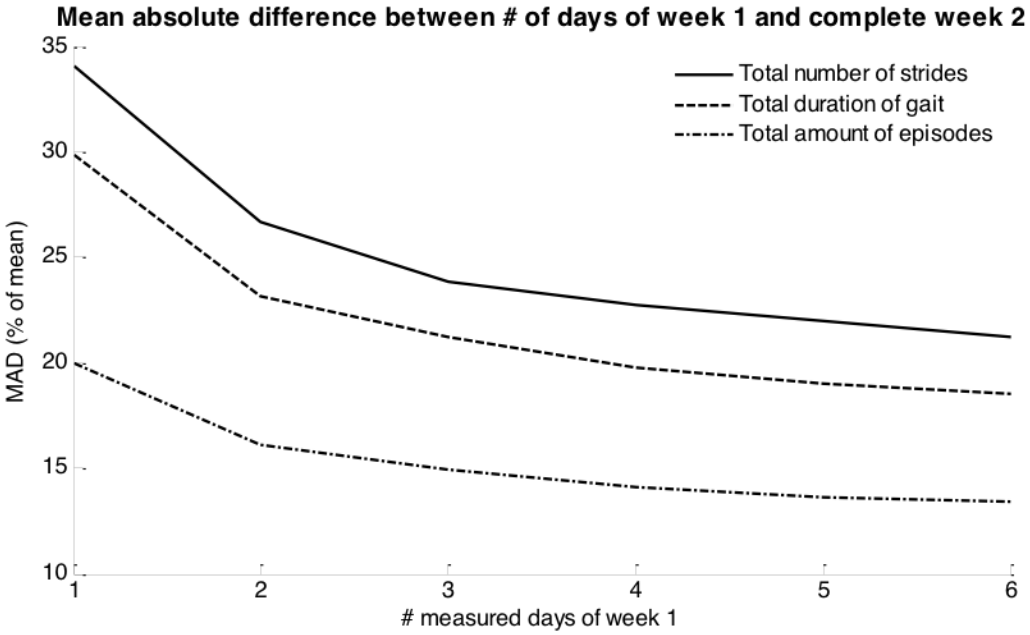
J - Activity Monitoring; Cognitive, attentional and emotional influences

P4-J-142 Number of days of trunk acceleration measurements to reliably assess the amount of daily walking in older adults

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

BACKGROUND AND AIM: The quantity and quality of daily activities in older adults could provide information on their health status and fall risk. Ambulatory measurements with wearable accelerometers allow assessment of daily activities, and provide more specific information on walking episodes than mere step counters. Our study addressed the question how many days of trunk acceleration measurements are required, to reliably quantify the amount of walking in older adults. METHODS: Twenty-six older adults wore a trunk accelerometer (MoveMonitor, McRoberts) for two weeks, on average 12 days apart. Day-time locomotion episodes were identified [1] for 6 days per measured week. Several parameters that quantify walking activity were calculated, i.e. the total number of episodes and the total, 25th percentile, median, and 75th percentile of the duration of these episodes and of the amount of steps per episode. To determine the effect of number of days measured on reliability, the means over 1-6 days from the first week were bootstrapped and compared to the mean of the second week (6 days), by calculating the mean absolute difference

between weeks (MAD) and the intra-class correlation coefficients (ICC). RESULTS: No systematic differences in any of the parameters were observed between complete weeks (all p>0.36). The MAD between 2 complete weeks ranged from 9-21% for all parameters, with highest values for the total number of strides (21%) and total duration of gait (19%).The ICC between 2 complete weeks ranged from 0.69-0.95, with lowest values for 25th and 75th percentile of the number of strides (respectively 0.69 and 0.78). The decrease in MAD was limited when analyzing more than 3 days (see Figure), and all ICCs exceeded 0.65. CONCLUSIONS: To reliably quantify the amount of walking activity from ambulatory trunk acceleration data, a minimum of 3 days of measurements appears sufficient, and 6 days of measurements result in good to very good reliability. The relatively high MADs for the total amount of strides, duration and episodes over days indicate that substantial intra-individual variations occur between weeks. Further analysis will focus on other types of daily activities such as standing and lying down. REFERENCES: 1. Dijkstra, B., Y. Kamsma, and W. Zijlstra, Detection of gait and postures using a miniaturised triaxial accelerometer-based system: accuracy in community-dwelling older adults. Age and Ageing, 2010. 39(2): p. 259-262.



P4-J-144 The effect of early Parkinsons disease on daily ambulatory activity

***Sue Lord*[1], Brook Galna[1], Alan Godfrey[1], David Burn[1], Lynn Rochester[1]**
[1]Newcastle University

Background: Maintenance of ambulatory activity is important in the early stages of Parkinson's disease (PD), given its potential to attenuate disease progression and to mitigate secondary deconditioning. Little is known about ambulatory profiles in early PD. Aim: To examine the effect of early PD on ambulatory activity and to compare activity outcomes with public health recommendations. Methods: Eighty-nine newly diagnosed PD (mean (SD) age 67.3 (9.9) years) and 98 controls (mean (SD) 69.1 (7.7) years) wore an activity monitor (activPALTM) for 7 days. Volume, pattern and variability metrics were extracted. Repeat measure ANCOVA compared stepping bouts for PD and controls controlling for age, gender and gait speed. PD were also classified by Hoehn & Yahr (H&Y) and activity outcomes were considered with respect to accumulation of 30 minutes of daily activity (sustained activity), per public health guidelines. Pearson's correlations were used to explore associations between motor, cognitive and affective characteristics and sustained activity. Results: Total step count was significantly lower for PD (P< .001), reflecting an inability to sustain medium bouts (P < .01) and long bouts (P <.001). Accumulation of 30 min activity from bouts >10 min, was achieved by only 12 (12.2%) controls and 3 (3.4%) PD participants (P= .03), and accumulation of bouts > 2 min walking was achieved by 60 (61. 2%)

controls and by 19 (21.3 %) PD (P < .001). The volume and pattern of inactivity was comparable across the disease spectrum. For PD, there were weak but significant correlations for age, disease severity, cognition, single leg stance, gait speed, and self-efficacy. Discussion: Ambulatory activity is compromised in early PD compared with controls. Once inactivity is established it does not change across the disease spectrum. People with PD find it particularly difficult to sustain longer bouts of ambulatory activity. This is likely to contribute to the burden of pathology and impact on broader aspects of mobility.

K - Balance support device; Falls and falls prevention

P4-K-146 Electromyography (EMG) Analysis of Trunk and Leg Muscles Activities during Whole Body Tilt of 3D Dynamic Exercise Device

Chang-Ho Yu[1], **Sun Hye Shin**[1], **Mi Yu**[1], **Kyung Kim**[1], **Ho Choon Jeong**[1], **Tae-Kyu Kwon**[1]
[1]Chonbuk National University

BACKGROUND AND AIM: The objectives were to assess the trunk and leg muscle activities during the trunk tilt exercise of a 3D dynamic exercise device capable of active and passive movements and to study how Root Mean Squire (RMS) values, and trunk positions could affect these muscle activities. METHODS: Eighteen healthy volunteers (18 males, height :176±2.3 cm; mass 69.9±2.7 kg; age 24.7±0.5 years) were selected. None of the subjects had any history of lumber and trunk muscle problems. Rotation capability enabled investigation of A (anterior), R (right), P (posterior), L (left), AR (anterior right), AL (anterior left), PR (posterior right), PL (posterior left) tilt directions. EMG signals of trunk (rectus abdominis, external obliques, latissimus dorsi, erector spinae) muscles and leg (rectus femoris, Biceps femoris, Tibialis Anterior, gastrocnemius) muscles was taken with active and passive tilt modes. Root Mean Squire (RMS) values were computed. RESULTS: The results showed that, in all directions except for rearward backward tilt, active tilt training showed higher values for muscle movements than passive tilt training. In contrast, in the case of passive tilt, tilting is maintained with excessive force through involuntary movements regardless of the alignment of the body; thus, the values of the muscle movements measured are high. In addition, the results for muscle movements according to direction, regardless of active or passive tilting mode, showed that erector spinae muscle movements had higher values in forward tilting, whereas rectus abdominis muscle movements revealed higher values in rearward tilting. CONCLUSIONS: The results of this study indicate that different exercise patterns can be applied depending on the exercise types that are appropriate and necessary to each user. We believe that the human body can be maintained in equilibrium through the interaction between the position and movement execution of the human body, contributing to the improvement of body balance control. Further quantitative data collection and analysis related to the development of various spinal stabilization exercise programs is required, and in the near future, we will conduct a study about the effects of trunk tilt exercise in active and passive modes on the strength of the tilting muscles and postural balancing ability.

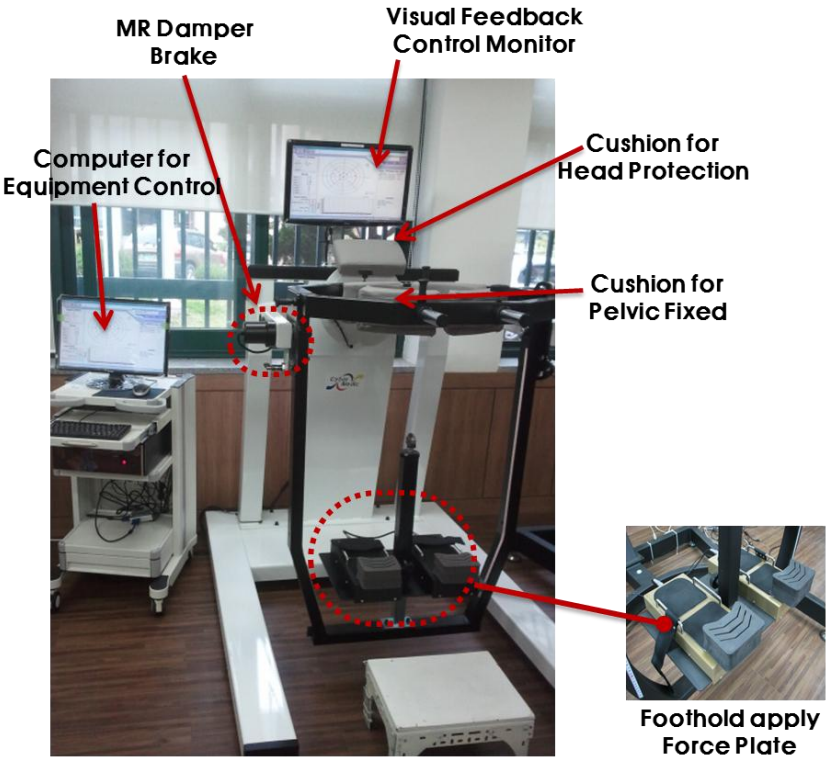


Fig. 1 3D dynamic exercise device (SpaceBalance 3D, CyberMedic Co. & Chonbuk National Univ., Korea) capable of balance and trunk exercise with various exercise program modes

P4-K-148 Sitting Balance in Individuals with Spinal Cord Injury and the Effects of Application of Functional Electrical Stimulation for Improving Sitting

Matija Milosevic[1], **Kei Masani**[2], **Meredith Kuipers**[1], **Noel Wu**[1], **Molly Verrier**[2], **Kristiina Valter McConville**[3], **Milos Popovic**[1]
[1]University of Toronto, [2]Toronto Rehabilitation Institute-UHN, [3]Ryerson University

BACKGROUND AND AIM: Individuals with spinal cord injury (SCI) above the first lumbar vertebra (L1) have impaired trunk muscle control which frequently leads to poor sitting balance. For standing balance, posturography has been successfully utilized to investigate balance control and the effects of neurological impairments, while fewer studies have investigated sitting balance using posturography. We hypothesized that individuals with SCI have deficient sitting balance compared to able-bodied (AB) individuals. Functional electrical stimulation (FES) can activate muscles by applying short electric pulses on the surface of paralyzed muscles. We also hypothesized that application of FES can activate trunk muscles to improve sitting. Thus, the objectives of our study are to: 1) compare sitting balance of AB individuals to people with SCI; and 2) assess sitting balance during application of FES on the trunk muscles. METHODS: Subjects were asked to maintain steady upright posture on an instrumented chair for a period of at least 60 sec during each trial. Center of pressure (COP) on the chair was recorded to evaluate changes in posturography between conditions. In Study 1 sitting balance of ten AB individuals (n=10; mean age = 31.0 yrs) was compared to six individuals with cervical-level, chronic SCI (n=6; mean age = 41.3 yrs; injury level C4 to C6). In Study 2 sitting balance of nine AB

individuals (n=9; mean age = 26.9 yrs) was compared during unsupported and FES-assisted quiet sitting. FES was applied bilaterally using surface stimulation to activate the rectus abdominis and lumbar erector spinae (L3) muscles. RESULTS: Individuals with SCI swayed significantly more than the AB group, as indicated by a 51% overall larger mean distance (MD) of COP fluctuations (p=.044). Moreover, the mean frequency (MF) was 24% overall smaller for the SCI group (p=.047). The results suggest that individuals with SCI have less effective postural control during sitting, and that they do not use the same regulatory activity to achieve sitting stability. Furthermore, when FES was applied to activate trunk muscles, MD decreased by 22% in the medio-lateral (ML) (p=.021) direction. MV increased by 5% in AP (p=.041), and the MF increased by 26% in ML (p<.001) direction. Our results suggest that body sway decreases and the postural control becomes more effective in maintaining stability during FES-assisted sitting. Increased velocity could perhaps be attributed to additional muscle stiffness caused by FES muscle activations. CONCLUSION: We have shown that posturography can quantify sitting balance impairment after SCI and evaluate the effects of an assistive device for sitting. Our results suggest that FES could be used to improve control of sitting, and perhaps increase mobility, performance of activities of daily living, and contribute to a better quality of life for individuals with SCI.

P4-K-150 Effect of Brainport balance device training on posture and gait in elderly patients with unilateral vertibular loss

***Toshiaki Yamanaka*[1], Yachiyo Sawai[1], Takayuki Murai[1], Taeko Ito[1], Naoki Shimizu[1], Hideyuki Okamoto[1], Nobuya Fujita[2], Hiroshi Hosoi[1]**
[1]Nara Medical University, [2]Nara Hospital

BACKGROUND AND AIM: Peripheral vestibular disorders cause severe vertigo, nausea, nystagmus and postural imbalance. These characteristic symptoms improve spontaneously with time in a process of behavioral recovery known as vestibular compensation. However, some elderly patients still have dizziness and imbalance over the long term involving a balance dysfunction due to a cessation of vestibular plasticity. In this study, we propose a balance function renewal therapy using the sensory substitution system with BrainPortTM?@Balance Device (BBD) which substitutes for diminished vestibular input by transmitting information about the patient's head position to the tongue. The purpose of this study was to evaluate the BBD as a new rehabilitation tool for elderly subjects with a failure of balance activity. METHODS: This study included 11 subjects aged over 65 (range, 65-79yr) with unilateral vestibular loss such as vestibular neuritis and acoustic nerve resection. They had a 5-year or longer history of consecutive dizziness and postural imbalance with medication and conventional vestibular balance rehabilitation, and presented with significant unilateral caloric canal paresis. The device consists of a tilt sensor for detecting head position, a 10?~10 tongue electrode array, and a controller. The tilt sensor is mounted to the back of the electrode array, delivering signals to the tongue that correspond to the head position. Subjects placed the electrode array on the anterior center portion of their tongue and were trained to maintain a centered body position by keeping the signals on the middle of tongue through the electrode array. All subjects had BBD training in the Romberg or Tandem-Romberg position with eyes open or closed and underwent two or three 5-20 minutes sessions per day corresponding to the patient's skill level for 8 weeks. RESULTS: All subjects showed pronounced improvements in their balance performance. Movement in the center of gravity (COG) with posturography and dynamic stability using Functional Gait Assessment (FGA) decreased immediately after the first training with the BrainPort device. These values showed further reduction at the end of the training period. Improvements were also noted in the quality of life assessments such as the Dizziness Handicap Inventory (DHI) and the Activities-specific Balance Confidence (ABC) Scale after 8 weeks of the BBD training. CONCLUSIONS: The training with BrainPort balance device produced an improvement in balance and functional activities in elderly patients with intractable chronic balance dysfunction due to vestibular balance deficit. These results suggest that alternative sensory input through the tongue substitutes for vestibular function and facilitate the brain plasticity.