Poster Session 1

Monday, June 24 between 13:15 and 15:15

A - Tools and methods for posture and gait analysis; Cognitive impairments

P1-A-1 The problem and device of notation for a power spectrum analysis on stabilometry

Masahiko Yamamoto[1], **Tomoe Yoshida**[1], **Fuyuko Ikemiyagi**[1], **Mitsuya Suzuki**[1]
[1]Toho University

BACKGROUND AND AIM:The frequency analysis of stabilometry was already recommended as an important indicator for many years. In it, the power increase near 3 Hz of a cerebellar disorder has been shown as power of frequency characteristic of a disease. Since many frequency band power spectra overlapped and the power spectrum analysis was difficult to distinguish in many cases when a FFT analytic method was used, the power spectrum was shown more often in MEM analysis by it these days. However, the problem in which it is difficult for the power spectrum which frequency has from the power-spectrum display also in MEM to judge from analysis whether it is significant is seen. Then, the legible notation was examined about the display of the analysis result of a power spectrum. METHODS:The subject being tested conducted the power spectrum analysis about the healthy person, and acute labyrinthine disturbance and spino-cerebellar degeneration. The stabilometry inspection performed record for each 60 seconds on eyes open and closed in the natural standing posture and a feet closed in accordance with the method by Japan Society for Equilibrium Research. Analysis examined a new power-spectrum notation as compared with the power-spectrum display by FFT and MEM. RESULTS:The display of a power spectrum analysis generally has many linear displays. A big power ingredient is shown by low frequency from this notation having many frequency components with low body sway. (figure 1-a FFT, 1-b MEM). For this reason, an ingredient with high frequency serves as a flat power display on a display. It is the power-spectrum display by this method, and Fig. 2 makes a subtraction notation MEM shown in Fig. 1. CONCLUSIONS:Power spectral analysis is a general parameter of stabilometry. However, when the analytical expression of frequency and a power spectrum is judged, it is difficult to judge a frequency power spectrum significant as frequency of the sway shown in the sway control of a living body. It is thought that the power ingredient of a significant sway can be shown by removing a healthy person's power-spectrum ingredient from this. Moreover, the power-spectrum-analysis method itself has a problem, and examination is due to be advanced from now on.

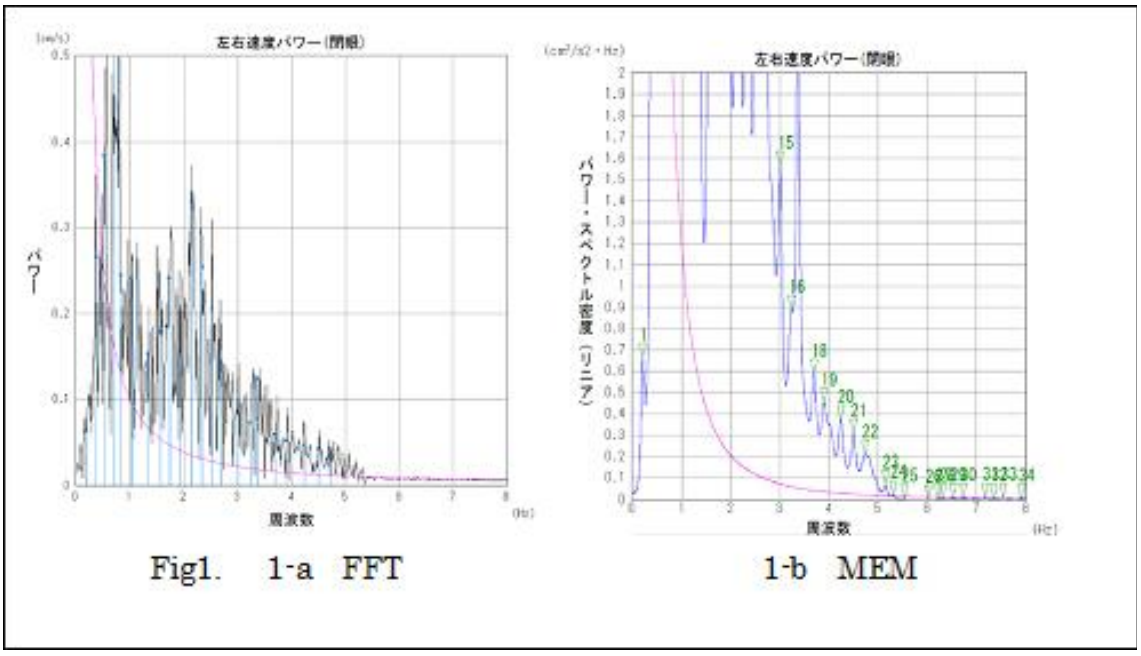


Fig1. 1-a FFT 1-b MEM

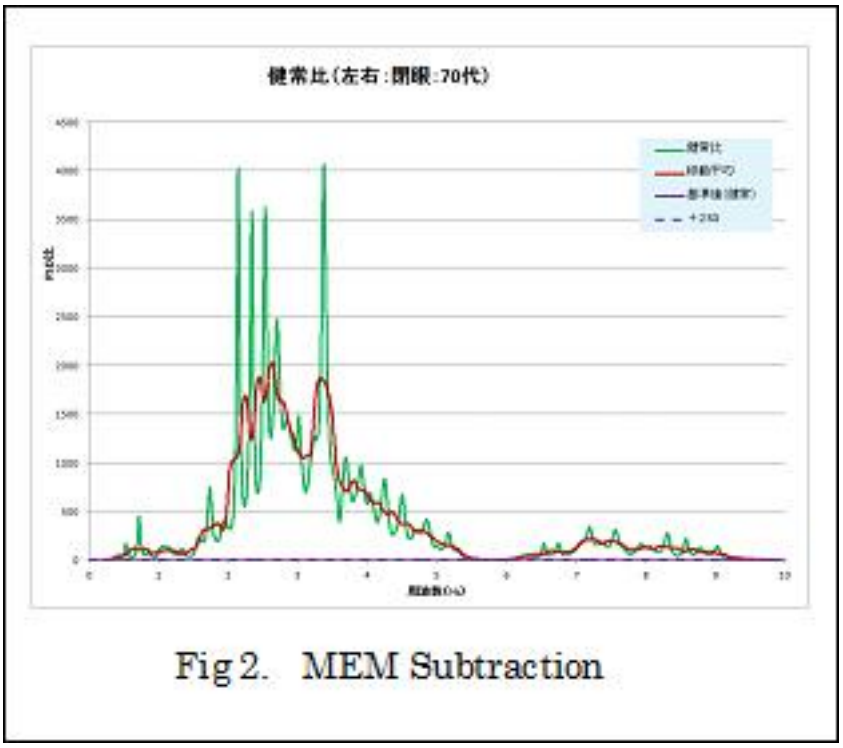


Fig 2. MEM Subtraction

P1-A-3 Clinical tools to assess balance in children and adults with cerebral palsy: a systematic review

***Rannei Sæther*[1], Jorunn Helbostad[1], Ingrid Riphagen[1], Torstein vik[1]**
[1]Norwegian University of Science and Technology

Title: Clinical tools to assess balance in children and adults with cerebral palsy: a systematic review. Background/ Objectives: One of the key features of children with cerebral palsy (CP) is impaired control of posture. Control of posture is required in order to obtain balance, which may be defined as the ability to maintain, achieve or restore the center of

mass relative to the base of support. Dysfunctional balance interferes with the activities of daily life. The aim of this study was to review tools used in clinical practice to assess balance in children and adults with cerebral palsy, to decribe their content and measurement properties and to evaluate the quality of the studies that have examined these properties. Materials/ Methods: Embase and PubMed/MEDLINE were searched. The Consensus-based Standards for selection of Health Measurement Instruments (COSMIN) was used to assess the "quality of studies"and the Terwee criteria was used to assess the "result of studies". Results: Twenty-two balance tools were identified from 35 papers. The content and focus of these tools varied significantly. Content validity and inter- and intra-rater reliability were the properties most often studied, while information on responsiveness was scarce. We found strongest level of evidence for the Trunk Control Measurement Scale and the Level of Sitting Scale both assessing the ability to 'maintain balance', the Timed Up and Go and the Segmental Assessment of Trunk Control assessing the ability to' achieve' and 'recover balance', respectively. Conclusions: Further studies providing better evidence for reliability and responsiveness for clinical balance tools are needed. In the meantime, results of studies evaluating effects of treatment of balance in subjects with CP should be interpreted with caution.

P1-A-5 Motion capture technique as a data source for computation of chosen gait indices as measures of gait asymmetry

Henryk Josinski[1], **Adam Switonski**[1], **Magdalena Stawarz**[2], **Romualda Mucha**[3], **Konrad Wojciechowski**[1]
[1]Polish-Japanese Institute of Information Technology, [2]Silesian University of Technology, [3]Medical University of Silesia

BACKGROUND AND AIM: The notion of the motion capture (mocap) technique exceeds the area of animation applied in films or games - recordings of patients with specified affection can be used as a valuable material for the purpose of medical diagnostic. The results achieved in examinations of patients with Parkinson's disease [1] became the motivation to commence the presented research. Its aim is verification of possibilities of gait asymmetry evaluation on the basis of chosen gait indices computed for mocap data of patients suffering from the following affections: hip joint degeneration, spinal degeneration and apoplectic stroke. METHODS: Gait sequences were recorded in the laboratory of the Polish-Japanese Institute of Information Technology by means of the Vicon system. 30 patients underwent the recording process twice - before and after three-week rehabilitation. The number of trials for an individual depended on his/her condition and stamina. Mocap data were used to calculate 4 gait indices Stride Length (SL) [cm] is the distance between successive points of initial contact to the ground of the same foot Decomposition index (DI) pertains to a pair of joints and is defined as the percentage of duration of a specific stride phase when only 1 of 2 considered joints is in motion, i.e. its angular velocity exceeds 5 [deg/s]. 3 pairs of joints: hip-knee, hip-ankle, and knee-ankle are considered to be most significant for determining gait abnormalities. Arm Swing Asymmetry (ASA) is based on the formula [2]: ASA = (45 - arctan(WDl/WDs)/90)*100%. WDl and WDs refer to larger and smaller value, respectively, from among distances travelled by both wrists of the examined individual. Wrist distance is the length of spatial trajectory determined by successive positions of the wrist. Arm Swing Size Symmetry (ASSS) is defined by the formula: ASSS = (FEADl/FEADs)*100%. FEADl and FEADs denote larger and smaller value, respectively, from among differences between maximal and minimal value of shoulder flexion/extension angle found within the limits of each gait cycle for left and right side separately. RESULTS: Final values of the indices computed for each trial were averaged across strides. The results were confronted with analogical outcomes for individuals without concerned affections. CONCLUSIONS: The experiments confirmed usefulness of the mocap data for the purpose of gait asymmetry evaluation based on gait indices. The project is supported by the Polish National Science Centre (decision DEC-2011/01/B/ST6/06988).
[1]M.Stawarz,S.Kwiek,A.Polanski,L.Janik,M.Boczarska-Jedynak,A.Przybyszewski,K.Wojciechowski: Algorithms for Computing Indices of Neurological Gait Abnormalities in Patients after DBS Surgery for Parkinson Disease Based on

Motion Capture Data. Machine Graphics & Vision,2011. [2]R.A.Zifchock,I.Davis,J.Higginson,T.Royer: The symmetry angle: a novel, robust method of quantifying asymmetry. Gait&Posture,2008.

P1-A-7 A new biomechanical interpretation of results from stabilogram-diffusion analysis

***Naoko Oba*[1], Shun Sasagawa**[1], **Akio Yamamoto**[1], **Kimitaka Nakazawa**[1]
[1]The University of Tokyo

BACKGROUND AND AIM: Collins and De Luca [Collins JJ, De Luca CJ (1993) Exp Brain Res 95: 308-318] introduced a method known as stabilogram-diffusion analysis (SDA), which analyzes the center of foot pressure (COP) trajectory during quiet standing as a fractional Brownian motion. According to the SDA, Collins and De Luca claimed that open- and closed-loop control mechanisms operate over short- (< 1 s) and long- (> 1 s) time intervals, respectively. Although the SDA has successfully detected changes in dynamic characteristics of postural sway associated with visual input, age, and so on, these interpretations of the experimental results were no more than conceptual ones. Therefore, the purpose of this study was to make more physiological and/or biomechanical interpretations of the results obtained from the SDA. METHODS: Eight healthy young male adults (24 to 31 years old) participated in this study. Subjects were instructed to stand quietly for 30 seconds on a force platform. During the trials, the COP in the anterior-posterior direction was obtained from the force platform measurement. Also obtained were the center of body mass displacement (COMdis), which represents "performance outcome" of the postural control, and the translational COM acceleration (COMacc), which represents "corrective adjustment" by the postural control system. RESULTS: The most intriguing result was that the diffusion coefficient in the short term region (Ds) of the COP was highly correlated with the root mean square of the COMacc (r = 0.996). In contrast, in the long term region the diffusion coefficient (Dl) of the COP was found to be almost equal to that of the COMdis, and significantly correlated with the SD of the COMdis (r = 0.935). CONCLUSIONS: These results suggest that the Ds and Dl of the COP represent the magnitude of corrective adjustments and the performance outcome of the postural control system, respectively.

P1-A-9 Validity of the step length asymmetry estimated by an accelerometer in patients with stroke

***Kazuaki Oyake*[1], Tomofumi Yamaguch**[2], **Shigeo Tanabe**[3], **Kunitsugu Kondo**[1], **Yohei Otaka**[1]
[1]Tokyo Bay Rehabilitation hospital, [2]Graduate School of Medicine, Keio University, [3]Fujita Health University

BACKGROUND AND AIM Gait asymmetry is one of the major characteristics of gait performance in patients with stroke. It is well known that the gait asymmetry is strongly related with impairments of motor function and gait performance. Previously, we reported the validity of step time asymmetry estimated by an accelerometer in patients with stroke (Oyake K, 2013). However, the evaluation of step length asymmetry using an accelerometer has not been reported and its validity has not yet been explored. The aim of this study was to investigate the validity of step length asymmetry estimated by an accelerometer in patients with stroke. In this study, the asymmetry in step length estimated by an accelerometer was compared with that measured from the force plates. METHODS Thirteen subacute stroke patients (46 - 83 years of age; 8 males and 5 females; 94.7 ± 53.0 days after a stroke) participated in this study. Brunnstrom recovery stages in the affected lower extremity were stage III in 2 patients, IV in 2 patients, V in 6 patients and VI in 3 patients. Three patients required an ankle-foot orthosis during walking. The following inclusion criteria were used for patient selection: (1) first-ever stroke within 6 months, (2) able to walk independently without any assistance or a cane for at least 10 meters, (3) able to communicate with others. Patients with limited range of motion or pain in the lower extremities, unstable medical conditions, or other diagnosed neurologic or musculoskeletal diseases were excluded. To estimate the step length asymmetry, we measured the trunk accelerations with a tri-axial accelerometer (WAA-006;

Wireless Technologies Inc. Japan) attached to the spinous process of the third lumber vertebra during walking on a 10 meters walkway at preferred speed. The vertical acceleration was adjusted by subtracting the gravitational acceleration. The step length asymmetry was estimated as the ratio of the integrated positive acceleration during the stance phase of the each leg. To evaluate the validity, we also simultaneously measured step length using 4 force plates (MA2000; ANIMA Corp. Japan). The step length asymmetry was calculated as the unaffected step length divided by the affected step length. The mean values of 5 trials obtained by both accelerometer and force plates were used for the analysis. We tested the correlation between the values obtained by the two methods with the Pearson's product-moment correlation. RESULTS The step length asymmetry estimated by the accelerometer was 0.91 ± 0.29 (mean ± standard deviation). The step length asymmetry measured by the force plates was 0.90 ± 0.17. There was a significant positive correlation between the values obtained by the two methods ($r = 0.87$, $p < 0.01$). CONCLUSION Our findings suggest that the estimation of step length asymmetry using an accelerometer is a useful monitoring tool for assessing gait performance in patients with stroke.

P1-A-11 Development of a Tool for Measuring Muscle Synergy in People with Stroke: A pilot study

***Rufai Ahmad*[1], Huzaifa Abubakar**[1], **Abdulhamid Maje**[1], **Rabiu Magaji**[2]
[1]Bayero University, [2]Ahmadu Bello University

BACKGROUND: Stereotyped patterns of movement referred to as abnormal synergy are common manifestations in people with stroke. To attain independence in activities of daily living, people with stroke need to break the stereotyped pattern into independent joint movements. The stereotyped patterns of movement are usually measured subjectively with objective methods carried out by sophisticated outcome tools that are usually not readily available in the clinics. We aimed to develop a tool for the objective measurement of upper limb motor synergy that could be easily accessed by clinicians. METHODS: Twelve squares were drawn in each of four quadrants formed by drawing an x and y axes on a 60 by 80 cm cardboard paper. Five people with stroke (Age: 54.20 ± 11.58 years) and five healthy controls (Age: 56.40±9.20 years) were asked to stand 0.5 meters away from the cardboard which was placed on a wall with an intersection of the two axes at the level of the sternal notch of the subject. The subjects were asked to point at the midpoint of two selected squares (one placed laterally and one placed medially) in each of the four quadrants. The accuracy of the task was measured using the coordinates on the x and y axes while the time of the task was measured with a stop watch. RESULTS: Analysis (between subject) of the accuracy data showed that the people with stroke had statisticaly significant ($P<0.01$) errors compared to the controls when pointing to squares in the lateral portion of the 4 quadrants; analysis (Within subject) showed that pointing to the lateral side of the quadrant was more inaccurate compared to pointing to the medial side of the quadrant in the people with stroke for both the upper ($p = 0.036$) and lower ($p = 0.043$) quadrants on the paretic side. Between subject analysis of the time data showed that the people with stroke utilized longer time to point at each of the squares in the 4 quadrants ($p<0.05$). CONCLUSION: measurement of upper limb synergy using the newly developed tool is in line with the results of many studies that reported pattern of movement of upper limb in people with stroke. These results can be confirmed in a study using appropriate sample size and the validity of the tool could be established using a gold standard for the objective measurement of muscle synergy in people with stroke.

P1-A-13 Deviation Tendency of Stepping Test

***Yasuyuki Nomura*[1], Teruo Toi**[1], **Yoshiro Wada**[2], **Jacob Bloomberg**[3], **Ajitkumar Mulavara**[1]
[1]Nihon University School of Medicine, [2]Nara Medical University, [3]NASA

Background: Stepping Test (Unterberger-Fukuda's Stepping test) is an examination using vestibular-spinal reflex. It is valuable because it tests not only the static balance but also it can follow the recovery of patients through their active whole body posture control. The original method of Fukuda's Stepping Test is to stretch both arms straight forward holding the arms horizontally, blindfolded with a Japanese towel and stepping 100 steps in bare feet at any speed the patient favors. We improved on this with the use of blind goggles instead of a Japanese towel, ear plugs to reduce any audio influences from the environment, and the stepping test is performed with a metronome at a fixed rate of 100 steps per minute. In our earlier study for American subjects, they tended to deviate towards the right. In this present study, we performed it on Japanese adults in order to observe the deviation tendency, and especially whether Japanese have the rightward tendency as well. Methods: Japanese normal adult subjects (n=111) wore blind goggles, ear plugs, and socks without shoes. An electronic metronome was attached to the posterior of their neck and a fixed stepping rate for 100 steps in one minute was used. The X-Y coordinates of the final position on the floor (cm) and the HD (heading direction) angle were measured. The same test was performed three times for each subject. Results: In three trials, the averages of the rightward deviation angle of the 111 subjects were 5.1, 11.9 and 4.3 degrees, respectively. We analyzed the relation between the direction variations and several items such as gender, height, sports history, left or right handedness. A significant difference was found between the right handed and left handed subjects in the first trial. (t-test, $p<0.05$) Discussions: The deviation of Stepping Test is caused on the swing phase. Individual differences are apparent but the average angle of the subjects is almost along the mid line forward. An earlier study of American subjects showed the rightward tendency which was supposed to be induced by some aspects of life style. In this study we found that with Japanese subjects their average was almost in the middle range with slight rightward deviation. Many individual differences were also found, of which left/right handedness was one of the deviation factors.

P1-A-15 Detecting Freezing-of-Gait Episodes in People with Parkinson Disease by Lower Limb Kinetic Energy

Wen-Chieh Yang[1], **Hung-Bin Chen**[1], **Wei-Li Hsu**[2], **Jian-Jiun Ding**[1], **Kwan-Hwa Lin**[2]
[1]National Taiwan University, [2]College of Medicine, National Taiwan University

BACKGROUND AND AIM: Freezing-of-gait (FOG) is a disabling gait symptom in people with Parkinson disease (PD), and leads to imbalance and fall. The leg trembling when tempting to reinitiate gait makes FOG episodes differentiable from normal gait pattern in the time-frequency space. Therefore, the purpose of this study is to test a FOG-detecting algorithm based on time-frequency analysis using the lower limb kinetic energy. METHODS: Sixteen idiopathic PD patients (age: 72.6±5.2 year, Hoehn-Yahr stage: 2.8±0.3) with FOG in the recent week were recruited. Participants conducted the FOG-provoking tasks including gait initiation and turning during their medication OFF period. Participants were videotaped throughout the study, and the video clips were examined by an independent therapist to find FOG episodes. Infrared-reflexive markers were placed on bilateral lower limbs to record the kinematics, and sampled in 120 Hz. The kinetic energy of thigh, shank and foot were submitted to short-time Fourier transform with 240-point Gaussian window. We defined the freezing index as the ratio between power in the high frequency freezing band (11-20 Hz) and power in the low frequency locomotion band (1 to 10 Hz). FOG episodes were detected as the index exceeds the preset threshold. We tested the accuracy of the algorithm using the classification results by visual inspection as the reference. RESULTS: After reviewing the video clips, a total of 77 FOG episodes were identified (duration 3.57±6.17 seconds). Our FOG-detection algorithm showed moderate-to-high classification performance (sensitivity and specificity > 0.7). In addition, distal segment (foot) showed higher sensitivity and proximal segment (shank) showed higher specificity. CONCLUSIONS: Our results demonstrated that the time-frequency representation of lower limb kinetic energy could be a valid approach detecting FOG episodes during walking. The detection of FOG may provide new perspective of patient assessment and intervention.

P1-A-17 Adaptive activity classification of compound activities facilitates detailed 3D kinematic and kinetic analyses in ambulatory monitoring

***Chris Baten*[1], Jose De Zeeuw[1], Ruben Wassink[1], Arjen Bergsma[1]**
[1]University of Twente

BACKGROUND AND AIM: Current technology facilitates ambulatory assessment of detailed 3D kinematics and kinetics of patients in a natural environment at home or at work. Examples: 1. the assessment of natural arm use and reaching kinematics in Duchenne patients serving prosthetic design [Dutch Flextension project] 2. the same in stroke patients for clinical monitoring [EG-FP7 project Interaction], 3. ambulatory assessment of actual back load exposure at work [Baten, IEA 2000]. However, for interpretation of kinematic data recorded under unsupervised conditions it is absolutely required to know it's context: the actual activity performed. Did the x degree elbow flexion angle occur during drinking water or during reaching for a fork? Most current activity monitoring methods can't deliver the desired automated activity classification. They are designed to just recognize standard singular activities, e.g. standing, sitting, lying, walking etc. and assume 'normal' patterns. METHODS: Here a solution is presented, FUSION Activity Classifier or FACT, developed from a desire for unsupervised monitoring of activities at work sites [Wassink 2007]. FACT uses speech recognition technology (Hidden Markow Modeling or HMM) but now applied to the available kinematic data. Through supervised learning it learns to classify any given set of named activities from sample sensor data with sufficient examples of each of the activities. RESULTS: In one pilot study classification accuracies of 87% were achieved for classifying correctly 'drinking', 'eating', 'working with computer keyboard', 'reaching across', 'reaching straight', 'rest' in 3 Duchenne patients. In a simulated ware house study classification accuracies of 93% to 97% were achieved in 6 subjects for 'lifting a load' (2 types and from 3 positions), 'putting the load down', 'walking', 'carrying', 'resting on chair'. Additionally already with 80% accuracy lifting 'light load' and 'heavy load' were distinguished correctly just using acceleration and angular velocity data. In all examples only acceleration and angular velocity data was used. PCA was used to maximize data vector entropy, revealing that the number of required data channels was around 1 to 2 times the number of the activities in the set. Reverse PCA delivered in all cases suggestions for optimal sensor placement. CONCLUSIONS: FACT can adapt to any set of activities offered at the price of the supervised learning effort. Future 'cost reduction' is possible by e,g, balancing pre-trained classifiers with incremental training. FUSION sensor location calibration methods have proven sufficiently accurate to facilitate re-use of trained FACT classifier over sessions with the same person without accuracy loss. FACT seems also competitive to traditional methods when used in patients. Here the ability to deal with deviating ways patients perform standard activities could outweight cost for training.

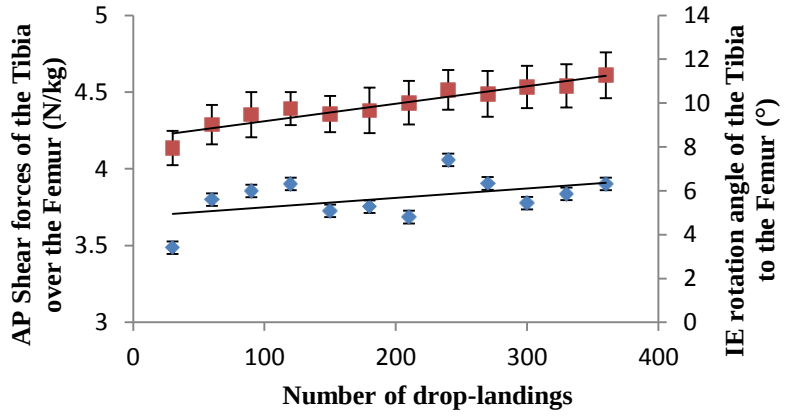


Figure 1: AP shear force (diamonds) of the tibia on the femur, and IE rotation angle (squares) of the tibia to the femur (mean, SE). Shear forces were normalized to body mass; a positive value represents the anterior direction. Positive values for IE represent external rotation.

P1-A-19 The effects of the knee braces on gait - toward leg disorder estimation from images

***Takuya Ogawa*[1], Hirotake Yamazoe**[1], **Ikuhisa Mitsugami**[1], **Yasushi Yagi**[1]
[1]Osaka University

BACKGROUND AND AIM: In this research, we analyze the changes in gait when healthy subjects wear knee braces, which constrain the subject's motion, such as the elderly simulation kits. We aim to estimate leg disorders from image sequences of the subject's walking. Since gait varies widely among individuals, there are many researches on the gait-based identification. In contrast to this, we want to obtain gait changes common to all subjects when the subject situations are changes, such as decreasing of a joint range of movement. METHODS AND RESULTS: For the purpose, we need to capture walking scenes of various subjects with same disorder situation. Here, we employ knee braces to simulate knee disorders. In the experiment, first, the subjects walk normally for one minute. Then, the brace are fixed on their left knee to prevent to bend. After that the subjects walk with the brace for 15 minutes. The subjects' motions are captured by a motion capturing system (VICON) and we compare gaits of normal walking and gaits with knee braces. Ten healthy subjects participate the experiment. From the comparison, we obtained the tendencies common to almost subjects such as walking with a stoop and leaning of the upper body to the right when the subjects wear the brace. CONCLUSIONS: We confirmed that we can observe gait changes with the left-knee braces and these changes are common to most subjects. Future works include further analysis of the effect of braces on gait and development of estimation method of leg-disorders from subjects gait. ACKNOWLEDGEMENTS: This research was partly supported by the JST CREST "Behavior Understanding based on Intention-Gait Model" project.

P1-A-21 Balance and gait measures as predictors of cognitive function in post-stroke patients

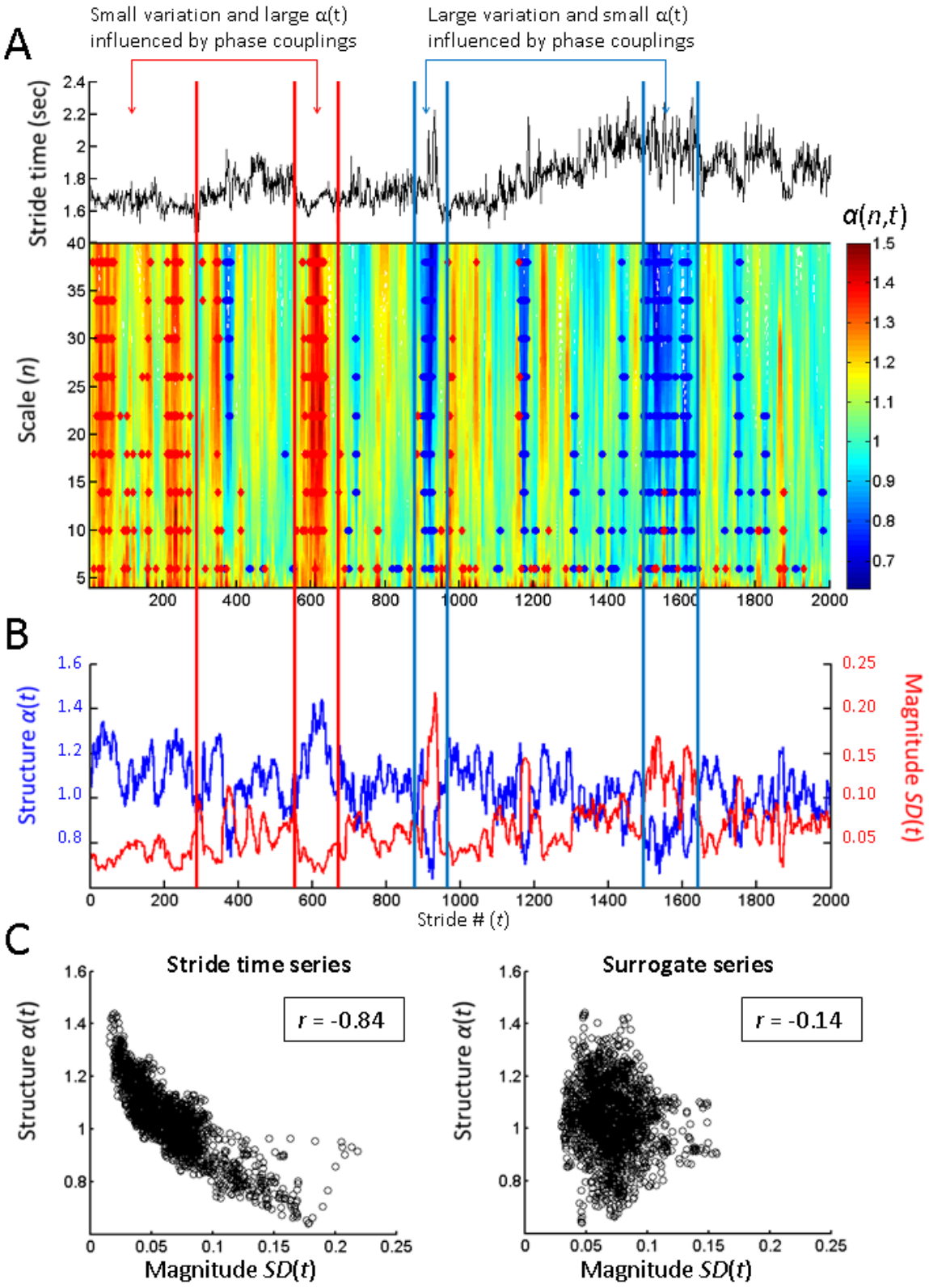
***Einor Ben Assayag*[1], Shani Shenhar-Tsarfaty** [1], **Efrat Kliper**[1], **Hen Hallevi** [1], **Ludmila Shopin** [1], **Natan Bornstein** [1], **Amos Korczyn** [1], **Nir Giladi**[1], **Anat Mike**[1], **Anat Mirelman** [1], **Aner Weiss**[1], **Jeffrey Hausdorff**[1]
[1]Tel Aviv Sourasky Medical Center

Background and Aims: Stroke patients are at risk for developing cognitive impairment. Associations between physical function and cognitive decline in older adults have been well established. While motor function changes and decline in physical performance may precede the onset of cognitive impairment, it is not easy to identify which post-stroke patients are likely to develop cognitive impairment. We sought to test whether quantitative balance and gait parameters can enhance the prediction of post-stroke long-term cognitive outcome. Methods: The TABASCO (Tel-Aviv Brain Acute Stroke Cohort) is a prospective study of first-ever mild-moderate ischemic stroke patients who were cognitively intact at baseline. Quantitative movement and balance parameters and cognitive tests were obtained at admission, 6, 12 and 24 months later. Results: Data were obtained from 211 stroke patients (mean age: 67.2±10.2 years). Thirty three participants (15.6%) were found to have clinically significant cognitive decline (CD) during the 2 years of follow-up post-stroke. The CD group and cognitively intact group did not differ in their neurological deficits 6 months after the index event. Nonetheless, at 6 months post-stroke, Timed up and go (TUG) test times were longer ($p<0.001$) in the CD group (13.3±5.7), compared to the cognitively intact group (9.5±3.1). The CD group also had lower scores on the Berg Balance Scale (BBS) (CD: 48.2±9.2; intact: 53.4±5.7; $p<0.001$). Multivariate regression showed that the TUG and BBS below 45 were significant independent predictors of cognitive decline ($p=0.002$ and $p=0.021$, respectively). Conclusions: Our results show that balance and mobility are significant predictors for cognitive status 2 years after stroke. Relatively simple, performance-based measures of balance and mobility may enhance the identification of post-stroke patients who have a heightened risk of developing cognitive decline. Using these tests may enable early adaption of rehabilitation strategies to delay the onset of cognitive decline and dementia in post-stroke patients.

P1-A-23 Detection of active co-regulation of the structure and magnitude of stride time variability

Espen Alexander Ihlen[1], **Beatrix Vereijken**[1]
[1]Norwegian University of Science and Technology

Introduction Detrended fluctuation analysis (DFA) has become a popular method to define the structure of stride time variability by a scaling exponent á. However, á(t) can be temporally modulated by adjustments to both internal and external perturbations, reflected by phase couplings between temporal scales. This study developed a new local DFA (DFAloc) of stride time variability that identifies temporal modulation in á(t) influenced by phase couplings between temporal scales. Methods DFAloc extends the conventional DFA in three important ways. The root mean square of the detrended residuals was computed in a floating time interval across the integrated stride time series instead of non-overlapping time intervals as in conventional DFA. Consequently, the obtained root-mean-square measure F(n,t) was dependent on both stride number t and interval sample size n in contrast to F(n) in conventional DFA that is only dependent on n. The temporal modulation of á(t) is defined as the linear slope of log[F(n,t)] versus log(n) for each stride t instead of the stride-independent log[F(n)] versus log(n) in conventional DFA. Finally, a Monte Carlo surrogate test was conducted in correspondence with DFAloc to identify whether á(t) was influenced by phase couplings between temporal scales [1]. DFAloc and the Monto Carlo surrogate test were employed in a reanalysis of the data sets in [2] available at [3]. Results and discussion Phase couplings significantly influenced á(n,t) in intermittent periods of large and small stride time variability (see blue circles and red diamonds within blue and red intervals, respectively, in Panel A). These intermittent periods of small and large variability coincided with periods of large and small á(n,t), respectively (see red and blue contours in Panel A), leading to an inverse correlation between the local structure á(t) and magnitude SD(t) (see Panels B and C). The inverse correlation was not present for the surrogate series where the phase coupling between temporal scales was eliminated (see right panel in Panel C). In conclusion, the present method shows that the local structure and magnitude of stride time variability are not independent features but actively co-regulated by phase couplings. This co-regulation may be an important feature for the prognosis of gait function in older persons and clinical groups at risk of developing gait impairments. References [1] Ihlen EAF, Vereijken B. Ann Biomed Eng, in press. [2] Hausdorff JM, Purdon PL, Peng CK, Ladin Z, Wei JY, Goldberger AL. J Appl Physiol 1996; 80(5): 1448-57. [3] www.physionet.org


A
Small variation and large α(t) influenced by phase couplings
Large variation and small α(t) influenced by phase couplings
Stride time (sec)
Scale (n)
α(n,t)
B
Structure α(t)
Magnitude SD(t)
Stride # (t)
C
Stride time series
r = -0.84
Surrogate series
r = -0.14
Structure α(t)
Magnitude SD(t)

P1-A-27 Dynamic models provide insight into how motor trainings improve posture in aging

Olivier Coubard[1], **Lena Ferrufino**[1], **Blandine Bril**[2], **Tetsushi Nonaka**[3], **Gilles Dietrich**[4]
[1]CNS-Fed, [2]Ecole des Hautes Etudes en Sciences Sociales, [3]Kibi International University, [4]Université Paris Descartes

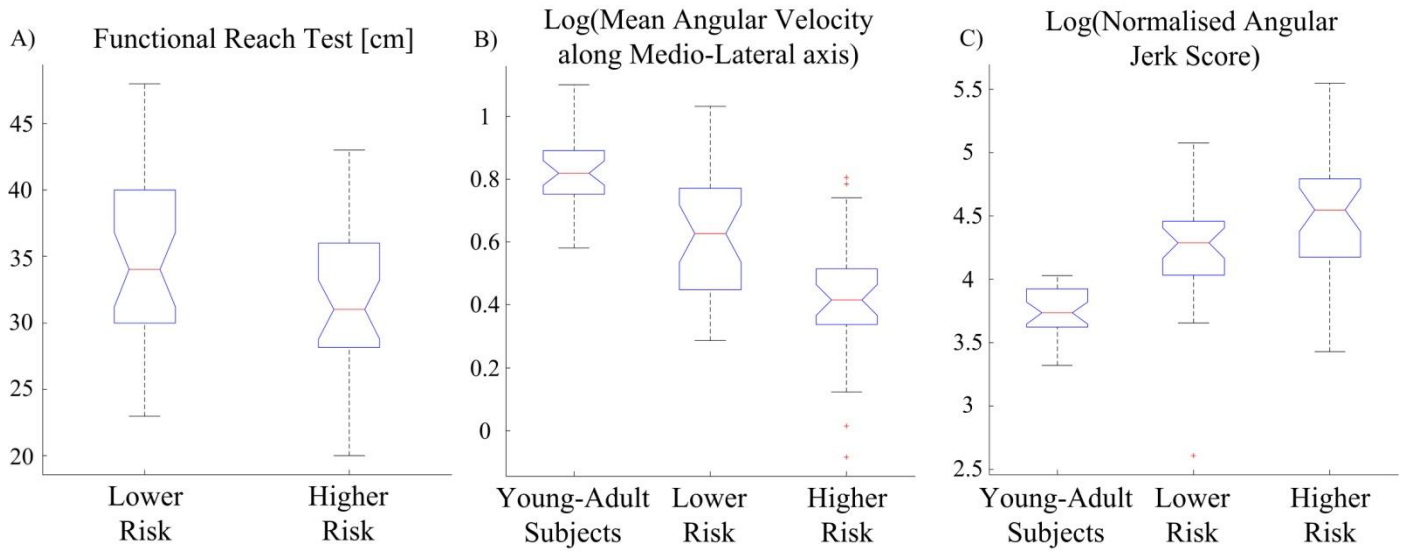
BACKGROUND AND AIM: As society ages and the frequency of falls increases, counteracting gait and posture decline is a challenging issue for countries of the developed world. Previous studies have shown that exercise and hazard management help to improve balance and/or decrease the risks for falling in normal aging. Motor activity based on motor-skill learning, particularly dance, can also benefit balance and decreases falls with age. Recent studies have suggested that older dancers had better balance, posture, or gait than non-dancers. Additionally, clinical or laboratory measures have shown improvements in some aspects of balance after dance interventions in elderly trainees. This study examined the impact of contemporary dance (CD) and of fall prevention (FP) programs on postural control of older adults. METHODS: Posturography of quiet upright stance was performed in forty-one participants aged 59-86 years before and after 4.4-month training in either CD or FP once a week. RESULTS: Though classical statistic scores failed to show any effect, dynamic analyses of the center-of-pressure displacements revealed significant changes after training. Specifically, practice of CD enhanced the critical time interval in diffusion analysis, and reduced recurrence and mathematical stability in recurrence quantification analysis, whereas practice of FP induced or tended to induce the reverse patterns. Such effects were obtained only in the eyes open condition. CONCLUSIONS: We suggest that CD training based on motor improvisation favored stochastic posture inducing plasticity in motor control, while FP training based on more stereotyped behaviors did not.

P1-A-29 Instrumented Functional Reach for Fall Risk Assessment

Andrea Cattabriga[1], **Sabato Mellone**[1], **Luca Palmerini**[1], **Carlo Tacconi**[1], **Chiara Mussi**[1], **Lorenzo Chiari**[2]
[1]University of Bologna, [2]Universita' degli studi di Modena e Reggio Emilia

BACKGROUND AND AIM: The Functional Reach (FR) is a clinical tool for assessing the margin of stability; it measures the maximal forward reach while standing in a fixed position [1]. A measured distance ≤ 15cm is associated with a high fall risk while a distance between 15 and 25cm is associated with a moderate fall risk [2]. The aim of our study was to verify if an instrumented version of the FR (iFR) can enhance its usefulness for fall risk assessment. METHODS: We examined 58 elderly subjects (78.5±6.4 years, range 65-91, 33 females) and 16 healthy Young-Adult (YA) subjects (27±12 years, range 20-51, 10 females) wearing a sensing device on the lower back embedding, tri-axial accelerometer, gyroscope, and magnetometer (Exel srl, Bologna, Italy, sample rate 100Hz). Elderly Subjects were assessed by qualified medical staff at the Geriatric Unit of the S.Agostino Estense Hospital (Baggiovara, Italy). Clinicians administered a fall risk screening protocol consisting of a clinical examination and a series of functional tests. iFR was included in the protocol. YA subjects only performed the iFR. Signals recorded during the iFR were used for extracting a set of descriptive features. Six risk factors, along with an associated Threshold (Th), were considered for classifying elderly subjects at low and high risk [3,4]: i) number of medications (Th≥4); ii) Timed Up and Go (Th≥14s); iii) Standing Balance (Th≤2); iv) number of falls in the last 12 months (Th≥1); v) Repeated Chair Standing (Th≥12s); vi) age (Th>75 years). Subjects were assigned to the Higher Risk Group (HRG) with at least 3 out of 6 factors above the Th's, or to the Lower Risk Group (LRG) otherwise. RESULTS: 31 subjects were assigned to the HRG and 27 to the LRG. Outcomes of the FR are reported in Figure A) while B) and C) report two features extracted from the signals, the Mean Angular Velocity of the bending movement and its smoothness (NAJS), respectively. Distributions in B) and C) were log-normalised. CONCLUSIONS: FR was not sensitive enough (ANOVA p>0.05) for discriminating between LRG and HRG. Using the Th in [2] 50 subjects would not be considered at risk and the remaining 8 subjects would be assigned to the LRG. On the contrary instrumental measures

show statistical significant differences among the groups (p<0.001). HRG is characterised by a slower and jerkier bending movement while YA group characterised by a faster and smoother movement; LRG is coherently positioned in between. These preliminary results support the hypothesis that iFR can become a useful tool for fall risk assessment. ACKNOWLEDGEMENTS: with the support of Regione Emilia Romagna, DGR n. 1631/2009 "pERsonal health lab" and the FARSEEING project, FP7 Grant Agreement no. 288940. REFERENCES 1. PW Duncan et al. J Gerontol; 45(6):192-7 2. PW Duncan et al. J Gerontol 47: 93-8 3. Panel on Prevention of Falls in Older Persons. J Am Geriatr Soc; 59(1):148-57. 4. JC Woolcott et al. Arch Intern Med; 169:1952-60

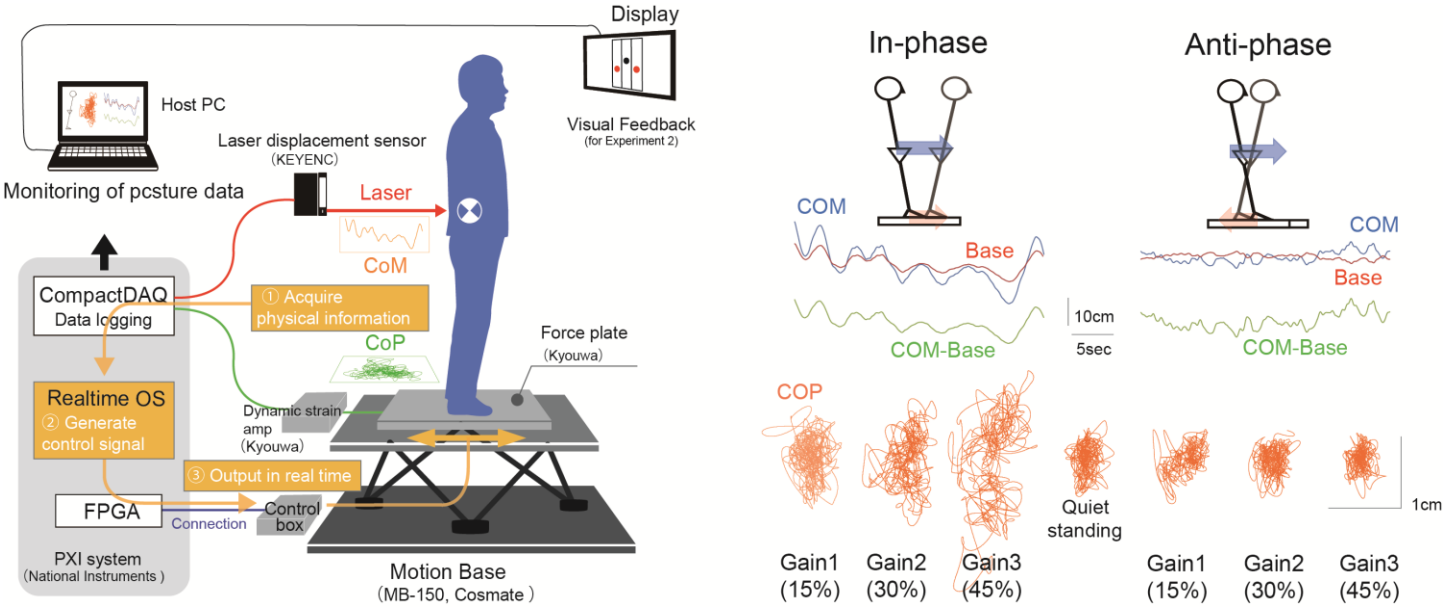


P1-A-31 Desired center of pressure describes falls caused by induced slips

Takeshi Yamaguchi[1], **Kei Masani**[2], **Shinya Fukuzawa**[2], **Hiroshi Onodera**[1], **Kazuo Hokkirigawa**[3]
[1]Tohoku University, [2]University of Toronto, [3]Japan Science and Technology Agency (JST)

BACKGROUND AND AIM: In this study, desired center of pressure (dCOP) was introduced to evaluate the loss of postural stability during walking. The dCOP is defined as a virtual point on the ground, which is calculated using the kinematics of the whole body center of mass (COM) (a modification of the Zero-Moment Point concept used in the Honda humanoid robot). In theory, when the measured center of pressure (mCOP) is at the same point as the dCOP, the resultant moment around COM becomes zero. Since the amount of moment is theoretically proportional to the distance between the dCOP and the mCOP (dCOP-mCOP), we hypothesized that this distance can be used as an indicator of postural stability loss. This study examined whether the dCOP-mCOP can indicate risk of falls caused by slipping during turning. METHODS: The study involved twelve healthy young adult males with an average age of 22.6 yrs. The subjects were asked to (1) walk straight on a dry floor surface, (2) walk straight and turn 60 degrees to the right on a dry floor surface, and (3) turn 60 degrees to the right on a slippery lubricated surface. Six force plates and a three-dimensional motion capture system were used to measure body kinetics and kinematics. The whole body COM behaviour (displacement, velocity and acceleration) was estimated using a thirteen-segment model, which was used to calculate the dCOP. The global center of pressure of the whole body, i.e., mCOP, was calculated using six force plates. A fall was identified when the force measured with the load-cell mounted between harness and guide rail exceeded 30% of the subject's body weight because of slipping. The spatial relation between the dCOP and mCOP was investigated and compared among conditions especially focusing on the fall. RESULTS: The maximum value of the dCOP-mCOP (Lmax) during straight walking was positively correlated with the moment around COM (R2= 0.77, p<0.001). The mean value of Lmax in turning

trial on a dry surface (0.27 m) was larger than that in straight walking trial (0.11 m). The mean value of Lmax in turning trial with fall followed by slip (0.60 m) was larger than that in turning trials without fall followed by slip (0.40 m). The results suggest that the increased dCOP-mCOP enhances risk of falls caused by slipping during turning. CONCLUSIONS: This study demonstrated that the dCOP-mCOP indicates the risk of falling caused by slipping during turning. The same method can be used for evaluating postural stability during normal gait to investigate gait affected by ageing and neurological diseases. The results also provide information about where and how the compensatory stepping should be made after postural balance loss caused by slipping. ACKNOWLEDGEMENT: This work was partially supported by Core Research for Evolutional Science and Technology (CREST) Program of Japan Science and Technology Agency (JST).

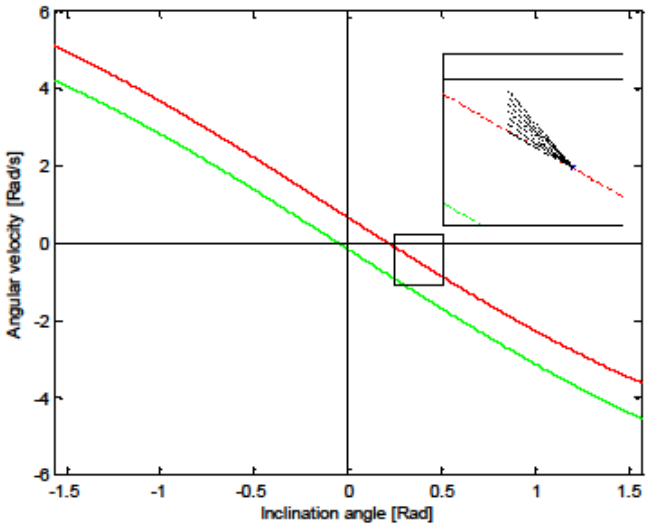


P1-A-33 An analytical approach to find the range of feasible body movements for the control of balance

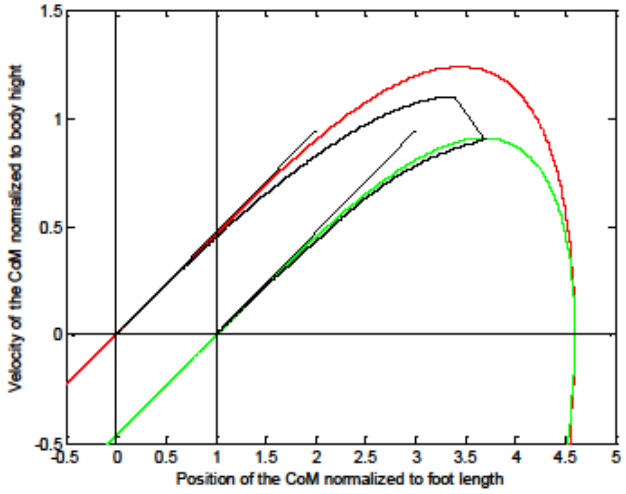
Mohammad Hadi Honarvar[1], **Motomu Nakashima**[1]
[1]Tokyo Institute of Technology

BACKGROUND AND AIM: This work addresses the question of what is the feasible range of body movements for the body to remain balanced while standing. For a long time the feasible movements were described by a single condition: the horizontal location of the body center of mass (CoM) has to be confined within the base of support (BoS). Pai & Patton (1997) suggested that the velocity of the CoM should also be accounted for and defined some "motion state" consisting of location and velocity of CoM. They obtained a region in the 2-d state space and suggested that the condition for the balance to be maintained is that its corresponding motion state lies within this feasible region. However, in order to figure out the feasible recovery region they used a numerical searching and optimization method which includes iteratively solving the problem of whether maintaining the balance is possible at initial motion states. It is computationally expensive. This work proposes an analytic method to figure out the feasible range of the movement states for a given mechanical characteristics of an individual, in which control of balance would be possible. METHODS: We introduce a subspace of the motion state space, namely the integrated stable subspaces (ISS), as a function of mechanical properties and torque constraints of the body model. Then prove that if a state lies within ISS the system will be able to keep it inside it forever. It also will be proven that for a state inside ISS the system will be able to decrease a positive definite variable associated with the it, and therefore, through the Lyapunov 2nd theorem it will be proven that every state inside ISS would be driven to the static upright posture, which shows that the control of balance is possible

all over the ISS and hence, it is the range of feasible movements for the control of balance. RESULTS: In order to illustrate how the method may be used in practice, the feasible region for a well-known one-degree of freedom (1-DoF) mechanical model as well as for a 2-DoF one is found using this approach, and compared to that found by the conventional method. CONCLUSIONS: We developed a new method to figure out the feasible range of body movements for the control of balance. In contrast with the conventional methods we find the borders of the feasible movements region analytically through a mechanical reasoning, thus the method is free from iterative numerical calculations, and hence, solution is very fast. The feasible region found by this method depends on the physical properties of a body including anatomical parameters of a body as well as the joints strength and whatever constrains the control input to the model. The method works with any arbitrary shape of the input constraint.



a)



b)

Figure. a) Stable subspaces corresponding to the maximum torque in dorsiflexion (green curve) and plantar flexion (red curve) directions, in angle-angular velocity (x) plane. The area between the two curves is balanceable. The criterion of Theorem 3 is checked and confirmed. As an example $f(x,u)$ at one state $x = [0.439 - 0.676]^T$ for all $u \in \mathcal{U}$ is shown. b) Boundaries of the balanceable region mapped in the z-plane (green and red curves), and those obtained in Pai & Patton (1997) (solid black) and in Hof et al. (2005) (dashed black).

P1-A-35 Kinematic analysis of segmental trunk movement during sit-to-stand in hemiplegic patients

***Kazuhiro Ito*[1], Yasuhiko Hatanaka[1], Takaaki Nakamata[2], Koichi Saito[2], Ryota Maegawa[2], Yuka Kitagawa[1], Yukiko Uno[1], Megumi Kitagawa[1], Kimiyoshi Tamura[1]**
[1]Oumionsen hospital, [2] Suzuka University of Medical Science

BACKGROUND AND AIM:The sit-to-stand (STS) movement is a very common movement in daily life. Therefore, an analysis of STS would be worthwhile for quantifying functional limitations of patients, identifying compensatory patterns, selecting rehabilitative programs, and improving therapeutic interventions. Many studies have examined kinematics and kinetics of the lower limb joints, and those that described sagittal trunk movements during STS have

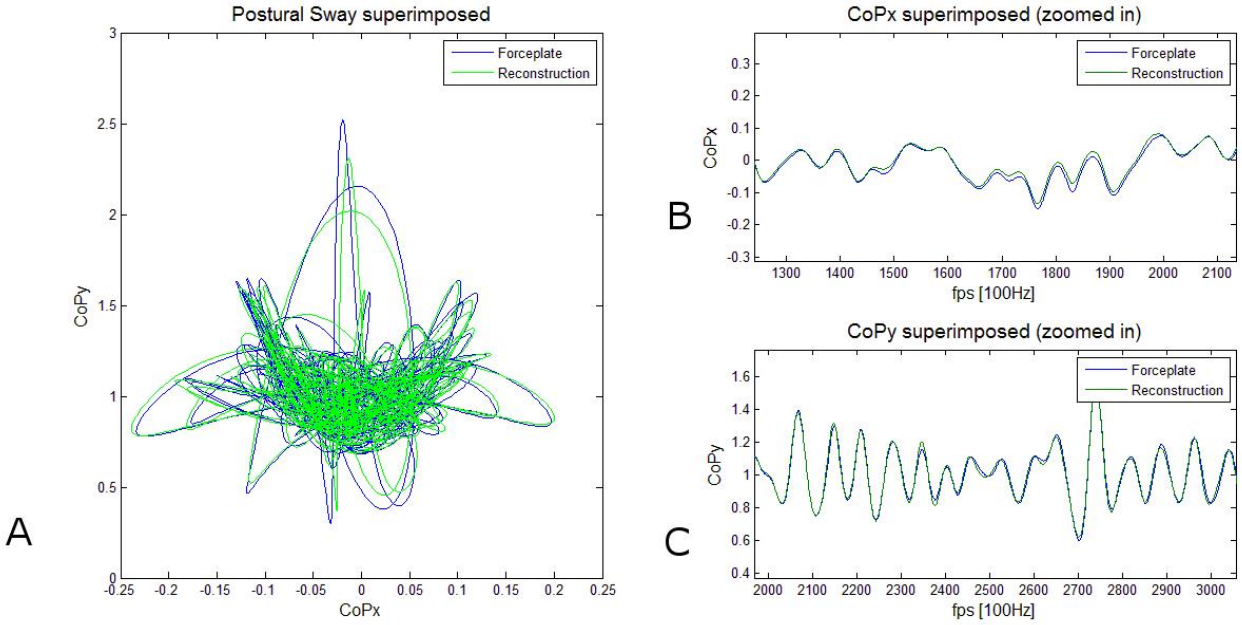
concluded that the thoracic and lumbar movements are important. Since trunk misalignment in hemiplegic patients is three-dimensionally complex, we propose a three-dimensional motion analysis of the trunk.The aims of this study were to clarify three-dimensional kinematics of the trunk and to analyze the association between kinematics of the trunk and disability in the trunk and lower extremity. METHODS:Thirteen hemiplegic patients (8, right hemiplegia; 5, left hemiplegia) were included in this study. Subjects were instructed to stand up at their own selected speed with their arms folded across their body. Two gyroscopic sensors (Gsport: Pocket-IMU) were employed to measure the following angles: sensor 1 measured the "upper-trunk angle" and sensor 2 measured the "pelvic angle". Then, we defined the angle between sensor 1 and sensor 2 as the "trunk relative angle". We employed the Fugl-Meyer physical performance scale as evaluating the function of the lower extremity on the paretic side. Evaluation of trunk movement included measuring the trunk relative angle while performing forward and backward bending motion in sitting with immobilization of the pelvis and lower extremity. RESULTS:All patients exhibited an extensional pattern after flexion. We identified 3 patterns of the trunk relative angle. Pattern 1 exhibited lateral bending and rotation to the unaffected side. Pattern 2 exhibited lateral bending to the unaffected side and rotation to the affected side. Pattern 3 exhibited lateral bending to the affected side and rotation to the unaffected side. The trunk relative angle motion patterns were incompatible with trunk function and lower extremity function of the paretic side. A negative correlation was observed between the lateral bending-rotation angle and the Fugl-Meyer physical performance score of the lower extremity. Evaluation of trunk function did not correlate with the maximum angle in all subjects. CONCLUSIONS:Our results suggest that the trunk relative angle motion pattern of the STS indicates compensation for instability. In addition, our results indicate that the lower extremity function of the paretic side was not responsible for the instability.Moreover, our results indicate that the problem of the trunk function was hidden. Therefore, further study is necessary to determine the trunk relative angle while performing forward and backward bending motion in sitting with mobilization of the pelvis.

P1-A-37 A validation method for BSIP estimation techniques

Gentiane Venture[1], **Clint Hansen**[2], **Nasser Rezzoug**[3], **Brice Isableu**[2], **Philippe Gorce**[3]
[1]Tokyo University of Agriculture and Technology, [2]Univ. Paris-Sud, [3]Univ Du Sud. Toulon Var

Introduction: The body segment inertial parameter (BSIP) estimation without taking extra anthropometric measurements should be preferred over classical anthropometric models and would be a very useful tool if it delivers reliable and validated calculations. Usually the obtained results are compared to data from the literature, which may not match the sample group or are based on regression methods or cadaver studies. The objective of this research was twofold first we introduce a method to improve the BSIP estimation for each subject and secondly we propose a general method to validate the calculations with measured contact forces of the force plate. Experiment: 12 subjects (22 ± 3 years) voluntarily participated in the experiment after signing a statement of informed consent as required by the Helsinki declaration. Subjects performed a 120 seconds predefined identification sequence which involves a variety of movements trying to use each DOF of the body and to perform it with different velocities and accelerations. The results show that classical methods overestimate the contact forces which will lead to a large calculations error. Results: To analyze the calculated BSIP, we used the framework of a motion capture based estimation technique and computed the external forces obtained from the force plate and the assessed contact forces from the model. Across all subject the proposed estimation technique shows its benefits and an individual BSIP estimation was possible including the validation with the external ground reaction forces. For further evaluation reasons the measured center of pressure movement and the efforts recalculated by the inertial parameters of each body were compared using classical parameters to evaluate postural sway, as the length of the postural sway, the root mean square and average speed. An ANOVA with an

alpha of 0.05 showed no differences between the parameters measured and recalculated which is a good indicator for the success of the proposed estimation technique. Discussion: This research was conducted to propose a new non-invasive and not radiation based method to obtain the individual BSIP for each subject. In comparison with the measured ground reaction forces the approach shows its advantages and proves itself to be very efficient. Further investigations have to show the advantage when testing special with different age, gender, body type, and fitness level. Our results do not contradict the findings of previous research (e.g., Chen, 2011), but also show the importance to validate the computed parameters with a ground truth as the GRF of a force plate to constructively compare different estimation techniques but also to compare results between subjects and studies.



P1-A-39 Developing a functionally relevant test for dual task assessment in Parkinsons Disease

Carolien Strouwen[1], **Pieter Ginis**[1], **Samyra Keus**[2], **Esther Molenaar**[2], **Liesbeth Münks**[1], **Marten Munneke**[2], **Alice Nieuwboer**[1]
[1]KU Leuven, [2]Radboud University Nijmegen Medical Centre

BACKGROUND: We developed a mobile phone task (MPT) to assess functional dual task (DT) interference in people with Parkinson's Disease (PD). AIM: To test whether using a mobile phone during walking is sensitive to DT interference in PD and healthy controls. METHODS: Eleven participants with PD (Hoehn and Yahr stage II or III) and 11 age-matched controls were included. Tests consisted of walking over the GaitRite mat under single and dual task conditions using the digit span, the auditory Stroop and the MPT. During the MPT, participants were supplied with a mobile phone with large buttons. They were asked to type the date while walking. DT interference on gait speed and step length was analyzed. RESULTS: While performing the MPT, spatiotemporal gait variables were significantly decreased in PD participants compared to controls ($p<0.05$). The MPT was able to detect DT interference for gait speed (18.3% - 95%CI[11.6% to 25.1%]) and step length (12.8% - 95%CI[6.0% to 19.6%]) in participants with PD and DT interference for gait speed (9.6% - 95%CI[3.3% to 15.9%]) and step length (5.8% - 95%CI[1.8% to 9.7%]) in healthy controls. In PD, but not in controls, the MPT induced larger DT effects than during the auditory Stroop or Digit span tasks. DT interference during MPT for step length was significantly correlated to ScopaCog performance ($R_s = -0.501$, $p = 0.018$). CONCLUSION: Using a mobile

phone during walking is a sensitive test to detect dual task interference on gait in PD and in healthy controls. In PD, but not in healthy controls, the test induced larger DT effects than during cognitive dual tasks, possibly because of the fine motor requirements of using a mobile phone.

P1-A-41 Quantification of changes in gait characteristics associated with intermittent claudication in patients with lumber spinal stenosis

***Koutatsu Nagai*[1], Tomoki Aoyama[2], Minoru Yamada[2], Masanori Izeki[2], Shunsuke Fujibayashi[2], Mitsuru Takemoto[2], Shu Nishiguchi[1], Tadao Tsuboyama[1], Masashi Neo[3]**
[1]Kyoto Tachibana University, [2]Kyoto University, [3]Osaka Medical College

Background and aim: Walking difficulty due to pain or neurologic symptoms accompanied by continuous walking may have negative effects on gait characteristics in patients with LSS. However, there are few detailed reports on the association of these changes with intermittent claudication and their relationship with walking capacity. The purpose of this study was to quantify changes in gait characteristics associated with claudication after continuous walking, and to investigate the relationship between walking capacity and gait characteristics in patients with lumber spinal stenosis. Methods: For this study, 11 LSS patients with intermittent claudication were recruited. The subjects continued walking until they expressed a difficulty in continuing further. Root mean square (RMS), autocorrelation peak (AC), stride frequency (SF), and coefficient of variance (CV) were analyzed using accelerometers. To detect changes in gait parameters, we compared acceleration at the start and at the end of the walking task. We also investigated the relationship between walking capacity and gait characteristics measured by accelerometers. Results: Walking difficulty during the test increased from 4 (inter quartile range [IQR]: 1-5) to 9 (IQR: 7-10). The RMS, an index of postural sway, significantly increased after the onset of maximum walking difficulty. AC, SF, or CV did not show significant change. Maximum walking distance significantly correlated with RMS at the cervical sensor ($r = -0.64$), and CV ($\rho = -0.66$); an index of gait variability. Conclusions: the change in gait parameters associated with claudication during continuous walking is detectable using accelerometers. Postural sway increases after the augmentation of walking difficulty due to pain or neurologic symptoms. In addition, walking capacity correlated with postural sway of the upper trunk and gait variability during walking initiation. This methodology warrants further studies in order to confirm its usefulness as an assessment tool for patients with LSS.

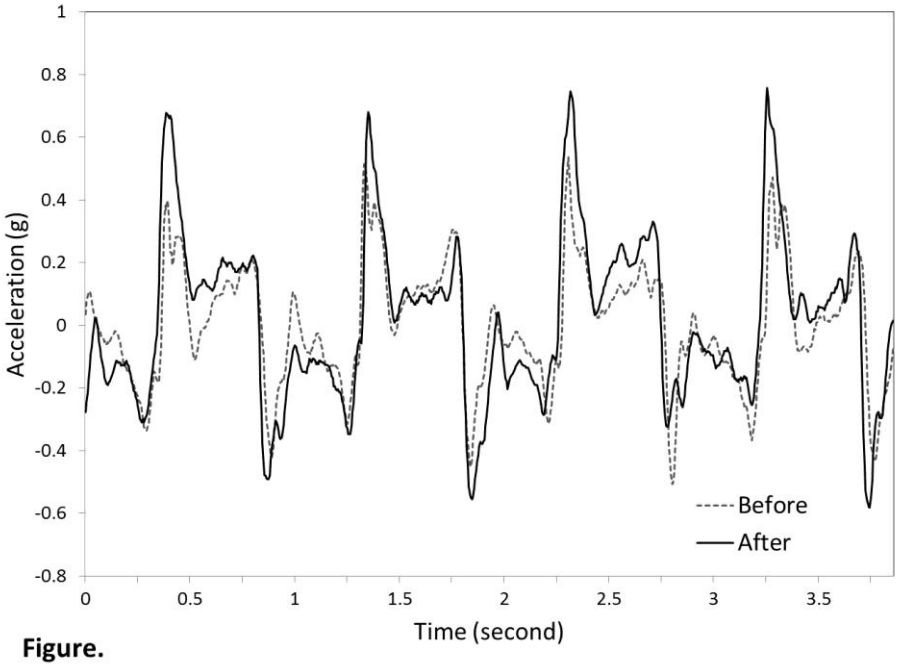


Figure.
Acceleration waveforms in the mediolateral direction at the cervical sensor in 1 representative patient before and after the augmentation of walking difficulty.

P1-A-43 Characteristic findings of stabilometry in patients with cervical vertigo

***Akiko Taura*[1], Kazuo Funabiki[2], Hiroko Torii[3], Mami Matsunaga[3], Juichi Ito[3]**
[1]Kyoto University Hospital, [2]Osaka Bioscience Institute, [3] Kyoto University

BACKGROUND AND AIM : There are lots of patients who suffer from vertigo and shoulder stiffness. Recently lots of people are involved with personal computers (PC) in public and also in private. Working with PC for a long time might cause shoulder stiffness and make cervical blood flow worse. Cervical vertigo is a symptomatic group of vertiginous diseases whose pathogenesis is believed to be in the neck region. The diagnosis of cervical vertigo is still difficult, mainly because no diagnostic examinations are particularly useful for the purpose. METHODS: In this study, we examined whether any features -- especially stabilometry with or without neck tilting, torsion, or extension -- are occasionally observed in patients with cervical vertigo. The subject population was recruited from patients who visited the ENT outpatient department at Kyoto University Hospital between January 2006 and January 2009. The subjects were patients with putative cervical vertigo, patients with unilateral peripheral vestibular disorders, and healthy individuals as control. RESULTS: With regard to oculomotor symptoms, most patients with peripheral vestibular disorders showed some pathological nystagmus. By contrast, only one out of seven patients with cervical vertigo showed pathological nystagmus. From an analysis of stabilometry, the control group exhibited some tottering only in the head-extended position. This tendency was also observed, though mildly in patients with peripheral vestibular disorders. Most of the patients with cervical vertigo, however, readily displayed tottering in any neck position. Further, the difference in the tottering in cervical vertigo patients between those in the neck-tilted or extended position and those not in such a position was significantly greater than in the control group and in patients with peripheral vestibular disorders, however there was no clear difference in the results between subjects in the control group and those with peripheral vestibular disorders. CONCLUSIONS: These results indicate the following. First, an oculomotor phenotype is not necessarily exhibited in patients with cervical vertigo. Second, stabilometry with and without neck extension or tilting provides

valuable information in the diagnosis of cervical vertigo. In order to establish a new diagnostic examination for cervical vertigo, furthermore investigations are needed.

P1-A-45 Cortical responses during the dynamic posturography detected by functional near infrared spectroscopy(fNIRS)

Hiromasa Takakura[1]**,** **Hideo Shoujaku**[1], **Hisao Nishijo**[1]
[1]Graduate school of Medicine and Pharmaceutical Sciences, University of Toyama

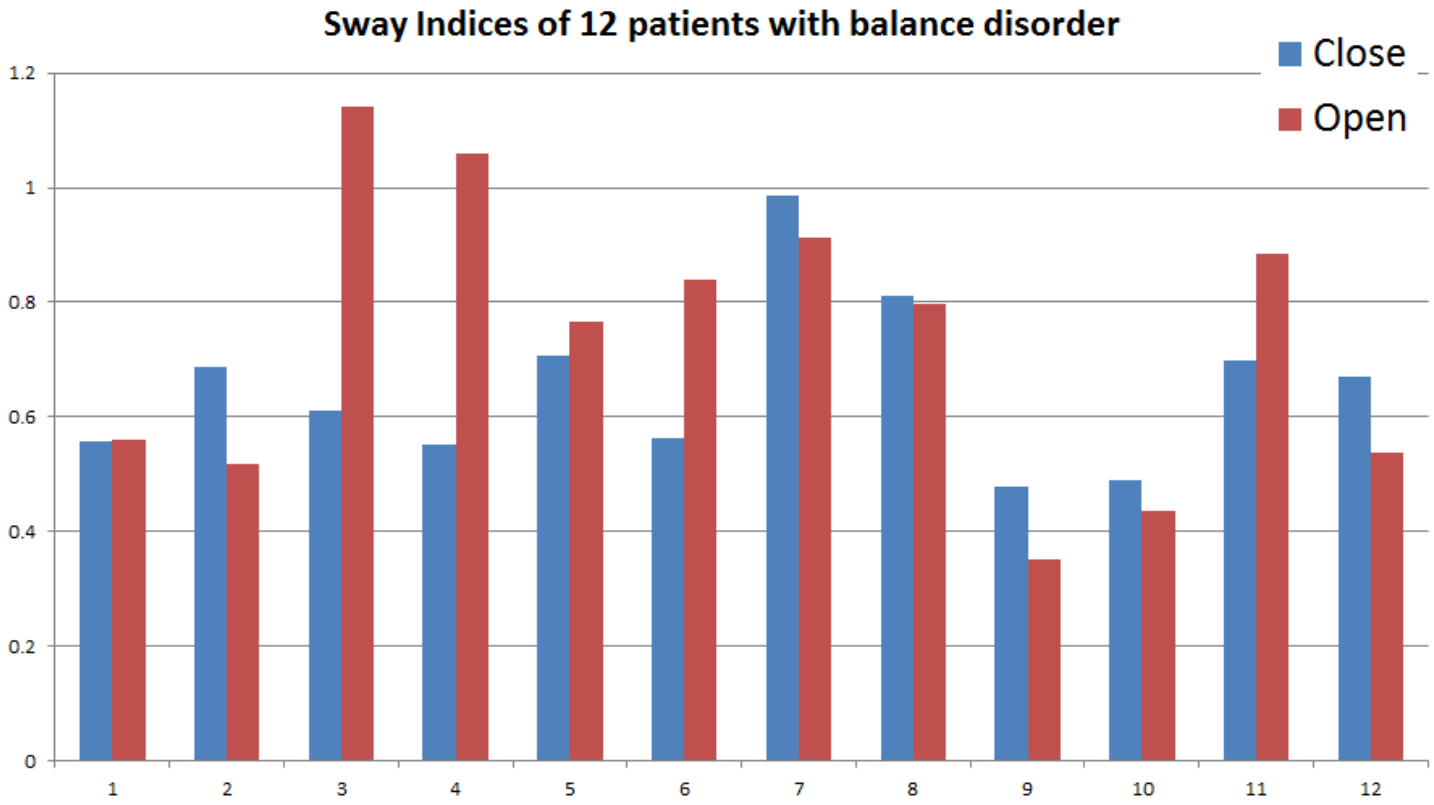
BACKGROUND AND AIM: To investigate brain activity to sensory conflict during standing balance, hemodynamic responses by near infrared spectroscopy (NIRS) were recorded simultaneously while subjects received the Sensory Organisation Test (SOT) as part of the EquiTest System and were recorded the cortical hemodynamic responses during SOT protcol. METHODS: Eleven male healthy subjects were enrolled (all right-handed). A head cap for NIRS (FLASH-PLUS; Shimadzu Co. Ltd., Japan) was set on the head of the subject. 31 NIRS probes (15 optical sources and 16 detectors) were set on the cap and hemodynamic data was recorded from 50 fNIRS channels. After recording, 3-D locations of fNIRS probes were measured and it was determined by stereotaxic superimposition on the surface of the 3-D MRI reconstructed brain of each subject. Changes in Oxy-Hb, which has been reported to be sensitive to neuro-hemodynamic relationships, are assessed inthis study. The NIRS data were summed and averaged with reference to the onset of stimulation in each SOT condition. The integrated values of the change in OxyHb concentration for 10sec were computed as hemodynamic responses in each channel in individual subjects. The NIRS channels were divided into 10 groups that covered the different cortical regions (the regions of interest: ROIs), and the data of all NIRS channels within the same ROI were averaged in each subject in each SOT condition. RESULTS:Statistical analyses revealed that right frontal operculum , right parietal operculum and right superior temporal gyrus were activated in SOT5 (the subject stood with the eyes closed and the visual surround fixed but the platform moved in response to his/her sway such that the ankle joints did not bend in response to the sway) and SOT6(the subject stood with the eyes open and the visual surround moved in response to the participant's sway, furthermore the platform moved in response to his/her sway such that the ankle joints did not bend in response to the sway) conditions. These regions have been considered as vestibular cortices in the previous studies. Conclusion: Frontal operculum, parietal operculum and superior temporal gyrus are likely essential for sensory integration and when standing balance is perturbated.

P1-A-47 Toward Instant Diagnosis in Balance Disorders Using Kinect

Hiroyuki Funaya[1]**,** **Tomohiro Shibata**[1], **Yoshiro Wada**[2], **Toshiaki Yamanaka**[2]
[1]Nara Institute of Science and Technology, [2]Nara Medical University

BACKGROUND AND AIM: Balance disorder is a malfunction of complex postural control systems such as visual systems, vestibular systems and proprioception systems. Compared to Center of Pressure, optical motion capture system (MoCap) is able to capture human body joints, and so has a possibility for medical doctors to diagnose balance disorders from multiple perspectives. A key to classifying the motion patterns of the patients and to developing a novel diagnosis method is to gather mass of data on balance disorders in variety of situations such as small medicare and in-home rehabilitation. Microsoft Kinect is an ideal device for this purpose in that it is cheap and small whereas marker-present MoCap has problems in cost and portability. The essential problem in using Kinect for balance disorder is that there is no quantitative correspondence between the joint positions provided by Kinect--a marker-less system--and the optical markers in MoCap. The system should also be easy to use for doctors and medical laboratory technicians. Aiming at solving these issues, our purposes in this study were to 1. assess the accuracy of Kinect in balance tests, and to 2.

develop an easy-to-use recording software and make a preliminary analysis. METHODS: Each joint position of Kinect SDK is modeled as a linear combination of the MaCap markers near to the joint. For example, the neck position of Kinect SDK is a combination of the for fore/back neck and left/right shoulder in MoCap. After calibrating the coordinates and the temporal delays of the two sensor systems, the model parameters were optimized so that the sum of Euclid distances between trajectories is minimized. We developed a graphical user interface to record the joint positions instantly and gather seven patients' data in a hospital. As an index for diagnosis of balance-disorder, we proposed sway index that is the mean ratio over time between sway speeds of neck and waist. RESULTS: Results show that Kinect can capture a small sway of healthy people even in the Romberg test with their eyes opened. The average error between the positions estimated by our method and the ones provided by Kinect was 5.4mm, which is about 9 times smaller than the one without our method. We deployed our software in a hospital and gathered 7 patients' data. Sway indices varies among people, and different in the two conditions as the figure shows. CONCLUSIONS: We investigated the accuracy of Kinect SDK by proposing a linear model that compensates differences between the Kinect and MoCap and our method can track subject's body accurately enough for a couple of balance tests. We further investigated the plausibility of our system by capturing patients with balance disorders. The system was able to detect quantitative difference in the sway ratio between the neck and the hip center among the patients. Developing new ways of the balance disorder diagnosis with the presented system is our near future work.



B - Sensorimotor control

P1-B-49 Enhanced proprioceptive postural control after inspiratory muscle training in individuals with low back pain

Lotte Jansssens[1], **Thierry Troosters**[1], **Alison McConnell**[2], **Roeland Lysens**[2], **Madelon Pijnenburg**[1], **Nina Goossens**[1], **Jonas Raymaekers**[1], **Simon Brumagne**[1]
[1]KU Leuven, [2]Brunel University

BACKGROUND AND AIM: Individuals with low back pain (LBP) decrease their reliance on back proprioceptive signals during postural control which enforces the use of an ankle-steered proprioceptive postural control (PPC) strategy. It has been shown that LBP is strongly related to respiratory disorders, and postural control is impaired in individuals with respiratory disorders. Moreover, the diaphragm plays an important role in postural control. Loading of the inspiratory muscles impairs postural control by decreasing lumbar proprioceptive sensitivity. However, it remains unclear whether inspiratory muscle training (IMT) might improve PPC in individuals with LBP. METHODS: Twenty-four individuals with LBP were randomly assigned into an intervention (IMT) and control group (c-IMT). The subjects were instructed to breathe (8 weeks) through an inspiratory resistance of 60% of their maximal inspiratory pressure (Pimax) (IMT) or 10% of Pimax (c-IMT). Outcomes were evaluated at baseline and after 8 weeks of (c-)IMT. Center of pressure displacement was determined during upright standing, and muscles vibration (ankle, back, ankle-back) was used to evaluate the PPC strategy. Inspiratory muscle strength was evaluated by measuring Pimax. Severity of LBP and disability were assessed using the Numeric Rating Scale (NRS) and Oswestry Disability Index (ODI-2), respectively. RESULTS: After 8 weeks of (c-)IMT, the IMT-group showed a decreased posterior sway during ankle vibration (pre -9.5±5.9cm, post -7.0±5.6cm, p=0.025), no difference in postural sway during back vibration (pre 2.2±3.1cm, post 3.7±1.7cm, p=0.272), although a significantly decreased posterior sway during ankle-back vibration (pre -11.5±5.9cm, post -6.6±4.8cm, p=0.006). In contrast, the c-IMT-group did not show a difference in PPC (p>0.05). Inspiratory muscle strength significantly improved after IMT (pre 94±31cmH2O, post 136±35cmH2O, p=0.001), but not after c-IMT (pre 92±27cmH2O, post 94±26cmH2O, p=0.984). Severity of LBP decreased significantly after IMT (pre 5±2, post 3±2, p=0.004), but not after c-IMT (pre 5±2, post 5±2, p=0.665). Scores on ODI-2 did not significantly change both in the IMT-group (pre 17±8%, post 13±10%, p=0.454) and the c-IMT-group (pre 20±8%, post 17±7%, p=0.680). CONCLUSIONS: After IMT, individuals with LBP decrease their reliance on ankle proprioceptive signals during postural control as shown by a smaller posterior body sway during ankle and ankle-back muscle vibration. Moreover, IMT improves inspiratory muscle strength and decreases the severity of LBP. These findings could not be confirmed by c-IMT. PPC might be improved following IMT by addressing the trunk stabilizing function of the diaphragm. This may enable individuals to reweight proprioceptive signals and to shift to a more optimal PPC strategy. Consequently, these findings may provide inspiratory muscles loading as an underlying mechanism of altered PPC and LBP.

P1-B-51 Establishing stimulation profiles for cutaneous receptors in the human foot sole

Nicholas Strzalkowski[1], **Leah Bent**[1]
[1]University of Guelph

BACKGROUND: Previous research has indentified four classes of cutaneous mechanoreceptors innervating the glabrous skin on the hands [1] and feet [2]. Each class exhibits unique firing properties, allowing them to provide different features of tactile and proprioceptive feedback (e.g. pressure, stretch). Cutaneous afferent class firing characteristics have been established in the hands [1], but have not been investigated in the foot sole. The glabrous skin on the hands

and feet differ in skin properties, likely to influence afferent firing characteristics [2]. The purpose of the current study is to establish vibratory tuning curves for the four mechanoreceptor classes innervating the foot sole. METHODS: Microneurography was used to record and classify fourteen cutaneous afferents from the tibial nerve in 9 human subjects (age22-25). Afferents were classified as fast adapting type I(FAI); fast adapting type II(FAII); slowly adapting type I(SAI); or slowly adapting type II(SAII). A mini shaker (Bruel&Kjaer, Denmark) with a 6mm diameter probe was used to deliver vibratory bursts (2 seconds) across a range of frequencies (3-250Hz) over the receptive field of each afferent. Vibration amplitude (0.001-2 mm peak-to-peak) was increased in frequency-specific steps. Afferent firing response was analysed over a representative second of stimulation. Vibratory tuning curves were made for (A) peak3 response (average of the three highest instantaneous firing rates) and (B) impulses per cycle (number of action potentials elicited per indentation of the probe). RESULTS/DISCUSSION: Of the fourteen afferents recorded to date, three were FAI (21%), two were FAII (15%), three were SAI (21%) and six were SAII (43%). Peak3 and impulses per cycle tuning curves of a representative FAII afferent (Figure1A,B) show that across most frequencies, the afferent is capable of firing at (1:1) or above (2:1 or greater) the stimulus frequency at relatively low amplitudes. However, higher amplitudes are required to maintain that 1:1 or 2:1 firing over a full second of stimulation. The current data suggest that the frequency profiles of the four cutaneous afferents innervating the foot sole are similar to those previously reported in the hand [1]. Of particular interest is that the SA afferents were able to fire 1:1 at high stimulus frequencies (>30Hz) but required greater stimulus amplitudes than the FA afferents. CONCLUSION: These preliminary data suggest that cutaneous afferents in the foot sole have similar frequency tuning curves to those previously established in the glabrous skin of the hand. Further investigation aims to reveal stimuli which selectively activate individual afferent classes in the foot sole. References: [1] Johansson et al. (1982) Brain Res. 244:17-25 [2] Kennedy & Inglis (2002) J Physiol. 538:995-1002

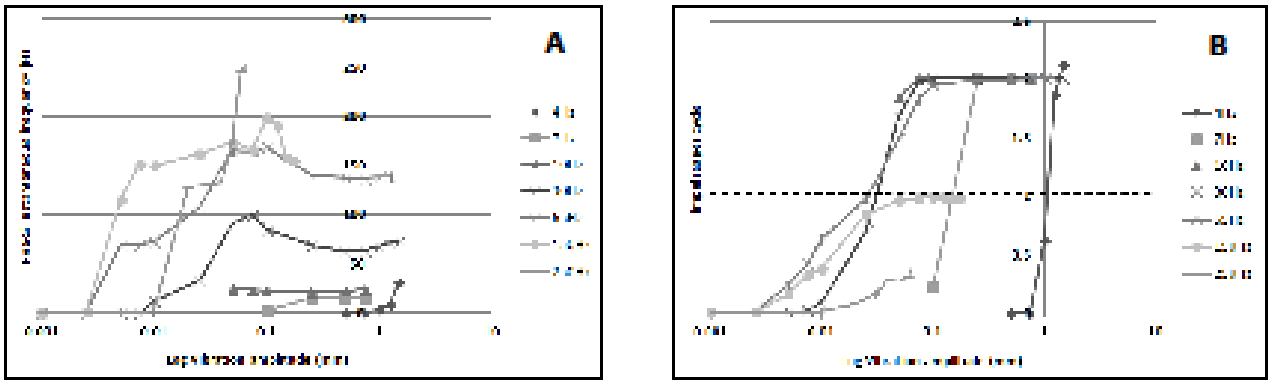


Figure 1: Vibratory tuning curves for a representative FAII afferent. (A) Peak3 response and (B) Impulses per cycle taken over one second of vibration

P1-B-53 Congenital nystagmus may be not conjugate eye movements? -Report of our two cases-

Tomoyuki Okada[1], **Masahiko Fukasawa**[1], **Yasuhiro Miyamoto**[1], **Yasuhiko Tanaka**[2], **Izumi Koizuka**[1]
[1]St Marianna University School of Medicine, [2]St Marianna University Yokohama City Hospital

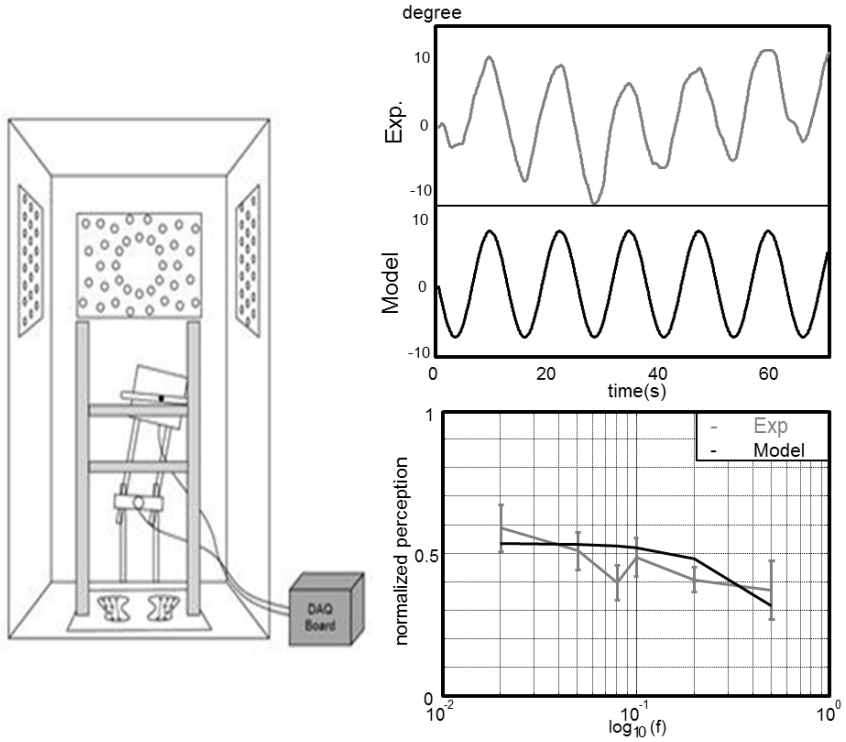
Background and Aim: Congenital nystagmus (CN) is almost always conjugate? Often, CN may be not conjugate, in smooth pursuit and OKN in our cases. To clarify this discrepancy, we examined CN patients' ocular dominance and stereopsis as a near vision, because CN is usually accentuated by the attempt to fixate an object, a near target can evoke CN and optokinetic stripes can influence the intensity of CN. And we investigate CN by using each eye recording ENG and a new goggle with bilateral infra-red CCD cameras (ON-1), we have developed, which can record bilateral eye

movements simultaneously. Methods: We asked two healthy male CN (born in 1972 and 1981) volunteers. We examined ocular dominance based on the hole-in-card test and stereopsis by using the fly test. We employed each eye recording ENG under the condition of smooth pursuit and OKN for them. We also use ON-1 and eye movements were recorded under gazing on the imagery (or imaginary) target, like examiner's nose, around ten seconds, in front of them at the primary position. We analysed whether or not each eye movement is different and alteration of each pupil' s area (pupillary constriction as a near vision) by use of the Image J as a new version of NIH Image. Results and discussion: Both volunteers possess right ocular dominance and borderline stereopsis about circle evaluation 4/9 and 3/9, respectively. There can be a sort of fusion problem, but not central origin. Recessive eye performed rather smooth eye movements and loafed, occasionally, notwithstanding just short period. On the other hand, analysing ON-1 data revealed almost synonymous but not the same waveform on each eye movement. As to pupillary constriction of dominant eye is almost always smaller than left eye. Never has been discussed the relationship amongst ocular dominance, nature of each eye's pupillary constriction and eye movements of CN, and also a sort of fusion problem for CN. The relationship could make the maze in which we have to deliberate on nature of CN. So we here just mentioned the maze may influence conjugate eye movements for CN.

P1-B-55 Dominant Effect of Visual Motion Cues on the Motion Perception Under Sensory Conflict Condition is Represented by High Sensory Weight in Internal Model

Sue Park[1]**,** **Hyerim Lim**[1]
[1]KAIST

BACKGROUND AND AIM: Sensory integration can be explained by internal model. Thus, there are some studies about sensory integration with the internal model. Among the studies, researchers also studied about the sensory conflict condition. However, these studise didn't measure the perception directly. Thus, in this study, we measured the motion perception directly, and studied about the sensory weight though the internal model. METHODS: 8 subjects who do not have somatosensory disorder participated in the test: conflict sensory condition. Sensory conflict condition was designed by fixing subjects to the experimental setting. The sinusoidally rotating visual stimulus (amplitude is 15 degree) was applied to subjects. The frequency rage was from 0.02 Hz to 0.5 Hz. Subjects were instructed to rotate the bar parallel to the real earth horizon. Rotation of bar is roll tilt perception about the visual stimulus. To see frequency response, we obtained amplitudes of each cycle and took an average of them. To reproduce the experiment, we modelled this roll tilt perception using a state estimator. By adjusting model parameter, we tried to find meaningful parameter which can explain human roll tilt perception well. RESULTS: First of all, we could reproduce the experimental data by modifying the state estimator. The experimental result shows that gain decreases as frequency increases. This characteristic also can be reproduced by the model. With the constant model parameter, we can capture the reduction of gain as frequency increases. Despite of reduction of gain, the noise covariance of vision was the smallest. CONCLUSIONS: Visually induced roll tilt perception can be explained by the Kalman model with small noise covariance of vision. Kalman model is an estimator which finds the true state value by reflecting sensor information depending on each noise level. This implies that human also handle the sensory information when they perceive their motion, and small noise covariance of vision implies that weight of vision is relatively high compared to other sensors.



P1-B-57 Effects of Aging on Vestibular and Lower Limb Somatosensory input Interaction for Head and Trunk control during Normal and Narrow-based Walking

Nandini Deshpande[1]**, Fang Zhang**[1]
[1]Queen's University

BACKGROUND AND AIM(S): The ability to maintain stability during walking is often assessed by asking individuals to walk on a narrow base that induces constraints in the medio-lateral (ML) direction. Evidence from vestibular deficit cohort suggests that while tandem walking both vestibular and lower limb somatosensory inputs contribute for maintaining stability in ML direction. The purpose of this study was to investigate vestibular and lower limb somatosensory input interactions for trunk and head control during normal and narrow-based walking and to understand possible age-related differences in these effects. METHODS: Fifteen young (age=20-30; YA) and fifteen older (age≥65; OA) healthy adults were asked to walk under normal condition and between lines of tape placed 25 cm apart (narrow-base condition, NB), at their usual pace. On randomly selected trials lower limb somatosensory and vestibular inputs were manipulated using foam mat and bipolar galvanic vestibular stimulation (GVS), respectively; either individually or concurrently. Average gait speed (global parameter) and average displacement of the head and trunk in the roll and pitch direction (axial postural control) were calculated. Mixed factor ANOVA was used to compare the effects of walking conditions and sensory manipulations on the two age-groups [age-group(2) x walking conditions(2) x surface conditions(2) x GVS conditions(2)]. RESULTS: Gait speed decreased in NB ($p=0.02$) but only in older adults. Head roll increased with GVS in older persons in foam mat condition ($p=0.01$) but not in normal surface condition, nor in young adults. Head pitch increased in NB in both age groups ($p<0.01$). In foam mat condition, trunk roll was increased in NB ($p<0.01$) and by GVS ($p<0.01$) in both groups, which was not observed in normal surface condition. Trunk pitch increased in foam mat condition in both young and older persons ($p<0.01$). CONCLUSION: While walking with NB, OA possibly adopted a more cautious strategy compared to YA by decreasing their gait speed. It is possible that older persons needed to implement the bottom up strategy for ML head position control when vestibular information was perturbed; despite having normal vision. Lack of NB effect on

head suggests that availability of appropriate sensory inputs is more critical for ML Head control. In contrast, trunk stability was further influenced by NB. Maintaining trunk ML stability in NB may require higher accuracy of lower limb somatosensory input, irrespective of age. Particularly for OA, reducing gait speed in NB did not translate into maintenance of trunk stability in absence of accurate lower limb somatosensory input.

P1-B-59 Characteristics of force- and timing-control in aging: A study of foot-tapping

Koji Takimoto[1], **Hideaki Takebayashi**[1], **Kenzo Miyamoto**[1], **Hideto Kaba**[2]
[1]Tosa Rehabilitation College, [2]Kochi Medical School

BACKGROUND AND AIM: The previous studies have focused on the timing and force control, but conclusions have been inconsistent. Although many previous studies have focused finger- tapping, force and timing in the lower limbs have not yet been investigated.Characteristics of the lower limbs may be different from those of the upper limbs because they are used more often to perform periodic motions. In this study, participants performed foot-tapping tasks at different tempos, and characteristics related to controlled movement were examined. METHODS: The participants were eight healthy younger subjects (18-32 years) and seven healthy older subjects (65-82 years). The dominant leg (the test leg) of all participants was the right leg. This study was approved by the Ethics Committee of the Tosa Rehabilitation College. Participants were seated for experiments, and their forefoot of dominant leg was set on to the plate of a dynamometer (Frontier Medic, Co., Ltd.). In this posture, the participants isometrically made periodic pressing movements with ankle joint. During the foot-tapping tasks, participants performed periodic foot-tapping (isometric plantar flexion exertion) under three different tempos of inter stimulus-onset intervals (ISI) with a force level of 20% MVC of plantar flexion. Foot-tapping was performed in synchronization with three ISI patterns (500 ms, 1000 ms, and 2000 ms) produced by an auditory metronome (Seiko), while visually monitoring their force output on a PC monitor that displayed the goal of 20% MVC. Three sets of 50 taps were performed for each of the ISI patterns. Peak force and foot-tapping interval were measured using software for the analysis of force and interval (EmileSoft Co., Ltd.). The values were calculated of the coefficient of variation (CV) and other value (for example, mean absolute error) to the each foot-tapping interval and peak force produced. To investigate the influence of ageing and ISI patterns on the accuracy of foot-tapping interval and force control, 2 (age) × 3 (ISI) analysis of variance (ANOVA) and post hoc analysis (Bonferroni's test) were performed. Statistical significance for all procedures was set at 5%. RESULTS: The mean absolute error for tapping intervals was significantly larger ($p<0.01$) in the elderly group than in the younger group. Errors were also significantly larger for the 2000-ms ISI pattern than for the other two patterns ($p<0.01$ and $p<0.05$, respectively). Greater variability in the CV for tapping intervals was observed in the elderly group ($p<0.01$). The CV for force control peak values was also more variable in the elderly group ($p<0.01$). However, the mean absolute error for muscular output, which was an important factor in this study, was greater in the younger group ($p<0.01$). CONCLUSIONS: We concluded that younger subjects showed greater variation in their ability to force control because they attempted to match their muscular output with the target force values.

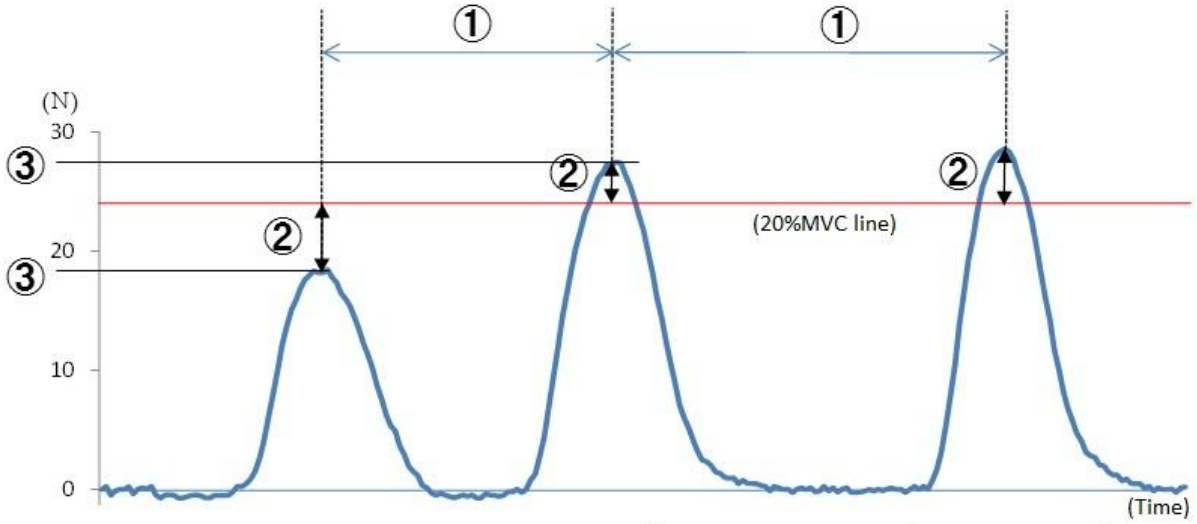


Figure 1. A data sample of the foot-tappin interval (①), muscular output error(②) and peak force(③).

P1-B-61 Head stabilization during walking on a compliant surface

Egidio Falotico[1]***,*** **Colas Authié**[1], **Kenji Hashimoto**[2], **Cecilia Laschi**[3], **Daniel Bennequin**[1], **Paolo Dario**[4], **Alain Berthoz**[1]
[1]Scuola Superiore Sant'Anna, [2]CNRS - Collège de France, [3]Waseda University, [4]Institut de Mathématiques de Jussieu

BACKGROUND AND AIM: In humans, the stabilization of the head in rotation creates a stable reference frame which may help gaze stabilization and the coordination of the body segments during locomotion [1]. In this work we studied the stabilization of the head (analyzing pitch and roll rotations) compared to other body segments (trunk and pelvis) rotation variation during straight walking on a compliant surface. MacLellan and Patla [2] were the first to study the effects of walking on compliant ground on locomotion stability. They found out that vertical center of mass (COM) position decreased during walking on a compliant surface. This lowering of the vertical COM peak would provide a more stable posture when walking on the surface. In this work we show how walking on a compliant ground has an impact on the head, trunk and pelvis stabilization. METHODS: Eight normal subjects were instructed to walk a straight-line trajectory (4 meters) at their preferred speed. They had to perform the task with two different ground compliances (compliant ground CG, an urethane foam with a density of 40 kg/m3 , and normal ground, NG). An optoelectronic VICON motion-capture system was used to record the behaviors at 120 Hz. The head, trunk and pelvis rotations were given in terms of the Euler angles around the body-fixed axes using a Fick rotation sequence (yaw, pitch, roll). The main variable used to evaluate the body segments stabilization is the peak-to-peak rotation amplitude [1] of the head, trunk and pelvis. RESULTS: We performed a two ways ANOVA (ground condition, body segment) to assess the behavior of the different body segments related to the peak-to-peak amplitude of pitch and roll rotation for NG and CG condition. A large effect of the ground was present for the peak-to-peak pitch and roll amplitude (see figure 1). For the pitch we point out an increase for the head, torso and pelvis from NG to SG condition ($p<0.05$). For the roll peak-to-peak rotation we find out a decrease in rotation for the pelvis in CG condition respect to the NG condition ($p<0.05$). ACKNOWLEDGMENTS: This study was supported in part by the RoboSoM project from the European FP7 program. CONCLUSIONS: The stabilization of the center of mass, showed in previous works [2] and probably related to the pelvis peak-to-peak amplitude reduction, remains one of the more important constraints while walking on a different compliance ground. The presented results indicate that a perfect stabilization of the head in rotation is not always necessary or possible. However, center of mass stabilization is always basic in order to keep balance. The presented results highlights the need

for further analysis to figure out the role of body segments stabilization during walking on a compliant surface.
REFERENCES: [1] Pozzo, T., Berthoz, A., & Lefort, L. (1990). [2] MacLellan, M. J., & Patla, A. E. (2006).

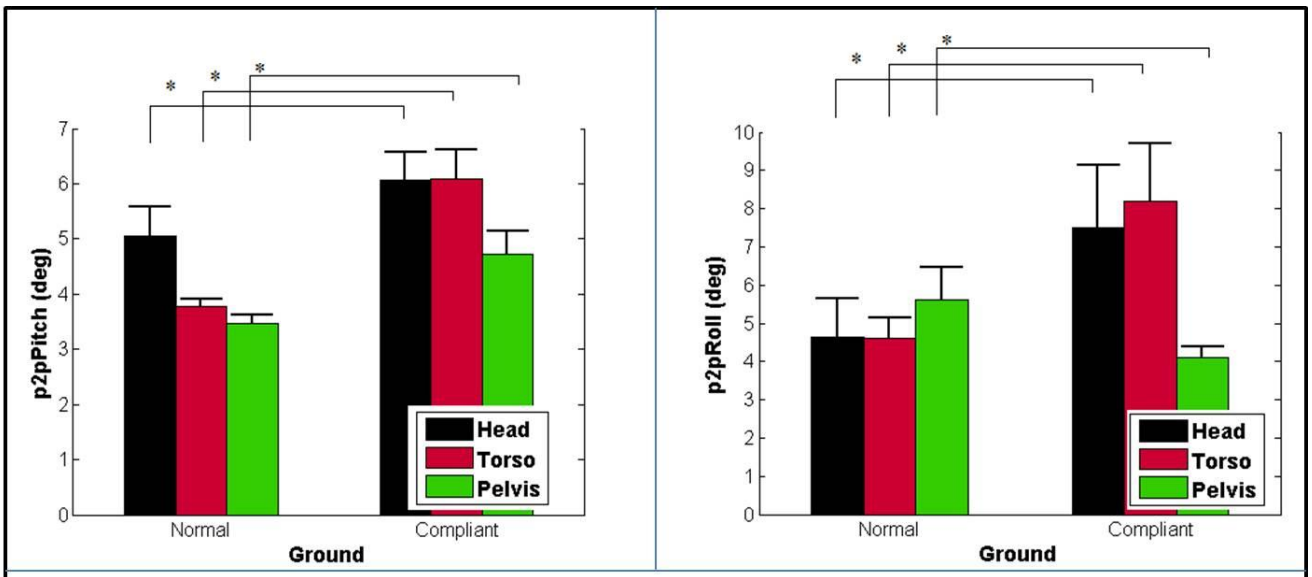


Figure 1: Peak to peak amplitude of pitch and roll rotations for head torso and pelvis during walking on normal and compliant ground. The symbol * indicates a significant difference.

P1-B-63 Is dynamic visual information obtained at remote place available for locomotion through apertures?

***Daisuke Muroi*[1], Takahiro Higuchi**[1]
[1]Tokyo Metroplitan University,

BACKGROUND AND AIM: Dynamic visual sampling at remote place is critical for planning and executing adaptive locomotor behavior. A previous study demonstrated that dynamic visual information obtained at remote place was superior to static visual information for stepping over an obstacle without vision. The present study was designed to investigate (a) whether such dynamic information would be available for passing through narrow apertures without vision, and (b) whether the dynamic information would also improve perceptual judgment of pass-ability. METHODS AND RESULTS: Exp. 1; Actual passage through apertures Twelve young adults (27.7 ± 3.2 yrs) participated. They were requested to initiate walking while holding a 66 cm horizontal bar and walk through an aperture of four widths (0.8, 1.0, 1.2, and 1.4 times the bar length). Their vision was occluded for 3 m in front of the aperture. Each participant performed this task under each of four initial visual conditions: (a) static vision (SV), standing at the 3 m distance and observed for 1.5 s, (b) forward walking (FW), observing the aperture while making two steps toward the 3 m distance and stopping their walking immediately after visual occlusion, (c) non-stop forward walking (FW-NS), the same condition as the FW but non-stopping after visual occlusion, and full vision (Control). The results showed that, when the relative aperture size was 1.2, the average number of passage without shoulder rotation was smaller for the SV and FW than for the FW-NS and control condition. This suggests that dynamic visual sampling could lead to an energetically efficient behavior only when the participants were allowed to non-stop their walking after visual occlusion. Exps. 2 & 3; Perceptual judgment Twelve (Exp. 2, 24.8 ± 4.6 yrs) and twelve (Exp. 3, 25.8 ± 4.1 yrs) participated. They were requested to judge from either a 3 m (Exp. 2) or 1 m (Exp. 3) distance whether door-like apertures of various widths (ranging from 36 cm to 82 cm with 2 cm interval) were passable or not passable when they walked while holding the 66 cm bar. Each participant

performed this task under each of the same four initial visual conditions as in Exp. 1. The results of both experiments failed to show any significant differences among the four visual sampling conditions. CONCLUSIONS: Dynamic visual information obtained at remote place was available for passing through a narrow aperture without vision. However, such information was not available to improve perceptual judgment of pass-ability, even when the judgment was performed at a place close to an aperture.

P1-B-65 Control of load and center of pressure of each left and right lower limb in anticipatory postural adjustments during multi-directional gait initiation

Masaki Yukimune[1], **Tomonori Sawada**[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 anticipatory postural adjustments (APAs) play an important role in GI. We hypothesized that the control of step direction during GI is performed in APAs. We studied load distribution and displacement of center of pressure (COP) of each right and left lower limb in APAs during multi-direction GI. METHODS: Kinetic and kinematic variables were collected on 20 healthy young adults (10 males, 10 females. 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 and analyzed by measured following values: Medial-lateral (M-L) and anterior-posterior (A-P) displacement of COP of each right and left lower limb in APAs, load distribution at the most lateral point of COP. A-P displacement of COP of each right and left lower limb in APAs were normalized by distance foot length (/mm), M-L displacement of COP of each lower limb were normalized to foot width (/mm). Each load distribution was indicated as rate to bilateral load (%). These variables were measured using a 8-camera Vicon motion system (VICON MX; Oxford, UK) and 8 force platforms (AMTI; Watertown, MA, USA). All data were analyzed using repeated one-way ANOVA. Statistical significance was set at $P<0.05$. RESULTS: All participants had ability to produce directional specific pattern of load distribution and displacement of COP of each right and left lower limb in APAs during multi-direction GI. Multi-direction GI affected the load of both lower limbs, anterior-posterior (A-P) displacement of COP in both lower limbs, and medial-lateral (M-L) displacement of COP in right lower limb (stepping limb). Especially, backward was significantly longer than other four directions for A-P displacement of COP in both lower limb and M-L displacement of COP in right lower limb, and load distribution of both lower limbs at left 30°was significantly different to other four directions. CONCLUSIONS: These results suggest that load distribution and A-P displacement of COP in both lower limbs, M-L displacement of COP in right lower limb were important for control of step direction. The outcome of this study could be used while developing rehabilitation strategies focused on fall prevention in older adults and individuals with CNS disorder.

P1-B-67 Effect of various information of sensory modality on the postural control

Hideaki Takebayashi[1], **Suzuno Hiroi**[1], **Koji Takimoto**[1], **Kenzo Miyamoto**[1], **Yutaka Takuma**[1], **Inoue Yoshikazu**[1], **Shoko Miyamoto**[1], **Takao Okabe**[1], **Shu Morioka**[2]
[1]Tosa Rehabilitation College, [2]Kio University

BACKGROUND AND AIM: Recent studies on sense of self-ownership and sense of self-agency have shown that phenomena such as the rubber hand illusion and out-of-body experiences occur as a result of temporal and spatial consistencies between various information of sensory modality. It has also been reported that the cause of chronic pain is inconsistencies between various information of sensory modality. To be properly aware of our bodies, it is necessary to integrate various sensory modality information. The aim of this study created inconsistencies in various information of sensory modality in real time and explored the effects on postural control. METHODS:The subjects were 18 healthy individuals (age:21.9±0.6 years). Measurements were made in a tandem position with a Head-Mounted display (HMD, HMZ-T2, SONY, Japan) attached. The HMD and the video camera(HDR-C270V, SONY, Japan) were synchronized, and footage captured from the back of the subjects was projected onto HMD in real time. The camera was rotated to the right frontal side for the footage, and five set angles (0°, 45°, 90°, 135°, and 180°) were randomly projected. The measurement time was 30s for each angle, with the set angle tilted at 15s and returning to 0° after 15s.For total postural sway, data were imported into a PC at a sampling frequency of 50Hz, and the overall locus length (LNG) and rectangular area(REC) were calculated. One-way ANOVA and multiple comparisons were used for Stabilometer (Anima, Japan). The subjects described their subjective sensations during the measurement. RESULTS: The LNG had significantly higher values with the footage rotation angle at 180° than at 0°($p<0.01$). The REC had significantly higher values with the rotation angles at 135° and 180° than at 0°($p<0.01$).The subjects' reports of their subjective sensations suggested that they were absorbed in their own projected body images. CONCLUSION: When the resulting rotation angle was large, postural sway increased significantly. This suggested that the extent of the inconsistencies between various information of sensory modality was large and that this had an effect on postural control when the information on body image was inconsistent. This is considered to be similar to a report on a mental rotation task, in which the reaction time was extended for a photo of the hand rotated 120° and 240°, movements that are difficult in reality. There are few empirical elements to visual images since this visual information is based on angles that are rarely seen on a daily basis. This could be because no body image is formed. Body image is formed when the rotation angle is small since these angles are experienced on a daily basis. Even when there are inconsistencies with the projected body image, changes in sensory weighing occur, suggesting the possibility that other sensory modality information is activated more than visual information and that postural sway can be controlled through predictive aspect.

Table 1: The results under different tasking conditions.

Variables		Single	Add	Subtract	P^*	$P^\dagger$	$P^\ddagger$	$P^\S$	partial η^2
Time distance values									
Velocity (m/s)		0.88 ± 0.44	0.71 ± 0.36	0.69 ± 0.34	<0.001	<0.001	<0.001	0.570	0.587
Stride length (m)		0.92 ± 0.33	0.81 ± 0.31	0.81 ± 0.30	<0.001	<0.001	<0.001	1.000	0.586
Cadence (steps/s)		1.82 ± 0.38	1.66 ± 0.37	1.64 ± 0.36	<0.001	<0.001	0.002	1.000	0.507
Acceleration analysis values									
RMS(m/s^2)	ML	1.41 ± 0.78	1.27 ± 0.73	1.27 ± 0.77	0.034	0.221	0.112	1.000	0.191
	VT	1.96 ± 0.50	1.64 ± 0.44	1.59 ± 0.42	<0.001	0.009	0.001	0.657	0.482
	AP	1.36 ± 0.51	1.17 ± 0.45	1.15 ± 0.47	<0.001	0.003	0.003	1.000	0.483
Entropy(bit)	ML	4.13 ± 0.56	4.05 ± 0.51	4.14 ± 0.57	0.641	1.000	1.000	0.696	0.027
	VT	3.69 ± 0.85	4.03 ± 0.76	4.16 ± 0.80	<0.001	0.001	<0.001	0.166	0.626
	AP	3.91 ± 0.36	3.94 ± 0.45	3.93 ± 0.38	0.849	1.000	1.000	1.000	0.006

Note: Values are mean ± SD. Single: Single-task condition, Add: dual-task condition with additional task, Subtract: dual-task condition with subtract task.

P^*: repeated-measure analysis of variance. $P^\dagger$: single vs add, $P^\ddagger$: single vs subtract, $P^\S$: add vs subtract (multiple comparison with bonferroni adjustment)

ML: medio-lateral axis, VT: vertical axis, AP: anterio-posterior axis.

P1-B-69 Effect of temporal and spatial predictions to perturbations on stretch reflex responses of ankle extensor and flexor muscles during standing

***Kimiya Fujio*[1], Hiroki Obata**[1], **Noritaka Kawashima**[2], **Kimitaka Nakazawa**[1]
[1]The University of Tokyo, [2]Research institute of the National Rehabilitation Center for Persons with Disabilities
BACKGROUND AND AIM: It has been known that postural electromyographic (EMG) responses of ankle muscles to mechanical perturbations are modulated when warning cue is provided before a perturbation is applied. Specifically in previous studies we have observed that stretch reflex (SR) EMG component of tibialis anterior (TA) was markedly more variable than that of soleus (SOL) muscle with the prior warning. However, it remains unclear which information is more important between temporal and spatial information about an upcoming perturbation. The present study, therefore, was designed to test whether the SR response would be specifically dependent on prior cue concerning temporal or spatial information, and to further examine if there would be any muscle specific difference in the SR responses elicited by mechanical perturbations with different prior warning cues. METHODS: Ten healthy subjects were instructed to stand still with their feet on a platform. The platform was rotated quickly to toe-up (TU) or toe-down (TD) direction randomly with a velocity of 200 deg/s and amplitude of 10 deg. EMG activities were recorded from both sides SOL and TA muscles. The SR EMG component was analyzed in a time window ranging from 40ms to 150ms after the perturbation. This experiment consisted of four different conditions with respect to pre-information about perturbation, 1) no cue (No-Cue), 2) timing only (TIM), 3) direction only (DIR), and 4) timing and direction (TIM/DIR). Twenty TU and TD perturbations were applied in each condition. RESULTS: The results demonstrated that the TA SR responses to toe-down tilt in TIM and TIM/DIR conditions were reduced significantly as compared to that in No Cue condition. The TA SR in DIR condition, however, was comparable to that in No-Cue condition. What was more noteworthy was that the SR response itself was sometimes not induced in the TA in TIM and TIM/DIR condition (occurrence rate: TIM 43.5%, TIM/DIR 36.5%), whereas in the other conditions the sizable TA SR was induced by around 80% of TD perturbations (No Cue 79.0%, DIM 78.0%). On the contrary, no significant differences in the SOL SR to TU tilt were observed in the four conditions. We confirmed that the level of background EMGs were in similar levels in all conditions. CONCLUSIONS: The present result clearly demonstrated that effect of prior warning of upcoming postural perturbation on the SR responses was different between TA and SOL. Temporal prediction contributed to modulate TA SR more than spatial prediction, while this modulation was not observed in the SOL SR response. It was suggested from these results that timing information of upcoming postural perturbation is a key factor to set stretch reflex excitability in the ankle flexor muscle when keeping an upright stance, while the stretch reflex of ankle extensor is rather hard-wired with little influence from the higher nervous centers.

P1-B-71 Walking on a split-belt treadmill independently affects H-reflex modulation and muscles background activation

***Firas Massaad*[1], David Drijkoningen**[1], **Karen Jansen**[1], **Pieter Meyns**[1], **Oron Levin**[1], **Ilse Jonkers**[1], **Jacques Duysens**[1]
[1]KULeuven

Introduction: The Soleus H-reflex shows pronounced suppression in the swing phase, which is partly due to reciprocal inhibition from the tibialis anterior (TA) activity [1]. This modulation is further fine-tuned by spinal and supraspinal mechanisms such as in backward walking where the Soleus H-reflex in midswing is equal to or exceeds the value in stance despite large activity in the TA [2]. It was suggested that these changes reflect task uncertainties. If so, one would expect to find similar deviations for other walking conditions with this type of uncertainties as in split-belt walking which simulates limping [3]. Methods: Ten healthy young subjects walked forwards and backwards on a split-belt treadmill in 4 conditions: Tied-belt: both legs at 1 km/h (condition 1R1L) or at 4 km/h (4R4L) and Split-belt: right leg at 4 km/h (4R1L)

or left leg at 4 km/h (1R4L). The gait cycle was divided into 16 bins. Tibial nerve was stimulated to elicit an H-reflex (10 stim/bin). Soleus and TA background EMG was calculated one cycle before the stimulation at the same time of the H-reflex. Results: Split-belt walking increased the H-reflex in the fastest limb in forward walking (4R1L larger H-reflex than 4R4L) and in the slowest leg in backward walking (1R4L larger H-reflex than 1R1L). In forward walking, the H-reflex changes in the fastest limb were correlated to similar changes in Soleus background. However, in backward walking the H-reflex changes in the slowest limb were not always correlated to changes in the TA or Soleus background. Soleus and TA EMG background also failed to explain the H-reflex modulation during tied-belt backward walking at the fastest speed (4R4L), which was also experienced as the most challenging condition. Conclusions: Split-belt walking facilitated the H-reflex independently of muscle background in the Soleus or TA especially in backward walking. This facilitation did not simply follow changes in the level of excitability of the motoneuron pool or reciprocal inhibition. The modulation in these cases is likely due to other factors such as cortical input related to perceived instability [2]. Acknowledgements: KULeuven grant (OT/08/034), Research Fund K.U.Leuven, Van Goethem Brichant prize and postdoc FWO fellowship. References 1. Capaday et al. J Neurosci. 6(5):1308-13,1986. 2. Schneider et al. J Neurophysiol. 89: 648-56,2003.

P1-B-73 Larger somatosensory stimuli contribute to the improvement of motor control and motor skill acquirement

Satoshi Kasahara[1], **Hiroshi Saito**[1], **Mina Samukawa**[2]
[1]Japan, [2]Hokkaido University

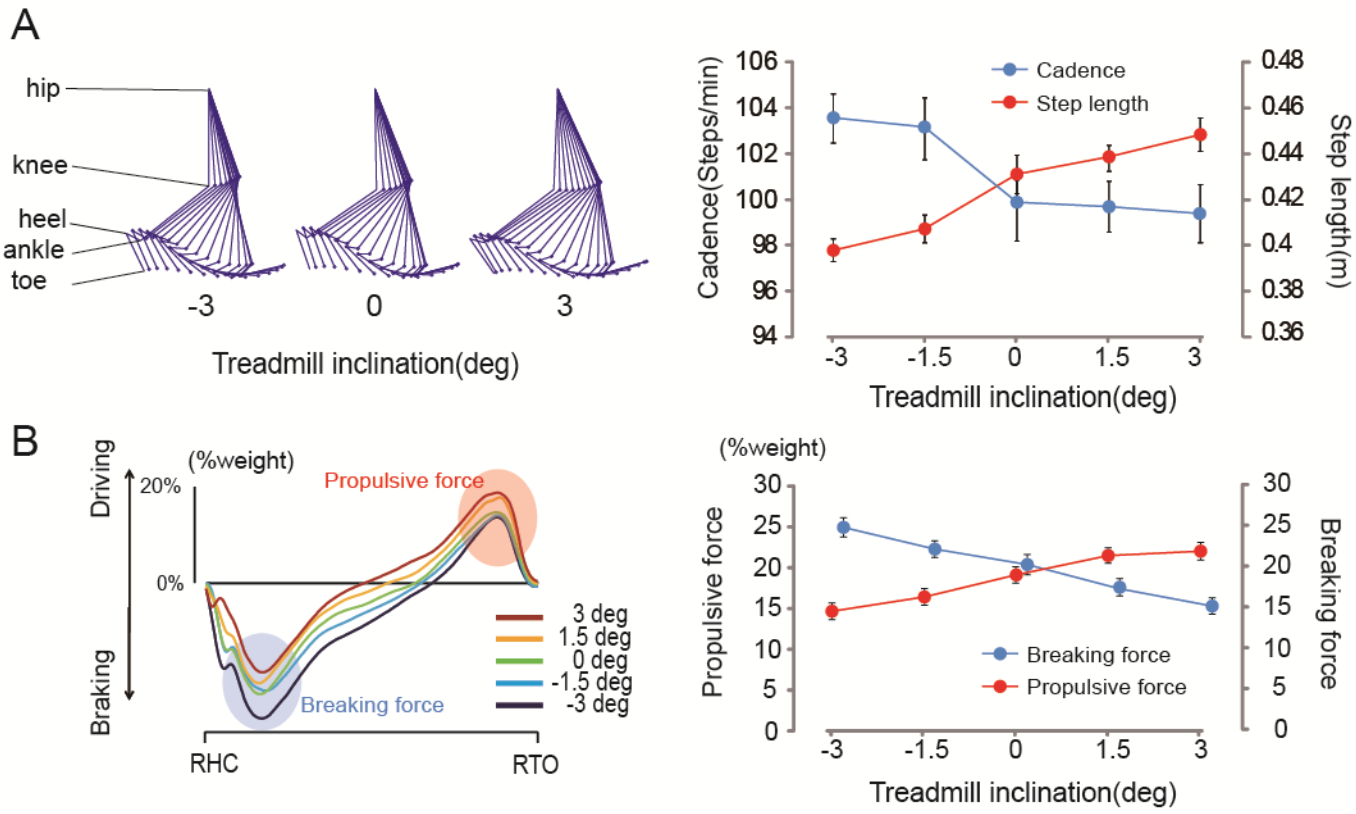
BACKGROUND AND AIM: Sensory information is very important for motor control and motor learning. Yet it is less obvious how the afferent input size - either small or large - contribute to the process of motor skills performance. The present study used two different weight loads to investigate the effect of somatosensory stimulus size on motor performance while standing. METHODS: Young healthy participants (n = 12) were asked to perform two weight shift tasks (light and heavy load stimuli) that were visually guided cyclically. Information about the participant's vertical ground reaction force (vGRF) and the target were displayed simultaneously and the participants, relying on visual information, were instructed to track the target and match their vGRF to the moving target. RESULTS: The spatial accuracy of the motor performance showed the positive effects during the large weight load stimulus. Although there was a positive correlation between motor performance lag and target frequency, the size of the weight load stimulus did not temporally affect motor performance. Also, spatially stable motor performance accuracy was learned faster with large weight load stimuli than in small weight load stimuli at faster target frequencies, and applying larger somatosensory stimuli at faster target frequencies may be a valid and feasible way for the compensatory improvement of motor skill acquirement. CONCLUSIONS: This study provides evidence of the importance of somatosensory information for motor control and motor learning by using a task with either small or large sensory stimuli. Especially, the larger somatosensory input was useful for improving the spatial accuracy of motor performance. A perceptible amount of sensory input through the feedback system is effective for the sensorimotor system, cognition, attention and awareness.

C - Exercise and physical activity

P1-C-77 Biomechanical characteristics of walking on a shallow slope

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

BACKGROUND AND AIM: During walking, even when we did not precisely percept the extent of slope or height of bump, steps and balance can be flexibly adjusted to external environments. Previous studies have demonstrated the characteristics of walking on a slope, those studies utilized relatively steep case. In the present study, we aimed to characterized gait behavior when the subjects walking on a shallow slopes. METHODS: Thirteen healthy subjects were asked to walk at 3.6km/h on treadmill at 5 different slopes (-3, -1.5, 0, 1.5, 3 degrees) during 30 seconds. During walking, three-dimensional motion analysis and muscle electromyographic (EMG) activity was recorded from six lower limb muscles (tibialis anterior (TA), soleus (Sol), medial gastrocnemius (mGas), lateral gastrocnemius (lGas), rectus femoris (RF), and biceps femoris (BF)). Ground reaction force (GRF) was estimated by using inverted dynamics model. RESULTS: The results demonstrated systematic modulations of the spatiotemporal parameters, joint angular of lower limbs, and ground reaction force due to the level of slope. Changes of the cadence (temporal) and step length (spatial) due to inclination angle showed tread-off manner. With increasing inclination angle, propulsive force gradually increase while breaking force decrease. CONCLUSIONS: Strategy for walking on upslope would be taking larger step with producing propulsive force. On the other hand, strategy for walking on downslope would shorten each step and taking much steps with producing breaking force. Given the fact that subjects cannot perceive slopes (/-1.5degrees) in the present study, the above mentioned alteration of the gait behavior modulation due to walking on slopes are environmentally-constraint induced pattern.



P1-C-79 Effects of Interactive Video-Game Based Exercise on balance in Diabetic Neuropathy

Shih-Ching Chen[1]**, Chien-Hung Lai**[1]**, Yu-Ru Wu**[1]**, Chih-Wei Peng**[1]**, Chun-Wei Kang**[1]**, Yu-Luen Chen**[1]
[1]Taipei Medical University

Shih-Ching Chen M.D., Ph.D.1,2, Chien-Hung Lai M.D., Ph.D.1,2, Yu-Ru Wu, P.T.1,2, Chih-Wei Peng P.T., Ph.D.1,2, Chun-Wei Kang M.D.1,2, Yu-Luen Chen Ph.D.3,4 1 Department of Physical Medicine and Rehabilitation, School of Medicine,

College of Medicine, Taipei Medical University 2 Department of Physical Medicine and Rehabilitation, Taipei Medical University Hospital 3 Catholic St. Mary's Medicine, Nursing and Management College 4 Department of Computer Science, National Taipei University of Education, Taipei, Taiwan Abstract Text BACKGROUND AND AIM: The issue of falls is one of a major public health concern with potentially serious implications. The consequences of falling include increased morbidity and health costs, fear of falling, and restriction of mobility and activity. Individuals with diabetic neuropathy (DN) may lead to a disturbance of normal gait pattern and an increase of the risk in falls. Exercise programs may be beneficial for individuals with DN. Previous studies showed that exercise programs could improve balance and mobility and quality of life, as well as increase strength. However, the participation rates are low because such exercises are often repetitive and unattractive. Interactive video game-based (IVGB) exercise has been shown to increase individuals' interest in performing related exercises. However, relevant literature provides only scattered evidence to support the positive effect of these IVGB exercises on the balance of individuals with DN. Therefore, the purpose of this study was to evaluate the effects of IVGB exercise on the balance of individuals with DN. METHODS: The participants of the study included the individuals with DN. The participants are divided into 2 groups. Group A underwent IVGB exercise during the initial 6 weeks, and was then suspended for the subsequent 6 weeks. Group B received no intervention during the first 6 weeks, and then participated in IVGB exercise during the following 6 weeks. The Berg Balance Scale, Modified Falls Efficacy Scale, Unipedal Stance Test, Timed Up and Go Test, Timed 10-Meter Walk Test and the Short Form (SF-36) Health Survey are evaluated before the experiment, after the initial 6 weeks, and at the end of the subsequent 6 weeks for all participants. RESULTS: Our results showed that IVGB exercises had positive effects on the balance of individuals with DN. CONCLUSIONS: IVGB exercise may be a promising option to improve balance or performance of individual with DN. Keywords: Interactive Video-Game Based Exercise, Diabetic Neuropathy, Balance, Berg Balance Scale, Unipedal Stance Test, Timed Up and Go Test, Modified Falls Efficacy Scale, Timed 10-Meter Walk Test, the Short Form (SF-36) Health Survey.

P1-C-81 The Effect of a Nintendo® Wii Exercise Intervention on Gait in Older Adults

Anna Lee[1], **John Biggan**[1], **Wyn Taylor**[1], **Ketaki Deo**[1], **Christopher Ray**[1]
[1]University of Texas at Arlington

BACKGROUND AND AIM: Falls are one of the leading causes of serious injury and accidental death in adults over 65 years of age. Approximately one third of adults over the age of 65 fall each year and half of these falls occur while walking. Gait is a sensitive predictor of fall risk and may be improved through exercise interventions. Advances in technology have attempted to provide alternatives to traditional exercise through the use of interactive video games with biofeedback that are more engaging than traditional exercise programs. However, the use of interactive video games with biofeedback to reduce fall risk in older adults has not been well explored. Therefore, the object of this study was to compare changes in spatiotemporal gait parameters following exercise interventions using either an interactive video game (Nintendo® Wii) or a traditional seated group exercise intervention in older, community-dwelling adults. METHODS: Eighty-two older adults (Female: 58), age 65 to 93 (75.2 ± 6.6yr) were randomly assigned to either a traditional group fitness or Wii group. Both 10-week interventions involved 45 minute exercise sessions (3 days/week). Spatiotemporal gait parameters were measured pre- and post-intervention. Of interest were gait velocity, stride length, cadence, swing time, double support time and the Coefficients of Variation (CV) for stride length and swing time. RESULTS: Both groups showed significant improvements in velocity, stride length, cadence, swing time and double support time ($p<.05$). However, there was no significant change for either group in CV stride length and CV swing time ($p>.05$). CONCLUSIONS: New methods for delivering exercise interventions offer promising strategies for reducing age-related gait decline and fall risk in older adults. An intervention using the Nintendo® Wii positively impacted important

gait parameters in such a way as to reduce fall risk in older adults and the improvements were similar to that of a traditional seated exercise. This data suggests that interventions based on new technology, such as the Nintendo® Wii, provide an inexpensive and enjoyable alternative to traditional exercises for fall risk reduction older adults

P1-C-83 The influence of taping on Kendo player

Jing-Min Liang[1], **Chun-Hao Huang**[1], **Wen-Lan Wu**[1], **Jing-Min Liang**[1]
[1]Kaohsiung Medical University

BACKGROUND AND AIM:Kendo is a kind of explosive movement. The rapid changing steps to move backward and forward (eccentric contraction and concentric contraction) while attack may result in Achilles tendon injury or Achilles tendon rupture. Therefore, the aim of this study was to examine the tapping effect on the movement of backward shuffle stepping. METHODS:Twelve college athletes were recruited in this study. Each participant was required to finish hitting and attacking movement for 5 trails before tapping. Then, athletic tape was applied to ankle, Achilles tendon, and Kinesio Tex Tape on Achilles tendon for each subject. Each type of tapping should do 5 trials. 3D motion capture system and force plate system were used to capture kinematic and kinetic data. Additionally, Electromyography was used to detect muscle activity signal. 3D motion capture system, force plate system and Electromyography were collecting data simultaneously. RESULTS: Compared with Achilles Tendon taping (Kinesio Tex Taping), athletic taping on Achilles Tendon resulted in a reduction in peak Achilles tendon force in Heel Down Phase (p=.04). EMG amplitude on Soleus muscle was significant higher in ankle athletic taping compared to athletic taping and Kinesio Tex taping on Achilles Tendon (p=.038; p=.033, respectively) during concentric contraction phase. Kinesio Tex Tapping on Achilles tendon showed significantly decrease in duration between eccentric and concentric phase compared with no tapping (p=.035). The EMG amplitude in eccentric contraction of Gastrocnemius muscle was significant lower on Kinesio Tex Taping on Achilles tendon than athletic tape taping on Achilles tendon (p=.019). CONCLUSIONS: To improve performance, it is suggested to use Kinesio Tex Taping on Achilles tendon or athletic tape taping on ankle. However, these two tapping methods are not suggested to athletes who usually injuries on Achilles tendon because it tend to increase Achilles tendon force after such taping. If the Achilles tendon was injured, we suggest using athletic tape on Achilles tendon.

P1-C-85 The predictors of improvement in walking ability in patients 1 month after total knee arthroplasty

Masashi Taniguchi[1], **Kazuki Uemura**[2], **Shoji Maegawa**[2], **Yuka Kojima**[1], **Chieko Ohzaki**[1], **Masato Kugo**[1], **Taku Kawasaki**[1]
[1]Division of Physical Therapy, Rehabilitation Units, Shiga University of Medical Science Hospital, [2]Graduate School of Medicine, Nagoya University

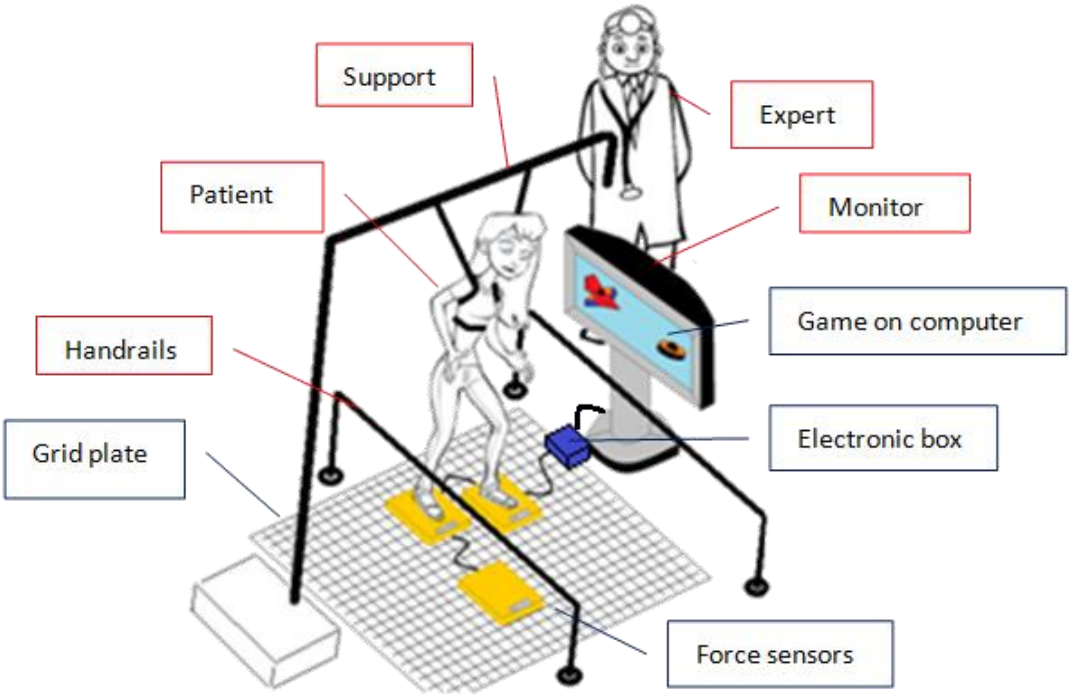
BACKGROUND AND AIM: The present study aimed to examine predictors of improvement in walking ability in patients after total knee arthroplasty (TKA) and to present evidence of physical therapy in this improvement. METHODS: The study included 121 patients undergoing primary unilateral TKA. Knee extensor strength, knee flexion range of motion (ROM), the sit-to-stand test (STS) results, weight-bearing asymmetry (WBA), and the Timed "Up & Go" (TUG) measurements were evaluated before and 1 month after unilateral TKA. The difference between these parameters before and 1 month after surgery were calculated to examine the degree of improvement after unilateral TKA and physical therapy. The amount of physical activity (average gait steps/day) was measured using a pedometer during each period (postoperatively at 3 and 4 weeks). At 1 month postoperatively, a stepwise multiple logistic regression analysis was performed using TUG measurements as a dependent variable and age, sex, the presence or absence of contralateral TKA, body mass index, pain, physical activity, and the differences in values of knee extensor strength, knee flexion ROM, STS, and WBA as independent variables. In addition, the preoperative TUG measurements were used for the

independent variables to compensate for the baseline. The patients were divided into 2 groups according to the TUG measurements at 1 month postoperatively based on a previous study: the good walking ability group (<10.2 s, n = 67) and the poor walking ability group (¡Ý10.2 s, n = 54). Receiver operating characteristic (ROC) curve analysis was used to identify a cutoff point for classifying the participants into the 2 groups. RESULTS: A stepwise multiple logistic regression analysis was performed by selecting 5 factors (preoperative TUG measurement, physical activity at 4 week postoperatively, STS test results, WBA, and age) as significant variables affecting 1-month postoperative TUG measurements. Moreover, ROC curve analyses revealed that the good walking ability after TKA was more accurately predicted by physical activity at 4 week postoperatively (cutoff point = 2882 steps, sensitivity = 62.9%, specificity = 72.9%, area under the curve = 0.74). CONCLUSIONS: The findings indicated that considerable physical activity and the improvement in STS test results and WBA were important in predicting improvement in walking ability after postoperative physical therapy. In particular, physical activity of approximately 2900 steps/day may have contributed to the improvement in walking ability after TKA.

P1-C-87 A Pilot Study of a Novel Arrangeble Light Weight Force Sensors Systems for Balance Training.

Suppachet Panya[1], **Prakarnkiat Youngkong**[1]
[1]King Mongkut's University of Technology Thonburi

BACKGROUND AND AIM: Standing balance deficit and gait instability is a common problem of stroke patents and also community dwelling elderly. Falling is a possible consequence which can be life threatening at times. High repetitions and task specific training are the currently accepted as the best method to re-train functions. Systematic reviews have showed that exercise may improve balance and prevent falling. It is also well accepted that feedback enhance sport performances. In this study, we aim to see if weight shifting training on a set of force sensor embedded mats in combination with custom designed games would result in improved motivation for training and better weight shifting performance during the exercises. METHODS: The magnitude of weight shifting of 10 persons with known balance impairments is calculated from the ratio of instantaneous weight bearing during the exercises. The average and standard deviation of maximal shifting to each leg during the voluntary self paced exercise were compared to those during computer games guided ones. Paired t-test showed significant difference of weight shifting magnitude in true lateral as well as diagonal foot mats arrangements. RESULTS: Arrangeable mats with force sensors in combination with computer games interface is an effective way to promote performance during balance training. CONCLUSIONS: Further study should evaluate long term effects or explore games design which may results in even greater facilitation.



P1-C-89 Effects of Interactive Video-Game Based Exercise on balance in Parkinson's disease

Chien-Hung Lai[1], **Hou-Chang Chiu**[1], **Shih-Ching Chen**[2], **Yu-Ru Wu**[1], **Chih-Wei Peng**[1], **Ming-Jun Lai**[1], **Yu-Luen Chen**[3]
[1]Taipei Medical University Hospital, [2]Shin Kong WHS Memorial Hospital, [3]Nursing and Management College

Chien-Hung Lai M.D., Ph.D.1,2, Hou-Chang Chiu M.D.3, Shih-Ching Chen M.D., Ph.D.1,2, Yu-Ru Wu, P.T.1,2, Chih-Wei Peng P.T., Ph.D.1,2, Ming-Jun Lai M.D. 1,2, Yu-Luen Chen Ph.D.4,5 1 Department of Physical Medicine and Rehabilitation, School of Medicine, College of Medicine, Taipei Medical University 2 Department of Physical Medicine and Rehabilitation, Taipei Medical University Hospital 3 Neurology, Shin Kong WHS Memorial Hospital, Taipei, Taiwan 4 Catholic St. Mary's Medicine, Nursing and Management College 5 Department of Computer Science, National Taipei University of Education, Taipei, Taiwan Abstract BACKGROUND AND AIM: Parkinson's disease (PD) is a progressive neurologic disorder and is the second most common neurodegenerative disease affecting the older adults. PD commonly has progressive postural instability, tremor, stiffness and slowed movement, and sometimes accompanies other neurologic, cognitive, and emotional symptoms. Although PD sporadically occurs and is variable in its presentation, the effects of PD on neurologic function consistently contribute to increasing disability over time. The consequences of PD often result in limited participation in physical activity, which, in turn, may reduce functional status, restrict mobility and activity, and contribute to secondary health complications and cost. Exercise programs may be beneficial for individuals with PD. Previous studies showed that exercise programs could improve balance and mobility and quality of life, as well as increase strength. However, the participation rates are low because such exercises are often not sufficiently interesting and attractive Interactive video-game based (IVGB) exercise has been shown to increase individuals' interest in performing related exercises. However, relevant literature provides only scattered evidence to support the positive effect of these IVGB exercises on the balance of PD individuals. Therefore, the purpose of this study was to evaluate the effects of IVGB exercise on the balance of individuals with PD. METHODS: The participants of the study included community-living individuals with PD. The participants are divided into 2 groups. Group A underwent IVGB exercise during the initial 6 weeks, and was then suspended for the subsequent 6 weeks.

Group B received no intervention during the first 6 weeks, and then participated in exercise during the following 6 weeks. The Berg Balance Scale, Modified Falls Efficacy Scale, Unipedal Stance Test, Timed Up and Go Test, Timed 10-Meter Walk Test and the Short Form (SF-36) Health Survey are evaluated before the experiment, after the initial 6 weeks, and at the end of the subsequent 6 weeks for all participants. RESULTS: Our results showed that IVGB exercises were beneficial on the balance of individuals with PD. CONCLUSIONS: IVGB exercise may be a promising option to improve balance or performance in the individuals with PD.

P1-C-91 Lower limb movement modifications affect trunk and pelvis in females with patellofemoral pain

Valentina Graci[1], **Gretchen Salsich**[2]
[1]University of Maryland School of Medicine, [2]Saint Louis University

BACKGROUND AND AIM: Poor neuromuscular control of the trunk predicts knee injuries (Zazulak et al 2007). However the relationship between trunk and pelvis movement and faulty lower limb kinematics is unclear particularly in individuals with patellofemoral pain (PFP). The aim of this study was to investigate if/how during single leg squat alterations of the lower limb movement pattern would impact pain levels and trunk, pelvis, and lower extremity kinematics. METHODS: Ten females with PFP greater than 2 months duration (mean (SD) age: 20.80 (1.99) yrs, height: 166.57 (5.15) cm; body mass: 60.96 (6.89) kg) and demonstrating observable medial collapse during a single limb squat test participated. Kinematic data (120Hz) were collected using an 8-camera 3D-motion capture system (Vicon Nexus). A 6-DoF model was used. Subjects performed a single leg squat 3 times under 3 conditions: preferred (P), exaggerated (E) medial collapse (instructed to let their knee fall in), and corrected (C) medial collapse (instructed not to let their knee fall in). After preferred, the order of test conditions was randomized. Three-dimensional hip, knee, trunk relative to lab and pelvis relative to lab angles were calculated at peak knee flexion (PKF). Pain was recorded after each condition using a visual analog (100 mm) scale. Pain level was expected to decrease in C compared to P and increase in E compared to P, so that a 1-tailed-T-test was used. Comparisons of hip, knee, trunk and pelvis angles between P and E and between P and C were determined with 2-tailed-T-tests ($p< 0.05$). RESULTS: Compared to P, in E subjects had greater hip medial rotation ($p<0.001$), knee abduction ($p=0.005$), and pelvis rotation toward the weight-bearing limb ($p=0.002$, Fig.1). Compared to P, in C, subjects had decreased hip adduction ($p=0.006$), knee lateral rotation ($p=0.06$) and increased trunk ($p=0.055$) and pelvis lateral flexion toward the weight-bearing limb ($p=0.016$, Fig 1). Pain increased in E compared to P (mean (SD) E: 30.6 (16.75) mm, P 23.5(19.5) mm $p<0.04$) while in C compared to P, the pain difference did not reach significance (C: 20.3(16.2) mm $p<0.16$). CONCLUSION: Instructing females with PFP to alter their faulty lower limb movement pattern indirectly modifies trunk and pelvis kinematics. The trunk and pelvis lateral flexion on the weight bearing limb found in C may have shifted the ground reaction force vector laterally to the knee joint center creating a valgus moment at the knee (Powers 2010). Hence the trunk and pelvis lateral flexion on the weight-bearing limb found in C might explain the lack of pain decrease in C. This finding may suggest the instruction to 'correct' dynamic knee valgus during a single leg squat might need to be accompanied by specific instructions to control trunk and pelvis movement in order to decrease pain. On the other hand the lack of pain decrease in C might be because the kinematics that changed in C was not necessarily related to pain.

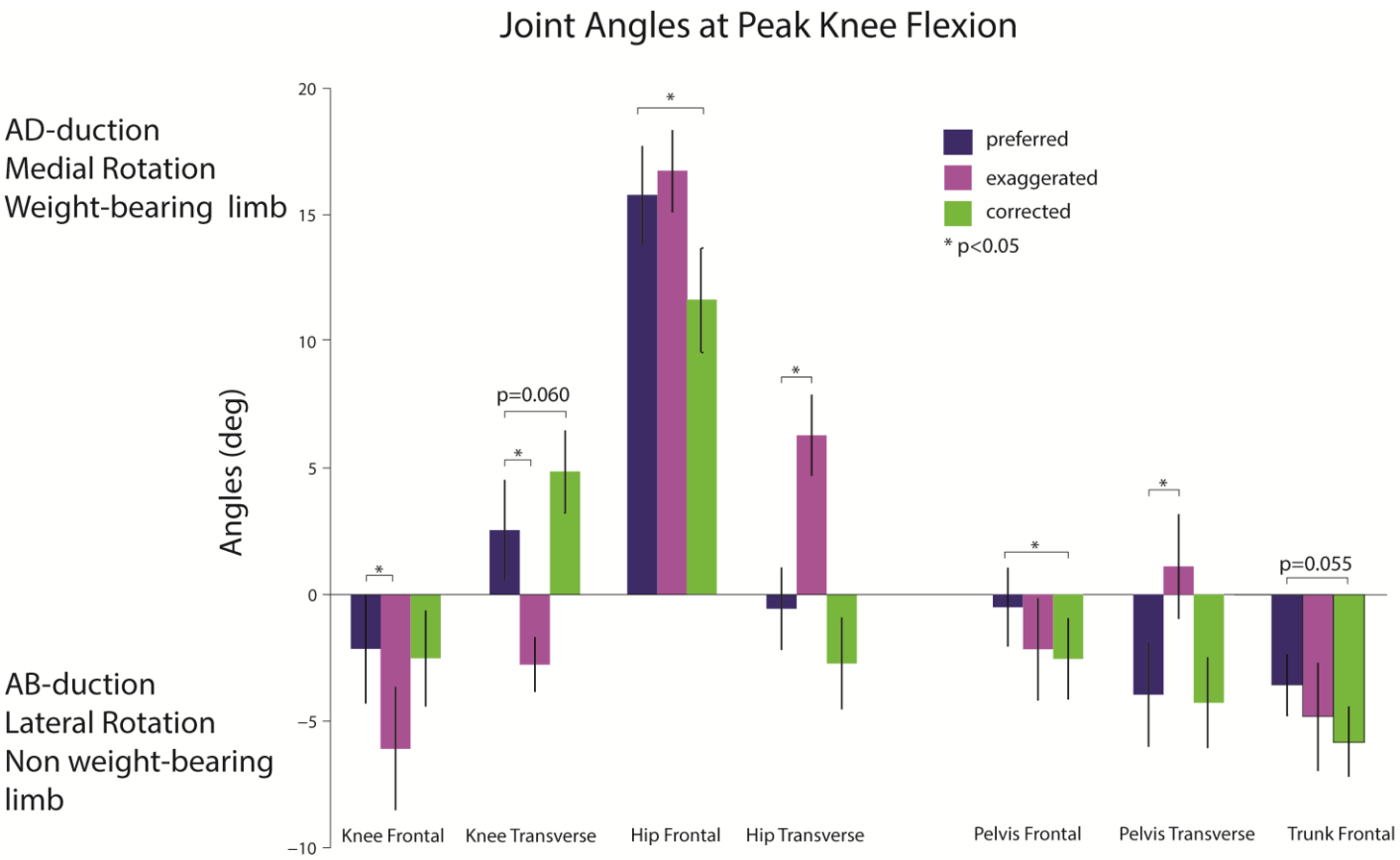


Fig 1. Mean (SD) of the kinematic variables that showed significant or close to significant statistical differences across conditions.

D - Vestibular function and disorders

P1-D-93 Correlations between foam posturography and vestibular-evoked myogenic potential tests in Meniere's disease

Bing-Yi Lin[1], **Chuan-Yi Lin**[1], **Shou-Jen Wang**[1], **Yi-Ho Young**[1]
[1]National Taiwan University Hospital

BACKGROUND AND AIM: This study adopted foam posturography coupled with inner ear test battery including audiometry, and cervical vestibular-evoked myogenic potential (cVEMP), ocular VEMP (oVEMP) and caloric tests in patients with Meniere's disease to investigate the relations between them. METHODS: Fifty patients with unilateral definite Meniere's disease were enrolled. All patients underwent audiometry, and caloric, oVEMP, and cVEMP tests. In addition, posturography was also performed under four conditions: A (firm surface, eyes open), B (firm surface, eyes closed), C (foam pad, eyes open) and D (foam pad, eyes closed). Romberg quotient (RQ) was measured as the value from eyes closed divided by that from eyes open. RESULTS: No correlation existed between Meniere stage and RQ measured with foam pad. Mean RQ of the sway area on foam pad in Meniere's patients with abnormal oVEMPs (1.75 ± 0.95) was significantly larger than 1.20 ± 0.70 in those with normal oVEMPs. However, neither cVEMP nor caloric test results were associated with RQ on foam pad (p>0.05). Further, the area under the receiver operating characteristic (ROC) curve of

the RQ of sway area on foam pad in discrimination between normal and abnormal oVEMP test was 0.65 (95% CI 0.51 ~ 0.79, p<0.05), implying that RQ of the sway area on foam pad may serve as a significant predictor for abnormal oVEMP test. CONCLUSIONS: By removing or reducing both visual and somatosensory inputs from foam posturography, the remaining vestibular cue, represented as RQ of sway area on foam pad, may reflect utricular function.

P1-D-95 Walking balance tests to screen for vestibular disorders

Helen Cohen[1], **Jacob Bloomberg**[2], **June Kampangkaew**[1], **Ajitkumar Mulavara**[3], **Brian Peters**[4], **Natalia Ricci**[5], **Haleh Sangi-Haghpeykar**[1], **Robert Williamson**[1], **Jeffrey Vrabec**[1]
[1]Baylor College of Medicine, [2]NASA/ Johnson Space Center, [3]Universities Space Research Association, [4]Wyle Science, Technology and Engineering Group, [5]Federal University of Sao Paulo

Background. Balance is a multifactorial sensorimotor skill. Although the meaning of balance tests for diagnostic purposes is often unclear balance is often examined during screening for vestibular disorders because it is easily tested. In two sets of experiments we have examined the usefulness of tandem walking and the Fukuda step test, for screening people suspected of having vestibular disorders. Methods. Experiment 11 used two groups of people, normals and patients known to have vestibular disorders, who did not have musculoskeletal problems, peripheral neuropathy or other otologic problems. They were tested on tandem walking for 10 steps with eyes open and with eyes closed. Dependent measures were the number of consecutive heel-to-toe steps taken without stepping out of line and kinematic variables. Experiment 2 used another set of normal controls and patients with vestibular disorders. Those groups were more heterogeneous and had some musculoskeletal problems, peripheral neuropathy and otologic disorders. They were tested on tandem walking, eyes open and eyes closed; the dependent measure was the number of steps taken. They were also tested on the Fukuda step test, with small steps walking in place with eyes closed, and with large steps marching in place with eyes closed. Dependent measures were the number of steps taken up to 20, the distance walked forward, the distance walked laterally and the degrees turned away from straight ahead. Results. Experiment 1 showed that normals took significantly more steps than patients with eyes open or closed and kinematic measures indicated greater instability in patients. ROC analyses, however, were weak and sensitivity and specificity were poor. Preliminary analyses from Experiment 2 have been performed. The findings to date replicate the finding that on tandem walking normals take significantly more steps than patients, however the data are highly variable. On the Fukuda step test most subjects move forward and laterally, and the groups do not differ significantly. The degree of turning during stepping, but not marching, indicates slight but significant differences between the groups. The data, however, are highly variable and more data must be collected for ROC analyses and determination of sensitivity and specificity. Conclusions. These data suggest that these easily administered, widely used tests do show significant differences between normals and patients. Their high variability, however, suggests that they might not be useful for screening patients in the clinic or for epidemiologic studies. Supported by NIH grant R01 DC009031 and the National Space Biomedical Research Institute through NASA NCC 9-58. We thank the staff of the Center for Balance Disorders, Baylor College of Medicine, for their assistance. 1) Cohen HS, Mulavara AP, Peters BT, Sangi-Haghpeykar H, Bloomberg JJ. Tests of walking balance for screening vestibular disorders. J Vestib Res 2012: 22;95-104

P1-D-97 Balance Symptoms at Referral of Patients With Peripheral Vestibular Disease

Kathrine Jauregui-Renaud[1], **Aralia Gutierrez-Marquez**[1], **Leticia Viveros-Rentería** [1], **Verónica Ramos-Toledo** [1], **Fátima Gómez-Alvarez**[1]
[1]Instituto Mexicano del Seguro Social

To assess the combination of balance symptoms reported by patients with peripheral vestibular disease, during the year just before their referral at a specialized clinic, and to compare these symptoms with those perceived by subjects with no history of vestibular disease, adjusted by their general characteristics and their report of nonspecific symptoms of common mental disorders. 282 patients and 282 controls were selected among the volunteers who, during their first visit to the clinic, reported their balance symptoms using a 9 item standardized questionnaire (Jáuregui-Renaud 2003), along with their nonspecific symptoms of common mental disorders (Goldberg 1988; Calderón-Narváez 1999). None of them had evidence or medical record of middle ear or retinal disease, migraine, neurological or psychiatric disorders, autoimmune or autonomic diseases. Vestibular patients reported an evolution time from 2 days to 28 years (median 8 months). Among the balance symptoms, the most frequently reported were: dizziness (93%), vertigo (89%), instability when moving the head rapidly (86%) and instability when changing posture (79%); just 24% reported frequent falls. In controls, the most frequent symptoms were dizziness (16%) and instability when moving the head rapidly (12%); just 1% reported frequent falls. A discriminant function analysis showed that the combination of 7 of the 9 items allowed the correct classification of 93.9% of the patients and 96.4% of the controls ($p<0.0001$); while the total score allowed the classification of 94.3% patients and 99.3% controls ($p<0.0001$). The report of frequent stumbles and falls correlated with the report of nonspecific symptoms of common mental disorders (Spearman´s r=0.2P1-0.24, $p<0.001$); in addition, the report of frequent falls correlated with the time of evolution of the balance symptoms (Spearman´s r=0.19, $p<0.001$). Multiple regression analysis showed influence on the total score from ($R2 =0.18$, $p<0.0001$): systemic high blood pressure (beta=0.20, 95%C.I. 0.12-0.28), dyslipidemia (beta=0.12, 95%C.I. 0.05-0.20) and the report of nonspecific symptoms of common mental disorders (beta=0.28, 95%C.I. 0.20-0.36). Conclusions. Patients with peripheral vestibular disease may be referred at a specialized clinic after several months since the beginning of their symptoms. Circa 10% of them may not report vertigo, but a combination of balance symptoms, with specific triggers for instability. Those with a longer time of evolution may report frequent falls. Even if co-morbidities may have an influence on the report of balance symptoms, the combination of symptoms reported through a standardized questionnaire could be useful as a screening tool to identify patients who may need vestibular evaluation.

P1-D-101 Balance control in phobic postural vertigo

Klaus Jahn[1], **Roman Schniepp**[1], **Sigbert Krafczyk**[1], **Thomas Brandt**[1], **Max Wühr**[1]
[1]University of Munich

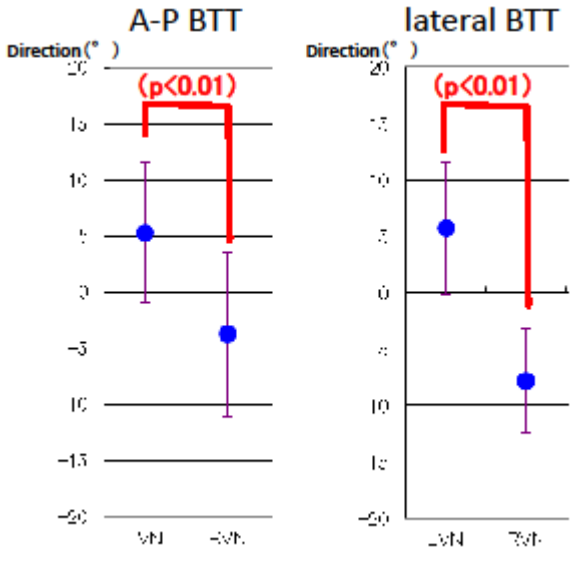
BACKGROUND AND AIM: Phobic postural vertigo (PPV) is characterized by subjective dizziness and postural imbalance. Changes in the postural control strategy may explain the disturbed postural control. Here we apply stabilogram diffusion analysis (SDA) to examine the characteristics and modes of interaction of open- and closed-loop processes that make up the postural control scheme in PPV. METHODS: Twenty patients with PPV and 20 age-matched healthy controls were recorded on a stabilometer platform with eyes open and with eyes closed. Spatio-temporal changes of the center of pressure (CoP) displacement were analyzed by means of SDA and complementary CoP amplitude measures. RESULTS: (1) Open-loop control mechanisms in PPV were disturbed because of a higher diffusion activity ($p< 0.001$). (2) The interaction of open- and closed-loop processes was altered in that the sensory feedback threshold of the system was lowered ($p= 0.010$). These two changes were comparable to those observed in healthy subjects during more demanding balance conditions such as standing with eyes closed. CONCLUSIONS: These data indicate that subjective imbalance in PPV is associated with objective changes in the coordination of open- and closed-loop mechanisms of postural control. Patients with PPV use sensory feedback inadequately during undisturbed stance. These changes are compatible with increased use of anti-gravity muscles and co-contraction during stance.

P1-D-103 The age difference of postural sway under the different eye-to-object distance and downward gazing

***Osamu Aoki*[1], Yoshitaka Otani[2], Kazuhisa Domen[3]**
[1]Shijonawate Gakuen University, [2]Kobe International University, [3]Hyogo College of Medicine

Aim: Some studies have reported that a short eye-to-object distance decreased upright standing postural sway. And it was also reported that the downward gazing increased postural sway. The eye-to-object distance in a downward gaze is relatively shorter than the distance between the eye and a distant object, and we postulated that the downward gazing would decrease postural sway. Our study aimed to investigate the effects of eye-to-object distance and downward gazing on postural sway in elderly and young individuals. Methods: Fourteen healthy elderly individuals and 14 healthy young individuals participated in this study (mean age: elderly group, 65.6 ± 3.1 years; young group, 25.5 ± 2.8 years). Upright standing postural sway for 30 s was measured using a force plate at a 50-Hz sampling rate. Root mean square (RMS) values of anteroposterior (A-P) and mediolateral (M-L) center of pressure displacement were measured under the following 5 visual conditions: eyes gazing 600 cm ahead in a straight direction (the 600-cm condition), eyes gazing 150 cm ahead in a straight direction (the 150-cm condition), eyes gazing downward (the downward condition), eyes gazing straight ahead without vision (the closed-forward condition), and eyes gazing downward without vision (the closed-downward condition). Results for the 600-cm and 150-cm conditions were compared to determine the effects of eye-to-object distance. To determine the effects of downward gazing, results for the downward condition was compared with those for the 600-cm and 150-cm conditions. To determine the closed-eye effect, the following conditions were compared: the 600-cm and closed-forward conditions, 150-cm and closed-forward conditions, and the downward and closed-downward conditions. The Wilcoxon signed-rank test was used to perform these comparisons, and Benjamini-Hochberg correction was applied to control statistical significances. Results: No statistical differences were observed in M-L RMS between the 600-cm and 150-cm conditions in either group. In the elderly group, the downward condition increased M-L RMS compared with the 600-cm and 150-cm conditions ($p = 0.011$, $r = 0.48$ and $p = 0.001$, $r = 0.65$, respectively). In contrast, the downward condition decreased M-L RMS compared with the 600-cm and 150-cm conditions in the young group; however, these differences were not statistically significant ($p = 0.056$; $r = 0.35$ and $p = 0.025$; $r = 0.41$, respectively). In the elderly group, the closed-forward condition increased M-L RMS compared with the 600-cm and 150-cm conditions ($p = 0.001$; $r = 0.70$ and $p = 0.001$; $r = 0.61$, respectively), whereas no such differences were found in the young group. Conclusion: We observed that the downward and closed-forward conditions increased postural instability in the elderly individuals compared with forward gazing. However, none of the visual conditions influenced postural instability in the young individuals, indicating that eye-to-object distance and downwar

P1-D-105 Changes in the tracking axis of the Body Tracking Test among healthy people and patients with vestibular neuronitis



***Tomoe Yoshida*[1], Masahiko Yamamoto[1], Yuya Tamura[1], Toshitake Tanaka[1], Fuyuko Ikemiyagi[1], Yoshihiro Ikemiyagi[1], Mitsuya Suzuki[1]**
[1]Toho University Sakura Medical Center

BACKGROUND AND AIM: We have reported the use of the Body Tracking Test (BTT), which is a method for quantitatively evaluating dynamic body balancing function, and how the body center moves during tracking . METHODS: The subjects were 719 healthy participants with no history of dizziness or balance

disorders and 78 patients with vestibular neuronitis?i42 patients with right vestibular neuronitis and 36 patients with left vestibular neuronitis?j. We investigated differences in the tracking axis depending on the affected side during the period of gaze nystagmus (first time) in vestibular neuronitis. For visual stimulus, we used a constant-speed antero-posterior (A-P) stimulus BTT and a constant-speed lateral BTT. BTT analysis involved principal axis analysis, in which the principal axis was the first principal component according to a principal component analysis technique. The axis tilt in the principal axis direction was assessed by calculating the coordinate Y-axis and X-axis tilt. A population mean test (t-test) and Wilcoxon T test were used as the statistical methods. RESULTS: In the antero-posterior (A-P) BTT, subjects of all ages exhibited an angle of tilt in the clockwise direction (the "plus" direction), with the velocity vector. In the lateral BTT, we observed that the subjects tracked with a tilt in the counter-clockwise direction (the "minus" direction), with the velocity vector. In left vestibular neuronitis, positive inclination angles and clockwise deviation were observed in both the antero-posterior (A-P) BTT and the lateral BTT. In right vestibular neuronitis, negative deviation angles and counterclockwise bias were observed in both A-P BTT and lateral BTT. We confirmed that at 1 month after onset, patients with vestibular neuronitis returned to the primary axis inclination observed in healthy people. CONCLUSIONS: There was a significant difference in the inclination angles of patients with left and right vestibular neuronitis. This suggests that the principal inclination axis in vestibular neuronitis is related to the left-right lesion deviation phenomenon or the involvement of uneven muscle tone.

P1-D-107 Two cases with Wernicke's encephalopathy

Yasuo Ogawa[1], **Nobuhiro Nishiyama**[1], **Taro Inagaki**[1], **Koji Otsuka**[1], **Mamoru Suzuki**[1]
[1]Tokyo Medical University

Introduction Wernicke's encephalopathy is characterized by a subacute onset of confusion, ophthalmoplegia and ataxia of stance and gait. It is caused by thiamine deficiency and is commonly encountered in alcoholics. The oculomotor findings in Wernicke's encephalopathy include weakness of abduction, gaze-evoked nystagmus, internuclear ophthalmoplegia, and central vertical nystagmus. We encountered 2 cases with gaze-evoked nystagmus and gait ataxia that were diagnosed as Wernicke's encephalopathy. We report the features of neuro-otological findings including nystagmus and their clinical course. Case reports Case 1. A 59-year-old woman with laryngeal cancer had difficulty in eating during radio-chemotherapeutic treatment. Transfusion without vitamins had been given for 40 days, and then dizziness on walking and gaze-evoked nystagmus developed. The equilibrium function tests showed a saccadic pattern of ETT, inhibition of OKP and reduced caloric response, but normal VEMP.?@ Symmetrical high-intensity lesions from the thalamus to the brain stem were observed on MRI. Since Wernicke encephalopathy was suspected, administration of vitamin B1 was started. Four days later, dizziness improved and appetite was increased. The ETT, OKP and MRI findings improved. Case 2. A 45-year-old man was transported to the emergency department in our hospital with disturbed consciousness. After admission, he had recovered consciousness, but vertigo and gait disturbance persisted. Gaze evoked nystagmus was observed. The equilibrium function tests showed a saccadic pattern of ETT, inhibition of OKP and reduced caloric response. Symmetrical high-intensity lesions from the thalamus to the brain stem were observed on MRI. Since Wernicke encephalopathy was suspected, administration of vitamin B1 was started, but the nystagmus and gait disturbance persisted. Discussion Pathologic changes had been reported in the vestibular nuclei of the patients with thiamine deficiency . Most of the clinical findings most likely occur secondary to thiamine-dependent enzyme loss in the brain stem and cerebellum. Only after prolonged and /or repeated episodes of deficiency irreversible structural changes may occur. If Wernicke's encephalopathy is suspected, administration of thiamine should start as soon as possible.

E - Orthopedic diseases and injuries

P1-E-109 Spatial perception Space perception and motor behavior in young adults with scoliosis

***Jensuh Chern*[1], Chia-Chi Gao**[1], **Lai Po-Liang**[2], **Chi-Wen Lung** [3], **Chia-ching Li** [1], **Szu-Yu Chen** [1]
[1]Chang Gung University, [2]Lin kuo Chang Gung Memorial Hospital , [3]Asia University

Background: Idiopathic scoliosis (IA) is the most common type of scoliosis and affects girls more than boys during their teenager years. Genetic, musculoskeletal or neural abnormality or dysfunction was shown to be associated with IA. Patients with IA subjectively report having problem with spatial perception. Studies also showed that their motor behavior while walking was different from age matched normal subjects. The relationship between visual spatial perception performance and motor behavior in patients with AI while walking is yet to be established. Understanding the relationship can clarify the speculation: Does the origin of this spinal derangement associate with central processing of spatial information? The present study is aimed to investigate the relationship between motor behavior and spatial perception in patients with AI and age matched normal subjects. Methods: Two groups of subjects, 20 scoliosis and 20 normal, will be recruited and measured of their motor behavior while standing and walking and of spatial perception performance. Motor behavior is measured by a foot-pressure measurement system which records the center of pressures (CoP). Amount of CoP sway is used to quantify motor behaviors while standing and individual foot CoP roll-over pattern is used to quantify motor behaviors while walking. Visual spatial perception is measured by line bisection test, bell cancellation and spatial relation part of Differential aptitude test (DAT). Cop sway is measured while patients were asked to stand two postures (standard stance and tandem stance) for 30s each. Patients were asked to walk in comfortable speed while the CoP roll-over pattern was measured. Results: At the time of writing up this abstract, 20 IS subjects but only one normal subject were measured. When comparing one IS with age matched normal, IS and normal subjects is not only different in CoP sway, and CoP roll-over pattern but also different in visual spatial perception. Conclusions: IS is not only associated with changes in motor behavior while postural control but also spatial perception dysfunction. Long term follow-up of the progression of IS, motor behavior while controlling their posture and visual perception performance is needed to elucidate the possible CNS origin of IS problems.

P1-E-111 Gait parameters and knee adduction moment during walking in subjects with knee osteoarthritis

***Yui Takagi*[1], Hiroshige Tateuchi**[2], **Yusuke Goto**[2], **Naoki Otsuka**[2], **Masashi Kobayashi**[3], **Koji Sato**[1], **Noriaki Ichihashi**[2]
[1]Nagoya University Hospital, [2]Kyoto University, [3]Kobayashi orthopedic clinic

BACKGROUND AND AIM: Recently, the relationship between knee adduction moment (KAM) and progression of knee osteoarthritis (OA) has attracted attention. Previous studies have reported a relationship between KAM and static factors such as varus alignment, laxity, and body weight. However, few studies have examined the relationship between KAM and kinematic, kinetic, and ground reaction forces during gait. No study has investigated the association between KAM and these parameters in patients with knee OA of varying severity. Our study aimed to identify kinematic and kinetic variables in the trunk and lower extremities and their contribution to the amplitude of KAM in patients with knee OA of varying severity. METHODS: Participants included 19 women with knee OA of varying severity. They performed walking trials at a comfortable speed. The kinematic and kinetic data of gait were calculated using three-dimensional gait analysis (VICON Nexus; Vicon Motion Systems) and force plates (Kistler) at sample frequencies of 200 and 1000 Hz, respectively. Ankle dorsiflexion angle, ankle plantar flexion moment, ankle eversion angle, knee flexion angle, knee

flexion moment, knee adduction angle, KAM, hip adduction angle, hip adduction moment, pelvis lateral tilt angle, and trunk lateral lean angle were analyzed. Data on the ground reaction force were collected using force plates. Partial correlation analysis controlling for gait speed and stepwise forward regression analysis were used to determine parameters contributing to KAM. Participants were divided into two groups on the basis of disease severity assessed using the Kellgren-Lawrence score: mild (grade ¡Ü2: grade 1, n = 2, grade 2, n = 9) and severe (grade ¡Ý3: grade 3, n = 5, grade 4, n = 3). To determine the parameters affecting KAM in patients with OA of varying severity, partial correlation analysis controlling for gait speed was used in each group. RESULTS: In all participants, correlations were observed between KAM and knee adduction angle ($r = 0.73$, $p < 0.01$), hip adduction angle ($r = -0.59$, $p < 0.01$), and trunk lateral lean angle ($r = 0.58$, $p < 0.05$). Stepwise forward regression analysis revealed that knee adduction angle contributed to KAM ($R2 = 0.45$, $p < 0.01$). In patients with severe OA, a correlation with KAM was observed only for ground reaction force ($r = 0.82$, $p < 0.05$). A correlation with KAM was observed only for knee adduction angle ($r = 0.72$, $p < 0.05$) in patients with mild OA. CONCLUSIONS: Although the whole-group analysis revealed that knee adduction angle was the parameter influencing KAM the most, only ground reaction force contributed to KAM in the group of patients with severe disease. These results suggest that parameters contributing to KAM differ on the basis of disease severity.

P1-E-113 Compensatory Muscle Activations during Forward Reach Task after Minimal Invasive Spinal Fusion Surgery

***Ting-Yun Wang*[1], Chen-Hsi Hsiao**[1], **Jwo-Luen Pao**[2], **Rong-Sen Yang**[3], **Wei-Li Hsu**[1]
[1]National Taiwan University, [2]Far Eastern Memorial Hospital, [3]National Taiwan University Hospital

BACKGROUND AND AIM: Lumbar fusion has been widely used for spinal disorders when conservative treatment fails. However, limited motion at the fused segment along with damaged paraspinal muscles could potentially lead to abnormal compensative movements. During forward reach, the back muscles contract to overcome the gravitational effect of the trunk, and thus the task itself is considered challenging for those with low back pain (LBP). The purpose of this study was to identify the compensatory muscle activation pattern after lumbar fusion surgery. METHODS: Nineteen patients with LBP underwent minimally invasive lumbar spinal fusion surgery at pre-operation and at one-month-post-operation, and 19 age- and gender-matched healthy participants were recruited. The patients were evaluated for pain severity (visual analog scale, VAS) and general daily activities (Chinese version of modified Oswestry disability index, ODI). All participants were asked to perform the maximum forward reach task 5 times, while their muscle activities were recorded by 8 pairs of electromyography (EMG) sensors placed on the trunk and lower limbs bilaterally: rectus abdominis (RA), rectus femoris (RF), tibialis anterior (TA), erector spinae (ES), multifidus (MUL), gluteus maximus (GM), biceps femoris (BF), and medical head of gastrocnemius (MEG). Changes in muscle activity of each muscle pair during forward reach was estimated by calculating the room-mean-square (RMS) value of the EMG signals averaged from right and left sides. The muscle activation patterns during forward reach were examined using principal component analysis (PCA) on the covariance matrix of the RMS value for each muscle pair from all subjects and trials. RESULTS: The patients showed significant improvements in pain intensity and daily activities (VAS: 7 to 3; ODI: 21 to 11, both $p < 0.05$) at post-operation, but demonstrated decreased muscle activities in back (ES and MUL) and leg (MEG) muscles (all $p < 0.05$, Fig. 1a) and an altered dominant muscle activation pattern (PC1) during forward reach (Fig. 1b) at both pre/post-operation. Significant loadings (loading > 0.5) were found on the back muscles (ES and MUL) for the control group, but on the leg (TA, MEG, and BF) muscles for the patient group at both pre/post-operation (Fig. 1b). CONCLUSIONS: The neuromuscular control was not fully recovered to the normal state at one-month after lumbar spinal surgery. The activation of the leg muscles might be used to compensate for insufficient function of the paraspinal muscles

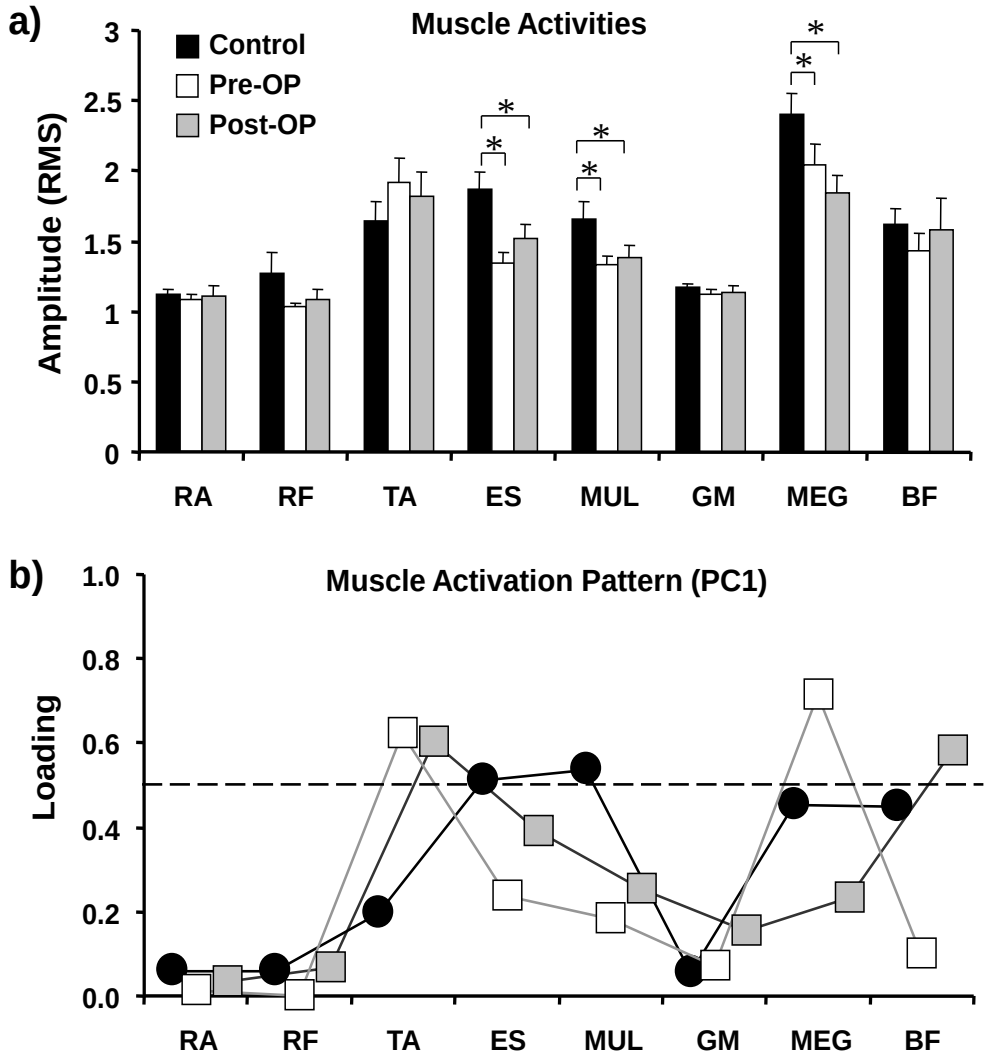


Figure 1: Shown are a) muscle activities and b) dominant muscle activation pattern (PC1) during forward reach for the control group and patient group at pre- and post-operation. Dash line represents the loading that is greater than 0.5. (Pre-OP: patient group at pre-operation; Post-OP: patient group at post-operation; RA: rectus abdominis, RF: rectus femoris, TA: tibialis anterior, ES: erector spinae, MUL: multifidus, GM: gluteus maximus, BF: biceps femoris, and MEG: medical head of gastrocnemius; *: $p < 0.05$)

P1-E-115 Do knee osteoarthritis patients perform efficient Sit-to-stand motion?

Masaya Anan[1], **Koichi Shinkoda**[1], **Kentaro Suzuki**[2], **Masahide Yagi**[3], **Takuya Ibara**[4], **Nobuhiro Kito**[5]
[1]Hiroshima University, [2]Nagoya University Hospital, [3]Midorii Orthopaedics Joint Reconstruction & Arthroscopy, [4]Kawashima Orthopaedic Hospital, [5]Hiroshima International University

BACKGROUND AND AIM: Sit-to-stand motion (STS) is one of the most frequently executed activities and is a dynamic motion that requires extensive joint movement in the lower extremities and trunk, and weight bearing on the lower

extremities during the posture change from sitting to standing. Weakness in the quadriceps femoris muscle and knee joint pain affects the STS ability of knee osteoarthritis (knee OA) patients. We predicted that knee OA patients cannot perform STS using the momentum generated through trunk movement. We aimed to investigate whether knee OA patients can efficiently perform STS by using moment power. METHODS: This study was approved by the Ethics Committee of the Division of Physical Therapy and Occupational Therapy Sciences, Graduate School of Health Sciences, Hiroshima University. Before the experiments, the study aim was thoroughly explained to the subjects, and oral and written consent were obtained. The participants were 24 women with knee OA (knee OA group) and 19 age-matched asymptomatic controls (control group). The subjects performed STS, from a chair with the seat height adjusted to the length of their lower leg, at a self-selected speed. Kinematic data during STS were collected using a three-dimensional motion analyses system (Vicon), and kinetic data were collected using 4 force plates (Tec Gihan). Center of Mass (COM) location, segment angles, joint moments, and energy changes generated by joint moments, individually calculated as the mechanical energy flow (moment powers), were calculated using BodybuilderTM software (Vicon). RESULTS: The thoracic forward lean angle variation was significantly greater in the knee OA group than in the control group. The anteroposterior horizontal distance from the COM to the heel at buttocks-off was significantly shorter in the knee OA group than in the control group. The negative power impulse in the proximal portion of the shank, the negative power mean in the distal portion of the pelvis and proximal portion of the shank, and the positive power mean in the proximal and distal portions of the thigh were significantly lower in the knee OA group than in the control group. CONCLUSIONS: Knee OA patients were primarily performing thoracic forward lean movement, bringing their COM closer to the base of support provided by the feet alone, in an attempt to guarantee stability at and after buttocks-off. However, enhanced control ability, which generates and absorbs kinetic energy quickly, was not shown, and their motion was unable to increase absorption of the mechanical energy in the hip extensors and reduce the load on the knee extensors. Furthermore, the STS of the knee OA patients had lowered energy absorption in the knee extensors from the shank forward lean movement after buttocks-off, reduced knee extensor efficiency, and a greater use of physiological energy. These findings suggest that knee OA patients do not perform STS efficiently from a standpoint of the energy flow.

P1-E-117 The effects of fatigue on adopted drop-landing mechanics

Brian Street[1]**,** **Dmitry Verniba**[1], **William Gage**[1]
[1]York University

Background: It has been observed through video analysis that athletes commonly demonstrate a 'valgus collapse' movement pattern during occurrence of a non-contact anterior cruciate ligament (ACL) injury. This movement is characterized by the simultaneous flexion of the knee and internal/external rotation of the tibia [1]. The frequency of game-related ACL injuries tends to increase in the later stages of competition [2] and fatigue has been proposed as an intrinsic risk factor that may explain this occurrence [3]. Fatigue affects the musculoskeletal and neurological systems, which may negatively influence dynamic knee stability [4] and neuromuscular control [5] and thereby potentially result in adoption of hazardous movement strategies. The purpose for this study is to investigate if there is a relationship between fatigue and demonstration of the 'valgus collapse' movement pattern. Methods: 11 healthy male participants (age: 23.4 ± 3.1 years, BMI: 23.3 ± 1.8) took part in this study. 3D lower-limb kinematic and kinetic data were recorded over a series of 360 drop-landings from a height of 22 cm. Participants landed on both feet simultaneously. Tibio-femoral anterior-posterior (AP) shear force and tibial internal/external (IE) rotation were measured at peak vertical ground reaction force. Lower limb muscle EMG was recorded and will be used to confirm development of muscle fatigue. Linear regression was used to investigate if the relationships between shear force and internal/external rotation, and drop-landing number were significant. Results: Tibial external rotation increased with consecutive drop-

landing trials; the slope of the best-fit line was 0.308 (p=0.004). Similarly, peak anterior tibio-femoral shear forces increased with consecutive drop-landings; the slope of the best-fit line was 0.204 (p=0.001). Conclusions: Fatigue-induced modifications in lower-limb control can lead to the adoption of unfavourable landing strategies and an increase in the peak anterior tibiofemoral shear forces. The findings of this study help to shed light on to why fatigue is associated with ACL injuries and a greater understanding of the effects of fatigue on dynamic knee stability and neuromuscular control will further to elucidate ACL injury mechanism and ultimately lead to improved prevention strategies. [1] Olsen OE et al. (2004). Am J Sports Med. 32(4):1002-12. [2] Gabbett TJ. (2000). Br J Sports Med. 34:98-103. [3] Chappell JD et al. (2005). Am J Sports Med. 33(7):1022-9. [4] Wojtys EM et al. (1996). Am J Sports Med. 24:615-621. [5] Johnston RB et al. (1998). Med Sci Sports Exerc. 30:1703-1707

F - Aging

P1-F-119 Gender specific associations of anthropometry with postural balance during feet-together stance in the elderly

Ji-Won Kim[1], **Yu-Ri Kwon**[1], **Gwang-Moon Eom**[1]
[1]Konkuk University

BACKGROUND AND AIM: Body characteristics such as height and weight affect postural stability. Based on the inverted pendulum hypothesis, postural balance has been compensated by either normalization by height or by using height as a covariate. On the other hand, it was shown that weight rather than the height is the major determinant of postural balance. Many studies have investigated the relationship between body characteristics and postural stability. However, they failed to consider the effects of age and gender though the relationship may depend on age and gender. Gender difference of the relationship in young subjects was shown recently. The purpose of this study is to investigate the associations of anthropometry with postural variables in the elderly and their possible gender difference. METHODS:Forty six elderly subjects (23 men: 73.9±4.3 years, 161±6cm, 61.6± 6.5kg and 23 women: 73.2±4.8 years, 149±6cm, 53.7± 8.8kg) participated in this study. Subjects performed quiet standing on a force platform (OR6-7, AMTI, Watertown, MA) in feet-together stance. COP (center of pressure) was measured 100s with a sampling rate 120Hz. COP data were filtered using a 4th-order zero phase Butterworth lowpass digital filter with a cutoff frequency of 5Hz. As outcome measures, mean distance (MD) and total power (TP) of COP were calculated for anterio-posterior (AP) and medio-lateral (ML) directions. Correlations between anthropometry (height and weight) and outcome measures in each gender, and their gender-difference were investigated. Also, step-wise multiple regressions of outcome measures with anthropometry were performed. RESULTS:There were significant gender-differences in correlations between weight and outcome measures in AP direction. In men, MDAP and TPAP increased with weight ($r=0.51$, $p<0.05$). In contrast, women showed no significant correlation in MD and TP ($p>0.05$). Height was not significantly correlated with MD and TP in both men and women. Stepwise multiple regressions revealed that weight were the major determinants of postural sway variables only in the elderly men. Fig. 1 shows the gender-difference in the associations of weight and balance performance. CONCLUSIONS:In this study, height did not affect postural balance in the elderly contrary to previous studies that showed height was associated with postural stability in the young . Anterio-posterior postural sway size increased with weight in men but net in women. Previous studies failed to consider age and gender when they investigated the relationship between body characteristics and postural stability. This study found that gender difference existed in the associations of weight with postural performance in the elderly group. These results suggest

that both age and gender effects have to be considered when performing normalization of the postural sway variables.
ACKNOWLEDGEMENTS This work was supported by the MKE (QoLT Technology Development, No. 10036494)

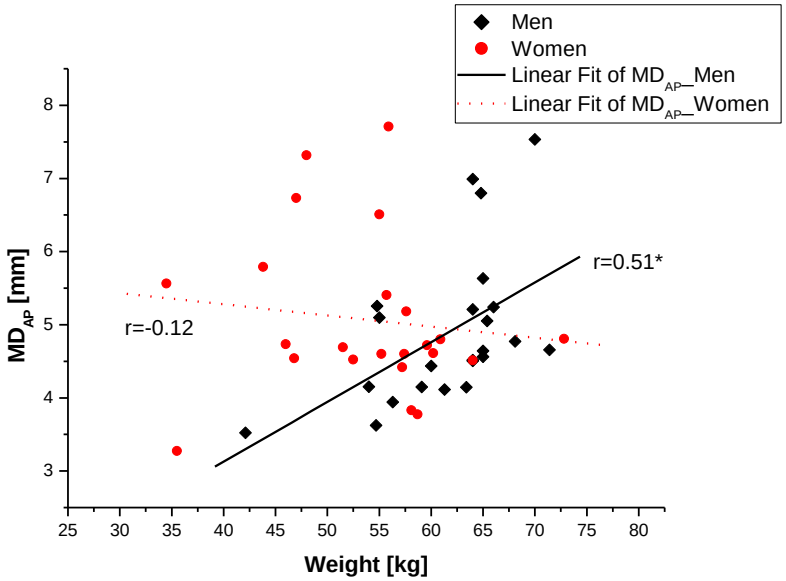


Fig. 1 Correlation between MD and weight in elderly men and women

P1-F-121 Effects of age and gender on mediolateral balance control in gait

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

BACKGROUND AND AIM: It has been reported that even healthy elderly people experience difficulty in controlling mediolateral balance, particularly during single stance phase in gait [1, 2]. The elderly tend to adapt their gait patterns to be safer and more stable with shorter step length, decreased push-off power and more flat-footed landing by fear of falling [2]. However, little is known about dynamic balance control in the frontal plane. The purpose of this study is to examine mediolateral balance control during single stance phase in gait with the middle-aged and the elderly of both genders from a viewpoint of the relationship between the center of mass (COM) position and the center of pressure (COP) position. METHODS: 22 healthy middle (13 males: 48.6±6.1yrs, 9 females: 49.2±4.4yrs) and 24 healthy elderly (12 males: 70.6±5.8yrs, 12 females: 69.5±3.9yrs) subjects participated in this study. We measured ground reaction forces with two force plates and 3D kinematic data using a motion capture system in gait at different speeds from slow to fast. Width of COM (WM), width of COP (WP), and averaged mediolateral difference between COM and COP during single stance phase (Dif) were calculated with step width, toe direction and maximum lateral displacement of COP in shoe (LD). All the parameters except for toe direction were normalized by height. Usual and maximum gait speeds in 10m (GS1, GS2), maximum leg extension power per weight (MLP) were also measured. A 2-way ANOVA and Bonferroni post-hoc test were used to compare the differences between the age groups and genders. RESULTS: MLPs differed significantly between the age groups and between genders. GS1 and GS2 were faster in the middle-aged. WM showed larger displacement in all groups as the gait speed was slower ($r=0.49$-0.63, $p<.05$). On the other hand, WP didn't show the speed dependency. Regarding age and gender differences about mediolateral balance, there was no consistent

difference in WM but significant differences were shown in WP and Dif between the age groups and between genders. The male elderly showed the largest WP and Dif with larger toe direction but with no difference in step width and LD. CONCLUSIONS: It was found that the healthy elderly tended to take COP trajectory laterally away from COM to control mediolateral balance during single stance phase in gait. The tendency was distinct in male elderly gait with their toe direction pointing outwards. It could be suggested that mediolateral balance in the elderly was improved by designing footwear. REFERENCES: [1] Maki BE et al., Control of compensatory stepping reactions: age-related impairment and the potential for remedial intervention. Physiother Theory Pract 1999; 15: 69-90. [2] Winter DA et al., Biomechanical walking pattern changes in the fit and healthy elderly. Phys Ther 1990; 70: 340-7.

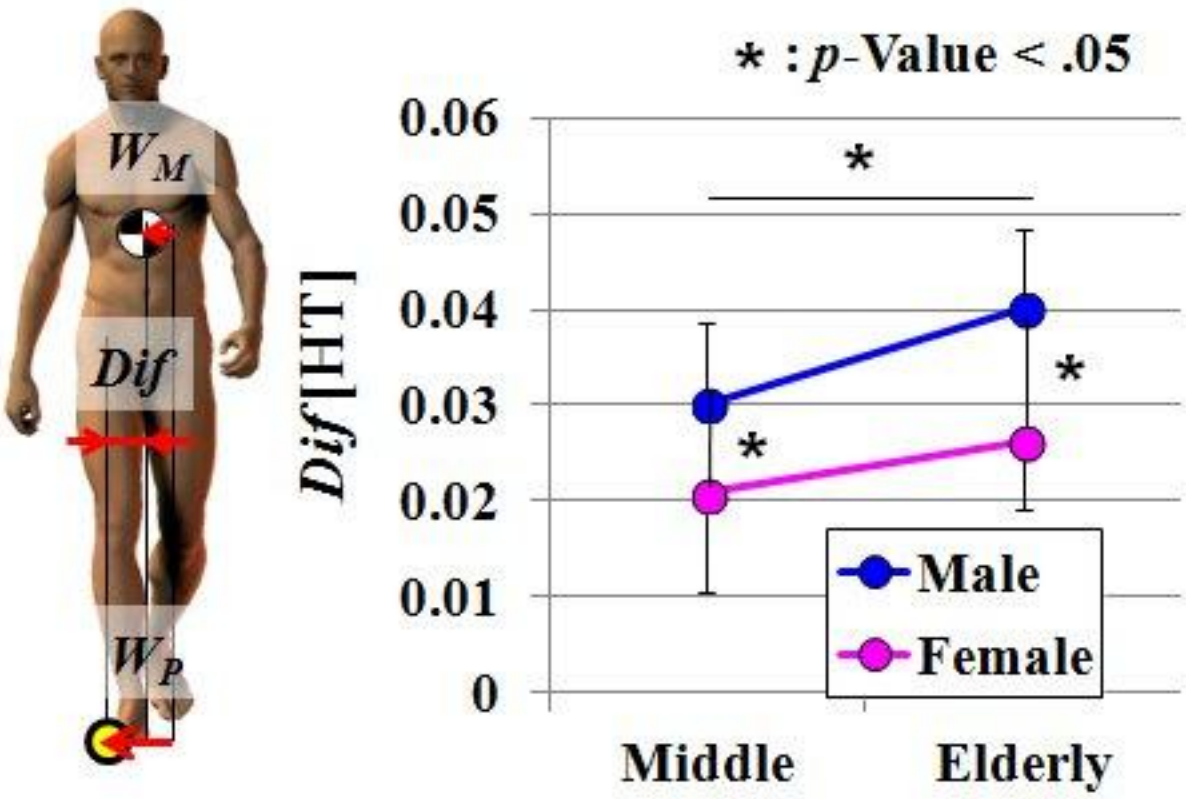


Fig.1 Mediolateral difference between COM and COP during single stance phase in gait (80-100min/km)

G - Aging; Coordination of posture and gait

P1-G-123 Trunk variability during gait decreases the year after cataract surgery in older people

Ole Petter Norvang[1], **Thorlene Egerton**[1], **Jorunn Helbostad**[1]
[1]NTNU

Background and aim: Cataract surgery has been shown to improve standing balance (P1-3) and cataract surgery on the first eye has been reported to reduce the incidence of falls (4). Inter-stride trunk acceleration variability can differentiate fit from frail older people and has therefore been proposed as a useful measure of balance control (5). The effect of cataract surgery on balance control during gait is not fully understood. This study aimed to assess changes in trunk acceleration variability during gait in full and subdued light, from before to one year after cataract surgery in older people. Methods: Ninety-one people referred for unilateral or bilateral surgery were assessed pre-surgery, 4-6 weeks after, and 12 months after surgery. Participants walked at preferred speed along a 7 meter walkway in full light (>250 lux) and subdued light (5-15 lux at floor level). Gait speed was measured by electronic photo cells. Trunk accelerations were measured by a triaxial piezoresistant accelerometer fixed to the L3 region of the lower back. Variability in trunk acceleration between steps was calculated using an unbiased autocorrelation procedure, where larger values of repeatability autocorrelation indicate less variability. Preferred speed and variability in trunk acceleration in three directions were compared at the three time points using a general linear model. Results: Mean age of the sample was 78.4±5.0 years, body mass index was 26.8±4.9 kg/m2, mean cognitive function measured by the Mini Mental State Examination was 27.1±2.4 points out of 30, and 70% were women. Mean pre-surgery visual acuity was 0.65±0.21 logMar. Preferred gait speed in full light increased during the year of follow-up (p=0.01) but there was no change in the subdued light condition (p=0.38) (Table 1). In addition, in the full light condition, vertical and mediolateral trunk variability decreased during the follow-up period (p<0.001). Conclusion: Cataract surgery improves gait speed and decreases variability of mediolateral and vertical trunk accelerations during gait in older people, which may suggest that cataract surgery leads to improved gait control. The small change when walking in subdued lighting may indicate that good visual conditions are important for gait in older people. 1. Kavanagh, JJ and Menz, HB. Accelerometry: A technique for quantifying movement patterns during walking. Gait Posture 2008;28:1-15 2. Costa, JC et al. Betydning af kataraktoperation for ældre menneskers balancefunktion. UGESKR LÆGER 2006;168:11 3. Schwartz, S et al. The Effect of Cataract Surgery on Postural Control. IOVS 2005;46:3 4. Hausdorff, JM et al. Gait variability and fall risk in community-living older adults: a 1-year prospective study. Arch Phys Med Rehabil. 2001;82(8):1050-6 5. Moe-Nilssen, R and Helbostad, JL. Interstride trunk acceleration variability but not step width variability can differentiate between fit and frail older adults. Gait Posture 2005;21:164-70

Table 1: Change in gait variability (larger repeatability = lower variability)

	Baseline	**4-6 weeks**	**12 months**	**Time effect**
	Mean (SD)	Mean (SD)	Mean (SD)	F (p-value)
Full light				
AP trunk repeatability (acorr)	0.71 (0.13)	0.73 (0.13)	0.73 (0.12)	1.03 (0.36)
V trunk repeatability (acorr)	0.71 (0.15)	0.74 (0.13)	0.76 (0.14)	9.59 (<0.001)
ML trunk repeatability (acorr)	-0.45 (0.18)	-0.50 (0.16)	-0.51 (0.18)	6.53 (<0.001)
Preferred gait speed (m/s)	0.89 (0.19)	0.89 (0.19)	0.93 (0.19)	8.09 (0.01)
Subdued light				
AP trunk repeatability (acorr)	0.73 (0.16)	0.74 (0.13)	0.73 (0.12)	1.06 (0.34)
V trunk repeatability (acorr)	0.73 (0.16)	0.75 (0.14)	0.76 (0.13)	3.25 (0.05)
ML trunk repeatability (acorr)	-0.49 (0.17)	-0.51 (0.18)	-0.51 (0.18)	1.14 (0.32)
Preferred gait speed (m/s)	0.92 (0.19)	0.93 (0.19)	0.93 (0.19)	0.77 (0.38)

AP = anteroposterior; V = vertical; ML = mediolateral; acorr = autocorrelation value

P1-G-125 Toe clearance and walking pattern on responding to unexpected surfaces in dual task; comparison between healthy older and young adults

***Nobuko Harada*[1], Shuichi Okada**[2]
[1]Osaka Yukioka College of Health Science, [2]Kobe University

AIM: The aim of this research was to describe age-related differences of toe clearance and walking pattern on responding to unexpected surfaces in dual task. METHODS: Twelve older and 12 young adults walked over 3 m unexpected surfaces (flat, rugged and soft) in the middle of a 10 m walkway and performed a calculating task simultaneously. To measure the kinematics of walking, five body markers were placed bilaterally on the following anatomical landmarks: shoulder(acromion), hip(greater trochanter), knee(lateral femoral epicondyle), ankle(calcaneus), toe(the head of the fifth metatarsal). Using 3D kinematic analysis we measured velocity and trail-10 markers velocities in the swing phase, toe clearance and the ratio of double stance phase, then compared these measurements during single-task and dual-task between older and young adults under three surfaces conditions. Results: Results revealed that toe clearance in dual task was decreased for older adults compared with young adults only when they walked over the flat surface but few differences in rugged and soft surfaces conditions. An interesting finding was that older adults increased toe clearance and trail-hip velocity in dual task when they performed the second step on the rugged surface compared to the flat surface, whereas the young adults didn't show any differences between surfaces conditions. CONCLUSIONS: The results suggested that surface condition on a walkway influences older toe clearance in dual task. Cuteneous stimulation possibly made toe clearance rising and trail-hip velocity rapidly in case of older adults.

H - Coordination of posture and gait

P1-H-127 Inter-joint Coordination in Patients with Cervical Spondylosis During Obstacle Crossing

***Tung-Wu Lu*[1], Zhi-You Chen**[1], **Dar-Ming Lai**[1], **Wei-Ching Lo**[1]
[1]National Taiwan University,

BACKGROUND AND AIM: Cervical spondylosis (CS) is a frequent clinical problem characterized by symptoms and signs consistent with cervical spine and spinal cord structural abnormalities, affecting several motor and sensory pathways travelling along the cord. Balance dysfunction due to CS can result in falls especially during obstacle crossing, a multi-joint movement requiring a high level of inter-joint coordination of both the stance and swing limbs. Quantification of the patterns and stability of the inter-joint coordination thus helps identify control deficiencies. The current study aimed to compare patterns and variability of the inter-joint coordination between patients with CS and healthy controls during obstacle crossing. METHODS: Eleven patients with CS and 11 healthy controls walked at self-selected pace and crossed obstacles (heights: 10%, 20% and 30% leg length) while the kinematic data were measured with a 7-camera motion analysis system (Vicon, U.K.). Phase angles for each joint were calculated from the joint angles and angular velocities [1]. Continuous relative phase (CRP) between two adjacent joints at each instance of the gait cycle was calculated by subtracting the phase angle of the distal joint from that of the proximal. Deviation phase (DP) was then calculated by averaging the standard deviations of the ensemble-averaged CRP curve points for the stance and swing phase over 6 trials [1]. A 2 by 3, 2-way mixed-model ANOVA (group x obstacle height) was performed (α=0.05). SPSS (Version 17, Chicago, IL) was used for all statistical analysis. RESULTS: Compared with the control, the CS group showed significantly reduced CRP values for the leading limb joints whether during leading or trailing limb crossing, while no significant differences were found for the trailing limb joints. Significantly increased variability of the hip-knee coordination during both swing and stance but reduced knee-ankle coordination during stance was also observed in the leading limb. Increased variability of the knee-ankle coordination was found in the trailing swing limb. No significant height effects

were found for all the variables. The observed changes of the patterns and variability of the inter-joint coordination may be related to the impaired sensory function and reduced muscle strength often found in this patient group. CONCLUSIONS: Patients with CS showed altered leading limb inter-joint coordination, with less stable leading hip-knee and trailing knee-ankle coordination, suggesting that clinical rehabilitation programs should include strategies to restore not only the primary motion of individual joints but also the coordination of movements between joints. REFERENCE 1. Wang TM, et al. J Biomech. 42: 2349-56, 2009.

P1-H-129 Control of Segment Variability and Postural Challenge with Varying Walking Speeds

Stephen Prentice[1], **Glynnis Pardo**[1], **Kunal Khare**[1], **Nicholas Frank**[1]
[1]University of Waterloo

BACKGROUND AND AIM: The purpose of this study was to assess the changes in body segment dynamics across varying gait speeds. Of particular interest are trunk dynamics as this segment accounts for a more than 50% of body mass and its control is fundamental to successful locomotion and often necessary to engage secondary tasks. It was hypothesized that participants adopt a gait showing an increase in trunk angle with decreased variability and postural challenge with increasing speed. Postural challenge was defined as trunk dynamics that attempt to cause the segment to pitch. Specifically, the couple, unbalancing moment, created by the accelerations of the trunk centre of mass and the hip joint was assessed with respect to the resulting angular acceleration of the segment. The moment of force produced at the hip has been shown to dampen the unbalancing moment resulting in minimal influence upon trunk kinematics. [1&2] METHODS: Body segment kinematics were tracked using a 3-D Optotrak Motion Capture System with markers placed on the lower limbs and trunk. Five separate rigid plates, each with three markers, were placed unilaterally on the right mid-thigh, shank, foot, pelvis and trunk. A digitizing probe allowed the identification of anatomical landmarks to transform the tracking markers to characterize limb motion. The collection consisted of seven, 3 minute walking trials each at a different speed. The first condition was a three minute baseline trial on a standard treadmill to determine a self-selected (Normal)pace. Once the normal speed was determined, speeds at 10%, 30%, and 50% faster and slower than the normal speed were calculated. The order of walking speeds for all subjects was randomized. Kinematic measures included the absolute (segmental) and relative (joint angle) angles as calculated throughout a three minute trial. In order to evaluate the change in segmental dynamics, the trunk segment was assessed by evaluating the changes in variability and postural challenge during the different walking speeds. Variability was established by determining the coefficient of variation across the entire stride. Postural challenge was quantified by calculating the unbalancing moment. RESULTS: This unbalancing moment at different walking speeds was seen to increase at faster rates, in particular, the two fastest speeds. In all conditions, this couple maintained the same periodicity. Interestingly, the resulting angular acceleration of the trunk showed little difference from that of the preferred walking speed. CONCLUSION: The muscle action at the hip confirms its role to dampen the potential oscillations imposed by walking at different speeds. The hip action is known to be in synergy with the knee action to ensure vertical support and it would be expected that the knee action would increase its role for support as the hip is taxed with the balance of the upper body.

P1-H-131 Implicit adjustment of postural control strategy with a real-time feedback movable footplate

Noritaka Kawashima[1], **Hisakazu Ihara**[2]
[1]Research Institute of NRCD, Japan, [2]Shibaura Institute of Technology

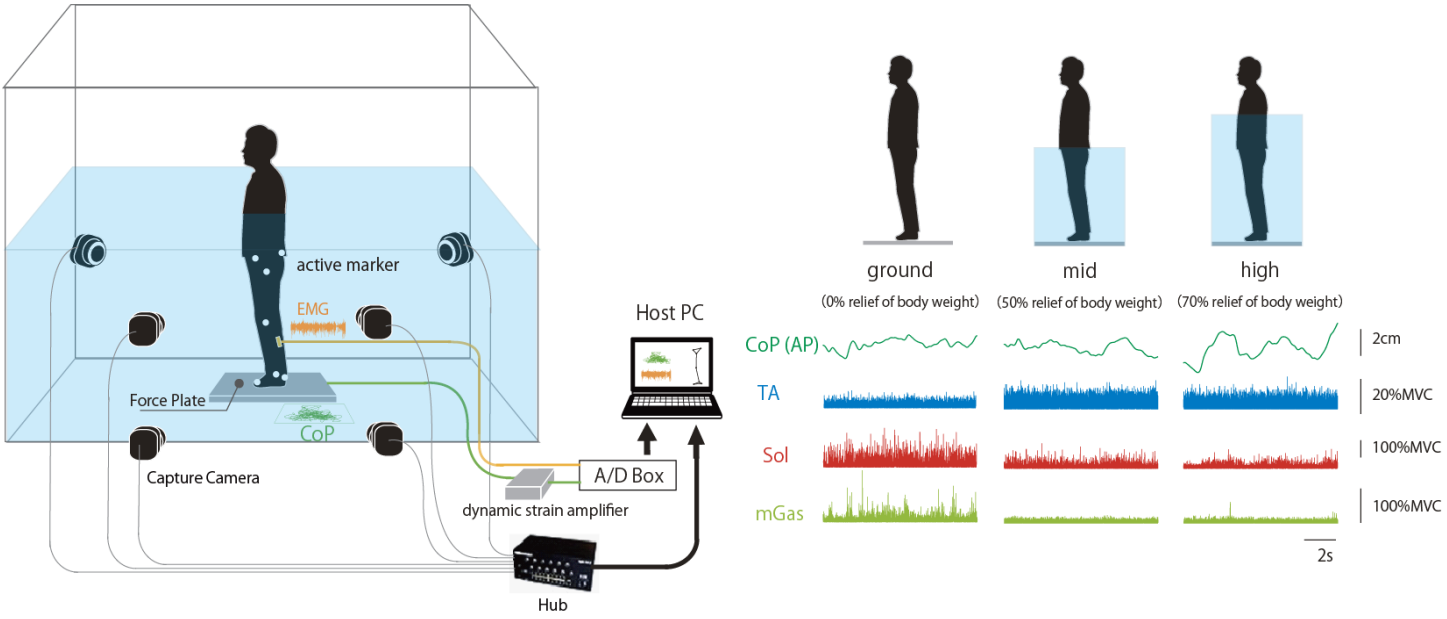
BACKGROUND AND AIM: Postural control relies on multisensory processing and its interaction to automatic control system which dominantly involves quick-responded reflex and vestibular system. Such control system enables us to

maintain seemingly-unstable bipedal posture without conscious awareness. Additional cortical demand would be increased when one faced to uncertain surroundings or unstable ground surface. We here attempt to develop real-time feedback movable force plate system to get a better understanding of human postural control. To observe postural responses due to augmented/reduced postural sway realized by established real-time feedback system. METHODS: 17 healthy volunteers stood on the movable force plate with eyes closed while support surface moved in-phase (reduced sway) and anti-phase (augmented sway) to the center of mass (CoM) displacement detected by laser sensor. Center of pressure (CoP) and muscle activity in the soleus (Sol) and gastrocnemius (Gas) muscles were recorded for the quantification of postural strategy in total seven different conditions, that is, three different feedback gains (15, 30, 45% of natural sway) for both in- and anti-phase and control condition (normal sway). RESULTS: The results demonstrated that CoP sway speed was gradually increased with feedback gain in anti-phase condition. The mean power of high frequency component of CoP (>1Hz) and EMG in the Sol and Gas (8-12Hz) under anti-phase condition was significantly larger than those under in-phase condition. Time-shift between CoP velocity and Gas EMG calculated by cross correlation analysis was significantly shorter in anti-phase condition. CONCLUSIONS: Anti-phase feedback causes an increase of the contribution of automatic neural control, presumably spinal reflex, system which is supported by the result of increasing the 8-12Hz power and shorter delay of EMG activity in response to CoP velocity. The real-time feedback system we developed in this study has a potential for accomplishing implicit adjustment of postural control strategy, and provide a novel methodological approach for further investigation regarding postural control system.

P1-H-133 Postural control strategy under water environment

Hisakazu Ihara[1]**,** **Shin-ichiro Yamamoto**[1], **Noritaka Kawashima**[2]
[1]Shibaura Institute of Technology, [2]Research Institute of NRCD, Japan

BACKGROUND AND AIM: We here attempted to characterize postural control strategy under water environment. Our hypothesis was that some of features in water, such as viscosity-dependent resistance and reduction of the gravity effect through buoyancy would change the postural control strategy. Seven healthy subjects participated in this study. METHODS: The experiment was conducted in an experimental water tank with three level of water height conditions; (1) High (thoracic level: approximately 70% of body weight reduced), (2) Mid (lumbar level: 50%), (3) Ground (without water immersion). Center of pressure (CoP), electromyographic (EMG) activity of the soleus (Sol), medial gastrocnemius (mGas) and tibialis anterior (TA) and position of makers placed on landmarks of lower limbs were recorded. The correlation and the time shift between motor command and body sway were estimated by means of cross-correlation analysis. RESULTS: The results demonstrated that the range and sway speed of CoP were increased with the height of water (ground < mid < high). Antigravity Sol and mGas muscle activities showed remarkable reduction. While there is a positive correlation with constant time shift between calf muscle activity and body sway (Cop displacement) in the ground condition, the extent of correlation tended to be weakened and time shift delayed when the subject stood in water. CONCLUSIONS: Our results suggest that the contribution of antigravity function, specifically reflexively-induced automatic postural adjustment, is less under water environment than ordinary ground situation. Given the result that the TA muscle activity was increased when the subjects stood under water, it is likely that compensatory descending motor command is required to maintain upright standing posture in water.



I - Learning, plasticity and compensation

P1-I-135 Using a robotic AFO to study the extent/limits of short-term adaptive plasticity during human walking.

Laurent Bouyer[1]
[1]CIRRIS-Universite Laval

BACKGROUND AND AIM: Human locomotion results from a tightly controlled muscle activation pattern. Tendon transfer surgeries have suggested that the latter cannot be easily modified. Indeed, when a transfer between antagonists is performed, although voluntary movements of the segment partly recover, locomotion worsens, as the transposed muscles revert to their original activation pattern during walking. These results have lead to the idea that the neural control of walking might be hardwired. However, studies performed using force field adaptation or split-belt walking have shown that less demanding changes in the locomotor pattern can be quite successful. The aim of the present study is therefore to address the extent/limit of adaptive plasticity in human locomotion. Understanding this question is important for the design of new gait rehabilitation therapies. METHODS: Four participants walked on a motorized treadmill while wearing a robotized ankle-foot orthosis (rAFO) on their right leg. The rAFO either followed participants' normal walking pattern ("force cancellation") or added a 5 Nm torque enhancing dorsiflexion at a specific phase in the gait cycle (late stance for 150 ms (LS150), late stance for 350 ms (LS350) and mid-swing for 150 ms (MS150); order randomized across subjects, 70 strides in each condition preceded and followed by 70 strides of force cancellation). Participants were asked to fight the force in order to walk normally. Ankle angular displacements (electrogoniometer) and surface EMG from ankle dorsi- and plantar- flexors were recorded. The advantage of this approach over surgical methods is that the sensory and motor systems remain intact, thereby allowing to test the real limit of adaptive plasticity. RESULTS: All subjects found LS350 easiest and MS150 most difficult. For LS150, the added torque required a prolongation of the ongoing ankle plantarflexor burst (low adaptive demand). EMG recordings indeed measured a small increase in burst duration. For LS350, the increased duration of the torque pulse required a burst prolongation into the swing phase with a reduction in dorsiflexor activation (larger adaptive demand). EMG recordings showed a bigger prolongation of the stance phase burst, followed by a short silent period and the appearance of a very small swing burst.

Dorsiflexor activation was not changed. MS150 did not affect the stance burst, but required the appearance of a new plantarflexor burst during swing (highest adaptive demand). Subjects were not able to perform this task, as shown by EMG recordings. CONCLUSIONS: These results suggest that the neural control of walking is capable of short-term adaptive plasticity, but within limits: the adaptive demand should not require reversal of muscle activation. Further studies are now required to see if this limit is fixed or could be changed by repetitive training.

P1-I-137 Type 2 diabetes alters the relationship between cerebral blood flow and gait speed in older adults

***Azizah Jor'dan*[1], Brad Manor**[1], **Vera Novak**[1]
[1]Harvard Medical School/Beth Israel Deaconess Medical Center

BACKGROUND AND AIM: Gait speed is an important predictor of health that is negatively affected by cognitive decline and underlying brain atrophy in older adults, particularly those suffering from type 2 diabetes mellitus (DM). In these populations, both cognitive impairment and brain atrophy have been linked to altered regulation of cerebral blood flow in response to stressors. The aim of this study was to investigate the association between gait speed and regional cerebral vasoreactivity as quantified by functional imaging of the brain in healthy older adults and those with type 2 diabetes mellitus. METHODS: Eight-one healthy older adults (66±8years) and 78 DM patients (65±8years) were studied. Gait speed was calculated during a 75m walk at preferred speed. Regional cerebral vasoreactivity was quantified using an established CO2 rebreathing protocol during Continuous Arterial Spin Labeling MRI. RESULTS: Healthy controls had higher gait speed (1.14 m/s) than those with DM (1.04 m/s) ($p<0.001$). There were no group differences in global or regional vasoreactivity. Linear models revealed that in DM patients only, and not in healthy controls, those with better global and regional cerebral vasoreactivity had faster preferred walking speed ($p=0.015$). This relationship was independent of age and other group differences in important confounders of cerebral blood flow (i.e., hematocrit concentration) CONCLUSIONS: Our results indicate that preferred gait speed is not related to regional cerebral vasoreactivity in healthy older adults. The observed link between gait speed and cerebral vasoreactivity in DM patients, however, suggests that in this population, functional outcomes may be dependent upon the capacity to regulate blood flow within the brain.

P1-I-139 Do individuals account for increases in body size when walking through apertures?

***Amy Hackney*[1], Michael Cinelli**[2], **Jim Frank**[1]
[1]University of Waterloo, [2]Wilfrid Laurier University

BACKGROUND AND AIM: The passability of apertures is based on the largest horizontal dimension of the body such that individuals will either rotate their shoulders (1,2) or walk around apertures that are less than 1.3 times their shoulder width (3) (i.e. Critical Point). The current study aimed to determine whether the Critical Point is scaled when the horizontal dimension of the body is suddenly enlarged by carrying a wide object. METHODS: Participants (N=13, mean age = 23.3 years) walked at a self-selected pace along a 10m path and passed between or around two vertical poles placed halfway along the path. Participants performed the task without or while holding a serving tray that was either 1.2, 1.4 or 1.6 times wider than their shoulder width. The distance between the poles was scaled such that it was 1.0-1.6 times each participant's widest dimension (shoulder or tray) in increments of 0.2. RESULTS: Results identified two distinct responses to carrying the tray: fast and slow adapters. Fast adapters (n=7): 1) maintained their Critical Point throughout the study (Figure 1); 2) approached the obstacles at the same velocity regardless of whether or not the tray was carried; and 3) sped up when crossing the obstacles while holding the tray. When carrying the tray, slow adapters (n=6): 1) increased their Critical Point (Figure 1); 2) reduced their approach velocity; and 3) decreased their walking speed when crossing the obstacles. CONCLUSION: Individuals appear to successfully account for sudden increases in body width, but adapt at different rates. REFERENCES: 1) Warren & Whang. J Exp. Psychol Hum Percept Perform. 13 [3]:

371- 83, 1987; 2) Wilmut & Barnett. Hum Move Sci. 29: 289-98, 2010; 3) Hackney & Cinelli. QJ Exp. Pyschol, May 29, 2012 [QJE-STD 12-179].

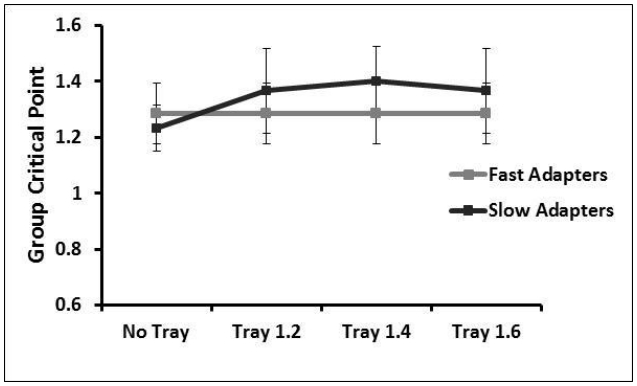


Figure 1. Average Critical Points for the fast and slow adapters.

J - Activity Monitoring; Aging

P1-J-141 Physical behaviour and function early after hip fracture - part of the Trondheim Hip Fracture Trial

Kristin Taraldsen[1], **Olav Sletvold**[1], **Pernille Thingstad**[2], **Ingvild Saltvedt**[1], **Malcolm Granat**[3], **Jorunn Helbostad**[2]
[1]NTNU, [2]St.Olavs University Hospital and NTNU, [3]Glasgow Caledonian University

Background and aim: Hip fracture patients are old and frail, and early mobilisation is important for regaining function. The aim of this study was to evaluate if a geriatric comprehensive assessment and intervention in a geriatric ward can increase physical behaviour and function early after hip surgery as compared to conventional treatment in an orthopaedic ward. Methods: Data from 317 patients from a larger RCT study including 397 hip fracture patients were included. Physical behaviour was monitored continuously over the fourth day post-surgery by an activity monitor worn on the thigh. Primary outcome was time spent in upright activities. Secondary outcomes were number of upright events, the Cumulated Ambulation Score (CAS) as a measure of need for assistance during ambulation on day 1-3 post-surgery, and the Short Physical Performance Battery (SPPB) assessing lower limb function the fifth day post-surgery. Results: Participants had a mean age of 83 ±6 years and 74% were women. 60% had intracapsular fractures, and of them 65% were operated by use of arthroplasty. On the fourth day post-surgery, patients treated with comprehensive geriatric assessment in a geriatric ward spent more time in upright position (median of 36 versus 29 minutes, p=0.042) and had more upright events (median of 18 versus 14.5 events, p=0.029) as compared to patients treated with conventional treatment in an orthopaedic ward. Furthermore, SPPB scores were better for those treated in the geriatric compared to the orthopaedic ward (median of 1 in both groups, interquartile range of 2 versus 1, p=0.006). The CAS did not differ between groups (median of 9 in both groups, p=0.196). Conclusion: Treatment in a geriatric as compared to an

orthopaedic ward has a positive effect on physical behaviour and function during the hospital stay for older persons after hip fracture.

P1-J-143 Observation of Gait Changes Associated with Human Intentions

***Mitsuru Nakazawa*[1], Ikuhisa Mitsugami**[1], **Hirotake Yamazoe**[1], **Yasushi Yagi**[1]
[1]Osaka University

BACKGROUND AND AIM: In our activity space, many surveillance cameras are located for the purpose of security. If we can estimate human intentions using these cameras, it will become possible to acquire variable information such as the number of people who are interested in a certain shop or a product in a market mall. Therefore, we aim to estimate intentions using surveillance cameras. A head direction is one of effective cues to estimate intentions. However, it is difficult to obtain a head direction from captured images of these cameras directly. Therefore we focus on gait changes that can be obtained from these cameras and express whole body changes. To confirm the possibility of estimating intentions from gait images, in this paper, we observe how gait varies with intentions. METHODS: For the observation, we construct a feature space of intention classification. First, based on the fact that a Gait Silhouette Volume (GSV: a size-normalized and position-registered silhouette image sequence) has been already used for some applications such as human identification, we acquire a GSV of one gait cycle from cameras. Then, to obtain gait features from a GSV, we calculate the amplitude spectrum at its each pixel. Finally, using the amplitude spectrum and given intention class labels, a feature space is constructed by linear discriminant analysis. RESULTS: To gather data of many subjects who walked with some intentions, we prepared a walking game at a museum of science as shown in Fig. 1. In this game, subjects walked beside a game character that appeared on an 18m-width screen. Considering intentions that often appear in human interaction, a game scenario was designed so that subjects could walk with three kinds of intentions: reaching toward, following and escaping from the character. Some cameras were located on the top of the screen to capture side view images of walking subjects. Using the above method, we constructed a classification feature space from captured data of over 100 subjects. To see the representation of each space axis, we picked up one subject whose feature values of intention classes were different as much as possible in both the x- and the y- axial direction. As the result, it can be said that gait changes in the x- and the y- axis represented the uprightness and the horizontal rotation of a head, respectively. CONCLUSIONS: We observed gait changes associated with intentions from data of over 100 subjects who walked with some intentions. The experimental result showed that a head direction, which has a key role of human intention estimation, was expressed in gait changes. In future work, we will observe a relationship between human intentions and gait changes from images captured in real environments. ACKNOWLEDGMENTS: This work was partly supported by the JST CREST "Behavior Understanding based on Intention-Gait Model" project.

Fig. 1 Scene of a walking game experiment

P1-J-145 Validity and reliability of accelerometers and GPS to measure community ambulation after stroke.

Niruthikha Mahendran[1]
[1]University of Queensland

BACKGROUND AND AIM: Many stroke survivors report difficulty ambulating outside the home. Accelerometers have been used to measure general physical activity after stroke, but are unable to separate walking activity completed within the home, from that performed in the community. Additional location information recorded by portable global positioning systems (GPS) may address this issue. However, as stroke survivors walk slowly and asymmetrically, the validity and reliability of these devices need to be confirmed in this group. This study aimed to determine the concurrent validity and retest reliability of two accelerometers (ActivPAL? and Sensewear® Pro2 Armband) and a GPS unit during tasks that reflect community walking and also concurrent validity during free-living community ambulation in people with stroke. METHODS: Fifteen community-dwelling stroke survivors attended 2 sessions and completed a 6-minute walk, treadmill walking at 3 speeds, and a 200 metre outdoor circuit over varied urban terrain while wearing the three devices. The devices collected measures of step counts, time spent walking, distance, energy expenditure and location. Investigators also simultaneously collected measures directly. Participants then wore the devices for four days, to measure free-living community ambulation, with time spent walking and location compared with a self-report activity diary. Intraclass correlation coefficients (ICC), Bland-Altman plots and absolute percentage of error (APE) were used to determine validity and reliability of all measures. RESULTS: ActivPAL? had excellent concurrent validity for time spent walking, (ICC > 0.997, APE <3.1%) and most episodes of step count (ICC >0.855, APE < 5.6%) and excellent retest reliability for step counts, time spent walking and energy expenditure (EE) measures during all walking tests (ICC > 0.872, APE < 6.5%). Sensewear had missing values for 21% of recordings and a high APE (>21.9%) for all measures. The GPS demonstrated excellent validity and reliability in time spent walking and step count (ICC > 0.926, APE < 8.5%) but was not accurate for distance (ICC = - 0.085, APE = 23.9%). During the outdoor circuit, the GPS was consistently accurate for start and stop location points, but not for the route taken. All devices had a high APE (> 44%) during free-living

community ambulation, possibly due to poor accuracy of self-report activity diaries, except for GPS location data, which was accurate for 88% of all community walking trips. CONCLUSIONS: ActivPALTM and the GPS together appear appropriate to measure community ambulation after stroke. Further investigation of the accuracy of GPS to measure over longer distances is required. Sensewear algorithms specific to stroke may improve its accuracy for community ambulation measurement.

K - Balance support device; Exercise and physical activity

P1-K-147 Evaluation of sitting balance in elderly persons

Kimio Saito[1], **Toshiki Matsunaga**[2], **Takehiro Iwami**[3], **Yoichi Shimada**[1]
[1]Akita University Graduate School of Medicine, [2]Akita University Hospital, [3]Akita University

Background: A change in the ability to balance with aging is regarded as an important factor that is associated with falling. We found that lumbar kyphosis and spinal inclination closely correlate with postural sway, and postural deformities comprise a risk factor for falling. We previously determined the risk of falling among elderly individuals by measuring postural sway while they stood on a force plate platform. However, to precisely define trunk balance in the elderly while standing is difficult because postural sway under this condition is controlled by the lower limbs, particularly the ankle. Therefore, we safely determined trunk balance in seated elderly and young persons using a new device. Subjects: Thirty-six healthy elderly volunteers (mean age, 77 years) and 36 healthy young volunteers (mean age, 26 years) were participated in this study. Methods: Postural sway was measured while seated using a novel balance device that we recently manufactured in-house. A force plate underneath a seat slanted to a maximum of 3º tracks the location of the center of pressure (CoP) of a seated person. The device inclines the seat to the right and left six times for 10 seconds each (0.6 Hz). The height of the weight-bearing surface is adjustable so that the participants cannot touch the floor with their feet. This avoids balance being affected by the lower extremities. The participants kept their arms crossed and their gaze fixed upon a point two meters ahead. We then measured CoP for 30 seconds. We determined locus length/second (LNG/TIME), the area surrounded by the maximal amplitude rectangle (REC-AREA), locus length per environmental area (ENV-AREA), the range and root mean square (RMS-AREA) and locus length per unit area (LNG/AREA). Results: Values for LNG/TIME, REC-AREA, ENV-AREA, and RMS-AREA were significantly worse for the elderly, compared with the young group ($p < 0.05$). However, LNG/AREA did not significantly differ between the two groups ($p = 0.0834$). Discussion: Locus length per unit area reflects minute postural adjustments controlled by the spinal proprioceptive reflex of the lower extremities. The seated balance device could precisely measure trunk balance without any influence of the lower extremities, which explains why LNG/AREA did not significantly differ between young and elderly participants. These findings represent that we can examine trunk balance safely in elderly to determine risk of falling. Conclusion: This novel device will be useful for examining variations in trunk balance among patients with deformities of the spinal column and spinal diseases.

P1-K-149 Limit of Stability Changes between Young and Middle-Old Aged Groups after Ankle Fracture

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

BACKGROUND AND AIM: The incidence rate of ankle fracture is especially high in older adults. In daily life, avoiding falling is the most critical factor for an older adult with ankle fracture while reaching objects located at a far and/or high

place is an important ability. The limit of stability test has been shown to indicate the ability how far people could reach around their ankle joints in any given directions without falling, stepping, or grasping to restore their equilibrium. The purpose of this study was to examine limit of stability for people with ankle fracture and test the aging effect. METHODS: Fifteen participants with ankle fracture after removing the internal pins were divided into the young (range: 17-29 years old) and middle-old aged (range: 30-59 years old) groups. All participants were asked to conduct the limit of stability test with Balance Master (NeuroCom, Inc, USA). The reaching distance of the limit of stability test was set at 75% of the age-matched norm for eight directions. Reaction time, movement velocity, directional control, endpoint excursion, and maximum excursion were calculated using the raw trajectory of center of pressure. The independent Student t-test was used to compare between groups. RESULTS: The tendency of longer reaction time (RT), shorter endpoint excursion (EPE) and maximum excursion (MXE) between the young and middle-old aged groups was expected (RT: young - 0.67 sec, middle-old - 0.77 sec; EPE: young - 79.75%, middle-old - 76.93%; MXE: young - 90.89%, middle-old - 89.58%). The significant difference was found in directional control (DC) between groups (young - 80.56%, middle-old - 67.28%, $p<0.05$). CONCLUDIONS: Compare to the young-aged group, the middle-old aged group demonstrated a longer reaction time, poor directional control, shorter endpoint excursion and shorter maximum excursion. Aging effect has to be taken into account when designing balance training programs for people with ankle fracture.