V. NOVAK (Convener) ***The analysis and improvement of elderly human body balance.*** *Gerontechnology 2014;13(2):111;* doi:10.4017/gt.2014.13.02.060.00 **Participants** V. Novak (USA). J-S. Shieh (Taiwan), B-C. Jiang (Taiwan), T-L. Sun (Taiwan). **Issue** Brain, balance and walking; Using dynamic center of pressure to measure human body's balance ability; Postural stability evaluation using entropy-based methods for the elderly; Evaluation of somatosensory gaming for one-leg lifting training to improve balance. **Content** Falls are a major public health concern among elderly people, and they often cause serious injuries. They most frequently occur during walking and are associated with the chronic deterioration in the neuromuscular and sensory systems, as well as with ankle muscle weakness and lower endurance of these muscles to fatigue. Falls are a major cause of morbidity and mortality in the U.S., and medical research has shown that the degradation of physiological functions and nervous system functions reduce the ability of the elderly to balance, so they may easily fall down while walking. In order to reduce the harm from falls in the elderly, it is suggested that a health care system is developed to improve and evaluate the sense of body balance. Postural stability, which can be measured by the displacement of center of pressure (COP), is an important feature to protect people from falls and to complete desired actions. The COP displacements in the two anterior-posterior (AP) and medial-lateral (ML) directions are often used to characterize the COP stabilogram. Furthermore, they are commonly applied to predict fall-risk and evaluate balance stability enhancement systems. Due to the non-stationary and non-linear characteristics of COP signals, we will demonstrate that the COP data analyzed by the multivariate multiscale entropy (MMSE) is effectively better than that processed by the traditional method. **Structure** There will be 4 paper presentations, followed by Q&A and a general discussion. The first paper will be focused on how the brain controls balance during walking. The following paper is on using dynamic COP to measure human balance. The third paper is focused on postural stability evaluation using entropy-based methods. Finally, the last paper is focused on using somatosensory gaming to improve balance. **Conclusion** We expect to give the audience a perspective of how to measure and improve the body balance via different measuring devices. We also hope to raise awareness on fall issues that are a major public health concern among the elderly, and how these issues can be explored and improved via by means of high advanced technology. This approach may give the development of Gerontechnology products and systems a more solid foundation, better user acceptance, and a higher possibility of success.

Keywords: fall, human body balance, center of pressure, multivariate multiscale entropy
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V. NOVAK. ***Brain, balance and walking.*** *Gerontechnology 2014;13(2):111-112;* doi:10.4017/gt.2014.13.02.380.00 **Purpose** Falls and mobility problems are common causes of morbidity and death in elderly people, yet their causes are poorly understood. Slowing of gait is a prominent feature of human aging, even in the absence of specific diseases, and it is strongly associated with falls, dementia, and mortality. At the same time, gait and balance are dependent upon the brain's ability to maintain cerebral perfusion during standing and walking. The concept of cerebrovascular reserve has emerged as a potential biomarker for a syndrome of slow gait speed, and as an indicator of both functional decline and fall risk. Cerebrovascular reserve is brain's ability to maintain perfusion during physical activities, and to redistribute blood supply to areas with high energy demands. However, the relationship between cerebral hemodynamics, cardiovascular control, and locomotion control for standing and walking is not well understood, and has not been adequately studied. **Method** Cardiovascular risk factors alter brain perfusion regulation and accelerate the effects of aging on gait and balance. Hypertension and diabetes are the most prevalent risk factors. Hypertension affects more than a third of world's population. Among those who are 65 years and older, almost 75% have hypertension[1,2] and 26% have diabetes[3]. Cerebromicrovascular disease associated with hypertension, diabetes, and other cardiovascular risk factors, including age, is linked with regional hypoperfusion, white matter hyperintensities (WMHs), and brain volume loss on MRI, as well as with neuronal degeneration, slower gait speed, and cognitive decline in elderly people[4-9]. Metabolic syndrome, hypertension, and stroke were each independently associated with cognitive and functional decline later in life[10].The Honolulu Aging study shows that high systolic BP (120-140 and >140 mmHg) in midlife increases the risk of late-life dementia[11]. Both diseases have been associated with syncope (fainting) or orthostatic hypotension (blood pressure decline during standing) that account for up to 6% of hospital admissions. Up to 58% of those with dementia experienced a systolic BP decrease of ≥10 mmHg in later life[11]. By the age of 70, half of the population has experienced syncope or a fall at least once. With increasing age, the frequency and severity of syncope events increases, further elevating the risk for injurious falls[12]. **Results & Discussion** Diabetes is associated with regional hypoperfusion[13,14], gray matter atrophy and peripheral neuropathy, slower gait speed, and worse functional outcomes. In diabetic subjects, slower walking correlates with worse perfusion in the brain and more brain volume loss. Furthermore, diabetic subjects with peripheral neuropathy that have slower and less steady gaits and increased risk of falling are dependent upon gray matter volume in the cerebellum and other brain regions to maintain balance[15]. Furthermore, the presence of WMHs in diabetic and hypertensive subjects worsens dynamic balance parameters[16]. In summary, cardiovascular risk factors accelerate brain aging and further aggravate the impact of aging on locomotion and balance, therefore increasing the risks for falls and fall related injuries.

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H-H. Chu, Z. Dong, C. Hans, J-S. Shieh. ***Using dynamic center of pressure to measure human body's balance ability.*** *Gerontechnology 2014;13(2):112-113;* doi:10.4017/gt.2014.13.02.293.00

Purpose Accidental falling is unpredictable, and it may cause serious injury especially in the elderly. One reason elderly people tend to fall more often that others is a physiological decline in their ability to maintain their balance. To understand a human's capacity for maintaining balance, we designed a convenient and low-cost wearable center of pressure (COP) device that can measure the dynamic COP of a person who is walking. The introduced analysis algorithms allow observation of the properties of human balance, and we hope to improve fall detection and prevention in the elderly. **Method** In this study, we present a custom made measurement device that contains three pressure sensors attached to an insole.

When the subject stands on the insoles, plantar pressure of the subject can be measured. Spatial plantar pressure distribution is an important and useful measurement for gait analysis[1]. In order to assure correct positioning of the sensors, the exact positions were determined using blueprints of the feet for each individual subject. The COP computations were performed for each foot individually[2], with the goal of computing the global dynamics of the COP. To calibrate and assess the functioning of the device, weights were placed on each sensor, one at a time, to observe changes in the COP. After calibration, subjects were asked to walk on their insoles to determine COP displacement during walking. **Results & Discussion** After repeated testing, the concept of using pressure sensors in the insoles can be demonstrated. *Figure 1* shows the three different time intervals that are divided by the timing that we put on each weight. The position of the COP is getting close to the weight-added sensor. The time between 0 to 25 seconds represents stepping (*Figure 2*). When the left foot goes up, the right foot goes down, and vice versa. Leaning forward and backward is shown between 30 to 45 seconds, so both left and right go up or down simultaneously. In the future, these dynamic COP insoles should be verified with commercial products, such as the Advanced Mechanical Technology Incorporation (AMTI) force plate for the accuracy of the device.

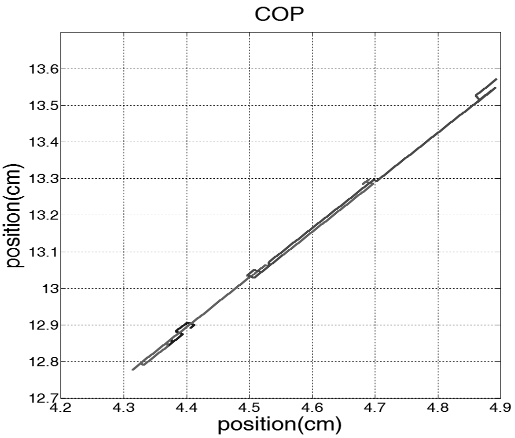

Figure 1. The COP moves in the direction of the sensor which is applied more weights

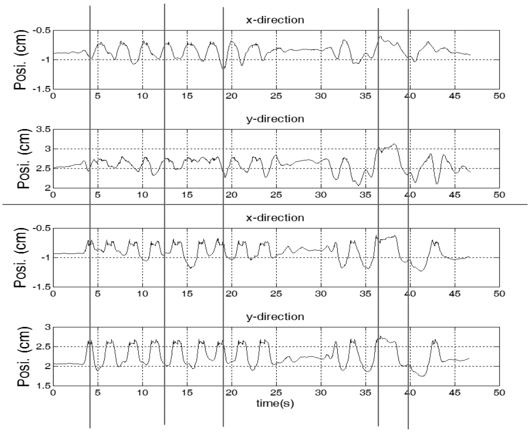

Figure 2. The COP results of left and right feet; Top two are right X and Y, lower two are left X and Y; Pos.i=position

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B-C. JIANG, J-S. SHIEH, J-S.Z. FAN, C-K. PENG. **Postural stability evaluation of the elderly using entropy-based methods.** *Gerontechnology 2014;13(2):113-114;* doi:10.4017/gt.2014.13.02.223.00 **Purpose** This study presents a relatively new method, 'multi-scale entropy' (MSE), to evaluate the center of pressure (COP) data for elderly persons under various conditions. The comparison between MSE and traditional COP stabilogram metrics is also discussed. **Method** The properties of physiological systems, such as COP data, often exhibit complex fluctuations that are not simply additive noise, but contain valuable information regarding the state of the system[1,2]. The 'sample entropy' values, normally used in physics, are first calculated, and then the MSE and its corresponding 'complexity index' (CI) are determined and represent the 'complexity' of the COP data. **Results & Discussion** The results of various studies are shown in *Table 1*. The conclusions are that the MSE method is effective to differentiate some obvious situations such as young vs. old and healthy vs. illness. There are also some positive results on the use of MSE as an 'improvement' index for the elderly, such as wearing vibration stimulation shoes, wearing shoes that are specifically designed for the elderly, and doing tai-chi exercises. Further study is needed to examine the subtle differences in COP signals and to see if the index can be used as a 'health maintenance' index for the elderly.

Table 1. Results of postural stability evaluation using entropy-based methods; AP=Anteroposterior; CI=Complexity Index; COP=Center of Pressure; EMD-MSE=Empirical Mode Decomposition; MSE=Multi-Scale Entropy; MEMD=Multivariate Empirical Mode Decomposition; MMSE=Multivariate Multi-Scale Entropy; TUG=Timed Up and Go

#	Study	Description	Results
1	Results for standing for young vs. elderly who suffered a fall	15 young and, 13 elderly who suffered a fall (standing still)	MSE-based CI: significantly lower for elderly who suffered a fall than for young; more powerful than traditional COP measures
2	Young vs. elderly standing at attention	15 healthy young, 8 healthy elderly, and 13 elderly who suffered a fall (dual-task standing still)	MSE-based CI: young > elderly > elderly who suffered a fall Significant impact of dual task on elderly who suffered a fall Percentage of CI cost due to dual task: 17.76% (elderly who suffered a fall) > 4.66% (elderly) > 0.92% (young)
3	Wearing vibratory shoes for elderly. (3 patents received)	40 young, 26 elderly; all healthy (short stimulation period - 6 minutes); portable force platform design	Improvement in postural stability for 61.5% of elderly subjects after wearing the shoes MEMD-MMSE more powerful than EMD-MSE in detecting the differences before and after wearing the shoes. Designed a low cost force platform.
4	Wearing shoes specifically designed for elderly	24 elderly wearing 'healthy shoes' measured every 2 weeks for 2 months	TUG test: time reduced 9% Statistical significance: TUG, MSE-AP, Total movement distance The elderly preferred to wear the specially designed shoes
5	Doing tai-chi exercises for elderly	18 elderly doing tai-chi every day measured every 2 weeks for 12 weeks	Statistical significance: 6-minute walk, TUG, MSE-AP EMG did not show significant differences

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T-L. SUN, C-H. LEE, C-H. HUANG. ***Evaluation of somatosensory gaming for one-leg-lifting training to improve balance.*** *Gerontechnology 2014;13(2):114-115;* doi:10.4017/gt.2014.13.02.241.00 **Purpose** The recent emergence of somatosensory gaming (SG) allows the elderly to undertake physical exercises while playing in a pleasant and stimulating environment, hence increasing their enjoyment, engagement, and adherence. This paper reports the design and evaluation of SG for one-leg-lifting training. Standing on one leg is a common posture in daily life, such as when navigating stairs, stepping over obstacles, and in normal walking. People are most likely to fall while standing on one leg as a result of a shift in the center of gravity. Because of this, many previous studies have used a one-leg stance as the posture for balance training[1]. **Method** The game scene is designed with an avatar, i.e., a 3D virtual human that is driven in real time by the player, and a posture model (PM)[2]. The PM appears on the screen and approaches the avatar to prompt the subject to raise one leg to the appropriate height. This study used two types of PMs: static and dynamic. The static PM simply approached the avatar. The player needed to assume the one-leg stance posture to make the avatar pass through the PM without colliding with it. The dynamic PM reached the avatar and then performed leg-lifting animation. The player had to follow the animation. Three evaluation experiments were conducted to study the effect of different PM design parameters on balance control ability. In the first experiment, the effect of the offset and the travel time of a static PM on posture stability was examined[3]. The offset is the distance between the PM boundary and the avatar. Postural stability was measured by center of pressure (COP) displacement. In the second experiment, the effect of leg-lifting time and angle of a dynamic PM on posture stability were studied. Participants in the first two experiments included 23 healthy individuals (M:12, F:11, age:21-30). In the third experiment, the effect of the presence or absence of avatar visualization on the participant's reaction time, movement accuracy to follow the leg-lifting animation, and COP displacement were studied. Participants in the third experiment included 24 healthy individuals (M:14, F:10, age:22-25). **Results & Discussion** For the first experiment, COP displacement along the anterior/posterior direction was affected by the travel time ($p<0.001$), while other COP metrics were not related to the offset or the travel time. For the second experiment, COP displacement along the medial/lateral direction ($p=0.003$) and total COP excursion ($p<0.001$) were affected by the leg-lifting time; other COP metrics were not affected. This means that increased game difficulty (e.g., small offset, faster travel time and leg-lifting time, and larger leg-lifting angle) may not result in increased training effectiveness. For the third experiment, the avatar visualization did not affect reaction time ($p=0.144$), but did affect movement accuracy ($p<0.001$) and COP displacement ($p=0.03$). This means that avatar visualization is important for balance training using SG. The avatar predicted the arrival of the PM. As a result, participants can prepare and accurately follow the leg-lifting animation.

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