A Wii pressure platform to assess balance in the elderly

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A. Olvera-Chávez, C. Garza-Hume, L.M. Gutiérrez-Robledo, V. E. Arango-Lopera, M.U. Pérez-Zepeda. A Wii pressure platform to assess balance in the elderly. Gerontechnology 2013;11(3):452-456; doi:10.4017/gt.2013.11.3.003.00 Use of low-cost technologies could simplify assessment of balance in elderly. **Objective** Determine the usefulness of the Wii™ pressure board in assessing balance in elderly. **Methods** We conducted a cross-sectional study in a group of elderly to test their balance with the pressure board compared to conventional tests used in geriatric practice. Community-dwelling adults over 60-years old were assessed. We compared the Short Physical Performance Battery scores with the Wii force platform results (average kinetic energy). Two blinded researchers classified each set of tests; and then a weighted kappa statistic was estimated. **Results** We assessed a total of 20 subjects, with a median age of 67.5 years (range 60-98), 75% women. The tests were concordant in 19 of the 20 subjects; with a resulting concordance of 0.6 (p=0.05). Conclusion The Wii pressure board has a good concordance with usual clinical assessment of balance in the elderly.

Keywords: balance, Wii pressure board, falls, elderly, mathematical models

The elderly population is growing due to a global demographic transition[1]. The appearance of diseases in this age group has some peculiarities, some of them grouped in the so-called geriatric syndromes, which are conceptualized as a sole manifestation caused by many risk factors[2]. These syndromes include falls, which are of particular interest due to their health and social consequences: fractures, immobility, dependence and early institutionalization. In addition, falls are markers of overall health in the elderly[3]. Balance and equilibrium require coordination and integrity of the musculoskeletal, cardiovascular and nervous systems (particularly sense organs), any failure or convergence of failures of these organs can result in balance and gait problems, which pose a greater risk of falling[4]. Falls have adverse consequences for the elderly, their families and the health care system. For many years, research has addressed the detection and modification of falling risk factors, such as balance and gait disorders, which can predict the future occurrence of falls. In a 14-month follow-up study, the group of Murphy et al. demonstrated that some specific tests can predict falling; particularly maintaining a tandem position more than 10 seconds and gait speed[5]. Other screening tools have also been reported to be useful, including self-report to predict falls[6]. The Wii Balance Board™ (WBB) is a force platform commonly available as part of a video game console. It is inexpensive, light, easy to acquire and has four pressure sensors located at the corners. It has been previously studied to assess balance in other age groups, and validated against posturography[7]. The aim of this study was to determine the effectiveness of the WBB in balance assessment of a group of community-dwelling elderly in Mexico City.

Methods

Elderly 60-year or older community dwelling subjects who accepted to participate and signed informed consent declarations were recruited. We excluded those subjects who had recently (the last two weeks) had a musculoskeletal injury, otitis; or who had a chronic balance disorder, as referred by them. The researchers in a non-randomized fashion recruited the subjects from the community. Three researchers applied the tests; those who performed the WBB batteries were blinded to the Short Physical Performance Battery (SPPB) and vice versa. The SPPB was used to be compared with the WBB which consists of three subtests: balance, gait speed and physical performance; each one giving a score, and the final test score was the sum of each score of these subtests; with a minimum score of 0 (worst) and a maximum score of 12 (best). This score and has been widely used in assessing risk for falls[8]. Two sets of tests were carried out with the WBB. In the first battery each subject had to stand on the board as still as possible for six different measurements of about 50 seconds each (with a sound alarm indicating the ending of the test): (i) with feet slightly apart, arms relaxed, eyes open looking at a fixed point; (ii) the same as (i) but with eyes closed; (iii) in tandem position, right foot forward, eyes open (arms could be used for balance); (iv) same tandem position but with eyes closed, (v) and (vi) as (iii) and (iv) but with the left foot forward. The measurements were taken continuously, just giving enough time for the subject to reach the new position. In the second battery of tests the subjects were asked to sit and place their feet on the platform, then stand onto it, stay still for ten seconds, sit again and repeat the sequence four times when prompted by acoustic signals. All data were registered in a Linux OS computer via Bluetooth® transfer. Data were processed with adapted freeware in C and Python[9].

The data from the four sensors were adjusted using the calibration curve of each sensor and stored together with the time of the measurements. The analysis in the time domain corresponds to plotting time versus amplitude of the signal for each sensor. It was possible to group the data and plot in real time the position of the center of pressure. To study the frequency domain a Fast Fourier Transform (FFT) was performed. This algorithm works best if the number of points is a power of two so we used 1024 or 2048 points. The sampling rate was 25Hz. An analysis of signal-to-noise ratio was carried out and showed that above 8Hz the

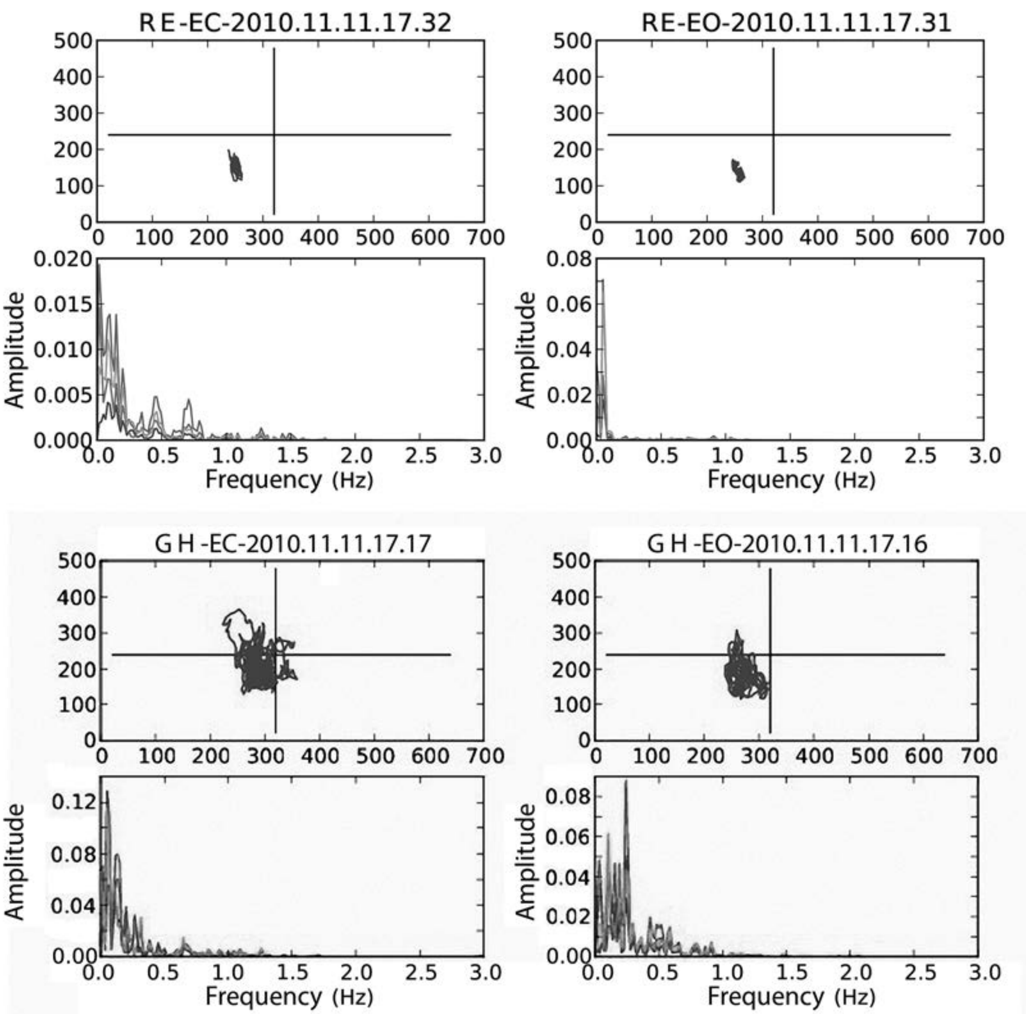

Figure 1. Sway and frequency analysis for (above) a stable person (above), and an unstable person (below); EC = Eyes Closed; EO=Eyes Opened

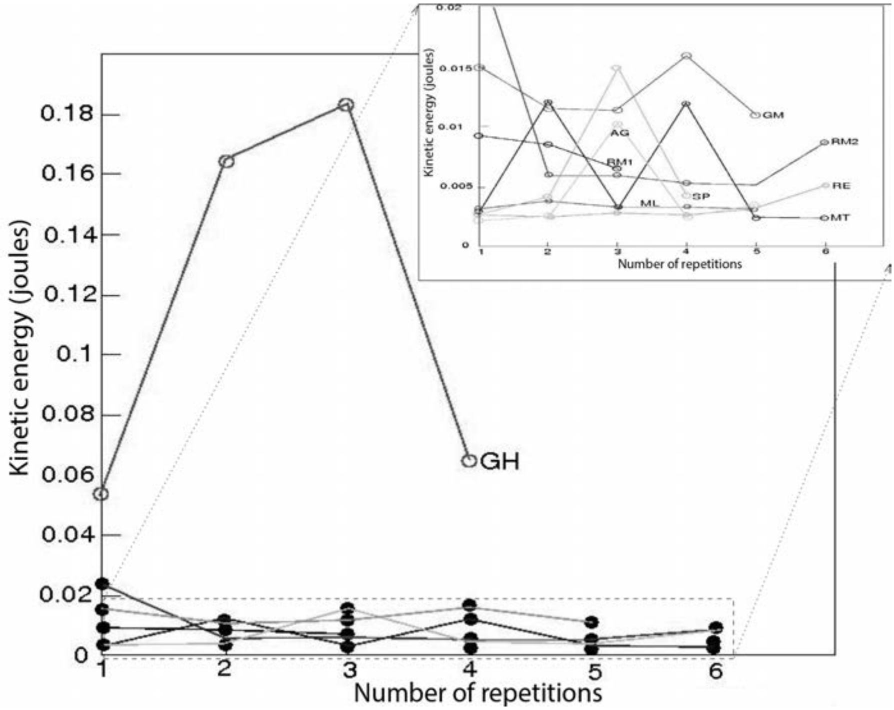

Figure 2. Average kinetic energy for each sit and stand cycle for different stable subjects (lower part of the figure, enlarged at upper right), and one unstable person, GH

signal is indistinguishable from noise. A low-pass filter (Butterworth) was tested but no difference was observed. In fact in all the measurements the relevant information occurred below 3Hz. We had to decide what range of frequencies to study and the best way to obtain measurements in that range. According to the literature and our previous experience, for most people the relevant frequency range is 0-3Hz[10]. The Balance Board allows adequate measurements in that range; it is only above approximately 8Hz that the signal becomes indistinguishable from noise. In order to optimize the resolution in the 0-3Hz range we had to choose the highest possible sampling rate permitted by the equipment for the longest possible time acceptable for the subjects. Additionally, the FFT algorithm requires a number of sample points which is a power of two. The limit in sampling rate of our device is approximately 30Hz; the time limit for the subjects is around one minute, especially in the tandem position. We chose a sampling rate of 25Hz and 1024 points which requires less than 50 seconds per position. This choice gives enough cycles and enough measurements within each cycle to have a good resolution. The use of a low-pass filter sometimes allows a better definition of the amplitudes of low-frequency oscillations but in this case the addition of a filter at 8Hz had no visible effect on the spectrum below 3Hz so we did not use it.

The data from the first battery of tests was displayed as movement of the center of pressure and also analyzed in the frequency domain after performing the FFT[11]. Then a series of graphics for each test were performed in order to identify common patterns between subjects, the balance of sway and amplitude versus frequency (*Figure 1*). The second battery of tests was processed to compute kinetic energy (joules) used in each standing effort (*Figure 2*).

In order to assess concordance with the tests, subjects were classified in three categories which were arbitrarily determined by the researchers: stable (SPPB 9-12; calculated kinetic energy 0.01-0.06), intermediate (SPPB 5-8, calculated kinetic energy 0.07-0.12) and unstable (SPPB 0-4; calculated kinetic energy 0.13-0.18); the assessed kinetic energy for concordance was the worst of the 5 standing efforts. Then a weighted kappa statistic was performed, we considered a $p<0.05$ to be statistically significant. We used the STATA®12 program for the analysis of the data.

The Instituto Nacional de Geriatría Ethics Research Committee evaluated and approved this study. All the subjects of the study signed informed consent declarations, with a previous explanation of the procedures.

Table 1. Concordance between two balance tests (n=20)

		Short physical performance battery		
		stable	intermediate	unstable
Wii balance board	stable	6	0	0
	intermediate	0	7	0
	unstable	1	0	6

Results

We recruited 20 subjects, with a median age of 67.5 (range 60-98), of whom 75% were women. Regarding the SPPB scores there was a mean of 6.2 (SD 1.1). Of all the subjects, 35% (n=7) were classified as stable, 35% (n=7) as intermediate and 30% (n=6) as unstable. The level of sway as seen from the movement of the center of pressure varied significantly between stable and unstable subjects (*Figure 1*). On the other hand, with the WBB only one subject was classified as stable, in contrast to the SPPB in which the classification was unstable (*Table 1*).

Subjects who were deemed unstable according to the medical tests used significantly more energy than those considered stable (*Figure 2*). In 19 out of 20 subjects the classification according to standard geriatric tests coincided with the classification according to energy spent, with a weighted kappa statistic value of 0.6, p=0.05 (*Table 1*).

Discussion

Fall prevention is an important part of elderly health care. A first step in developing a versatile tool to predict falls is to know if it can discriminate in grossly different subjects, and its capacity to perform at least as well as clinimetric available scales. This study demonstrated that the WBB had a good concordance with the SPPB, a widely used tool in the clinical and research settings to assess falls risk[5].

A recent study suggests, that available energy decreases with age, but the level of energy needed to perform activities of daily living increases; this phenomenon was observed in this study, where the oldest subject used the greater amount of energy in the sit/stand test in the platform[12]. This study has also added more information to a mathematical model of body equilibrium on which our group is working at the moment. Stability is achieved through the interplay of numerous systems in the body and many or all can reduce their performance in old age. However, even if curing stability loss is not an option, some degree of rehabilitation might be possible and many relatively simple measures can be put in effect to reduce the risk of falls if people are made aware of their condition, in an early stage[13].

One of the main flaws of our study was the lack of representativeness of the study subjects. Nevertheless, these results could lead to new research in a wider population, due to the portability of the board. In addition, subjects in the sample were from a wide range of age groups, 60 to 98 years old, a representative span of age present in Mexico City. With a bigger sample also questions regarding cost and effectiveness of this test could be answered, with more potential benefit in public health due to the fact that a procedure with the WBB takes less than one minute per test, and the SPPB could take up to five minutes; an issue that could lead to assessment of falls risk even in a busy primary health care setting.
Postural instability not only increases the risk of falls, but also greatly influences the decline in the quality of life (QOL) of the elderly[14,15]. Falls are one of the most frequently and expensive geriatric syndromes; for clinicians and the sanitary system one of the most important achievements would be a test that could detect early, and effectively, the risk of falling. Until now, in order to predict the fall risk in the elderly, balance ability has been measured with various methods in the laboratory and in clinical settings. Typical tests include the Berg Balance Scale (BBS), Tinetti's Test, and the Timed 'Up & Go' Test (TUGT). However, these tests were developed mainly to evaluate the functional capacity of the elderly in the nursing home, not for ambulatory ones. The Wii™ Balance board is a promising tool to detect loss of stability in the elderly, as shown in this study, in a broad spectrum such as young healthy elders, and also in the very old. In this study the platform was able to discriminate between stable and unstable patients according to the standard clinical tests. Similar results were found by Melzer et al., who were able to discriminate between elderly fallers and non-fallers[13]. The board is also easy to transport, easy to install and use whenever it's needed, inexpensive and versatile. Also this board has the advantage that it can measure weight, which we believe is important, together with other body measurements, to determine the normal sway frequency for each individual. We are currently working on a mathematical model of equilibrium that takes into account body measurements to predict such frequencies, a feature that to our knowledge has not yet been exploited. The use of open software makes the system very adaptable. Further research should aim to assess which tests are more predictive of balance problems without posing risk to the subject.

Conclusion

The balance board is a promising tool regarding assessment of postural stability in elderly; in a cheap and portable fashion.

Acknowledgements
We would like to thank Dr. David Kersenobich Stalnikowitz and Dr. A.A. Minzoni of the Interdisciplinary Biomedical Research Seminar at Universidad Nacional Autónoma de México for their support. The first two authors thank A. Pérez and R. Chávez

for computational support.

References

1. Kinsella KG. Future longevity - demographic concerns and consequences. Journal of the American Geriatric Society 2005;53(Suppl 9):299-303
2. Inouye SK, Studenski S, Tinetti ME, Kuchel GA. Geriatric syndromes: clinical, research, and policy implications of a core geriatric concept. Journal of the American Geriatric Society 2007;55(5):780-791; doi:10.1111/j.1532-5415.2007.01156.x
3. Stevens JA, Baldwin GT, Ballesteros MF, Noonan RK, Sleet DA. An older adult falls research agenda from a public health perspective. Clinics in Geriatric Medicine 2010;26(4):767-779; doi:10.1016/j.cger.2010.06.006
4. Thurman DJ, Stevens JA, Rao JK. Practice parameter: Assessing patients in a neurology practice for risk of falls (an evidence-based review): report of the Quality Standards Subcommittee of the American Academy of Neurology. Neurology 2008;70(6):473-479; doi:10.1212/01.wnl.0000299085.18976.20
5. Murphy AMOL, Protas EJ, Overby AR. Screening for Falls in Community-Dwelling Elderly. Journal of Aging and Physical Activity 2003;11(1):66-80
6. Vivrette RL, Rubenstein LZ, Martin JL, Josephson KR, Kramer BJ. Development of a fall-risk self-assessment for community-dwelling seniors. Journal of Aging and Physical Activity 2011;19 (1):16-29
7. Clark RA, Bryant AL, Pua Y, McCrory P, Bennell K, Hunt M. Validity and reliability of the Nintendo Wii Balance Board for assessment of standing balance. Gait Posture 2010;31(3):307-310; doi:10.1016/j.gaitpost.2009.11.012
8. Guralnik JM, Simonsick EM, Ferrucci L, Glynn RJ, Berkman LF, Blazer DG, Scherr PA, Wallace RB. A short physical performance battery assessing lower extremity function: association with self-reported disability and prediction of mortality and nursing home admission. Journal of Gerontology 1994;49(2):M85-M94; doi:10.1093/geronj/49.2.M85
9. www.mattcutts.com/blog/linux- wiimote-via-bluetooth; retrieved January 2012
10. Baratto L, Morasso PG, Re C, Spada G. A new look at posturographic analysis in the clinical context: sway-density vs. other parametrization techniques. Motor Control 2002;6(3):246-270
11. Lyons RG. Understanding digital signal processing. Reading: Addison Wesley; 1997
12. Schrack JA, Simonsick EM, Ferrucci L. The energetic pathway to mobility loss: an emerging new framework for longitudinal studies on aging. Journal of the American Geriatrics Society 2010;58(Suppl 2):S329-S336; doi:10.1111/j.1532-5415.2010.02913.x
13. Melzer I, Kurz I, Oddsson LI. A retrospective analysis of balance control parameters in elderly fallers and non-fallers. Clinical Biomechanics 2010;25(10):984-988; doi:10.1016/j.clinbiomech.2010.07.007
12. Legters K. Fear of falling. Physical Therapy 2002;82(3):264-272
13. Salkeld G, Cumming RG, O'Neill E, Thomas M, Szonyi G, Westbury C. The cost effectiveness of a home hazard reduction program to reduce falls among older persons. Australian and New Zealand Journal of Public Health 2000;24(3):265-271; doi: 10.1111/j.1467-842X.2000.tb01566.x