Published in final edited form as:

J Geriatr Phys Ther. 2017 ; 40(1): 37–41. doi:10.1519/JPT.0000000000000065.

Measurements of Weight Bearing Asymmetry Using the Nintendo Wii Fit Balance Board Are Not Reliable for Older Adults and Individuals With Stroke

Derek M. Liuzzo, DPT, Denise M. Peters, DPT, Addie Middleton, DPT, Wes Lanier, DPT, Rebecca Chain, DPT, Brittany Barksdale, DPT, and Stacy L. Fritz, PT, PhD

Department of Exercise Science, Physical Therapy Program, University of South Carolina, Columbia

Abstract

Background—Clinicians and researchers have used bathroom scales, balance performance monitors with feedback, postural scale analysis, and force platforms to evaluate weight bearing asymmetry (WBA). Now video game consoles offer a novel alternative for assessing this construct. By using specialized software, the Nintendo Wii Fit balance board can provide reliable measurements of WBA in healthy, young adults. However, reliability of measurements obtained using only the factory settings to assess WBA in older adults and individuals with stroke has not been established.

Purpose—To determine whether measurements of WBA obtained using the Nintendo Wii Fit balance board and default settings are reliable in older adults and individuals with stroke.

Methods—Weight bearing asymmetry was assessed using the Nintendo Wii Fit balance board in 2 groups of participants—individuals older than 65 years ($n = 41$) and individuals with stroke ($n = 41$). Participants were given a standardized set of instructions and were not provided auditory or visual feedback. Two trials were performed. Intraclass correlation coefficients (ICC), standard error of measure (SEM), and minimal detectable change (MDC) scores were determined for each group.

Results—The ICC for the older adults sample was 0.59 (0.35–0.76) with $SEM_{95} = 6.2\%$ and $MDC_{95} = 8.8\%$. The ICC for the sample including individuals with stroke was 0.60 (0.47–0.70) with $SEM_{95} = 9.6\%$ and $MDC_{95} = 13.6\%$.

Discussion—Although measurements of WBA obtained using the Nintendo Wii Fit balance board, and its default factory settings, demonstrate moderate reliability in older adults and individuals with stroke, the relatively high associated SEM and MDC values substantially reduce the clinical utility of the Nintendo Wii Fit balance board as an assessment tool for WBA.

Conclusions—Weight bearing asymmetry cannot be measured reliably in older adults and individuals with stroke using the Nintendo Wii Fit balance board without the use of specialized software.

Keywords

assessments; balance; geriatric; stroke

INTRODUCTION

Clinicians continually implement new technology to obtain more precise measurements. In recent years, video games consoles have gained popularity in physical therapy settings as both assessment and intervention tools. Although these devices provide enjoyable treatment options for patients,¹ further research is needed to determine the psychometric properties of the various measurement capabilities the console provides. One video game system employed by clinicians is the Nintendo Wii Fit. The system is being used to assess weight bearing asymmetry (WBA) in individuals with impaired balance.

Before the Nintendo Wii Fit balance board, more conventional options were available including 2 digital bathroom scales,² a balance performance monitor with visual and auditory feedback,^{3,4} a postural scale analyzer measuring weight distribution,² or posturography via force platforms.⁵ Force platforms provide accurate and reliable measurements of an individual's center of pressure and ground reaction forces and are considered the "gold standard" for measuring WBA.⁵⁻⁸ Use of dual platforms is the most accurate method; however, Genthon et al⁶ demonstrated that measurements of WBA were reliable when using a single force platform. Another instrumented platform, the Nintendo Wii Fit balance board, could provide clinicians with a novel method for assessing WBA.

The Nintendo Wii Fit balance board is an appealing alternative to the force platform, as it can also be used to measure WBA but is less expensive—less than \$200 for the Wii bundle. Sensors and strain gauges in the balance board measure the user's center of pressure and the weight placed through each foot.⁹ Clark et al⁹ demonstrated that the Nintendo Wii Fit balance board provides a reliable tool for measuring WBA in young adults. In their sample, the within-device intraclass correlation coefficient (ICC) was 0.66 to 0.94 and the between-device ICC was 0.77 to 0.89 when comparing measurements of WBA collected with the Nintendo Wii Fit balance board with those measurements collected with a force platform. Clark and colleagues also examined whether measurements of WBA could be reliably obtained using dual Nintendo Wii Fit balance boards. In this study, participants stood on 2 balance boards for 2 different trials. One trial was without feedback, whereas the other trial utilized visual feedback. The ICC was 0.91 (standard error of measure [SEM] = 0.66) without feedback and 0.81 (SEM = 0.76) with visual feedback.¹⁰ Although these studies demonstrate the reliability of capturing young adults' WBA with the Nintendo Wii Fit balance board, there is little cross-over into the clinical arena, as both studies required modification of the balance board's output via specialized software.^{9,10} In addition, both studies used healthy, young participants to investigate reliability.

The Nintendo Wii Fit balance board continues to gain popularity in clinics as an assessment and intervention tool for various populations including older adults and those who have suffered neurological insult.^{1,11} Many clinicians prefer to use the balance board with the software that comes from the company due to the ease of setup and minimal learning curve. However, evidence on the use of the Nintendo Wii Fit balance board to measure WBA is limited in populations other than healthy, young adults. Therefore, the purpose of this study was to determine whether measurements of WBA were reliable in (1) older adults and (2) individuals with stroke using the factory settings on the Nintendo Wii Fit balance board.

METHODS

Participants

Two groups of participants were selected from 2 larger, concurrent studies being conducted at the University of South Carolina. The first group was composed of older adults from a local, residential community center. To qualify, participants had to be 65 years or older, able to stand without an assistive device or bracing for approximately 1 minute, and able to follow verbal instructions. Those with a lower extremity amputation or difficulty bearing weight through 1 or both lower extremities were excluded.

The second group consisted of individuals with chronic stroke. To qualify for this arm of the study, participants had to be 18 years or older, greater than 6 months poststroke, have a clinical presentation of unilateral hemiplegia, be able to stand without an assistive device or bracing for approximately 1 minute, and be able to follow verbal instructions. Exclusion criteria were the same as the older adult group. All participants signed an informed consent form approved by the university's institutional review board prior to participation.

Procedures

A general avatar was created for the participant and was assisted through the Wii Fit's setup programming during which WBA was analyzed. For WBA assessment, participants were instructed to stand on the Nintendo Wii Fit balance board using the following standardized instruction set: "Please step onto the board by placing your left foot evenly on the left side and your right foot evenly on the right side. You may use the grab bar beside you to assist you stepping onto the board. Now, please attempt to EVENLY or EQUALLY distribute your weight on each foot. This distribution of weight should be what you PERCEIVE to be equal weight." Participants were not permitted to use the grab bar for balance once standing on the balance board, prohibiting the use of upper extremity support while the Wii calculated percentages of body weight through each lower extremity. Two trials were performed and results from both trials were included in data analysis. Practice trials were not provided. Percentage of weight through each foot was the outcome of interest. Following recording of percentages of weight through each foot, the participant stepped off the balance board, rested for a minute to allow for a reset of the Wii Fit System, and then a second trial was initiated.

During WBA assessment, the Wii Fit system gave a representation of the participant's center of pressure by using a green dot. The green dot floated on a grid showing the individual

where the center of pressure is in relation to his or her feet. The system also provided percentages of the amount of weight supported by each lower extremity. To avoid providing external cues to correct any WBA and ensure that a true representation of WBA was recorded, the balance board was positioned so that participants could not see the display. Participants were also not provided with verbal feedback during the 2 trials.

Statistical Analysis

Descriptive statistics were calculated for demographic variables and WBA outcomes for the 2 groups. Normality of the data was assessed using the Shapiro-Wilk test ($P > .05$). To determine reliability, ICC values were calculated using a single measure, 2-way fixed model with consistency. For the ICC, repeated measurements of weight bearing through 1 extremity were compared. Data from the affected lower extremity were analyzed for the individuals with stroke and data from the left lower extremity for the older adults. The ICC was interpreted using the Shrout and Fleiss rating system (>0.75 = excellent, 0.40 – 0.75 = moderate, and <0.40 = poor).¹⁰ The standard error of measurement (SEM) and minimal detectable change (MDC) values were then calculated using the following equations: $SEM = SD \sqrt{1 - ICC}$ and $MDC = z_{\text{score}_{\text{level of confidence}}} \times SD_{\text{baseline}} \times \sqrt{2[1 - ICC]}$.¹⁰ The SEM was calculated to estimate the amount of measurement error that occurs during assessment, and the MDC was established to determine the amount of change needed to be confident a true change has occurred.

RESULTS

Two outliers were removed from the older adult group (final, $n = 41$) to achieve a normal WBA distribution. These participants had WBAs greater than 2 standard deviations from the mean WBA for the older adult group ($>73\%$ of their body weight through 1 lower extremity). Demographic information for both groups is presented in Table 1.

In the older adult group, average weight bearing through the left lower extremity was 51% (4.9%) with a minimum of 39.1% and a maximum of 59.6% for the first trial and 50% (4.7%) with a minimum of 40.1% and maximum of 58.6% for the second trial. Average WBA was 3.2% (3.1%), with a range of 0.1% to 6.3% (Table 2). Measurements of WBA using the Nintendo Wii Fit balance yielded moderate test-retest reliability for older adults with an ICC of 0.59 (0.35 – 0.76).

The group of individuals with stroke also consisted of 41 participants. These participants were measured multiple times throughout a larger study, yielding 127 individual observations for analysis. Average weight bearing through the affected lower extremity was 47% (7.6%) with a minimum of 28.2% and a maximum of 72.5% for the first trial and 47% (6.7%) with a minimum of 30.7% and maximum of 64.5% for the second trial. The average WBA was 5.3% (3.8%) and ranged from 1.5% to 9.1% (Table 2). Measurements of WBA using the Nintendo Wii Fit balance yielded moderate test-retest reliability for individuals with stroke with an ICC of 0.60 (0.47 – 0.70). The ICC values, as well as SEMs and MDCs for both groups, are presented in Table 3.

DISCUSSION

Falls secondary to asymmetric weight bearing are common for older individuals and individuals poststroke.^{5,13} Therefore, the need for clinically feasible assessments tools is paramount. Although a variety of options are available, most existing equipment is expensive, large, or not supported by sufficient research.^{2,4,14} This study tested if measurements of WBA were reliably reproduced between trials for older adults and adults with stroke using a new assessment tool—the Nintendo Wii Fit balance board.

We used 2 types of reliability to examine the accuracy and clinical utility of the Nintendo Wii Fit balance board—relative reliability and absolute reliability. Relative reliability, which can be expressed as an ICC, is unitless and denotes the degree of agreement between repeated measurement trials.¹⁵ In addition to relative reliability, absolute reliability is also important to consider. An example of an absolute reliability metric is the SEM. This value indicates the amount of random error that occurs when a single individual is tested multiple times. The SEM is expressed in terms of the units of measure; for example, if something is measured in feet then the SEM will also be in feet.¹⁵ In this article, the SEM is expressed as percentage of weight bearing.¹⁵ The SEM can be used to calculate another clinically useful metric—the MDC. The MDC values are indicative of the minimal amount of change needed to exceed measurement error.¹⁶

Although Clark et al⁹ reported excellent reliability when collecting measurements of WBA with the Nintendo Wii Fit balance board in healthy, young adults, the findings in this study suggest a moderate consistency when using the system to assess older adults (ICC = 0.59 [0.35–0.76]) and individuals with stroke (ICC = 0.60 [0.47–0.70]), 2 populations that commonly demonstrate WBA.^{9,10} The differences between the populations may explain the discrepancy in findings; however, it should also be noted that Clark et al studies utilized custom software, whereas this study used the factory default settings in an effort to mimic clinical use.

On the basis of the ICCs for WBA assessment (moderate consistency) in our samples, one may conclude that the Nintendo Wii Fit balance board could be used as a relatively inexpensive, commercially available measurement tool in clinics where the more expensive force plate is not feasible; however, the absolute reliability must also be considered. The SEM_{95s} for the 2 groups (6.2% for older adults and 9.6% for individuals with stroke) indicate that the magnitude of error that occurs when measuring WBA with this system may reduce its clinical utility.¹⁵ For example, on the basis of our findings if a participant with stroke bears 43% of his or her weight on the affected leg, we can be 95% confident that the true weight bearing measurement lies somewhere between 33% and 53%. To further explain, if this individual is bearing 33% of his or her weight through the affected leg, the other leg must bear the remaining 67%. However, if this individual is actually bearing 53% of his or her weight through the affected leg, then the individual's weight is more equally distributed. The potential error in measurement is too large to accurately give a picture of how the person is bearing weight.

The relatively high measurement error also results in a relatively large MDC; a large change is needed to be confident that a true change in WBA has occurred when assessing with the Nintendo Wii Fit balance board. On the basis of our results, WBA measurements would have to change by more than 8.8% for older adult patients and 13.6% for individuals with stroke before a clinician could be 95% confident that WBA had truly changed. For example, suppose an individual with stroke initially loaded 45% of his or her weight onto the affected leg at evaluation and then 49% 4 weeks later at discharge. The clinician cannot be confident there was a true improvement in WBA since the observed value is less than the MDC_{95} (13.6%). The relatively large SEM_{95} and MDC_{95} values indicate that caution should be exerted when using the Nintendo Wii Fit balance board and factory settings to assess and monitor WBA in older individuals and individuals with chronic stroke.

Limitations in study design should be considered when interpreting and applying our results. One limitation is the variability in the length of time the Wii Fit took to provide readout. This variability could be due to error messages caused by excessive movement of the participant. However, movement and error messages will also likely occur during clinical use, so our results reflect how the system would behave in clinical settings. A lack of practice trials for the participants may be another potential limitation. Although practice trials would have provided participants the opportunity to familiarize themselves with the device and protocol, the task of standing with weight perceived equally distributed between feet was fairly straightforward and practice trials are unlikely to be employed in a clinical setting. Sensory testing was not performed on the older adult participants. As sensory impairments could impact an individual's performance on a WBA assessment, this is a limitation in study design. However, patients assessed in clinical settings will have various sensory disorders and be measured by the device. The participants included reflect the population seen by clinicians.

CONCLUSIONS

Measuring WBA of older adults and individuals with stroke can be performed with moderate reliability when using the factory settings of the Nintendo Wii Fit balance board in a clinical setting. However, the accompanying SEM and MDC values indicate the system should be used with caution for this purpose, as the large measurement errors diminish the clinical utility. Therefore, the Nintendo Wii Fit balance board is not recommended for assessment of WBA in these populations using only the factory settings and specialized software.

Acknowledgments

Financial support for this study was provided by a grant from Health Games Research, a national program of the Robert Wood Johnson Foundation, grant 64450.

References

1. Buck M, Fink ML. Nintendo Wii fall reduction effectiveness in the elderly and its ability to assess balance using center of pressure: a literature review. *Orthop Phys Ther Pract*. 2012; 24(3):148–153.
2. Pyoria O, Era P, Talvitie U. Relationships between standing balance and symmetry measurements in patients following recent strokes (3 weeks or less) or older strokes (6 months or more). *Phys Ther*. 2004; 84(2):128–136. [PubMed: 14744203]

3. Haas BM, Burden AM. Validity of weight distribution and sway measurements of the balance performance monitor. *Physiother Res Int*. 2000; 5(1):19–32. [PubMed: 10785908]
4. Sackley C, Baguley B. Visual feedback after stroke with the balance performance monitor: two single case studies. *Clin Rehabil*. 1993; 7(3):189–195.
5. Marigold DS, Eng JJ. The relationship of asymmetric weight bearing with postural sway and visual reliance in stroke. *Gait Posture*. 2006; 23(2):249–255. [PubMed: 16399522]
6. Genthon N, Gissot AS, Froger J, Rougier P, Perennou D. Posturography in patients with stroke: estimating the percentage of body weight on each foot from a single force platform. *Stroke*. 2008; 39(2):489. [PubMed: 18174486]
7. Bohannon RW, Wald D. Accuracy of weightbearing estimation: stroke patients versus healthy subjects. *Percept Motor Skills*. 1991; 72(3):935–941. [PubMed: 1891331]
8. Bohannon RW, Waldron RM. Weightbearing during comfortable stance in patients with stroke: accuracy and reliability of measurements. *Aust Physiother*. 1991; 37(1):19–22.
9. 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. [PubMed: 20005112]
10. Clark RA, McGough R, Paterson K. Reliability of an inexpensive and portable dynamic weight bearing asymmetry assessment system incorporating dual Nintendo Wii balance boards. *Gait Posture*. 2011; 34(2):288–291. [PubMed: 21570290]
11. Bainbridge E, Bevans S, Keeley B, Oriel K. The effects of the Nintendo Wii Fit on community-dwelling older adults with perceived balance deficits: a pilot study. *Phys Occup Ther Geriatr*. 2011; 29(2):126–135.
12. Shrout PE, Fleiss JL. Intraclass correlations: uses in assessing rater reliability. *Psychol Bull*. 1979; 86(2):420–428. [PubMed: 18839484]
13. Forster A, Young J. Incidence and consequences of falls due to stroke: a systematic inquiry. *BMJ*. 1995; 311(6997):83–86. [PubMed: 7613406]
14. Deutsch JE, Borbely M, Filler J, Huhn K, Guarrera-Bowlby P. Use of a low cost, commercially available gaming console (Wii) for rehabilitation of an adolescent with cerebral palsy. *Phys Ther*. 2008; 88(10):1196–1207. [PubMed: 18689607]
15. Bruton A, Conway JH, Holgate ST. Reliability: what is it, and how is it measured? *Physiotherapy*. 2000; 86(2):94–99.
16. Steffen T, Seney M. Test-retest reliability and minimal detectable change on balance and ambulation tests, the 36-item short-form health survey, and the Unified Parkinson Disease rating scale in people with Parkinsonism. *Phys Ther*. 2008; 88(6):733–746. [PubMed: 18356292]

Table 1Demographic Information and Outcome Assessments for Older Adults and Individuals With Stroke^a

Participant Characteristics	Older Adults	Individuals With Stroke
Number of participants	41	41
Men	10	28
Women	31	13
Age (y)	84 (6.65)	67 (13)
Side of stroke		
Right	NA	26
Left	NA	15
Time since stroke (mo)	NA	63 (53)
Number Using AD or orthotics	7	12
Walking speed (m/s)		
Self-selected	0.96 (0.46)	0.58 (0.29)
Fast-paced	...	0.8 (0.4)
Berg Balance Scores	...	45 (10)
Dynamic Gait Index	-	16.5 (4.7)

Abbreviations: AD, assistive device; NA, not applicable.

^a A full representation of the 2 groups. The 2 groups were collected from 2 larger studies that did not record all of the same outcome assessments. Those measurements denoted by "...;" were not recorded by the larger study for the older adults. The older adult participants did not have any concurrent neurological conditions thus negating the need to record the side of stroke and time since stroke.

Table 2Weight Bearing Percentage and Weight Bearing Asymmetry for Older Adults and Individuals With Stroke^a

Weight Bearing Data	Older Adults	Individuals With Stroke
Weight bearing asymmetry	3.2% (3.1%)	5.3% (3.8%)
1st trial weight bearing percentage		
Average	51% (4.9%)	47% (7.6%)
Minimum	39.1%	28.2%
Maximum	59.6%	72.5%
2nd trial weight bearing percentage		
Average	50% (4.7%)	47% (6.7%)
Minimum	40.1%	30.7%
Maximum	58.6%	64.5%

^a All weight bearing data analyzed from the Nintendo Wii Fit Balance Board. The left lower extremities were observed for all of the older adults, whereas the affected lower extremities were observed for all individuals with stroke.

Table 3

Intraclass Correlation Coefficients With 95% Confidence Intervals, Standard Error of Measure, 95% Standard Error of Measure, 90% Minimal Detectable Change, and 95% Minimal Detectable Change for Both Older Adults and Individuals With Stroke

Group	ICC	ICC 95% CI	SEM	95% SEM	90% MDC	95% MDC
Older adults	0.59	0.35–0.76	3.2	6.2	9.1	8.8
Individuals with stroke	0.60	0.47–0.70	4.9	9.6	11.5	13.6

Abbreviations: CI, confidence interval; ICC, intraclass correlations; MDC, minimal detectable change; SEM, standard error of measure.

^aThe intraclass correlations are shown along with their 95% confidence interval, standard error of measure, 95% SEM, and minimal detectable change for 90% and 95% confidence. The SEM, 95% SEM, 90% MDC, and 95% MDC are shown in units of percentage of body weight.