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Validity of the Nintendo Wii® balance board for the assessment of standing balance in Parkinson's disease

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Abstract

Background: Impaired postural stability places individuals with Parkinson's at an increased risk for falls. Given the high incidence of fall-related injuries within this population, ongoing assessment of postural stability is important.

Objective: To evaluate the validity of the Nintendo Wii® balance board as a measurement tool for the assessment of postural stability in individuals with Parkinson's.

Subjects: Twenty individuals with Parkinson's participated.

Intervention: Subjects completed testing on two balance tasks with eyes open and closed on a Wii® balance board and biomechanical force platform.

Main Measures: Bland–Altman plots and a two-way, random-effects, single measure intraclass correlation coefficient model were used to assess concurrent validity of centre-of-pressure data.

Results: Concurrent validity was demonstrated to be excellent across balance tasks (intraclass correlation coefficients = 0.96, 0.98, 0.92, 0.94).

Conclusions: This study suggests that the Wii® balance board is a valid tool for the quantification of postural stability among individuals with Parkinson's.

Keywords

Parkinson's disease, postural control, balance, assessment, validity, Nintendo Wii®

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Introduction

Parkinson's disease has been found to be a leading cause of falls in the elderly. Prospective studies suggest that up to 70% of individuals with Parkinson's report experiencing a fall over one year,[1] and that 10% report falling more than once per week.[2] Given the high incidence of fall-related injuries within this population, ongoing assessment of postural stability is important in disease management. The Wii® balance board has recently emerged as a new technology that could potentially be used to assess standing balance. The balance board possesses similar characteristics to a laboratory force platform, in that it contains sensors that assess force distribution and the resultant movements of the centre of pressure. The key benefits of the balance board over a force platform is that it is portable, inexpensive and readily available, thus theoretically providing clinicians a means with which to objectively assess biomechanical measures of postural stability.

Recently, Clark et al.[3] investigated the validity and reliability of the balance board by comparing data collected on a balance board and a force platform in a sample of healthy, young adults during the performance of four standing tasks. Results were promising and suggested that the balance board is a valid and reliable tool capable of objectively assessing postural stability in a healthy population. Although a number of studies have used single or multiple balance boards to assess factors, such as weight bearing asymmetry[3,4] or the ability to control external environments,[5] to the best of our knowledge to date there has been only one published study that has utilized the balance board as a means to acquire biomechanical centre-of-pressure data in a clinical population during a standing balance trial.[6] Given the limited research in this area and lack of validation in populations with known balance deficits, additional research is needed to examine the utility of using the balance board in a clinical population. The aim of this study was to evaluate the validity of the balance board in measuring static balance among individuals with Parkinson's disease using a biomechanical force platform as a 'gold standard' for comparison.

Methods

Twenty participants with idiopathic Parkinson's were recruited to participate from a neurological practice in Southwestern Ontario, Canada. Disease severity was tested using the motor subscale of the Unified Parkinson's Disease Rating Scale,[7] and the Modified Hoehn and Yahr Staging Scale.[8] To help ensure that all participants were within the 'ON' phase of their medication cycle, testing was conducted approximately two hours after individuals took their usual medications. Participants were excluded from the study if they were experiencing major back or lower limb pathology that could influence standing balance, or if they obtained a score higher than stage 3 on the Modified Hoehn and Yahr Staging Scale, as these individuals have (by definition) difficulty standing without assistance, and were considered to present an unacceptable risk of falling. The research protocol, recruitment method, and mechanism for obtaining informed consent were approved by the Health Sciences Research Ethics Board, at the University of Western Ontario. All participants provided free and informed written consent.

Postural stability of each participant was evaluated during four standing balance tasks on a laboratory-grade force platform (AMTI Model OR6-5,Watertown, MA, USA), which measured 50 cm × 46 cm in size, and was mounted flush with a wooden walkway; and a Wii® balance board, which has a useable surface of 45 cm × 26.5 cm and was mounted flush with a wooden platform situated adjacent to the walkway. Data from the force platform were sampled at 100 Hz, and were collected, filtered and analysed using the proprietary Netforce and BioAnalysis (Version 2.2) software. The balance board was connected to a laptop computer (via Bluetooth) using custom-written software (Labview 8.5 National Instruments, Austin, TX, USA), and was calibrated as per the protocol described by Clark et al.[3] Data for each individual sensor were streamed to the software, with interpolation of the data and the timepoint of data acquisition ensuring a stable 100 Hz sampling rate. To remove signal noise, the data for each individual sensor were filtered using a 12.5 Hz low-pass filter utilizing a

Table 1. Validity analysis of centre-of-pressure path length (cm) measures during each of the four standing balance trials.

	FP mean (SD)	WBB mean (SD)	Mean diff (95% CI)	ICC (95% CI)
Eyes open, feet apart	57.4 (20.2)	57.8 (22.6)	0.4 (–3.6, 4.4)	0.96 (0.90, 0.99)
Eyes open, feet together	64.1 (19.8)	66.8 (24.7)	2.7 (–0.4, 5.8)	0.98 (0.94, 0.99)
Eyes closed, feet apart	64.3 (22.2)	66.2 (30.6)	1.9 (–5.1, 8.9)	0.92 (0.79, 0.97)
Eyes closed, feet together	85.1 (28.1)	91.6 (41.6)	6.5 (–1.4, 14.5)	0.94 (0.85, 0.98)

FP, forceplate; WBB, Wii® balance board; SD, standard deviation; CI, confidence interval; ICC, intraclass correlation coefficient.

two-level undecimated Symlet-8 wavelet with the detail levels removed, converted to centre-of-pressure coordinates using the equation outlined previously,[3] then low-pass filtered at 6.25 Hz using a three-level undecimated Symlet-8 wavelet with the detail levels removed.

The four balance tasks included: 1) eyes open, feet apart; 2) eyes closed, feet apart; 3) eyes open, feet together; and 4) eyes closed, feet together. These tasks were selected based on their varying difficulty and common use in previous literature.[9,10] Participants completed two 30-second trials of each task on each of the two devices, for a total of 16 trials. For each trial, participants were instructed to keep their hands at their side, look straight ahead, and remain as still as possible. All trials were completed with participants wearing their regular footwear. Participants received 30 seconds of rest between successive trials within each condition and 60 seconds of rest when changing between tasks or devices. Half of the participants were tested on the balance board first, and the order of task presentation was randomized. Testing for each participant was completed on the same day and took approximately 30 minutes to complete.

Trials were averaged within each task such that a single value for each task per device was obtained. The outcome measure used in this study was the total centre-of-pressure path length, a valid and reliable measure of postural stability.[11] Bland–Altman plots and a two-way, random-effects, single measure intraclass correlation coefficient ($ICC_{(2,1)}$) model were used to assess concurrent validity. Point estimates of the ICCs were interpreted as follows: excellent (0.75–1), modest (0.4–0.74), or poor (0–0.39).[12] All statistical analyses were conducted using SPSS version 19.

Results

Twenty participants with idiopathic Parkinson's (13 male, seven female), with a mean age of 67 (SD 8) years and mean duration of illness of 8 (SD 4) years, participated in this study. Unified Parkinson Disease Rating Scale and Hoehn and Yahr Scale scores ranged from 9 to 49 (M = 25.7, SD = 11.1), and from 2.0 to 3.0 (M = 2.3, SD = 0.4), respectively.

Results for each of the four balance tasks are presented in Table 1. One participant was found to consistently have mean path length values falling more than three standard deviations away from the group mean, and was therefore removed from all subsequent analyses as an outlier.[13] Concurrent validity was shown to be consistently excellent across all balance tasks (ICCs = 0.92–0.98).

Bland–Altman plots for each of the balance tests are presented in Figure 1. While no obvious systematic bias was observed for any of the balance tasks, all balance tasks showed a bias towards higher mean path length values in the trials performed on the balance board, as compared with the force platform (mean difference = 0.4–6.5 cm).

Discussion

The results of this study suggest that the balance board is a valid assessment tool that can be used to accurately quantify the centre of pressure among

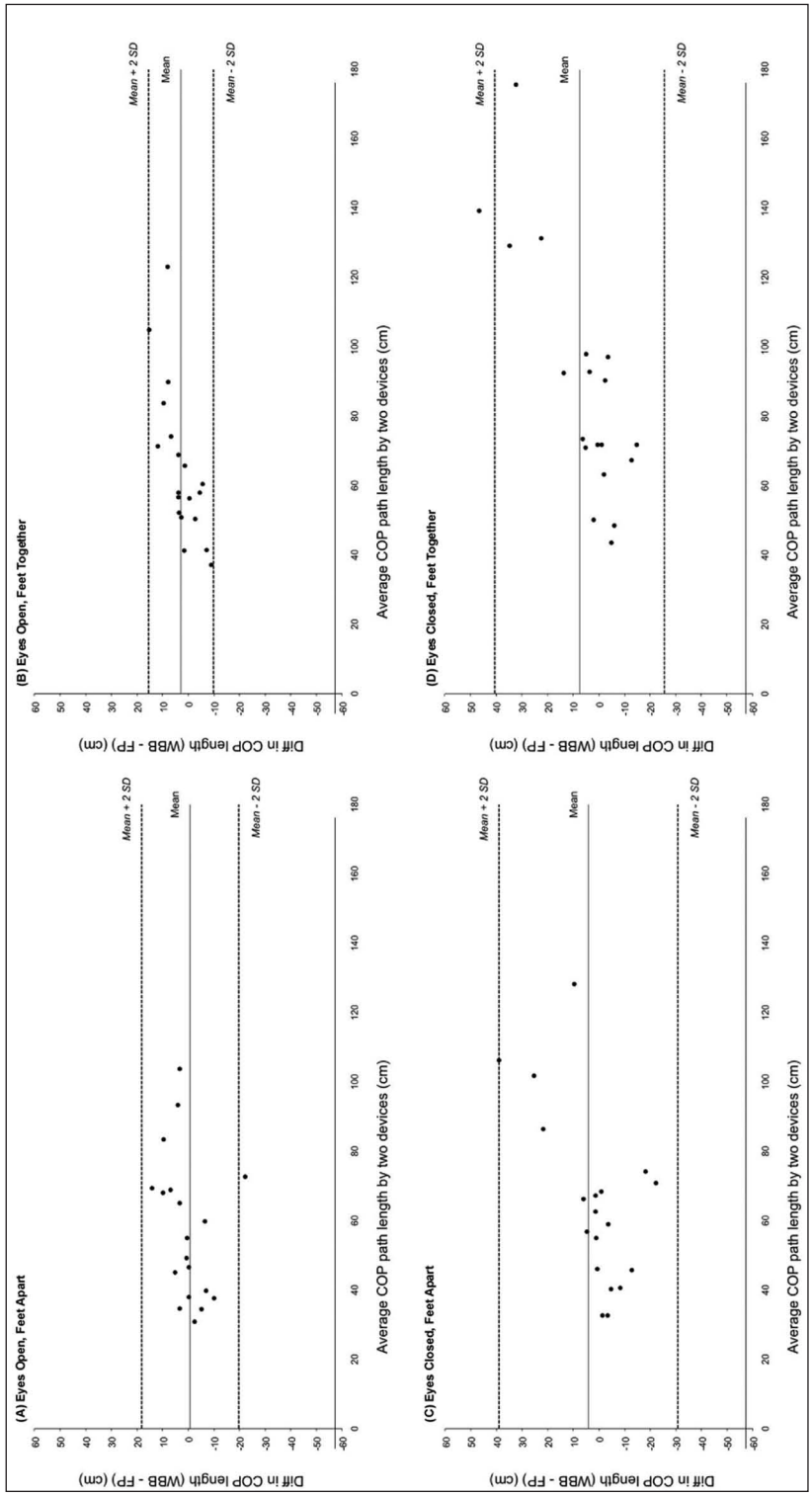

Figure 1. Bland–Altman plots for all four experimental conditions.
COP, centre of pressure; WBB, Wii® balance board; FP, forceplate; SD, standard deviation.

individuals with Parkinson's. When compared with the results of Clark et al.,[3] the ICC point estimates for concurrent validity are noticeably higher in the present study (ICCs = 0.92–0.98 versus ICCs = 0.77–0.89). This is potentially owing to the fact that the signal processing scheme used in the current study is much improved over the one used in the initial validation study. While the original filtering scheme worked well, continued research with the balance board has allowed us to improve the signal-to-noise ratio, and therefore, improve the accuracy of our measurement, and increase the magnitude of the ICCs.

Similar to findings reported by Clark et al.,[3] Bland–Altman plots revealed small differences in path length values between the balance board and force platform. As discussed by Clark et al.,[3] it is likely that the disparate values obtained between the two devices are the result of device-specific factors, such as the precision and sensitivity of the sensors and/or differences in surface texture, hardness and size. Qualitative feedback from research participants supports this reasoning, as several participants indicated they felt kinesthetically 'less stable' on trials conducted on the balance board in comparison to those that were conducted on the force platform – a phenomenon that might be owing to the fact that the balance board is much narrower than the force platform (26.5 cm versus 45 cm), and owing to its plastic shell being less rigid.

A limitation of this study is the lack of a follow-up session to assess the reliability of the instruments. The reliability of centre-of-pressure values derived from a force platform in this population has, however, been examined previously,[14] and given the aim of this study we chose to only evaluate the concurrent validity of the devices under the assumption that they will possess similar reliability metrics, as per Clark et al.[3] Another weakness of this study is that the mean of each condition was calculated from only two trials, a factor that may have contributed to increased variability. However, pilot testing identified that three trials per task raised concerns related to fatigue and medication wearing off, a finding that is not surprising given that fatigue, dyskinesia, medication wearing-off and day-to-day variability associated with Parkinson's makes testing (of any device) difficult within this population.[15]

The present findings of this study extend the work of Clark et al.[3] to suggest that the balance board can potentially be adopted as a new clinical tool to assess postural stability in a population with known balance impairments (i.e. Parkinson's). However, before the balance board can be put into practice, software applications, such as that used in the present study, must first be made commercially available; an undertaking that is currently underway.

Clinical message

- The Wii® balance board is an innovative tool that can provide clinicians a valid means in which to objectively quantify postural stability among individuals with Parkinson's disease.

Author contributions

JH acts as guarantor of the study. JH, AJ, MH, and RC were responsible for the research project conception; JH, AJ and MJ the organization; JH and MJ the recruitment and execution; and RC the software development. JH, AJ, MH and RC were responsible for the statistical analysis design; JH and AJ its execution. JH was responsible for the writing of the article, including revisions, with manuscript review and critique from AJ, MJ, MH and RC.

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Conflict of interest

The authors have no current conflicts of interest in this study, however, author RA Clark may commercialize and/or make freely available this or similar software in the future.

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