

# Safety, Feasibility and Effectiveness of Balance and Gait Training Using Nintendo Wii Fit Plus™ on Unstable Surface in Patients with Parkinson's Disease: A Pilot Study

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## Abstract

**Objective:** The objective of this study was to analyze the safety, feasibility and effectiveness of the Nintendo Wii Fit Plus™ performed over unstable surfaces, on balance and gait of four patients with Parkinson's disease (PD).

**Methods:** Patients had a mean age of 67 years ( $\pm$  8.2) and diagnosed with idiopathic PD as defined by stage 2 and 3 of the Hoehn Yahr scale, without signs of cognitive impairment (Mini Mental Status Examination  $>$ 23). Patients were assessed by a blinded examiner pre and post 14 training sessions. Each session was 60-minutes in length, three times a week. In all sessions of training, patients played four times each game: the first two attempts of the games were performed on stable surface and the final two attempts were performed over unstable surface, standing on the balance board placed over four mats or mini-trampoline.

**Results:** The main outcome was safety, assessed by the number of adverse events during the intervention. The secondary outcomes were: (1) feasibility, assessed by the performance of patients in the games and (2) the effectiveness, assessed by the Balance Evaluation Systems Test (BESTest). No adverse events were reported. Patients improved their scores on games over the 14 sessions. After the intervention, patients demonstrated improvement of 9.19% (8.12%) on BESTest score.

**Conclusions:** Motor training using the Wii Fit Plus™ performed over an unstable surface was safe, feasible and promoted improvement on static and dynamic balance of people with PD.

**Keywords:** Parkinson's disease; Virtual reality; Wii Fit; Physical therapy; Postural control

## Introduction

Parkinson's disease (PD) is a neurodegenerative disorder caused by progressive damage of dopaminergic neurons in the substantia nigra of the basal ganglia, which carries the classic tetrad of the disease: rigidity, resting tremor, bradykinesia and postural instability. Balance deficiency is refractory to treatment based on dopaminergic replacement [1], but rehabilitation is often shown to improve mobility and prevent falls [2]. Many studies have shown that physical therapy can improve balance impairment and gait through exercise programs [3] and training conducted with external cues [4-8]. Recently, the Nintendo Wii Fit Plus™ games have been used to improve the activities of daily living and balance of patients with PD [9, 10]. This is thought to be due to the complexity of the virtual tasks required within the games that involve cognitive process associated with motor performance [10-12]. On the other hand, several studies have shown that balance training performed on unstable surfaces improves postural instability of patients with PD [13], but there are no studies that focus on the association of both kinds of training: Wii Fit Plus™ performed over an unstable surface. The objective of this study was to analyze the safety, feasibility and effectiveness of balance training through the Nintendo Wii Fit Plus™ performed over unstable surface on balance and gait of patients with PD. Our hypothesis is that the combination of a highly challenging training involving cognitive stimulation and motor skills performed on unstable surface can promote improvement of postural control in patients with PD.

## Methods and Materials

Four patients with PD participated of this case series. The inclusion

criteria were: (1) patients diagnosed with idiopathic PD in stages 2 and 3 of Hoehn and Yahr scale [14]; (2) in dopaminergic replacement therapy by levodopa; (3) with absence of any other neurological or orthopedic dysfunction and (4) without signs of dementia [assessed by Mini Mental State Examination(MMSE); cut off= $\geq$ 23] [15]. All patients signed a consent term before the beginning of the study, which was approved by the Ethics and Research Committee of the São Camilo University Center (number 0119.0.166.000-09).

## Settings

This study was conducted at the Center for Health Promotion of São Camilo University Center (PROMOVE – São Camilo) located in São Paulo, Brazil.

## Intervention

Patients performed a total of 14 training sessions of 60 minute each

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**Received** December 20, 2013; **Accepted** January 16, 2014; **Published** January 27, 2014

**Citation:** Pompeu JE, Andrade G, Mendonça MS, Pompeu SMAA, Lange B (2014) Safety, Feasibility and Effectiveness of Balance and Gait Training Using Nintendo Wii Fit Plus™ on Unstable Surface in Patients with Parkinson's Disease: A Pilot Study. J Alzheimers Dis Parkinsonism 4: 136. doi: [10.4172/2161-0460.1000136](https://doi.org/10.4172/2161-0460.1000136)

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one, three times per week. The intervention consisted of a training based on 10 Nintendo Wii Fit Plus™ games, five games per session. In the first session, each participant was instructed by a physiotherapist about the rules and objectives of each game. At this time, patients were allowed to freely practice each game. In the remaining sessions, the games were practiced twice with the balance board on stable surface and then twice more on unstable surfaces, with the balance board placed over mats or a mini-trampoline. In the first attempt of each condition, the therapist directed the movements of the participant and on the second one; the participant played the game without assistance. The scores of the second trial of each game were recorded primarily on a stable surface and later an unstable surface. The games were divided into three groups: (1) Static Balance (Single Leg Extension and Torso Twist), (2) Dynamic Balance (Table Tilt, Tilt City, Soccer Heading, Penguin Slide and Balance Bubble) and (3) Stationary Gait (Obstacle Course, Basic Step and Basic Run).

### Primary outcome

The primary outcome was safety assessed by the number of adverse events during the study.

### Secondary outcome

The secondary outcomes were feasibility and efficacy. Feasibility outcome was defined by the scores in the games in the second and the

last training session. Efficacy outcome was defined by the pre and post scores of the Balance Evaluation Systems Test (BESTest) that consists of a series of Balance tests designed to evaluate six different systems of postural control [16].

### Results

Four patients with PD, mean age of 67 (8.2) years, on stages 2 and 3 of the Hoehn and Yahr scale [mean of 2.25 (0.5)], mean score of the MMSE of 26 (2.6) participated of this study (Table 1).

There were no adverse effects recorded during the study. Patients improved their score in eight games in stable surfaces and in all games on unstable surfaces (Table 2).

The games in which the participants did not have improvement in stable surfaces were Table Tilt and Balance Bubble, in which their performance reduced -11.8% and -47.9%, respectively. In the other games, on stable surfaces, the lower improvement was in Penguin Slide (24.5%) and the higher improvement was in the Obstacle Course game (337.5%). On an unstable surface, the lower improvement was in Torso Twist (10%) and the higher improvement was in Obstacle Course (542.9%), as with stable condition. There was an improvement of 9.19% (8.12%) in the BESTest score (Table 3) following the training.

### Discussion

Despite the existence of studies about the benefits of the Nintendo Wii Fit Plus™ on balance of patients with Parkinson's disease [9,10], this is the first that assessed the safety, feasibility and efficacy of this kind of training performed over unstable surfaces. Our results showed that: (1) there were no adverse events; (2) patients were able to perform and to improve their performance in the ten games on the unstable surface and in eight games on the stable surface; (3) patients showed improvement in balance and gait after intervention.

Despite the absence of adverse events, we recommend the use of

	P1	P2	P3	P4	Mean (SD)
Age (years)	78	65	67	58	67 (8.2)
MMSE	23	27	29	25	26 (2.6)
UPDRS	50	33	17	30	32.5 (13.6)
HY	3	2	2	2	2.2 (0.5)

Abbreviations: MMSE: Mini Mental State Examination; UPDRS: Unified Parkinson's Disease Rating Scale, HY: Hohen and Yahr Scale; P1: Patient 1, P2: Patient 2; P3: Patient 3; P4: Patient 4

**Table 1:** Demographic and clinical characteristics.

Games	Stable Surface		Unstable Surface		% Difference (Last Session - Second Session)	
	Second Session Mean (SD)	Last Session Mean (SD)	Second Session Mean (SD)	Last Session Mean (SD)	Stable Surface	Unstable Surface
Soccer Heading	8.5 (3.8)	26 (10.2)	6.5 (6.4)	17.2 (7.2)	205.9	164.6
Torso Twist	55.2 (11.9)	75.7 (15)	65.2 (4.5)	71.7 (18.4)	37.1	10.0
Penguin Slide	37.5 (5.8)	46.7 (5.6)	30.2 (8.1)	36.7 (4.9)	24.5	21.5
Single Leg Station	33.7 (5.8)	76.2 (16.3)	52.7 (37.4)	62.5 (17.7)	126.1	18.6
Basic Run	19.7 (4.7)	32.2 (5.7)	23.5 (5)	29 (4)	63.5	23.4
TableTilt	42.5 (5)	37.5 (9.5)	25 (17.3)	30 (14.1)	-11.8	20.0
Balance Buble	585 (223.1)	305 (405.7)	423 (140.7)	740 (313.4)	-47.9	74.9
Obstacle Course	3.2 (4.2)	14 (9)	7 (11.3)	45 (22.9)	337.5	542.9
Basic Step	98.5 (27.2)	178 (50.8)	116 (34)	139.2 (38.9)	80.7	20.0
Tilt City	35.5 (11.4)	62.7 (26.8)	33.5 (18.4)	55.5 (8.3)	76.6	65.7

SD: Standard Deviation

**Table 2:** Score of the games performed on stable and unstable surfaces

	BESTest Before	BESTest After	Absolute Difference	Relative Difference (%)
P1	70	80	10	14.2
P2	84	86	2	2.3
P3	92	94	2	2.1
P4	78	92	14	17.9
Mean (SD)	81 (9.3)	88 (6.3)	7 (6)	9.1 (8.1)

SD: Standard Deviation; P1: Patient 1, P2: Patient 2; P3: Patient 3; P4: Patient 4

**Table 3:** Scores of BESTest before and after intervention.

a security belt in order to guaranty the security of the training due the high risk of falls of patients with PD. During the sessions, patients experienced instability during the training and the security belt and the assistance of the physiotherapist helped the patients to recover their balance. The training on an unstable surface increases the stimulation of postural adjustments and the requirement of vestibular information in order to maintain balance, due the conflict of information among the systems of perception related to postural control [17]. Furthermore, the visual system is used to perform the virtual tasks of the games that involve moving virtual objects, which could bring greater requirement to the vestibular system [18]. The unstable surface causes greater displacement of the center of pressure of the body that increase the muscle recruitment required to recover the balance [19].

Some studies have shown that patients with PD require more attentional resources to balance control [20-22]. The division of attention among the performance of virtual tasks, the movements of the body and the postural responses make this kind of training highly challenging [23]. According to the guidelines of physical therapy directed to patients with PD, challenge training is recommended to improve balance [3,24].

Despite the high challenge of the training, some characteristics of the Nintendo Wii Fit Plus™ could have facilitated the learning of the virtual tasks. The wide range of visual and auditory stimuli offered by the games could be considered as virtual external cues. Several studies have shown that the motor performance of patients with PD improves in the presence of external cues and that these may favor the process of learning and transfer to tasks performed in real environment [9]. The knowledge of results and performance can improve the motor learning of the games [9,10] and contribute to the improvement on gait speed and balance [25]. The results of this study reinforced the observations of Pompeu et al. [10] and Mendes et al. [9] because the patients showed improvement in both surface conditions: stable and unstable. Thus, environmental condition, or the support surface modification had no effect on learning capacity of games. In fact, the variability of the environmental training condition could facilitate the motor learning process and the transfer [9]. We propose that the improvement in the scores of the games, both on stable and unstable surfaces, may have promoted an improvement in balance and gait of the participants due to the intense demands imposed by the training. Mendes et al. [9] verified that patients with PD were able to transfer the motor skills trained on the Nintendo Wii Fit games for a similar task which was not trained. In their study, the intervention also lasted 14 weeks, and the patients trained nine similar games used in our study. The results showed that the ability of patients with PD to learn, retain and transfer the improved performance after training on Nintendo Wii Fit depends largely on the involved demands of the games, especially the cognitive, reiterating the importance of the game selection for rehabilitation. It was suggested that the appropriate selection of games associated with unstable surface can further improve the performance of patients in balance and gait.

The results of our study are consistent with Pompeu et al. [10] who investigated the effect of Nintendo Wii Fit Plus™ compared to exercise therapy for balance on activities of daily living in patients with PD. The authors found that both types of training promoted an improvement in balance and activities of daily living of patients with PD. Furthermore, it was observed that patients with PD were able to improve performance in the games. We propose that the improvement in BESTest may be related to the motor and cognitive demands of the games that required displacement of the center of gravity keeping feet static on balance board, thus improving the limits of stability, anticipatory and

compensatory postural adjustments. While the improvement in the gait domain of BESTest may be related to the motor demand of games that required alternating steps.

In the present study patients were not able to improve their score in two games performed on stable surfaces: Table Tilt and Balance Bubble. Accordingly with our results, patients started the training in these two games on stable condition with high scores since the beginning. Beside this, there was a higher variability among the patients in both games.

## Limitations

A limitation of this study was the small number of patients, which may limit the statistical analysis and generalization of the results. Despite the stimulation of the division of attention due the motor and cognitive requirement of the games, this effect was not analyzed. Probably the ability to share attentional resource could improve with this kind of training and future studies can evaluate this hypothesis.

We concluded that the training with the Nintendo Wii Fit Plus™ performed over an unstable surface was safe, feasible and promoted improvement on balance and gait of patients with PD. However, further studies with larger numbers of patients are needed for a better analysis of the results.

## Acknowledgement

The authors would like to acknowledge the Brazil Parkinson Association.

## Ethical Approval

Research Ethics Committee of the São Camilo University for use of humans in research (number 0119.0.166.000-09).

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