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COMPARATIVE STUDY

# Nintendo Wii Fit for balance rehabilitation in patients with Parkinson's disease: A comparative study

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**Abstract** *Background:* Impaired postural stability places individuals with Parkinson's disease (PD) at an increased risk for falls.
*Objective:* We evaluated the effectiveness of 10 vs. 15 sessions of Nintendo Wii Fit for balance recovery for outpatients PD.
*Methods:* Twenty-seven patients, 48.1% female (66 $\pm$ 8 years), with PD. Patients with PD were consecutively assigned to one of two groups receiving either 10 or 15 sessions (low dose or high dose group, respectively) with Nintendo Wii Fit in recovering balancing ability. All outcome measures were collected at baseline, immediately following the intervention period, and 1-month following the end of the intervention. Main outcome measure: Falls risk test (FRT), Stability index (PST), Berg balance scale (BBS) and Tinetti scale.
*Results:* The patients undergoing the 10 sessions demonstrated significantly improvement on the balance performances (Tinetti balance and gait scales, BBS and BSF) (all, $P < 0.05$) as those undergoing 15 treatment with Nintendo Wii Fit, but no significant group effect or group-by-time interaction was detected for any of them, which suggests that both groups improved in the same way.

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*Conclusions:* The results suggest that functional improvement can be made in fewer visits during outpatient rehabilitation sessions with Nintendo Wii Fit improving the efficiency of intervention.


## Introduction

Preserving the control of balance is essential for maintaining functional independency. This is not only degraded by the age (Era and Heikkinen, 1985), but also and independently, by degenerative diseases of nervous and musculoskeletal system (Horak et al., 1989).

During stabilometric platform evaluation of patients with Parkinson disease (PD) do not always show more oscillation than normal subjects, but they are unable to scale the oscillations in order to assume different stable posture (Schieppati et al., 1994; Schieppati and Nardone, 1991). Stabilometric measures have revealed balance impairments and sensory disorders with increase of body sway and velocity of body sway especially in the sagittal plane (Cattaneo et al., 2012; Langella et al., 2015). Controversial results have been reported in subjects with PD, some investigators found that postural sway can be decreased, increased or the same when compared to healthy subjects (Cattaneo et al., 2016; Frenklach et al., 2009). Therefore, this device can act on several fundamental aspects of PD such as the narrow-based gait, the loss of automatisms, and the altered functionality of the trunk muscles (Frazzitta et al., 2015; Redgrave et al., 2010; Bissolotti et al., 2015).

Poor balance control, along with the loss of postural reflexes, is one of the major and most disabling signs in PD. The Nintendo Wii Fit ("Wii Fit") is a software/hardware game package for the Nintendo® Wii, designed to improve balance and fitness, while providing entertainment. The Wii Fit uses a novel balance board system that tracks changes in the center of pressure during exercise games. It is widely available, portable, and far less expensive than typical costs incurred with therapy interventions (Tomlinson et al., 2012). In addition, several studies suggests that a balance program using Wii Fit with balance board could improve static and dynamic balance, mobility and functional abilities of patients affected by PD (Herz et al., 2013; dos Santos Mendes et al., 2012; Mhatre et al., 2013; Pompeu et al., 2012; Esculier et al., 2012).

Little more is known regarding the optimum number of exergaming training sessions at present other than multiple sessions are better than a single session (Herz et al., 2013; dos Santos Mendes et al., 2012; Mhatre et al., 2013; Pompeu et al., 2012; Esculier et al., 2012). As well resumed by a recent review by Barry et al., the number of sessions necessary to induce a significant improvement in balance in PD patients can move from 12 up to 24, but the minimum amount of treatment that is able to induce this improvement is still far to be defined (Barry et al., 2014). The variability in these training paradigms raises the question of any dose—effect relationship between the amount of training sessions and the treatment effectiveness.

If comparable improvements in balance can be obtained in fewer interventions this would increase the efficiency of interventions provided and potentially decrease patient burden. After a final revision of what actually available in the literature 10 sessions were assumed to be the less intense possible program with the possibility to obtain a significant change in balance.

The aim of this study, therefore, was is to compare the effectiveness of 10 vs. 15 sessions of intervention programs using the Nintendo Wii Fit for balance recovery for outpatients PD.

## Methods

### Study design

This was a prospective controlled cohort study. Procedures were conducted according to the Declaration of Helsinki. Prior to participation in the study, all patients signed an informed consent form. The protocol was approved by the Ethical Committee.

### Patients

The study enrolled 27 consecutive patients (14 males, 13 females) who were diagnosed with idiopathic PD by a neurologist according to the UK Brain Bank Parkinson's criteria were included in the study protocol (Bissolotti et al., 2014, 2016). None of the patients exhibited dyskinesias. To be included in the study, the patients had to be 50—90 years of age; diagnosed with PD (>6 months from onset) and able to walk independently or with supervision; limitation in dynamic or static balance; limitation in activities of daily living (Self Assessment Parkinson Disease $< 100$); (Functional Ambulation Classification scores $\geq 3$) (Masiero et al., 2007); absence of cognitive impairment (Mini-Mental State Examination cut-off $> 26$) (Folstein et al., 1975); ability to balance (cut-off $> 5$ Tinetti balance scale and $>19$ Berg Balance Scale). All patients followed their normal medication regimen during testing and the functional evaluation was performed during the ON phase. Patients were excluded if: cognitive inability to participate, the presence of at least one lower limb problem, including musculoskeletal, neurological and vascular; any history of falls; or the presence of any other health problem except PD (Villafañe et al., 2015). Patients with multiple cerebrovascular lesions or with infratentorial lesion were not recruited. Patients were also excluded if their pharmacological therapy changed during the trial or in the previous month.

## Outcome measures

### Balance performance

Different assessment tools were used to determine the balance abilities of the patients. All evaluation procedures were performed by the same examiner who was blinded to the aims of the study and to which group the patients were allocated. To assess the balance function, the falls risk test (FRT) protocol of Balance System SD® was used and the "Stability index" (PST) was calculated (Cho et al., 2012), Berg balance scale (BBS) score (Pegg et al., 2005; La Porta et al., 2012) and Tinetti scale were used to assess balance clinically (Tinetti, 1986).

All outcomes measures were captured at baseline (Pre), immediately post-intervention (Post), and at 1-month post-intervention by an assessor blinded to group assignment. The sequence of testing for the outcome measures was randomized among patients. The trial was designed according to the STROBE publishing guidelines (von Elm et al., 2008).

## Intervention

The program consisted of a pre-determined number of repetitions for different exercises in the game. This was identical for all subjects. Patients received a multimodal treatment intervention consisting of 20 min of Wii Fit game using the balance board; 10 min with the Wii Balance game (Table Tilt, Ski Slalom, Balance Bubble, Ski Jump and Penguin Slide) (Esculier et al., 2012).

## Protocol

The patients in both groups were treated by a physiotherapist with Post-Graduate training and more than 10 years of clinical experience in the management of neurological disease. The patients were consecutively included to one of two groups, according to the availability of the interest and possibility of the patient in attending to Wii-Fit training. The physiotherapist attended to the treatment for safety purposes, in the aim to educate the patients in the use of Wii-Fit and to drive them in the selection of different exercises. Patients performed a specific program of 30 min for 2 days per week during 5 weeks (10 total training sessions) for low dose group and 15 sessions over a period of 5 weeks (3 sessions per week) for high dose group. The two different intensities of treatment were selected to define the best cost-effective strategy and to define the minimum amount of treatment necessary to improve the balance in PD patients. All outcomes were collected by an external assessor blinded to the treatment allocation of the patients. The variables were measured at baseline, after intervention and follow-up according to the sequence mentioned previously. All the subjects completed the assigned treatments once they were included in one of the two groups.

## Data analysis

Data were analyzed using SPSS version 20.0 (SPSS Inc, Chicago, IL, USA), conducted following an intention-to-treat analysis using the last value forward method. Group data were summarized using means and standard deviations. The Kolmogorov—Smirnov test confirmed the normality of the distribution of the data, so a repeated measures analyses of variance (ANOVAs) with time (before, after and follow-up rehabilitation) as the within-subjects factor and treatment (10 sessions versus 15 sessions) as the between-subjects factor were performed for each of the balance measures. The Bonferroni test was used for the post hoc analysis of specific comparisons between variables. The main effects of time, treatment option and the time-treatment option interaction effects were evaluated. Simple contrasts were conducted for each significant time main effect to determine the source of the significant difference. Finally, between-groups effect sizes were calculated using Cohen's d coefficient. An effect size greater than 0.8 was considered large, around 0.5 moderate, and less than 0.2 small. The statistical analysis was conducted at a 95% confidence level, and a $P < 0.05$ was considered statistically significant.

## Results

Twenty-seven consecutive subjects with idiopathic PD were screened for eligibility criteria. All patients (mean ± SD age: 66 ± 8 years; 48.1% female) satisfied all eligibility criteria, agreed to participate, and were consecutively assigned to the 15 sessions ($n = 11$) or 10 sessions ($n = 16$) group. Baseline features of both groups were similar for all variables (Table 1). No adverse effects were detected during or after the application of the treatment, and none of the subjects started or changed his or her drug therapy during the study.

Outcomes for Tinetti balance and gait scales, BBS and FRT demonstrated a significant time factor ($F_{[2.0]} = 13.599$; $P < 0.001$, $F_{[2.0]} = 11.132$; $P < 0.001$, $F_{[2.0]} = 24.800$; $P < 0.001$ and $F_{[2.0]} = 30.860$; $P < 0.001$, respectively), but not for group-by-time interaction ($F_{[2.0]} = 1.355$; $P = 0.3$, $F_{[2.0]} = 1.379$; $P = 0.3$, $F_{[2.0]} = 0.166$; $P = 0.8$ and $F_{[2.0]} = 1.353$; $P = 0.3$, respectively). The post hoc analysis revealed significant differences between the pre-treatment with post-treatment and follow-up periods for the low dose group and for the high dose group (all, $P < 0.02$) for BBS and FRT, but not significant difference was identified between the pre-treatment and follow-up in Tinetti balance and gait

**Table 1** Baseline demographics for both groups.[a]

| | 10 sessions (n = 11) | 15 sessions (n = 16) | P-value |
|---|---|---|---|
| Age (years) | 67 ± 9 | 66 ± 8 | 0.96 |
| Female gender [n (%)] | 6 (54.5%) | 7 (43.8%) | |
| MMT | 166 ± 0.07 | 167 ± 3.0 | 0.91 |
| Self Assessment Parkinson Disease | 6.6 ± 3.0 | 7.6 ± 4.0 | 0.24 |

MMT = Mini-Mental State.
[a] Data are expressed as means ± standard deviations (SD).

**Table 2** Mean (SD) for balance performances at all study visits for each group, mean (SD) difference within groups, and mean (95% CI) difference between groups.

| Outcome | Groups | | | | | | Difference within groups | | | | Effect size | Difference between groups | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Week 0 | | Week 5 | | Week 9 | | Week 5 minus week 0 | | Week 9 minus week 0 | | Cohen's d | Post | Post |
| | 10s (n = 11) | 15s (n = 16) | 10s (n = 11) | 15s (n = 16) | 10s (n = 11) | 15s (n = 16) | 10s | 15s | 10s | 15s | 10s minus 15s | 10s minus 15s | 10s minus 15s |
| Tinetti balance scale | 11.9 (3.2) | 12.2 (3.0) | 14.3 (2.3) | 13.5 (3.0) | 14.5 (3.2) | 13.6 (3.1) | 2.4# (0.5) | 1.3# (0.4) | 2.6# (0.9) | 1.4 (0.7) | 0.3 | 0.7 (−1.9 to 3.3) | 0.9 (−3.9 to 2.1) |
| Tinetti gait scale | 8.1 (2.9) | 9.0 (1.8) | 9.8 (1.4) | 10.0 (2.2) | 10.4 (1.8) | 10.1 (2.2) | 1.6# (0.5) | 1.0# (0.4) | 2.3# (0.7) | 1.1 (0.6) | 0.2 | −0.3 (−2.4 to 1.9) | 0.3 (−1.7 to 2.3) |
| BBS | 46.6 (5.8) | 40.1 (7.6) | 50.4 (5.3) | 45.1 (6.8) | 51.3 (7.2) | 46.3 (7.1) | 3.8# (0.8) | 4.3# (0.6) | 4.6# (1.5) | 5.5# (1.2) | 0.7 | 5.3 (−0.6 to 11.2) | 4.9 (−1.8 to 11.7) |
| PST | 0.9 (0.4) | 1.2 (1.1) | 0.5 (0.3) | 0.8 (0.4) | 0.7 (0.4) | 1.2 (1.3) | −0.3 (0.2) | −0.4 (0.2) | −0.1 (0.3) | 0.0 (0.3) | −0.5 | −0.3 (−0.7 to 0.1) | −0.5 (−1.5 to 0.6) |
| FRT | 4.6 (2.0) | 5.2 (2.1) | 3.2 (1.4) | 3.3 (1.2) | 3.2 (1.3) | 3.1 (1.7) | −1.3# (0.3) | −1.9# (0.4) | −1.4# (0.3) | −2.1# (0.4) | 0.1 | −0.1 (−1.8 to 1.6) | −01.1 (−1.8 to 1.9) |

15s = 15 sessions group, 10s = 10 sessions group, BBS = Berg balance scale, PST = Postural stability testing, FRT = Fall risk testing.
#Significantly different within-group, $P < 0.05$ (95% confidence interval).
*Significant difference between-group, $P < 0.05$ (95% confidence interval).

scales (all, $P = 0.2$) for the high dose group. There was no significant difference between the groups ($P > 0.05$). Between-group effect size was greater ($d = 0.9$) for the BBS, moderate ($d = 0.4$) for the Tinetti balance and small ($d < 0.2$) for the Tinetti gait scale and PST and FRT after the intervention. The data are summarized in Table 2.

## Discussion

The major interesting finding of the study is represented by the amount of treatment necessary to obtain a significant change from the baseline in balance performance. So far, a program with fourteen sessions was the minimum volume of treatment able to determine some positive effects on balance. In our protocol, the number of sessions needed to reach a strong treatment effect was 10 and, as demonstrated for the low dose group, patients reached a significant improvement at 10 sessions. According to other studies published in the literature, the high dose treatment group reached a significant improvement to the 15th session. According to the evidence provided by this data and to the low cost of equipment, this study confirms the suggestion that Wii-Fit has to be considered a cost effective rehabilitation strategy for home balance training in PD patients. In fact, once provided adequate education in the use of the device and in the selection of the different exercises Wii-Fit could be easily used in home environment with a minimal surveillance provided by one of the relatives. Despite the absence of specific qualitative data about patients' satisfaction in Wii-Fit treatment is interesting to note that all the patients included in this group showed a positive opinion about this strategy. Another strength of the study is represented by the comparative use of another instrumental platform to confirm the positive effect on fall risk reduction. The use of Biodex Balance platform provided an objective confirmation of the improvement in postural stability and, according to our opinion, highlighted how the positive change determined by Wii-Fit was not provided merely by a specific learning effect determined by the use of the device (Table 3).

To our knowledge, no prior studies have determined that only 10 sessions of Nintendo Wii Fit are needed for balance recovery for outpatients Parkinson's disease. In both groups, all the balance scores (Tinetti balance scale, Berg Balance Scale and FRT), improved at a significant level at the end of the treatment and maintained the results even four weeks after the end of the last session. As previously revealed by other studies on different populations of patients (Padala et al., 2012; Esculier et al., 2014) training with Nintendo Wii-Fit games has been effective as standard rehabilitation programs in improving balance in people affected by PD with a mild imbalance impairment. These results are similar to what obtained in elderly people after a balance training program on Wii-Fit and confirm the possibility to maintain the improvements obtained for at least four weeks after the end of the treatment (Dougherty et al., 2011). The adopted protocol and the number of PD patients involved in the study have been similar to what previously described in other published researches where treatment was lasting from 3 to 8 weeks for an average number of three sessions each week and patients were ranging from 16 to 32 sessions (Herz et al., 2013; dos Santos Mendes et al., 2012; Mhatre et al., 2013; Pompeu et al., 2012). In our study, the 15 sessions group received 300 min of treatment, that is much less of what typically proposed in other studies where the total amount of treatment is ranging from 420 to 840 min as recently described by Barry et al. (2014).

Another potential advantage is represented by the fact that, as yet demonstrated by other experiences, to participate in the program it is not mandatory to have a perfect integrity in cognitive performance. This enhanced stimulatory environment can help persons affected by PD to rely more on the "implicit" learning process and to compensate for the presence of any "explicit" learning defect that can be present since the early phase of disease (Abbruzzese et al., 2009). It is our opinion that other interesting components of the training program are represented by the paradigm of action observation strategies and reward expectation effect intrinsically linked to the nature of Wii-Fit games. The former is actually considered a potentially useful strategy to improve the motor relearning process of PD patients through the involvement of mirror neurons (Esculier et al., 2014). The latter may play a role either as a motivating strategy or as a stimulus of dopamine from the ventral striatum (De la Fuente et al., 2003).

The main limitation of the study is represented by the small sample size. Another limitation is the lack of the true 10 sessions group along with the lack of randomization.

Further research is needed concerning the prediction of the optimal number of treatment sessions and the implementation in different fields of Wii-Fit, in PD patients.

**Table 3** Spearman's rank correlation coefficients between the Tinetti balance scale and the other parameters.

| Basal metabolic data | Spearman's r | P-value |
|---|---|---|
| Age | −0.49 | 0.01 |
| Tinetti gait scale | 0.78 | 0.001 |
| BBS | 0.71 | 0.001 |
| PST | −0.57 | 0.012 |
| FRT | −0.66 | 0.002 |

BBS = Berg balance scale, PST = Postural stability testing, FRT = Fall risk testing.

## Conclusion

The results suggest that during outpatient rehabilitation is not needed to extend rehabilitation sessions with Nintendo Wii Fit to 15 sessions: 10 are enough to obtain short term positive results, further studies are needed to evaluate long term results after this type of treatment based upon a 10 sessions Wii Fit program dedicated to balance training. It study confirms the efficacy of exploiting Wii-Fit Balance Board as an integrative treatment in subjects with mild balance impairment.

## Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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