Effects of using the Nintendo Wii Fit Plus Platform in the sensorimotor training of gait disorders in Parkinson's disease

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Abstract

The use of the Nintendo Wii has been considered a good alternative in the motor rehabilitation of individuals with Parkinson's disease (PD), requiring simultaneous interaction to develop strategies for physical, visual, auditory, cognitive, psychological and social activities in the performing of virtual activities, resulting in improvement in functional performance and gait. The aim of this study was to analyze the effect of virtual sensorimotor activity on gait disorders in people with PD. Fifteen subjects with a clinical diagnosis of PD were submitted to the Unified Parkinson's Disease Rating Scale (UPDRS III), Schwab and England Activities of Daily Living Scale (SE), Functional Independence Measure (FIM), and biomechanical gait analysis using digital images taken with a video camera before and after the treatment program. The activities with the Nintendo Wii virtual platform were standardized into three categories: aerobics, balance and Wii plus exercises. Participants carried out separate virtual exercises for 40 min, twice a week, for a total of 14 sessions. The program improved sensorimotor performance in PD gait, with an increase in stride length and gait speed, in addition to a reduction in motor impairment, especially in items of rigidity and flexibility of the lower limbs evaluated by UPDRS III, and greater functional independence, as evidenced in the SE and FIM scales. Improvements in items related to locomotion and stair climbing were also observed. The training was effective in motor recovery in chronic neurodegenerative diseases, showing improvement in motor performance and functional independence in individuals with PD.

Introduction

Improvement in motor disorders in Parkinson's disease (PD) involves drug and rehabilitation therapy, in which physiotherapy activities are of major importance. According to this premise, physical therapy for people with PD prioritizes the execution of isolated motor tasks at all stages of the disease, especially when patients are in the moderate and advanced stages.[1-3] From this perspective, the use of virtual reality through Nintendo Wii has been considered a good alternative in the motor rehabilitation of individuals with PD, requiring simultaneous interaction to develop physical, visual, auditory, cognitive, psychological and social strategies in carrying out activities, and improving functional performance and gait.[4-6] The aim of this study was to analyze the effect of virtual sensorimotor activity on gait disorders in people with PD.

Materials and Methods

The study included 15 individuals diagnosed with PD, presenting gait disturbance that had been observed and examined in the Movement Disorders Section of the Neurology Department at the Pedro Ernesto University Hospital, Rio de Janeiro State University (HUPE/UERJ). Gender and disease duration were not taken into consideration and participants were aged 45-85 years. Those with dementia, mental disorders or the need for changes in medication were excluded. Participants were selected according to anamnesis, functional motor assessment, Mini Mental State Examination, and disease staging by the Modified Hoehn and Yahr Scale with scores 2-4.

Selected participants were submitted to the motor subscale of the Unified Rating Scale for PD (UPDRS III), Schwab and England daily living activities scale (SE), Functional Independence Measure questionnaire (FIM), and biomechanical analysis of gait using images taken by digital video camera, always during the on phase of the disease, and repeated at the end of the program.

Images were acquired with a Sony® digital camera with 5.1 megapixels of resolution (Super SteadyShot DSC-T70). Each participant individually performed three laps on a 3-meter track. The number of steps and walking speed to cover the 18 meters were evaluated by means of the images using Windows Media Player.

After these assessments, participants started playing with the Nintendo Wii platform. Sessions lasted 40 min and were performed twice a week for a total of 14 sessions, with two min between each exercise. For this program, three categories with different virtual exercises were standardized: aerobics, balance and exercise plus.

Aerobics

It consists of: Free Step, Rhythmic Step and Rhythmic Boxing.

Step Free Step involves stepping on and off the platform with each leg (L), before progressing to Rhythmic Step and Rhythmic Boxing, performed by standing on one leg (MI) while the other leg moves in a rhythmic sequence, alternating the foot and arm movement (A).

Balance

It consists of: Ski Slalom, Advanced Skiing, Ski Jumping, followed by Header and Jump Rope (three series for each exercise).

Ski Slalom is performed standing on both feet while the body moves side to side (as if moving forward in a zigzag movement) to change direction.

Ski Jump involves standing with the feet slightly apart, bending the knees, leaning the upper body forward, and holding the arms straight back in a straight line. The feet stay in contact with the platform. The participant straightens up the body position at the end of the *Jump*, arms by the side.

The same position is used to perform Header and Jump Rope, but with specific sensorimotor stimulations.

Exercise Plus

It consists of: Segway Circuit and Cycling.

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Table 1. Characteristics of the virtual exercises performed with the Nintendo Wii.

Exercise category	Initial activity	Average evolution	Final progression
Aerobic	Free STEP (<600 steps) Rhythmic Boxing (with help and without rhythm)	Free STEP (800 steps) Rhythmic Boxing (with help and with rhythm)	Rhythmic STEP Duration: 2×6 minutes Rhythmic Boxing (without help and with rhythm)
Balance	Slalon Skiing (with and without help) Jump Skiing (with and without help)	Advanced Skiing (with help) Header (with and without help)	Advanced Skiing (without help) Jump Rope (with and without help)
Plus exercises	Segway Circuit (with help and without control of Upper Limbs) Cycling (with help and without control of Upper Limbs)	Segway Circuit (without help and with control of Upper Limbs) Cycling (without help and with control of Upper Limbs)	Advanced Segway (without help and with control of Upper Limbs) Advanced Cycling (without help and with control of Upper Limbs)

The Segway Circuit is performed standing on two legs. When the participant leans forward he or she goes faster, and upper body movement enables the player to move the handlebars and change direction.

The Cycling activity is performed with a sequence of steps on the platform. Upper body movements, and moving the hands up and down as if beating a drum, enable the participant to change direction.

Both these exercises also have an Advanced level. The activities performed, their characteristics and therapeutic outcome are summarized in Table 1.

Results

The study included 8 women and 7 men, mean age 68.70±10.2 years, mean disease duration 7.3±3.7 years, and Hoehn and Yahr average of 2.1±0.3. To check whether the differences found between pre- and post-treatment were statistically significant at a 95% confidence level (TP) we used the paired means test for Student's t-test distribution.

In the initial analysis with UPDRS III the average score was 28.5 points, while a second evaluation gave an average of 15.8. P<0.05 was considered significant. P=8.522e-07 (sig.P=0.0000008522 <0.05) (paired Student's t-test).

The Schwab and England Activities of Daily Living Scale indicates mean values of 79.33% and 90%, pre-and post-treatment, respectively. P<0.05 was considered significant. P=4.072e-05 (sig.P=0.00004072 <0.05) (paired Student's t-test).

Evaluation of the Functional Independence gave 114.3 points for the initial mean; mean score after treatment was 121.3. P<0.05 was considered significant. t-test for mean gave P=8.442e-05 (sig.P=0.00008442<0.05). Descriptive statistics of the initial and final assessments are shown in Table 2.

Table 2. Descriptive statistics of the UPDRS motor sub-scale, Schwab & England and MIF, before and after virtual training.

Assessments	Virtual program	Mean	Standard Deviation	Student's t-test
Motor sub-scale	Pre-treatment	28.5	9.9057	Sig.P =0.0000008522
	Post-treatment	15.8	7.4948	<0.05
Schwab & England	Pre-treatment	79.3	9.611	Sig.P=0.00004072
	Post-treatment	90.0	6.546	<0.05
MIF	Pre-treatment	114.3	6.07	Sig.P =0.00008442
	Post-treatment	121.3	2.65	<0.05

Evaluation of the gait motor behavior gave average number of steps as 54.23, whereas in a second evaluation this was 46.92. Mean values of average linear speed ranged from 0.48 m/s in initial assessment to 0.53 m/s in second evaluation.

Discussion

The implementation of a program developed through sensory-motor exercises specific to Wii Fit Plus improved gait performance in PD patients, with an increase in stride length and gait speed, demonstrated through an analysis of images, when comparing the results obtained before and after the selected program.

Zettergren performed a case study on a 69-year-old individual with PD who underwent three exercises (Penguin Slide, Table Tilt and Balance Bubble) with Nintendo Wii Fit twice a week for eight weeks, and observed improvement in functional performance and higher gait speed.[5]

Kadivar *et al.*[7] analyzed the effect of multistep training with rhythmic auditory stimulation, step aerobic activity (similar to that of this study), in the functional performance of individuals with PD, showing that the combination of step training with rhythmic auditory stimulation offers benefit for functional improvement of gait and balance in PD patients.

In addition to the activities performed by the Nintendo Wii Fit Plus, there are other non-virtual therapeutic strategies for the treatment of motor disorders of gait in PD that resemble the proposed study. Among these, there are activities that involve sensorimotor combinations with external auditory rhythm and visual stimulation,[8,9] as well as coordination physical exercises, dexterity, gait initiation, quick changes in direction, walking with long strides overcoming obstacles and sensorimotor agility.[10] In the present study, in addition to the increase in the average linear speed and length of patients' steps, there was a reduction in motor impairment, especially in the items of rigidity and flexibility of the lower limbs evaluated by UPDRS III, and greater functional independence, as evidenced in the SE and FIM scales, with improvements in items related to locomotion and stair climbing. This improvement was observed in the initial months and then progressively decreased, especially in individuals who did not continue the activities; this underlines the importance of maintaining physical exercise.

A randomized study comparing two groups of PD performing different gait training exercises, with visual tracks or physical therapy, showed improvement in both groups. It

showed greater functional independence, increased speed and step length in the gait of those participants undergoing sensorial training than those who underwent conventional physiotherapy.[2] This led us to conclude that this difference may have been facilitated by the greater visual attention needed to complete the tasks, similar to what happens in virtual exercises.

The use of motion exercises and cognitive abilities in Nitendo Wii Fit™ showed that, after training, the ability of those with Parkinson's disease to learn, retain and transfer performance improvements was totally dependent on the cognitive demands of the games involved, reaffirming the importance for rehabilitation purposes, the need for the selection of the games to be used in activities.[11] Some studies suggest physical exercises as therapeutic strategies in mesencephalic lesions in the substancia nigro (SN). Yoon *et al.*,[12] in experiments with rats submittted to physical exercise on a treadmill for 14 consecutive days after SN injury, demonstrated improvement in functional activity and found high levels of brain neurotrophic factors in glial cells. The same was found by Tajiri *et al.*[13] in an experimental Parkinsonian model where rats received infusion of 6-hydroxydopamine in the striatum and were then forced to take physical exercises on a treadmill for four weeks. These rats showed elevated levels of neurotrophic factor, glial derived, greater proliferation of neuron progenitor cells, and a significant reduction in neuronal death, as well as better performance of animals in a cylinder behavioral test when compared to sedentary animals. Experimental models of PD have been useful to investigate the influence of physical exercises, neurotrophic factors and glial cells as mediators of neuroplasticity in the central nervous system. Such exercises performed later in the SN lesions may improve motor symptoms and preserve striatal dopaminergic terminals, although it is not very clear whether prior physical exercise or its intensity are able to provide protection against 6-hydroxydopamine. Given this, the possible neuroprotection through physical exercises and neurotrophic factors may be important in addressing neurodegenerative diseases and thus improve the response to drug treatment.[14]

The physical exercise proposed in this study using the Nintendo Wii Fit Plus may represent a non-invasive practice to achieve neuroprotection.

Conclusions

Gait motor training in PD using the Nintendo Wii Fit Plus platform was effective and efficient in a short time period. This activity program was shown to be useful for motor recovery of neurodegenerative diseases, showing improvement in motor performance and functional independence in individuals with PD.

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