The effects of Nintendo Wii Fit training on gait speed, balance, functional mobility and depression in one person with Parkinson’s disease

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A 69 year old male with idiopathic Parkinson’s disease participated in a 60-minute, bi-weekly training program using the Nintendo Wii fit gaming system. Pre-test/post-test assessments included: 1) The Timed up and go (TUG), 2) The Berg Balance scale (BBS), 3) Self selected gait speed, 4) Fall history, and 5) Geriatric Depression Scale (GDS). After 8 weeks, the subject’s BBS score increased from 31 to 42 (35% improvement), the TUG decreased from 36.5 seconds to 24.1 seconds (34% improvement), gait speed increased from .26 m/s to .37 m/s (42% improvement) and GDS scores remained unchanged. The Nintendo Wii Fit may be a viable alternative to independent exercise programs for people diagnosed with idiopathic PD.

Keywords: Nintendo Wii Fit, Parkinson’s disease.

Introduction

Approximately 500 000 people suffer from Parkinson’s Disease (PD) in the United States and there are approximately 50,000 new cases reported annually (Parkinson’s Disease Backgrounder, 2011) Postural instability, impaired gait, and freezing episodes are all common occurrences in PD (Gray and Hildebrand, 2000). These impairments contribute to falls and increase the risk of falling in people with PD. Several researchers have explored treatment options that can reduce the risk of falling and improve mobility in people with PD (King and Horak, 2009; Hackney and Earhart, 2010; Hackney and Earhart, 2009).

Agility activities, including supine-to-stand, ambulation, turning, and reaching activities, have been used to reduce freezing episodes, particularly in the early stages of PD (King and Horak, 2009). Dancing (specifically the Argentine Tango) incorporates rhythmic rocking and alternating weight shifts which both decrease freezing episodes during gait (Hackney and Earhart, 2010). In addition, the tango, the foxtrot, and the waltz all significantly improved the Berg Balance Scale scores in subjects with PD (Hackney and Earhart, 2010; Hackney and Earhart, 2009).

Bradykinesia, rigidity, shuffling steps, decreased speed, small stride length, reduced arm swing, rigidity in trunk movements, and propulsion/retropulsion can occur during gait in people with PD (Protas et al., 2005). Individuals with PD may also experience increased difficulty when initiating gait and may have a reduced ability to shift weight from one lower extremity to another. Increasing self-selected gait speed may lead to increased independence in mobility, improved health status and physical function, decreased healthcare expenses, fewer disabilities, and decreased mortality (Hardy, Perera, and Roumani, 2007; Fritz and Lusardi, 2009). Several studies have examined overall gait patterns in people with PD.
Protas et al. (2005) compared the gait characteristics of people with PD to those of healthy individuals. Initially, people with PD exhibited slower initiation of movement and decreased weight shifting in standing. After an eight-week intervention, the authors noted reduced falls, improved gait speed, and improved stride length in the treatment group. The authors concluded that gait training and “step perturbation” training improves measures of gait and reduces falls in people with PD (Protas, Mitchell and Williams, 2005). Dibble et al. (2004) examined two velocity variables, mean swing limb velocity and sacral velocity, at maximal gait speed. The authors compared people with PD to healthy elderly individuals. Participants with PD demonstrated overall slower mean swing limb velocities and sacral velocities when compared to the healthy elderly individuals. When moving at maximal gait speed, individuals with PD ambulate at a normal speed for a shorter period of time and fail to demonstrate equivalent center of pressure displacement or movement outcomes (Dibble et al., 2004). Abnormalities in gait can lead to a fall in a person with PD.

One third of the US population over 65 experiences a fall each year (Gray and Hildebrand, 2000). The incidence of falls in individuals with PD increases due to both the severity of PD and its secondary complications (Gray and Hildebrand, 2000). Gray and Hildebrand (2000) assessed 118 subjects with PD to identify risk factors for falling that may be unique to PD. Of the 118 subjects, 70 (59%) reported one or more falls. In addition, 80% of individuals that experienced episodes of freezing also fell. Freezing was shown to be the most common cause of falls (36%) in people with PD. (Gray and Hildebrand, 2000) Various interventions have been aimed at reducing the number of falls and risk of falling in this population (Protas, Mitchell and Williams, 2005). However, no studies currently exist that examine the use virtual reality (specifically the Nintendo Wii Fit) to rehabilitate people with PD.

The Nintendo Wii has been shown to increase stance stability, improve postural control and improve functional mobility in subjects with neurological disorders. (Detsch et al., 2008) Other benefits that have been associated with the Nintendo Wii include an increase in patient compliance with physical therapy, increase in patient participation, increased socialization, and increased self esteem. (Coyne, 2008) According to the manufacturer’s website, the Nintendo Wii Fit is intended to incorporate fitness with fun for people of all ages. (Nintendo, 2011) The Wii Fit was specifically chosen for this study since specific activities included in the software (ie: yoga, balance, and strength) may serve to improve movement in people with PD. In addition, the use of the Nintendo Wii Fit as an exercise intervention was found to improve the timed up and go and Berg balance scale scores in an elderly woman status post CVA (Brown, Sugarman and Burstin, 2009). Therefore, the purpose of this study was to evaluate the effects of several Nintendo Wii Fit activities on balance, gait, and mobility in one person with PD.

Case description

The subject of this case study was a 69 year-old African-American male diagnosed with idiopathic PD in 2008. Prior to participation in the study, the subject was receiving outpatient physical therapy, three times per week for 14 weeks, for functional abnormalities in gait, balance, and posture secondary to PD. The subject was approached by the researchers regarding the study and volunteered to participate. The study was approved by the Quinnipiac University human subjects review board. The subject met the following inclusion criteria: diagnosis of idiopathic PD, an ability to ambulate household distances (150 ft) with no greater than minimal assistance, and an ability to stand independently without a device for at least 30 seconds. The exclusion criteria included a history of neurological disorders other than PD, any orthopedic disorders that would prevent ambulation or treatment with the Nintendo Wii Fit, a history of seizures, cancer, or use of Deep Brain Stimulation. At the onset of the study, the subject was no longer receiving physical therapy. The subject did, however, continue to take daily walks and
attend a local gym twice per week. The subject lived alone and was unable to drive. He relied on family, friends and public transportation for visits to the MD, grocery store, and other activities. At the time of enrollment, the subject was taking Metformin ER 500 mg, Amlodipine 5 mg, and Azilect 1 mg. Informed consent was explained to the subject and signed.

**Examination**

At the onset of the study, the subject ambulated independently with the use of bilateral straight canes. He ambulated on even and uneven surfaces (outdoors, curbs and ramps) without limitations on distance. The subject could negotiate one flight of stairs with bilateral canes independently. He was independent in all other mobility tasks. The subject received assistance at home for light meal preparation. The following data were collected by blinded examiner:

1. **Berg Balance Scale (BBS):** The Berg Balance Scale assesses balance and has been extensively researched for identifying patients who are safe in ambulation and those that may need assistive devices (Berg, Wood-Daphinee and Williams, 1992). Scores below a 54 indicate an increased risk of falling and unsafe ambulation in people with PD with a sensitivity of 79% and specificity of 74% in this population. (Berg, Wood-Daphinee and Williams, 1992)

2. **Timed-Up-and-Go (TUG):** The Timed Up and Go measures basic mobility skills in the community-dwelling elderly and has a sensitivity and specificity of 87%. (Steffen, Hacker and Mollinger, 2002). It has been considered a valid tool for measuring both functional mobility and risk of falling. (Shumway-Cook, Brauer and Woollacott, 2000) Thompson and Medley found that using a cut off score of 7.95 seconds on the TUG increased the sensitivity of the test to 93% (Thompson and Medley, 1998)

3. **Gait Speed:** Gait speed is an indication of overall health and walking performance (Fritz and Lusardi, 2009; Steffen, Hacker and Mollinger, 2002; Studenski, Perera and Wallace, 2003). The minimal detectable change score for comfortable gait speed is 0.18 m/sec. (Steffen, Hacker and Mollinger, 2002). Normal comfortable gait speed for an individual with PD is 1.16 m/s. (Steffen, Hacker and Mollinger, 2002)

4. **Number of falls:** Assessed via subject self report

5. **Geriatric Depression Scale (GDS):** The Geriatric Depression Scale was used to measure depression. A cut off score of 11 results in a sensitivity of 84% and a specificity of 95% (Peach, Koob and Kraus, 2001) A higher value on the GDS increases the patient’s risk for falls (although the link between the two is still unknown) and functional dependence (Biderman et al., 2002)

**Intervention**

The subject was treated with the Nintendo Wii Fit two times per week for a total of eight weeks. There were three weeks, out of the eight weeks, where the subject attended once per week due to scheduling conflicts. Initially, the subject tolerated 40 minutes of activity due to complaints of fatigue. However, by the fourth week, the subject was able to tolerate 60 minutes. All activities were chosen to address the subject’s decreased gait speed, moderate risk of falling, decreased balance, and impaired functional mobility.

The subject began the intervention six days after the initial assessment. Each treatment session began with a warm up stretching exercise called the Sun Salutation that lasted an average of 5 minutes. If further stretching was necessary, the Half Moon, Rowing Squat, Torso Twists, or the Chair followed the Sun Salutation. Balance exercises followed the stretching exercises. Three exercises were chosen, progressing from the least challenging to the most challenging: Penguin Slide, Table Tilt, and Balance Bubble. The Penguin Slide was performed 2-3 minutes per session. As the subject progressed, 3-4 minutes of the Table Tilt was added. The table tilt was performed with bilateral canes since this
mimicked the subjects’ typical mobility pattern and improved weight shifts with the activity. Finally, the Balance Bubble was added. The subject performed this activity for 1-5 minutes per session. Treatment sessions ended with Nintendo Wii Fit gait activities. There were four activities chosen progressing from least challenging to most challenging: Free Step, Island Cycling, Obstacle Course, and Rhythm Parade. Most treatment sessions ended with the Free Step. The activity was modified to include the use of bilateral straight canes to mimic the subject’s typical gait pattern. Island Cycling was done one time and was discontinued due to difficulty. The Obstacle Course was performed twice but again, was discontinued due to difficulty. The obstacle course includes a series of stops and starts which were particularly difficult for the subject. The Rhythm Parade was the hardest of all stepping activities, because it required the subject to keep up with the beat of the music. After one session, it was also discontinued due to the subject’s inability to keep up with the fast paced beat.

**Outcomes**

The results of the clinical outcome measures are summarized in Table 1. The subject’s TUG score decreased by 12.3 seconds, surpassing the minimal detectable change (MDC) of 2 seconds. The subject’s BBS score improved by 11 points surpassing the MDC of 5 points (Clark and Kraemer, 2009). The results of the Geriatric Depression Scale did not change, and remained a 0.

<table>
<thead>
<tr>
<th>Outcome Measure</th>
<th>Pre</th>
<th>Post</th>
<th>Change</th>
<th>% Change</th>
<th>MDC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gait (m/sec)</td>
<td>0.26</td>
<td>0.37</td>
<td>0.11</td>
<td>42%</td>
<td>.21</td>
</tr>
<tr>
<td>TUG (sec)</td>
<td>36.4</td>
<td>24.1</td>
<td>12.3</td>
<td>34%</td>
<td>2</td>
</tr>
<tr>
<td>BBS</td>
<td>31</td>
<td>42</td>
<td>11</td>
<td>35%</td>
<td>5</td>
</tr>
<tr>
<td>GDS</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0%</td>
<td>-</td>
</tr>
</tbody>
</table>

**Table 1.**

<table>
<thead>
<tr>
<th>Game</th>
<th>Shortest Time (min:sec)/Lowest Score</th>
<th>Longest Time (min:sec)/Highest Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sun Salutation</td>
<td>1:57/41 points</td>
<td>8:50/98 points</td>
</tr>
<tr>
<td>Half Moon</td>
<td>4:20/9 points</td>
<td>7:30/87 points</td>
</tr>
<tr>
<td>Chair</td>
<td>0:48/10 points</td>
<td>4:03/86 points</td>
</tr>
<tr>
<td>Rowing Squat</td>
<td>1:37/0 points</td>
<td>3:59/80 points</td>
</tr>
<tr>
<td>Torso Twists</td>
<td>2:13/41 points</td>
<td>7:53/90 points</td>
</tr>
<tr>
<td>Penguin Slide</td>
<td>1:30/32 points</td>
<td>4:40/53 points</td>
</tr>
<tr>
<td>Table Tilt</td>
<td>2:41/0 points</td>
<td>6:16/60 points</td>
</tr>
<tr>
<td>Balance Bubble</td>
<td>1:05/0 yards</td>
<td>5:00/1000 yards</td>
</tr>
<tr>
<td>Free Step</td>
<td>3:10</td>
<td>6:35</td>
</tr>
</tbody>
</table>

**Table 2.**
The subject also improved his ability to perform many of the activities on the Wii Fit. These improvements are summarized in Table 2. With the Sun Salutation, initially, the subject weight shifted posterior and was retropulsive. After a few sessions, he began to visually correct the distribution of weight via the visual Wii Fit cue. During this and the other stretching exercises, the treating therapist would cue the subject to “stand up tall” to promote both spinal and hip extension. The score on the Sun Salutation exercise improved by 57 points. Scores on other stretching activities also improved. The Half Moon score improved by 78 points, the Chair score improved by 76 points, the Rowing Squat score improved by 8 points, and the Torso Twists score improved by 49 points.

For the penguin slide, the therapist would cue the subject to laterally shift his weight by saying “lean a little to the left and try to catch the fish.” Because of these cues and overall practice, his score improved 21 points. Throughout the Table Tilt exercise, the treating therapist cued the subject to “stand up tall” and to “lean forward” to prompt an anterior weight shift (which was difficult for the subject). The Table Tilt exercise improved from 0 points with bilateral canes to 60 points without the use of bilateral canes. Finally, the score on the Balance Bubble improved from 0 to 1000 yards with verbal cues from the treating therapist.

The free step was done with bilateral canes throughout the 8 weeks. The treating therapist frequently reminded the subject to “lift his left foot” to clear the balance board and to “take big steps.” There were also cues for posture such as “come up tall in between steps.” Initially, the subject tolerated 3 minutes of the activity. At the end of 8 weeks, he tolerated the Free Step for a little over 6 minutes. The subject more than doubled his time standing from 14 minutes and 28 seconds to 35 minutes and 42 seconds by the end of the study. In addition, rest breaks decreased from 8 minutes and 12 seconds (Session 1) to 2 minutes and 28 seconds (Session 14).

Discussion

The results show significant improvements in both the TUG and the BBS, with the results exceeding the minimal detectable change for their respective outcome measures. The subject started with a 0 on the Geriatric Depression Scale (GDS) and ended with a 0, signifying no signs of depression initially or at the end of the treatment sessions. The results of the GDS did not change and, therefore, it can be inferred that the patient remained satisfied with his plan of care. Also, he was extremely motivated and competitive. We infer that the floor effect of his score, along with his natural positive outlook, had a positive impact on the results.

Gait speed improved by 42% from pretest to posttest. The interventions that were chosen to improve gait included the Free Step, Penguin Slide, Torso Twists, Obstacle Course, Island Cycling, Rhythm Parade, and the Balance Bubble. The interventions that were implemented initially were the Penguin slide and the Torso Twists. The penguin slide promoted medial and lateral weight shifting challenging the subject’s balance, which would ultimately improve the subject’s gait and increase weight bearing on the left. People with PD have a decreased ability to weight-shift laterally (Protas, Mitchell and Williams, 2005); therefore, the penguin slide was intentionally chosen to target this impairment. Torso Twists were utilized to increase trunk rotation, which we noted was decreased during assessment of gait speed. The Balance bubble and Tilt Table were similar to the Penguin slide but promote weight shifting in all directions, so these interventions were implemented later in treatment. The Free Step requires the subject to step onto and off the balance board, mimicking reciprocal gait. There was also an audible click produced by the Nintendo Wii Fit to facilitate rhythm throughout the free step. It has been shown that external cues, such as audible clicks or music, help to prevent freezing episodes in gait in individuals with PD (Hackney and Earhart, 2010; Hackney and Earhart, 2009).
As previously noted, severe limitations in gait present in people diagnosed with PD (Protas, Mitchell and Williams, 2005). We chose the Nintendo Wii fit activities to improve weight shift and trunk mobility. These activities include the Free Step, Penguin Slide, Torso Twists, Obstacle Course, Island Cycling, Rhythm Parade, and the Balance Bubble. The subject performed well with the penguin slide and balance bubble, demonstrating improvements as evidenced by an increase in score. These results are expected as persons with PD have been shown to improve balance with an external focus (Wulf et al., 2009). Furthermore, weight shifting exercises, such as the penguin slide and balance bubble, have been shown to decrease the incidence of freezing episodes (King and Horak, 2009). The subject, however, was unable to perform Island cycling or rhythm parade.

The subject’s scores on the TUG improved by 34% after intervention. Although several activities may have contributed to these changes, the Free Step, Chair, Penguin slide, Torso Twists, and Balance Bubble may have contributed most. The eccentric, concentric, and isometric contractions of the knee and hip extensors during the Chair activity simulate standing up from a sitting position and vice versa. This strengthening, promoted mainly through isometric exercise, appears to strengthen the quadriceps for the function of performing a sit to stand transfer. This form of exercise was chosen because the inability to rise from a chair is an intrinsic fall risk factor for persons with PD (Clark and Kraemer, 2009). For problems in functional mobility, Robinson et al. (2005) suggested interventions that included “gait training using external visual and auditory cues [and] proximal lower limb strengthening/flexibility/muscle endurance training” (Robinson et al., 2005, p.179).

The subject improved on the BBS by 25% from pretest to posttest. As decreased posture has been shown to increase risk for falls. The sun salutation, half moon, chair and rowing squat were all chosen to improve the subject’s posture, since individuals with Parkinson’s disease often present with a stooped, kyphotic posture (Gray and Hildebrand, 2000). The sun salutation involves the subject reaching backwards (which promotes shoulder flexion and thoracic extension and to reach downward toward his toes (which lengthened his hamstrings). The half moon required the subject to lean to the left and the right, which lengthened the subject’s abdominal oblique muscles and required him to reach upward into shoulder flexion. The chair activity promoted shoulder flexion, thoracic extension, and quadricep strengthening. The rowing squat acted similar to the chair but instead of promoting shoulder flexion, it promoted scapular adduction and shoulder extension. The torso twists and rowing squat also had the added benefit of improving the subject’s overall strength.

Conclusion

Selected activities performed with the Nintendo Wii Fit gaming system improved gait speed, TUG and BBS scores in one individual with PD. Further research is needed to evaluate the efficacy of the Nintendo Wii Fit gaming system as a valid and reliable adjunct to traditional physical therapy in people with PD.

References


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