Six Weeks of Unsupervised Nintendo Wii Fit Gaming is Effective at Improving Balance in Independent Older Adults

Vaughan Patrick Nicholson, Mark McKean, John Lowe, Christine Fawcett, and Brendan Burkett

Objective: To determine the effectiveness of unsupervised Nintendo Wii Fit balance training in older adults. Methods: Forty-one older adults were recruited from local retirement villages and educational settings to participate in a six-week two-group repeated measures study. The Wii group (n = 19, 75 ± 6 years) undertook 30 min of unsupervised Wii balance gaming three times per week in their retirement village while the comparison group (n = 22, 74 ± 5 years) continued with their usual exercise program. Participants’ balance abilities were assessed pre- and postintervention. Results: The Wii Fit group demonstrated significant improvements (P < .05) in timed up-and-go, left single-leg balance, lateral reach (left and right), and gait speed compared with the comparison group. Reported levels of enjoyment following game play increased during the study. Conclusion: Six weeks of unsupervised Wii balance training is an effective modality for improving balance in independent older adults.

Keywords: Wii Fit, balance, active video games

Age-related deterioration in postural control and balance are well recognized (Lord & Ward, 1994) and these changes are associated with an increased risk of falling and fall-related injuries (Lord & Clark, 1996). Declines in balance performance are evident from age 40 (Isles, Low Choy, Steer, & Nitz, 2004), while more rapid declines begin around age 60 (Era et al., 2006). Previous research has shown that various forms of exercise, including balance training, can improve balance and reduce the risk and incidence of falls in older adults (Gillespie et al., 2009). While there are many balance interventions available, interactive gaming technologies such as the Nintendo Wii (Nintendo, Redmond, WA) have been used recently as an effective tool to enhance balance and mobility in older adults (Larsen, Schou, Lund, & Langberg, 2013; Taylor, McCormick, Impson, Shawis, & Griffin, 2011). Utilizing existing, relatively inexpensive gaming technologies such as the Nintendo Wii may be an economical option for preventative intervention in regards to balance decline and falls prevention (Nitz, Kuys, Isles, & Fu, 2010) in older adults. Furthermore, Wii-based activity can be undertaken at home, either alone or within a small group, which may make the activity more attractive and accessible to many older adults (Yardley et al., 2006). Research has demonstrated that Wii-based training can improve balance in older adults with both normal (Bieryla & Dold, 2013; Williams, Doherty, Bender, Mattox, & Tibbs, 2011) and impaired balance (Griffin, Shawis, Impson, McCormick, & Taylor, 2012; Jorgensen, Laessoe, Hendriksen, Nielsen, & Aagaard, 2013). Although these findings are promising, these studies have all provided close supervision to participants. Currently there is a paucity of literature investigating the appropriateness of unsupervised Wii-based interventions in older adults. To date, no study has used a two-group design to assess the effectiveness and safety of unsupervised Wii Fit training in older adults.

A recent systematic review update recommended that balance interventions should target both the general community and those at high risk for falls (Sherrington, Tiedemann, Fairhall, Close, & Lord, 2011) and some have suggested the need for preemptive strategies to be implemented during the preclinical period of balance decline (Low Choy, Brauer, & Nitz, 2008).

The aim of this study was therefore to determine the effectiveness of a six-week unsupervised Nintendo Wii Fit program in a group of apparently healthy older adults. The pre- and postoutcome clinical measures included those commonly associated with falls risk (balance, mobility, gait, and fear of falling). Furthermore, the study aimed to determine the relative safety of unsupervised Wii Fit game play and the level of enjoyment experienced by participants. It was hypothesized that a Wii Fit balance program undertaken without supervision, within one’s own residence, would improve measures of static and dynamic balance and would allow for good program adherence. A cohort made up of elders with apparently normal balance was deemed appropriate for this unsupervised study as the likelihood for adverse events would be reduced compared with a group of balance-impaired individuals.

Method

Design
A two-group prepost design was used. Ethical clearance was obtained from the Human Research Ethics Committee of The University of the Sunshine Coast and each participant provided informed consent.

Study Population
Participants were recruited from a convenience sample from two local retirement villages and a local adult education facility. Eligibility criteria included: aged 65 years or older; not involved in balance or resistance type training in the previous three months; able to independently ambulate; able to clearly see characters on a television screen from three meters; and free of chronic medical conditions that would limit participation in low-moderate intensity exercise. All participants were physically active and involved in

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various activities including golf, table tennis, swimming, and walking. Intervention group participants had to reside in one of two local retirement villages to ensure access to the Wii gaming systems. The comparison group was comprised of participants from both the local adult educational facility and retirement villages.

Participants from both groups were familiarized with all testing procedures approximately one week before baseline testing to minimize any learning effect and to ensure appropriate technique where applicable. Testing sessions were conducted in a nationally-accredited motion analysis laboratory at week 1 and week 7 of the research project.

Measurements

Height and Weight. Height was measured without shoes to the nearest 0.1 cm using a portable stadiometer (S & M Instrument Company). Weight was measured in light clothing to the nearest 0.1 kg using portable electronic scales (Tanita, Japan). Body mass index (BMI) was calculated as weight (kg)/height(m$^2$).

Balance and Mobility. All balance and mobility measures were assessed per established protocols with participants unshod and were designed to assess components of function that may be influenced by the intervention. The timed up-and-go (TUG) (Shumway-Cook, Brauer, & Woollacott, 2000), functional reach (Duncan, Weiner, Chandler, & Studenski, 1990), lateral reach (Brauer, Burns, & Galley, 1999), single-leg balance, 30 s chair stand (Jones, Rickli, & Beam, 1999), usual gait speed, and 10-item Iconographical Falls Efficacy Scale (Icon FES) (Delbaere, Smith, & Lord, 2011) were completed by all participants pre- and postintervention. An eight-item modified Physical Activity Enjoyment Scale (PACES) (Mullen et al., 2011) was completed by the Wii Fit group during week 1 and 6 of the intervention. Due to the variability in assessment methods used for single-leg balance and usual gait speed within the literature, a brief description of methods used for both follows.

Single-leg Balance. Single-leg balance was assessed with eyes open; participants lifted the nonstanding leg so that the raised foot was near but not touching the ankle of the stance limb. Stance time was measured to the nearest 1/100th of a second with a digital stopwatch (Junso, China). Time commenced when the subject lifted the foot off the floor. Timing ceased when the subject either: (1) moved their arms beyond 45° abduction to balance, (2) moved the weightbearing foot to maintain balance, (3) a maximum of 60 s had elapsed, (4) placed their nonstanding leg on the ground, (5) placed their hands on the chair in front of them, or (6) required assistance to maintain balance. A total of three successful trials for each leg were conducted with 30 s of rest between trials. The average time for three trials for each leg was used for analysis.

Usual Gait Speed. Participants were instructed to stand still with their feet just behind a starting line marked with tape. On the examiner’s command of “Go” participants walked at their normal, comfortable pace along a 6-m course until a few steps past the finish line. Timing with a digital stopwatch commenced with the first footfall and stopped with the subject’s first footfall after crossing the 6-m end line. The mean of two trials (in m/s) was used for data analysis.

Wii Fit Intervention

Approximately one week after baseline testing (week 0) an orientation session was held at each retirement village to familiarize each participant in the Wii intervention group with the Nintendo Wii, Wii balance board, and Wii Fit Plus game, and to ensure each participant could safely play the games. Detailed instructions were also provided for each participant to refer to throughout the study. Participants were contacted every two weeks by the lead researcher as a routine follow-up. The Wii intervention was conducted from week one through six.

Participants in the Wii group were encouraged to complete 3 × 30 min Wii Fit sessions per week for six weeks. Participants undertook all gaming unsupervised within the community hall of their retirement village. Participants were encouraged to undertake the sessions in pairs. Participants in the intervention group completed a logbook to document their playing time and games played on the Wii. Participants also noted any slips, trips, falls, or discomfort associated with each gaming session. Participants in the comparison group received no intervention but were encouraged to continue with their usual everyday activities and exercise routines.

Participants in the intervention group were encouraged to play selected balance games from Wii Fit Plus for at least 30 min three times per week for six weeks. Eight games from the balance and training plus components of Wii Fit Plus were chosen based on balance challenge, perceived safety, and enjoyment. The games available for play were: soccer heading, penguin slide, ski slalom, ski jump, table tilt, snowball fight, perfect 10, and tightrope walking. Participants were encouraged to play at least three games from the eight options each session, and all eight games were to be played at least once in the first week of the study.

Statistical Analysis

Descriptive statistics were used to describe the participant characteristics and to present pre- and postintervention results. All dependent variables were checked for normality and transformed where necessary. Independent $t$ tests were used to determine any differences between groups at baseline. A univariate general linear model was used to determine the extent of any change in outcome variables between pre and posttesting. Sex and group were set as fixed factors and age was a covariate. Effect size estimates were also calculated to provide information regarding the magnitude of change over the intervention. With the exception of the PACES (which was only assessed in the Wii group), effect size calculations were based on pooled standard deviations for each task (Cohen, 1977; Kazis, Anderson, & Meenan, 1989). Pearson’s correlation coefficient was used to determine the strength of relationships between clinical measures. A paired samples $t$ test was used to identify any change in PACES scores between week one and six in the Wii group. Statistical significance was set at $P < .05$ and IBM SPSS (Version 20; IBM Corp., Armonk, USA) was used for all analyses.

Results

Characteristics of Participants

Summaries of subject characteristics are displayed in Table 1. Testing was completed by 41 participants, with a mean age of 74.5 (5.4) years and an age range of 65 to 84 years. All participants ambulated freely without an assistive device.

Adherence to the Intervention

Twenty-one participants commenced the intervention in the Wii Fit group and two participants ceased their involvement within the first
three weeks of the program due to low back and hip pain. All 22 participants in the control group started and completed the program. The 19 participants that completed the intervention in the Wii Fit group attended an average of 17.5 sessions (out of a recommended 18) over the course of the six-week program and completed 32.3 min of game play per session. Total sessions completed ranged from 12 to 21.

**Adverse Events**

There were no reported acute adverse events such as trips or falls while playing the Nintendo Wii. Two participants did cease their involvement in the program after two and three weeks, respectively. Both participants reported exacerbations of low back pain but did not require medical attention.

**Effect of Wii Fit training**

There were significant group-by-time interactions for five out of nine outcome measures assessed in both groups; all interactions indicated an improvement in the Wii Fit training group compared with the comparison group. All tasks that produced significant group-by-time interactions also demonstrated small to moderate effect sizes, while lateral reach left was the only task to demonstrate a large effect size (> 0.8) (Cohen, 1977). There was a significant time effect for lateral reach left only. There were no sex or age effects for any measure. Table 2 provides a summary of the test results in terms of mean difference (post measure—pre measure) for clinical measures.

### Table 1 Characteristics of Participants at Baseline

<table>
<thead>
<tr>
<th>Variable</th>
<th>Wii Group (n = 19)</th>
<th>Control Group (n = 22)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>75.11 (5.85)</td>
<td>73.91 (5.12)</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>25.66 (4.82)</td>
<td>26.20 (3.70)</td>
</tr>
<tr>
<td>Males</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Fallers (1 fall in previous 12 months)</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Medications</td>
<td>2.68 (2.31)</td>
<td>3.09 (2.41)</td>
</tr>
<tr>
<td>TUG (s)</td>
<td>7.85 (1.16)</td>
<td>7.53 (1.86)</td>
</tr>
<tr>
<td>*Functional reach (cm)</td>
<td>27.00 (5.03)</td>
<td>29.73 (4.37)</td>
</tr>
<tr>
<td>Lateral reach left (cm)</td>
<td>19.84 (5.67)</td>
<td>21.25 (4.47)</td>
</tr>
<tr>
<td>Lateral reach right (cm)</td>
<td>19.39 (4.68)</td>
<td>21.09 (3.14)</td>
</tr>
<tr>
<td>Single-leg stance left (s)</td>
<td>13.78 (13.48)</td>
<td>19.89 (19.85)</td>
</tr>
<tr>
<td>Single-leg stance right (s)</td>
<td>16.29 (14.67)</td>
<td>16.78 (15.17)</td>
</tr>
<tr>
<td>30-s chair stand</td>
<td>15.82 (3.68)</td>
<td>15.09 (3.38)</td>
</tr>
<tr>
<td>Gait (m/s)</td>
<td>1.34 (0.15)</td>
<td>1.41 (0.19)</td>
</tr>
<tr>
<td>Icon FES</td>
<td>12.84 (2.81)</td>
<td>13.86 (4.89)</td>
</tr>
<tr>
<td>PACES</td>
<td>40.47 (9.63)</td>
<td></td>
</tr>
</tbody>
</table>

*Note. Values are expressed as mean (SD). BMI = body mass index; TUG = timed up-and-go; Icon FES = Iconographical Falls Efficacy Scale; PACES = Physical Activity Enjoyment Scale.

*Significant difference between groups (P < .05) at baseline.

### Table 2 Mean Difference (Post—Pre) for Outcome Measures

<table>
<thead>
<tr>
<th>Outcome Measure</th>
<th>Group</th>
<th>Mean (SD)</th>
<th>Group × Time Interaction</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>TUG (s)</td>
<td>Wii</td>
<td>–0.61 (0.79)</td>
<td>.60 .03*</td>
<td>.31</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>–0.14 (0.88)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Functional reach (cm)</td>
<td>Wii</td>
<td>2.47 (5.08)</td>
<td>.87 .27</td>
<td>.24</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>1.32 (5.07)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lateral reach left (cm)</td>
<td>Wii</td>
<td>2.24 (4.79)</td>
<td>.02* &lt; .01†</td>
<td>.90</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>–2.34 (4.41)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lateral reach right (cm)</td>
<td>Wii</td>
<td>1.77 (4.88)</td>
<td>.20 &lt; .01†</td>
<td>.72</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>–1.04 (5.11)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SLS left (s)</td>
<td>Wii</td>
<td>2.68 (11.73)</td>
<td>.68 .03*</td>
<td>.55</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>–6.52 (10.28)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SLS right (s)</td>
<td>Wii</td>
<td>2.89 (11.6)</td>
<td>.66</td>
<td>.32</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>–1.95 (12.33)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30-s chair stand</td>
<td>Wii</td>
<td>1.9 (2.16)</td>
<td>.13 .81</td>
<td>.02</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>1.96 (2.97)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gait (m/s)</td>
<td>Wii</td>
<td>0.04 (0.12)</td>
<td>.91 &lt; .01†</td>
<td>.47</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>–0.04 (0.11)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Icon FES</td>
<td>Wii</td>
<td>0.58 (1.55)</td>
<td>.12 .54</td>
<td>.08</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>0.28 (1.42)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note. TUG = timed up-and-go; SLS = single leg stance; Icon FES = Iconographical Falls Efficacy Scale.

*Significant (P < .05); †significant (P < .01).
There was a significant increase ($P = .01$, effect size = 0.02) in the PACES from week one (40.47 ± 9.63) to six (42.42 ± 10.07) in the Wii Fit training group. There were significant correlations between the TUG and gait speed ($r = -.36$, $P = .02$), the TUG and single-leg stance left ($r = -.34$, $P = .049$), and lateral reach left and right ($r = .37$, $P < .01$).

**Discussion**

The six-week unsupervised Wii Fit based training was effective at improving five out of nine clinical tests used to assess mobility, balance, and fear of falling. To the best of our knowledge, this is the first comparison group study that has demonstrated the benefits of an unsupervised Wii Fit based training program in a group of independent, community-dwelling older adults. A previous single group study with minimal supervision (Agmon, Perry, Phelan, Demiris, & Nguyen, 2011) also found home-based Wii Fit gaming to be safe and effective at improving balance and gait speed in older adults while others reported no improvement in field tests assessing balance following eight weeks of unsupervised Wii gaming (Pluchino, Lee, Asfour, Roos, & Signorile, 2012). A number of recent supervised Wii-based studies have also demonstrated positive changes in balance and mobility measures in older adults (Hagberg, Lindahl, Nyberg, & Helenius, 2009), while previous Wii-based research found no change in enjoyment over the course of a 12-week intervention (Agmon et al., 2011). It is difficult to specify the reason for increased enjoyment in this program, but it could be argued that enjoyment grew as participants began to master the games and challenge their own abilities. In addition, participants undertook the Wii-based training in pairs or small groups. The development of social interactions and relationships within these small groups may have made the gaming process more enjoyable and possibly competitive. Previous research has suggested that social interactions are important for making physical activity a more positive experience (Allender, Cowburn, & Foster, 2006).

The measured values for balance and mobility tasks in this study compare well (Isles et al., 2004) or exceed (Bohannon, 1997) previous normative values for this age group, which highlights that the sample was made up of apparently healthy, mobile older adults. Of particular interest are the significant improvements demonstrated by the Wii Fit group for tasks assessing medial-lateral stability. The lateral reach test improved by approximately 2 cm in the Wii Fit group in each direction. The lateral reach test is an accurate and valid indicator of lateral stability limits and accordingly, a useful tool for assessing medial-lateral stability (Brauer et al., 1999). Deficits in medial-lateral stability are associated with increased falls risk in the elderly (Hilliard et al., 2008), so an improvement in any test assessing such an important postural control mechanism is an encouraging result after a six-week intervention. The improvements demonstrated in the Wii Fit group for single-leg balance are also noteworthy considering the reduced performance in the comparison group and the fact that poor stance times have been associated with future falls (Maki, Holliday, & Topper, 1994).

There were no significant changes in fear of falling over the course of the six-week intervention as measured by the 10-item Icon-FES. The lack of change was most likely due to a combination of the relatively short duration of the intervention and low baseline values for both groups (12.84 and 13.42, respectively). Low values represent low levels of fear, which may have produced a floor effect similar to that seen with other fear of falling questionnaires (Delbaere et al., 2010). Previous studies of longer duration have shown a reduction in fear of falling with appropriate exercise interventions (Barnett, Smith, Lord, Williams, & Baumdard, 2003; Sattin, Easley, Wolf, Chen, & Kutner, 2005).

The significant improvements in clinical tests observed in the Wii Fit group occurred in tasks assessing medial-lateral stability (lateral reach and single-leg balance), gait, and functional mobility (TUG). Although statistically significant, the improvements observed in the Wii group for these tasks do not necessarily represent practically significant results. For example, the 0.04 m/s improvement in usual gait speed for the Wii group is well below the recommended improvement of 0.1 m/s indicative of a substantial meaningful change (Perera, Mody, Woodman, & Studenski, 2006).

The improvements in medial-lateral stability were largely expected given that seven out of eight games played required participants to shift weight left and right to achieve success. Improvements in medial-lateral stability are also likely to have contributed to the positive changes observed in the gait-related tasks. Strong correlations have been found previously between single-leg stance time and gait speed in older adults (Ringsberg, Gerdhem, Johansson, & Obrant, 1999), and left single-leg stance was significantly correlated with gait speed in this study. There is growing evidence that age-related balance deficits are more pronounced in the medial-lateral direction (Bergland, Jarnlo, & Laake, 2003; Lord, Ward, Williams, & Anstey, 1993) so targeting this aspect of balance, which Wii Fit balance training appears to do, is an important target area for balance improvement and fall prevention interventions (Maki et al., 1994). These combined improvements, together with the excellent program adherence, suggest that unsupervised Nintendo Wii Fit training may be an appropriate intervention to improve balance in well-functioning older adults.

A number of study limitations require attention. Firstly, although both groups were well matched for age and physical ability, the groups were self-selected and the assessor was not blinded to the participants’ group. Despite the study recruiting more participants than many others associated with Wii-based training, the participant numbers were still relatively low. The short duration of the study is another limitation. Importantly, the participants in this study are unlikely to be representative of the 65 to 85 year age group as a number of potential participants were excluded primarily based on musculoskeletal and neurological deficits and only five out of 41 participants (12%) had experienced a fall in the previous 12 months, indicating that the cohort was largely made up of nonfallers. The participants in the study had good balance ability and would be classified as normal walkers (gait speed 1 to 1.4 m/s), so any improvements identified cannot be expected to be seen in individuals at a greater risk of falling. Furthermore, although there was a comparison group, there was no comparative balance training group to compare with the Wii group.

The results suggest that unsupervised Wii Fit balance training is a simple, effective, safe, and enjoyable intervention that can improve balance, usual gait speed, and functional mobility in apparently healthy, independent older adults. Further research of longer duration needs to be conducted on a larger group of older...
adults with a more diverse range of balance and gait abilities to better determine the effectiveness of unsupervised Wii-based training on improving balance and potentially reducing falls risk in this age group. Future unsupervised Wii-based balance interventions should also be compared with traditional balance interventions to better determine its relative efficacy.

Acknowledgments

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