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# Modern Technology and an Aging Population: Can the Use of Wii Fit Gaming System Improve Functional Balance in Community Dwelling Seniors?

Curtis N. Phillips
*Utah State University*

# MODERN TECHNOLOGY AND AN AGING POPULATION: CAN THE USE OF THE Wii FIT GAMING SYSTEM IMPROVE FUNCTIONAL BALANCE IN COMMUNITY DWELLING SENIORS?

by

Curtis N. Phillips

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Approved:

| | |
|---|---|
| Judith Holt, Ph.D.<br>Major Professor | Tim Slocum, Ph.D.<br>Committee Member |
| Eadric Bressel, Ed.D.<br>Committee Member | Gretchen Gimpel Peacock, Ph.D.<br>Committee Member |
| Sarah Rule, Ph.D.<br>Committee Member | Jared Schultz, Ph.D.<br>Committee Member |

Mark R. McLellan, Ph.D.
Vice President for Research and
Dean of the School of Graduate Studies

UTAH STATE UNIVERSITY
Logan, Utah

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## ABSTRACT

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by

Curtis N. Phillips, Doctor of Philosophy

Utah State University, 2013

Major Professor: Judith Holt, Ph.D.
Department: Special Education

Seniors are a growing percentage of the population in the U.S. estimated to reach 19% of the overall population by the year 2030. More than one third of seniors experience a fall each year. This is often due to decreased balance. This combination of decreased balance and increased falls lead to social, financial, and functional challenges for seniors and their caregivers. A significant body of research has been dedicated to finding an intervention that will ameliorate the problem. To date there have been interventions identified but these are often unavailable, cost prohibitive, or difficult to access. The purpose of this research study was to assess the effect of a low-cost balance training system (Wii Fit) on the functional balance and balance confidence of seniors. Four participants trained on the Wii Fit system 3x/week for 30 minutes per session until improvement was noted for three consecutive assessments. Functional balance was assessed weekly using the Berg Balance Scale (BBS) and Timed Up and Go (TUAG) test. Additionally, the Activities-specific Balance Confidence (ABC) scale was given prior to and following the study to assess participants' perceived balance confidence. Qualitative data on the Wii Fit's motivational qualities were collected post-intervention from the participants via interview. The study design was a single subject, multiple-baseline design. Each participant demonstrated improved functional balance as assessed by BBS and TUAG. Further, positive trends were noted on the ABC scale. Qualitative data gathered in a semistructured interview also demonstrated generally positive feelings regarding ease of use and motivational qualities of the Wii Fit, although some participants viewed the system as difficult to operate. The results of this study indicate that the Wii Fit gaming system may be an effective in-home, inexpensive tool that can be used by seniors to improve functional balance and balance confidence. Ease of use and motivational qualities, however, were noted to be somewhat controversial.

(92 pages)

**PUBLIC ABSTRACT**

Modern Technology and an Aging Population: Can the Use of the Wii Fit Gaming System Improve Functional Balance In Community Dwelling Seniors?

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Seniors are a growing segment of the population of the United States. By 2030 they will make up nearly 20% of the general population. Senior citizens face many health challenges as they age. Injury due to falling is a major concern for many in this age group. Research shows that approximately one third of seniors will fall each year. Injuries that result from falls have been identified as the number one cause of accidental death in this age group each year. While falls have been studied by researchers for a number of years, and some progress has been made in finding ways to improve balance in seniors, the high incidence of falls continues to plague this demographic. Many of the current treatments to improve balance are too expensive, not accessible, or not motivating for seniors. This research project explored the effect of using a readily available video-game system to address these barriers. The Wii Fit gaming system was used with participants three times each week for 30 minutes and the resulting changes were documented. The Berg Balance Scale and Timed Up and Go test, both frequently used by professionals to assess balance in seniors, were used to document balance change. Every participant showed improvement. The Activities-specific Balance Confidence scale, which is used to measure a person's fear of falling, was also used to assess the participant's confidence in their balance as well as the level of fear associated with falling. The results of this test were positive but not to the extent of the balance tests. Finally, each participant was interviewed to assess how easy to use the participants felt the Wii Fit was as well as the motivational qualities of the Wii Fit as a balance tool. Answers given by the participants in the interview were generally positive. These results indicate that the Wii Fit gaming system may be beneficial for improving balance in seniors.

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Curtis N. Phillips

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# CHAPTER I

# INTRODUCTION

Balance is an essential component of physical movement. Defined in biomechanical terms, balance is the maintenance of upright posture with minimal deviation from the center of gravity and vertical axis (Winter, 1995). During typical aging, the ability to maintain balance declines. This decline in balance often leads to falls, which have been shown to increase fear of falling and/or injury (Sheffer, Schuurmans, van Dijk, van der Hooft, & de Rooij, 2008). A systematic review of literature conducted by Ganz, Bao, Shekelle, and Rubenstein (2007) noted that the most consistent predictors of future falls are clinically detected abnormalities of gait or balance. An inverse relationship exists between the level of gait and balance scores and the likelihood of falling. While interventions to improve balance are often effective, they can be difficult for seniors to access.

## Purpose

The purpose of this study was to assess the effectiveness of a readily available and low cost balance intervention system. This study investigated the effect of consistent balance training on functional balance and balance confidence in seniors using the Wii Fit game system in the home setting. Further, motivational qualities and ease of use factors were investigated.

## Significance

The elderly population is growing rapidly. The Administration on Aging, a part of the U.S. Department of Health and Human Services, estimated that in 2009 there were 39.6 million Americans age 65 years and older (12.9% of the population; Administration on Aging, 2011). They estimated that by the year 2030 the number of seniors will grow to 72.1 million (19% of the population). As this group of people age, falls become more likely. Hausdorff, Rios, and Edelber (2001) noted that more than one third of all adults aged 65 and older in the U.S. fall at least once each year. Finkelstein, Prabhu, and Chen (2007) reported that secondary medical conditions further increase the incidence of falls which often lead to a decreased ability for seniors to care for themselves, live in their own home and function independently. Further, many falls result in financial burdens due to medical costs if an injury does occur. Akyol (2007) noted that falls are the leading cause of accidental death and the seventh leading overall cause of death among persons over 65 years old. The results of these studies indicate a need for effective interventions to increase balance and thus decrease the likelihood of falls in this vulnerable population.

Research conducted over the past several years has focused on interventions aimed at decreasing the incidence of falls through improvement of balance. The link between decreased balance and increased incidence of falls has been well documented in the literature. Pajala and colleagues (2008) reported that use of a balance platform to assess center of pressure was an effective method of predicting falls in the elderly. Further, Ashburn, Hyndman, Pickering, Yardley, and Harris (2008) indicated that scores from functional balance measures were valid predictors of falls in the elderly. In response to these and similar studies, effective interventions have been researched and implemented with seniors. Some of the interventions commonly used are strength training, Tai Chi and computerized balance training (CBT). Each intervention has been demonstrated to improve functional balance measure scores in seniors; however, they are often difficult to access, expensive or unavailable for many of the most vulnerable seniors. These barriers have led researchers to investigate alternative interventions that are accessible, low cost and motivational for seniors.

The current study addressed each of these barriers to effective, cost-efficient, accessible and interesting balance training. Recent research has been performed assessing balance improvement while using the modality of video-gaming systems, particularly the Wii Fit system. This intervention is low cost, can be used in the home and has been reported in several studies to be motivational for seniors (Billis et al., 2010; Brox, Luque, Eversten, & Hernandez, 2011). The research questions addressed in this study were as follows.

1. To what extent does three times per week training on the Wii Fit gaming system increase or decrease functional balance, as measured by the Berg Balance scale (BBS) and Timed Up and Go (TUAG) test, in community dwelling seniors aged 65 years old or older?

2. To what extent does three times per week training on the Wii Fit gaming system increase or decrease the fear of falling, as measured by the Activities-specific Balance Confidence (ABC) scale, in community dwelling seniors aged 65 years old or older?

3. In a semistructured interview, how motivating and easy to use is the Wii Fit game system considered to be by community dwelling seniors aged 65 years old or older who have been trained three times per week on the Wii Fit system?

# CHAPTER II

# LITERATURE REVIEW

The following review of literature was organized based on research design. The relevant research studies were identified using the search tools Medline and Google Scholar. The initial search focused on peer reviewed journals and used the keywords "Wii Fit," "elderly," "senior," "fall prevention," and "balance." Only four research articles were identified with one of the four being online (publish ahead of print), so the search criteria were widened to include any scholarly research product using the same keywords. This search increased the number of appropriate articles to nine, including master's theses and doctoral dissertation manuscripts. Three additional articles were found via use of citations from previously identified articles. Twelve articles met the revised criteria.

The body of research acquired has been divided into groups including three case studies, five unpublished group studies and four published group studies. A summary table of the articles reviewed is included as Appendix A. The 12 studies include a variety of treatment protocols, disability/injury status, research objectives and participant outcomes. While the research format used by the authors varied, the intent of the research for all studies was to identify whether the Wii Fit gaming system made a difference in functional balance in seniors.

## Single Case Design

Three single case studies investigating the effect of Wii Fit use on balance in seniors were found. These included a conference presentation by Sugarman, Weisel-Eichler, Burstin, and Brown (2009), a single case study by Pigford and Andrews (2010), and a single-subject research study by Gardner (2011) as part of the requirements for her master of science in occupational therapy at East Carolina University.

The studies were similar in many ways. Each study used the Wii Fit in conjunction with another intervention or activity to improve balance in seniors. Sugarman and colleagues (2009) used Wii Fit with traditional physical therapy for an 86 year-old female who had recently suffered a stroke. Pigford and Andrews (2010) used Wii Fit with "therapeutic interventions" to intervene with an 87-year-old male who had experienced several recent falls. Finally, Gardner used the Wii Fit with a standard walking program with a 68-year-old male with Myasthenia Gravis, a degenerative neurological disorder. All participants were affected by a medical condition that affected their balance and were enrolled in the research projects to assess the effect of using the Wii Fit gaming system as a balance enhancement tool.

Interventions used in each of the studies varied greatly in frequency and duration. Sugarman and colleagues (2009) used an intensive 4-day program for 45 minutes each day. Pigford and Andrews (2010) used a 5-times-per week for 2 weeks with 60 minutes per session duration. Each of these sessions included 15-20 minutes on the Wii Fit. Gardner used a daily program with various lengths of each phase of her study. She noted that the Wii Fit was used for 60 minutes in each session. During her study, the Wii Fit activities varied as well. Sugarman and Weisel-Eichler used a specific set of activities while the other two studies allowed for participant choice.

The three research studies were similar regarding the types of measures used to assess balance in the participants. While the exact choice of balance assessment differed from study to study, all authors used functional balance assessment tools that are commonly used. These assessment tools included the Berg Balance Scales (BBS; Berg, Wood-Duphinee, & Williams, 1995), Functional Reach Test (FR; Duncan, Weiner, Chandler, & Studenski, 1990), Lateral Reach Test (LR; Brauer, Burns, & Galley, 1999), Timed Up and Go test (TUAG; Shumway-Cook, Brauer, & Woollacott, 2000), Four Square Step Test (FSST), and Gait Speed test (GS). While only the BBS and TUAG have been shown to be valid and reliable (Langley & Mackintosh, 2007), the other tests are commonly used and are reported to be "practical" measures of balance. In addition to functional measures, Gardner (2011) used the balance measurement tool included in the Wii Fit gaming system. To date, no published data on the reliability of this measure are available. However, Clark and Kraemer (2009) reported that the Wii Balance board is a valid measure of balance when compared to the "gold standard" of a laboratory-grade force platform.

Results from each of the studies indicated that use of the Wii Fit gaming system in conjunction with another intervention effectively improved balance. Sugarman and colleagues (2009) noted a 10-second decrease in the TUAG test while Gardner (2011) noted a significant (0.048) change in FSST score. Pigford and Andrews (2010) used minimal detectable change criteria to show improvement in both the BBS and TUAG scores of their participant. The other measures were listed as not significant in the respective studies but were still reported as trending toward improvement.

The results reported indicate improvement in balance using the Wii Fit and another intervention; however, there were several limitations noted in each study. The most obvious is the lack of appropriate numbers of participants to allow generalization. The authors note this as a limitation but indicate that the study is to inform a possible future direction for balance research. A second limitation, present in all three studies, is the lack of maintenance data to assess the lasting effect of the Wii Fit or to assess whether the participant continued using the Wii Fit following the intervention. This data would have been informative to direct future studies as to optimal frequency and duration of use as well as motivational qualities of the Wii Fit with seniors. Additionally, Sugarman and colleagues (2009) were unable to determine whether the improvement shown in their study was due to the Wii Fit or due to natural improvement, which is common following a stroke. Gardner (2011) had several limitations THAT stemmed from a poorly designed study. While she claimed to be using a single-subject reversal design, her actual implementation of that design was seriously flawed. The control that is usually the strength of any good single-subject research project was not present. First, using a reversal design to assess improvement in a "learned skill" is not recommended. Second, using a reversal design in conjunction with a skill that when taken away could lead to harm in the patient is also not recommended. She violated both of these tenets of reversal design. In addition to these flaws, the timetable of her study was inconsistent. She noted that the each intervention phase was of different length and the "reversal phase" was only used to gather data. There was also a three week break between interventions one and two due to holiday vacations. Finally, she used statistical analysis ($p = 0.048$) rather than visual inspection of a graph to assess significance of results. These violations of good single subject research make much of her research questionable.

These single case studies form a weak foundation of research due to the lack of appropriate control, maintenance data and lack of appropriate rigor but do indicate that there are trends toward improvement in balance using the Wii Fit. Each study indicated that more research is needed to validate the positive results and thus the authors knew the limitations of their studies. The following review of group studies increase not only the body of research available but also to some degree the rigor and control needed to produce more generalizable research.

## Unpublished Group Studies

A second set of studies exploring the effect of the Wii Fit gaming system on seniors are divided into unpublished and published group studies of which there are five and four respectively. The unpublished studies are comprised of three student products for master or doctoral degrees (Allen, 2009; Bomberger, 2010; Pluchino, 2010) and two conference presentations (Bieryla & Dold, 2011; Hermes, Hitch, Honea, Stephenson, & Bauer, 2010).

As with the single-case studies, all studies focused on the use of the Wii Fit to improve the functional balance in seniors. The number of participants varied from a minimum of three (Allen, 2009) to a maximum of 40 (Pluchino, 2010). Three of the studies used control or alternate experimental groups (Bieryla & Dold, 2011, Hermes et al., 2010; Pluchino, 2010) while the two remaining studies used only the Wii Fit intervention group and intraparticipant comparisons.

The interventions used in each study included the Wii Fit gaming system but varied in the intensity and duration of the intervention. The longest intervention (8 weeks) was instituted by Pluchino (2010), Allen (2009), and Hermes and colleagues (2010). Pluchino and Allen saw their participants 3x/week while Hermes and colleagues did 2x/week. Bieryla and Dold (2011) had an intervention of 3x/week for 3 weeks and Bomberger (2010) intervened 3x/week for 4 weeks. Each of these frequencies and durations are common to the rehabilitative field and are generally decided upon by the rehabilitation professional working with the seniors. Pluchino and Hermes were most similar in their intervention approach as they each had a Wii Fit group, a traditional balance exercise group. In addition, Hermes had a control group while Pluchino had a Tai Chi group. Bieryla and Dold had only a control and Wii Fit group while the other two used only a Wii Fit group.

Similarities were also evident in the measures used by the several study authors. The BBS, which is considered by most rehabilitation professionals to be the gold standard of functional balance assessments, was used by Bieryla and Dold (2011), Allen (2009), and Bomberger (2010). Pluchino (2010) used the TUAG test as well as the single leg stance and functional reach which are also standardized. Hermes varied from the norm of the group by using a self-developed “functional fitness” metric along with a computer generated balance scores. The variation in his measures comes in the form of no standardized functional balance measure. Computer generated balance scores are typically standardized but are not necessarily functional measures.

The results of these studies noted more differences. The only study that reported significant gains on the BBS was Bieryla and Dold (2011). Bomberger (2010) noted that in the nonimpaired group of participants, BBS scores improved significantly but in the mild to moderately impaired group there was only significant improvement on item #14 of the BBS, which is a single leg stance skill. Allen reported that the BBS scores were not significant (*p* = 0.549). However, Allen only had three participants that were compared pre and post-intervention within participant. Pluchino (2010), who had the largest number of participants, noted no significant differences between groups (traditional balance activities, Tai Chi and Wii Fit). While this may sound like an undesirable result, she notes that traditional balance activities and Tai Chi have both been proven in numerous studies to improve balance in seniors. Her results confirm that there are several methods, including Wii Fit that may be used to improve functional balance in seniors. Finally, Hermes and colleagues (2010) noted that the Wii Fit trained group showed little change in score on his “functional fitness” metric which included assessment of strength, cardiorespiratory endurance and flexibility. He did note however that there were comparable changes between traditional activity and Wii Fit participants when measured by a computer generated balance device. These results certainly indicate the need for more research to identify the optimal intervention technique needed to improve functional balance in seniors.

This group of unpublished studies, while similar, shows many different ways to implement, measure and address the balance fitness of seniors. Each study has strengths and weaknesses. There are several limitations indicated by the authors which need to be addressed. Allen (2009) noted the results may not be truly indicative of the effect of the Wii Fit training due to the small number of participants (*n* = 3). Also, the use of parametric statistics on a number as small as 3 is not a proper application of statistical analysis. Bieryla and Dold (2011) reported significantly improved BBS test scores however did not report data nor statistical analysis in the conference report. Another important consideration with this study was the lack of data for inter-group comparison. The results reported were for intraparticipant improvement only. No intergroup data were given that may leave the results susceptible to internal validity threats. Bomberger (2010) used specific examples of what her intervention entailed which allows for better replication of the study than in other studies in this group. However, a small convenience sample with parametric statistical analysis and conflicting results on two commonly used balance measures (the BBS and Tinetti Balance measure) leave her results in question. Hermes and colleagues (2010) used a measure of "functional fitness" which includes metrics that are important to but not indicative of functional balance ability. The other measure, computer generated balance scores, is an accurate assessment of balance but not necessarily functional balance. Hermes et al. also used a small sample of convenience which makes generalization to the larger population difficult. Pluchino (2010), despite being a student researcher, presented perhaps the best of the unpublished studies. Her sample size (*n* = 40) was much larger than any other study and her statistical analysis was done in an appropriate fashion. Her primary limitation was a lack of observer training and any data collected to indicate interobserver agreement.

## Published Group Studies

The final group of studies to be reviewed is group studies that have been published. There are four studies in this group. All four studies were published in 2011. They included a study done by Agmon, Perry, Phelan, George, and Nguyen (2011); Bainbridge, Bevans, Keeley, and Oriel (2011); Bateni (2011); and Williams, Doherty, Bender, Mattow, and Tibbs (2011).

These studies used the Wii Fit gaming system as an intervention device to explore the effect of intervention on the functional balance of seniors. The studies varied in number of participants from seven (Agmon et al., 2011) to 22 (Williams et al., 2011). Each study used only people ages 65 and above except Bateni (2011) who included participants aged 53-91years old. However, the mean age of participants in Bateni's study was 73 years old. This study was included because of the number of participants (*n* = 18) and the mean age being above the typical 65-year-old criteria.

The intervention frequency, duration and supervision varied. All were within what would be considered a therapeutic duration although the study by Williams and colleagues (2011) only had the participant on the Wii Fit for balance a total of 10 minutes and the 10 additional minutes on the Wii Fit for aerobic activities. While this may seem to be of concern, it is important to note that the Wii Fit aerobic activities also engage balance responses. Three of four studies used a typical intensity of 3x/week but Bainbridge et al. used a 2x/week intensity. The amount of time per session varied from 20-40 minutes. Each of the studies compared preintervention scores with postintervention scores with the exception of Bateni (2011) who used three groups (physical therapy, physical therapy + Wii Fit and Wii Fit only). Finally, Agmon and colleagues (2011) used a self-reporting method for data collection where the others were direct observational research.

The type of measure used to assess functional balance was more uniform across all studies. Each researcher chose to use the BBS as a primary assessment tool. Bainbridge and colleagues (2011) additionally used the multidirection reach test and Agmon and colleagues (2011) used the 4-meter walk test as an additional measure.

The results of the four studies indicated improvement with two (Agmon et al., 2011; Williams et al., 2011) reporting significant changes in scores pre vs. post-intervention. Bateni (2011) reported significant changes, based on the MDC for the BBS, for PT, and PT+WF groups but only positive trends for the WF only group. Bainbridge et al. reported the BBS scores were "approaching significance" ($p$ = 0.066). In contrast to the previous group of unpublished research, this group all found improvement in pretest versus posttest scores for participants.

Each of the studies did have limitations although they were less glaring when compared with the single case and unpublished group study collection. Concerns about recruitment location (Bainbridge recruited from a fitness center and Bateni from a physical therapy clinic), balance of men and women participants (Williams and Bainbridge) and small sample size (all studies) leave each study suspect to threats to internal or external validity. The study performed by Bainbridge et al. (2011) also was limited by a potential ceiling effect. Four of the six participants who completed the study had initial BBS scores of 49 or greater (of a total possible score of 56). While there is not research available to indicate an exact score constituting a ceiling effect, it may be presumed that the closer to the total possible score you are, the less likely you are to make large gains. As a group, the published studies were more carefully designed and had fewer limitations than did the other two groups. All studies in this group indicated at least positive trends in functional balance in seniors as measured by a standardized balance measure even though only two claimed significant changes occurred.

The entire body of current literature investigating the effect of training on seniors using the Wii Fit regularly is sparse. There are no large, irrefutable studies that have been done to this point. However, the body of research is growing in this needed area. The studies that have been do have been carried out on a small scale and have been noted to have several limitations. While the evidence thus far is not absolutely conclusive, there are many trends noted that indicate a need for further research in this area to allow more definitive conclusions to be drawn concerning the possible effect of this low cost, motivational balance training device.

# CHAPTER III

# METHODS

## Overview

The purpose of this study was to determine to what extent training on the Wii Fit affects the functional balance and balance perception of seniors. Interview data was also collected to assess the motivational qualities and ease of use of the Wii Fit. A single subject multiple baseline design was used to answer the following two questions.

1. To what extent does three time per week training on the Wii Fit gaming system increase or decrease functional balance, as measured by the Berg Balance scale (BBS) and Timed Up and Go (TUAG) test, in community dwelling seniors aged 65 years old or older?,

2. To what extent does three time per week training on the Wii Fit gaming system increase or decrease balance confidence, as measured by the Activities-specific Balance Confidence (ABC) scale, in community dwelling seniors aged 65 years old or older? In a structured interview format, researchers also assessed how motivating and easy to use the Wii Fit game system is considered to be by these same seniors.

## Participants

Participants were selected as a convenience sample from the Logan, Utah, area. Four participants were chosen. The requirements for participation included a minimum age of 65 years with no history of a lower extremity joint replacement surgery within the past 6 months. Further, no participant had a diagnosed neurological condition which may have adversely affected their ability to understand commands or complete study related tasks. The participants were all able to ambulate at least 25 feet and transfer from sitting in a standard chair to standing without assistance. These criteria were included to meet requirements of the TUAG test, which was a part of the study's assessment. To assess level of safety and potential fall risk in participants, a single leg stance test was administered. Vellas and colleagues (1997) noted that ability to stand on one foot for less than 5 seconds increases the likelihood of falls by 2.1 times. Item 14 of the BBS is a single leg stance so these data were used to inform the researcher of the level of potential fall risk that allowed appropriate safety precautions. Finally, the complete BBS served as criteria for inclusion of the study. All participants were required to score in the low to moderate fall risk category on the initial BBS (at or above a score of 21/56). However, participants scoring above 49/56 were not included due to potential ceiling effects. This is based on research by Bainbridge and colleagues (2011), who recommended that a score of 49/56 or greater on the Berg be set as the upper limit BBS score to avoid a ceiling effect. Finally, participants who regularly used the Wii Fit game system at the time of recruitment were excluded from the study as the benefits of using the Wii Fit may have been already realized in previous use.

## Recruitment/Screening of Participants

Due to the small number of participants needed ($n = 4$), participants were sought through postings at senior activity centers and in senior classes. The researcher explained to the interested individuals the purpose, scope and potential benefits of the study, responded to questions, and had the individual sign an informed consent document indicating agreement to participation. A copy of this consent form is included as Appendix B.

The participant was assessed by a physical therapist to ensure they met the study criteria documented above. The participant then obtained a statement from their personal physician indicating he/she was sufficiently healthy to participate in the study.

## Materials

The materials used in the intervention were all commercially available and common to many households. The intervention materials included a standard television, Wii gaming system, Wii remote, Wii balance board, and the Wii Fit plus game CD.

The materials used for the assessment are also all commercially available. The required tools for the BBS are a ruler, standard chair with armrests (18-20 inches high at the seat), standard chair without armrests, footstool or step, stopwatch or wristwatch, and an area with a straight 15-foot walkway. Similar items are required for the TUAG test. They include a chair with armrests, stopwatch, distance indicator and any assistive mobility device typically used by the participant.

Additional materials necessary to ensure the safety of participants were acquired as needed. One item common to all participants was a gait belt which is placed on the participant to allow the researcher to grab and support the participant safely in the event of loss of balance. Others included canes and walkers when needed.

## Intervention

Intervention was performed by the researcher (a licensed physical therapist). The intervention was preceded by one training session which allowed each participant to familiarize themself with the operation of Wii gaming system. The study intervention was initiated upon participant report of comfort in using the Wii remote and game system. The intervention was completed with the participant three times per week for 30 minutes. The 30-minute session began with a 3- to 5-minute warm-up that consisted of exercises to engage upper and lower extremity muscles. Some participants chose to do their own warm up prior to the session so a shorter warm up was offered. Following the warm up, the participant completed a series of activities using the Wii Fit game system. The Wii Fit games can be categorized as (1) using only lower body movement to play or (2) using both lower body and upper body movement (with the Wii remote). A listing of these games is included as Appendix C. Primary movements involved weight-shifts to the front, back, and side with the lower body and movements in all planes while manipulating the Wii remote with the upper body. Individual game movements are included as part of Appendix C. Each game has a final score which is recorded if it is the “high score.” This feature can be a motivational tool to encourage participants to improve upon their previous high score.

The intervention was administered by first having the participant use only games which use lower body movement. When a participant reached the “intermediate level” on at least two lower body games, more difficult games using upper and lower body games were included in the session. During initial visits, the researcher suggested a variety of games meeting the lower body criteria. Following one week of intervention, the participant was given a choice of which games to train with; however, at least three different games were used in each session to add variety to the training session. Following the 20-minute balance intervention session, participants were led through a 3- to 5-minute cool down period to ensure appropriate cool down exercises and stretches were performed.

## Setting of Intervention

The intervention sessions were completed in the participant's home. The requirements of the intervention setting were: (a) sufficient room to ambulate 15 feet in a straight line, and (b) a space approximately 6 feet by 6 feet where participants could safely engage in balance training.

## Measures

Three measures were used during this research study. These measures included BBS, TUAG test, and the ABC scale. Qualitative data were collected via interview which assessed the ease of use as well as the motivational aspects of the Wii Fit system.

The BBS is an easily administered tool that is considered a highly effective, valid, and reliable tool that yields functional results. A copy of the BBS is included as Appendix D. Several authors report high intra- and interrater reliability as well as high validity. Newstead, Hinman, and Tomberlin (2005) reported that the interclass correlation (ICC) for intrarater test/retest reliability was 0.986 for the BBS. Conradsson and colleagues (2007) supported this result with research that showed an ICC of 0.97 for intrarater reliability. A recent review of literature completed by Langley and Mackintosh (2007) reviewed 17 functional balance scales for reliability, validity and practical application of the testing protocol. Of the 17 tests reviewed, four (including the BBS) earned a positive score in all three categories. The BBS was the focus of three studies that were reviewed as a part of Langley and Mackintosh's systematic review. The intrarater reliability ICC varied in these studies from 0.68 to 0.99. However, the interrater reliability ICC was more consistent at 0.88-0.98. In all of the above studies, the reliability of the BBS is noted as either good or excellent.

Results of studies examining the validity of the BBS have been equally favorable. A study by Muir, Berg, Chesworth, and Speechley (2008) dichotomized BBS results into those that score above 45 and those that score 45 or below. It has been a common practice to assign 45 as a "predictive cut-off score" for determining fall risk. The purpose of their research was to explore the predictive value of the BBS based on the above cut off scores. Results from this study differed from previous research for cut of scores and they indicated that dichotomizing the BBS is not a recommended practice as the predictive value may not be valid. A second measure of validity is the ability of the BBS to correlate with other balance measures. The review of literature by Langley and Mackintosh (2007) demonstrates that the BBS has moderate to excellent correlation with other balance assessment tools. Additionally, Blum and Korner-Bitensky (2008) reported that the BBS has excellent correlations with several balance measures. Langley and Mackintosh also stated, "Results indicate that the BBS is a reliable and valid test of functional balance for older community dwelling adults. The BBS is often used as a gold standard to validate other functional balance measures."

The second objective measure used in this research project is TUAG Test. A copy of the TUAG is included as Appendix E. This is a functional test focused on a person's ability to rise, walk and return to a sitting position safely. Multiple studies have been performed to assess the reliability of the TUAG. A review of 21 studies was completed by Langley and Mackintosh (2007) in which the results indicated a high level of interrater as well as intrarater reliability (ICC = 0.98-0.99 and ICC = 0.97-0.98, respectively). This report indicated a moderate ICC value (0.56) in a study by Rockwood, Awalt, Carver, and MacKnight (2000) but noted that there was a significant amount of time that lapsed between first and second administration of the TUAG and possibly differing environments for the two administrations. The results of Langley and Mackintosh are supported by numerous other studies including Schoppen and colleagues (1999). The interrater and intrarater reliability in this study showed a high correlation ($r$ = .93 and $r$ = .96, respectively). This study used two administrations of the TUAG within the same day to test interrater reliability and two administrations with the same rater with an interval of two weeks to test intrarater reliability. These studies along with others published by Ries, Echternach, Nof, and Blodgett (2009) and Perell and colleagues (2001) are strong evidence of the reliability of both inter- and intrarater reliability.

The validity of the TUAG test has also been researched extensively. In their review of literature, Langley and Mackintosh (2007) reported fair to moderate correlations between the TUAG and several other balance measures including the

Clinical Test of Sensory Interaction and Balance (*r* = 0.44), Tinetti Performance Orintated Mobility Assessment (*r* = 0.55), and the Multi-Directional Reach Test (*r* = 0.26-0.52). Bennie and colleagues (2003) also reported moderate, but significant correlation between the TUAG and the BBS (*r* = 0.47, *p* = 0.04) and a moderate but significant correlation between the TUAG and the Functional Reach test (*r* = 0.56, *p* = 0.04). Other studies including Schoppen and colleagues (1999) also reported fair to good correlations between TUAG and other functional balance tests.

The ABC scale is a measure used to assess balance confidence/fear of falling. A copy is included as Appendix F. This test was developed in the 1990s for use with seniors. Research indicates that the test is both reliable and valid. Jorstad, Hauer, Becker, and Lamb (2005) reported that the test-retest reliability of the ABC is *r* = 0.95 while the internal consistency is reported as 0.96 using the Cronbach α. The author also noted that in comparison with 23 total measures of fear of falling included in the systematic review, the ABC scale scored the highest for validity (noted to have "adequate" research support) and near the top for reliability ("good to adequate" research support). While there are several potential measurement tools that could be used, results of a study by Powell and Myers (1995) indicate that the ABC scales is an appropriate selection. They state that the ABC scale is "more suitable to detect loss of balancing confidence in more highly functioning seniors" (when compared with the Falls Efficacy Scale). Because of the "active" population that is the focus of the current study, the ABC was identified as the measurement of choice.

The final assessment administered was a semi-structured interview (Appendix G).

This was used to gather data to inform researchers as to the motivational and ease of use qualities of the Wii Fit gaming system for community dwelling seniors. This was completed at the final assessment following the two-week maintenance phase.

## Interrater Reliability

All assessments used in this research with the exception of the interview have been rigorously reviewed for validity and reliability. Statistical documentation is found above in the measures section.

The primary assessor for each assessment tool was a physical therapist with over 15 years of experience in working with seniors and administering both the BBS and TUAG assessment protocols. The second assessor was a fitness instructor with over 10 years of experience in teaching senior fitness classes.

Initial training was performed using the BBS and TUAG protocols. The five persons performing the tasks during training were members of the assessors' families. Each person was over the age of 65 and was asked to do their best on the tasks. The instructions were given in each case by the physical therapist. Both assessors scored the performance and after completion of the assessments the written scores were compared. The method of assessing agreement between raters was the "total agreement" model as described in Kennedy (2005). This total agreement percentage score is found using the following formula:

*Smaller score / Larger score x 100% = percentage agreement*

This score was then assessed to assure it met the previously set minimum criteria of 80% agreement.

Interrater reliability data was taken during the course of the study on every third assessment (33.3% of the assessments). Kennedy (2005) indicated that 20% is the minimum but 33% is preferable. Kennedy also noted that an interrater agreement level of 80% is considered acceptable.

## Design

Effects of balance training using the Wii gaming system was evaluated using a multiple baseline single subject design. The purpose of single subject design is to document causal, or functional, relationships between independent and dependent variables (Horner, Carr, & Halle, 2005). Horner and colleagues reported "Single-subject research designs provide experimental control for most threats to internal validity…" (p. 168). The primary reason for use of single subject design is that the requirement that a licensed physical therapist be present during all sessions makes a group design, large enough to be robust, impractical. One reason for the choice of the multiple baseline design is that other forms of single subject research which require a reversal phase are impractical due to the nature of the skills learned during balance training. Also, ethical issues arise if an effective treatment (balance training) is suspended when continuation may provide safer living conditions for the participant.

Each participant was assessed using the BBS, TUAG, and ABC scale on initial visit. The BBS and TUAG were then assessed weekly until a stable baseline was achieved. Baseline was considered stable after three consecutive sessions with similar scores and no increasing trend. The intervention (using Wii Fit in 3 30 minute sessions per week) then began for the first participant. When visual inspection indicated an upward trend, the next participant began the intervention phase. This process continued until all participants completed the intervention phase. During this phase, assessments continued on a weekly basis on the same day of each week. All participants, whether in the baseline or intervention phase, were assessed weekly. For this study, an intervention effect was defined as consistent improvement in three or more sessions consecutively and a change from the pattern established in baseline. Following a noticeable effect, the intervention was discontinued and a final assessment completed. Maintenance data—a final BBS and TUAG assessment—on each participant was collected 2 weeks following the final intervention session. This was done to ascertain the lasting effect of the intervention.

## Analysis Methods

The three primary tests (BBS, TUAG, and ABC) were performed at preset intervals in the study. The BBS and TUAG were administered at the initial contact, each week following, and after a 2-week maintenance interval. The ABC was administered on the initial and final visit only. The qualitative interview was performed on the final visit only.

The BBS scores were evaluated using visual inspection of weekly data points to determine change. In addition, these scores were evaluated with respect to confidence intervals. Donoghue and Stokes (2009) reported that BBS scores are considered to have improved significantly when they meet the criteria presented below. This analysis is based on initial BBS scores and the degree of change indicating clinically significance differences for each initial score category. Table 1 shows the criteria.

Change for the TUAG test was demonstrated when a visual inspection of the weekly assessment data show a consistent decrease in time needed to complete the test. While the TUAG scores are important and have been shown to correlate with the BBS scores, the BBS scores will be used to determine an intervention effect if there is conflicting data. This is due to research indicating that the BBS is found to be valid and reliable more consistently than the TUAG.

Visual inspection was also applied to analysis of the ABC scale. Due to the minimal number of data points (two), visual inspection was used in place of *t* test or other parametric statistics because of the low number of participants ($n = 4$). This visual inspection does not allow conclusions to be drawn as to the statistical significance of any change present but does give information on trends related to balance confidence/fear of falling.

Finally, a short interview to assess the motivational qualities and ease of use of the Wii Fit game system was given at the final visit. This assessment was designed to

Table 1

*BBS Score Change Needed for Clinical Significance*

| Initial BBS Score | 0-24 | 25-34 | 35-44 | 45-56 |
|---|---|---|---|---|
| Point change needed to be 95% confident change occurred | 5 | 7 | 5 | 4 |

inform the author regarding possible future research using the Wii Fit game system in the home. If interview results indicate that the Wii Fit is motivational, future research may be pursued using the system to improve home exercise compliance.

# CHAPTER IV

# RESULTS

## Participants

Four individuals participated in this single subject study. All study participants were over the age of 65 with a mean age of 76.75 years old. The four participants consisted of two male (mean age = 80) and two female (mean age = 73.5). All participants identified themselves as Caucasian and all were retired. The living situation of the participants varied as did their marital status. Table 2 provides important demographic information.

## Interrater Reliability

Interrater reliability data was taken during this study at regular intervals of at least 30% of sessions and total agreement score of 80% was considered acceptable. Prior to beginning, interrater reliability data was taken. Data were collected during the course of

Table 2

*Participant Demographic Information*

| Participant number | Age | Gender | Marital status | Ethnicity | Educational level | Medical history | Living situation | Activity level |
|---|---|---|---|---|---|---|---|---|
| 1 | 72 | F | S | Caucasian | Some college | CVA x 1 year | Alone | In-home exercise only |
| 2 | 77 | M | S | Caucasian | Post bachelor | none | With relative | Frequent outdoor activity |
| 3 | 75 | F | M | Caucasian | bachelor degree | none | With spouse | 3-5x/week outdoor walking |
| 4 | 83 | M | M | Caucasian | Some college | none | With spouse/child | Occasional home exercise |

five rater training sessions for the BBS and TUAG (see Table 3). As part of the study, interrater reliability data were taken during the baseline and intervention phases for each participant (see Table 4). A full listing of rater reliability data is included as Appendix H.

In addition to total agreement, which documents overall agreement of total scores, point by point analysis was done on the BBS. This method takes into account not just agreement on the aggregate score, but individual test item agreement. Two methods of point-by-point agreement were explored. The first was to look at interobserver agreement

Table 3

*Interrater Reliability*

| | Berg Balance Scale | | | Timed Up and Go | | |
|---|---|---|---|---|---|---|
| Training session | Rater #1 | Rater #2 | Total agreement (%) | Rater #1 | Rater #2 | Total agreement (%) |
| 1 | 48 | 45 | 93.75 | 8.74 | 8.13 | 93.02 |
| 2 | 36 | 38 | 94.74 | 9.96 | 10.45 | 95.31 |
| 3 | 31 | 35 | 88.57 | 13.27 | 12.86 | 96.91 |
| 4 | 49 | 50 | 98.00 | 7.68 | 7.45 | 97.01 |
| 5 | 52 | 54 | 96.30 | 7.12 | 6.79 | 95.37 |

Table 4

*Total Agreement Across Participants*

| Participant # | Mean total agreement BBs (%) | Mean total agreement TUAG (%) |
|---|---|---|
| 1 | 95.97 | 98.27 |
| 2 | 97.27 | 96.46 |
| 3 | 97.57 | 95.67 |
| 4 | 96.84 | 97.76 |

on a participant by participant basis. Each participant was assessed by two observers every third assessment and scoring was documented. For example, participant #1 was assessed by both observers three times during the course of eight total assessments. The total number of interobserver assessments was based on the total number overall assessments. The BBS has 14 test items so in the case of participant #1, there were 42 potential test items to be compared (14 items x 3 assessments = 42 opportunities for agreement). Table 5 notes the interobserver agreement percentage for each participant based on the following formula for point by point agreement which is found in Kennedy (2005): A/(A+D) x 100% where A = agreements and D = disagreements. The range of interrater agreement in this point by point analysis was 80.36% - 88.10% and the mean was 85.27%.

The second method of point by point interobserver agreement analysis was done by analyzing agreement across participants on each individual item. The same formula was used to find percentage of agreement. Because of the size of the table required to report this data, it is found in Appendix I. The range of interobserver agreement in this point by point analysis was 61.11% - 100% and the mean was 85.32%.

Table 5

*Point-By-Point Agreement for Each Participant Across BBS Test Items*

| Participant # | Agreements | Agree + disagree | Calculation | % agreement |
|---|---|---|---|---|
| 1 | 37 | 42 | 37/42 x 100% | 88.1 |
| 2 | 45 | 56 | 45/56 x 100% | 80.4 |
| 3 | 60 | 70 | 60/70 x 100% | 85.7 |
| 4 | 73 | 84 | 73/84 x 100% | 86.9 |

## Research Questions

The first research question explored was, “To what extent does three times per week training on the Wii Fit gaming system increase or decrease functional balance, as measured by the Berg Balance Scale (BBS) and Timed Up and Go (TUAG) test, in community dwelling seniors aged 65 years old or older.” A multiple baseline approach was used to assess significance of research findings. As seen in Figures 1 and 2, all participants were found to have significant improvement on BBS (increased) and TUAG (decreased) scores. These changes varied in intensity of improvements but each demonstrated a consistent baseline followed by improvement on initiation of intervention.

Participant 1 demonstrated a stable baseline for three assessment sessions followed by a dramatic increase in BBS and decrease in TUAG scores when the intervention was introduced. Experimental control is demonstrated by this changing trend in scores recorded by participant one. Scores went from a stable baseline to an increasing trend on BBS and decreasing trend on TUAG scores during the intervention phase. It should be noted that during participant one’s intervention phase, each of the other participants continued in baseline phase with no significant change in trends for their scores.

Participant 2 had results similar to participant one but the changes were not as dramatic. Following a stable baseline, scores on the BBS increased and on the TUAG times recorded decreased for participant two. These changes in trend indicate a second time that the Wii Fit intervention had an effect on functional balance as measured by

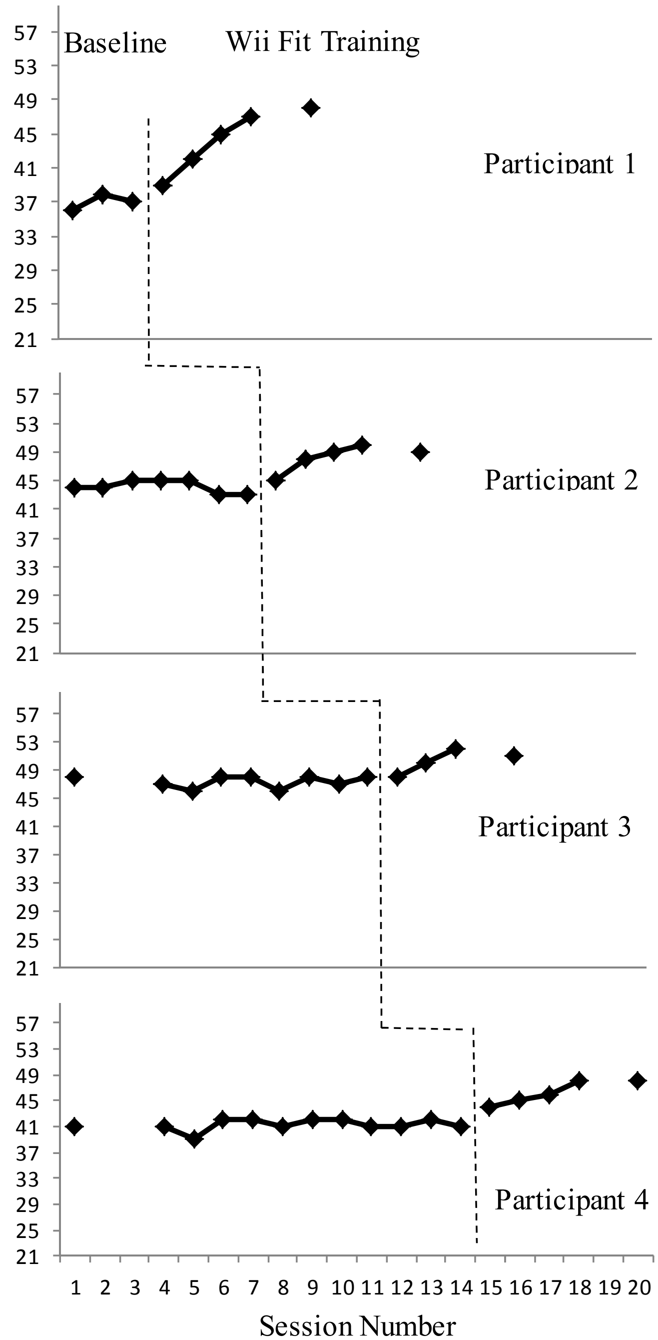


*Figure 1.* Berg Balance Scale scores.

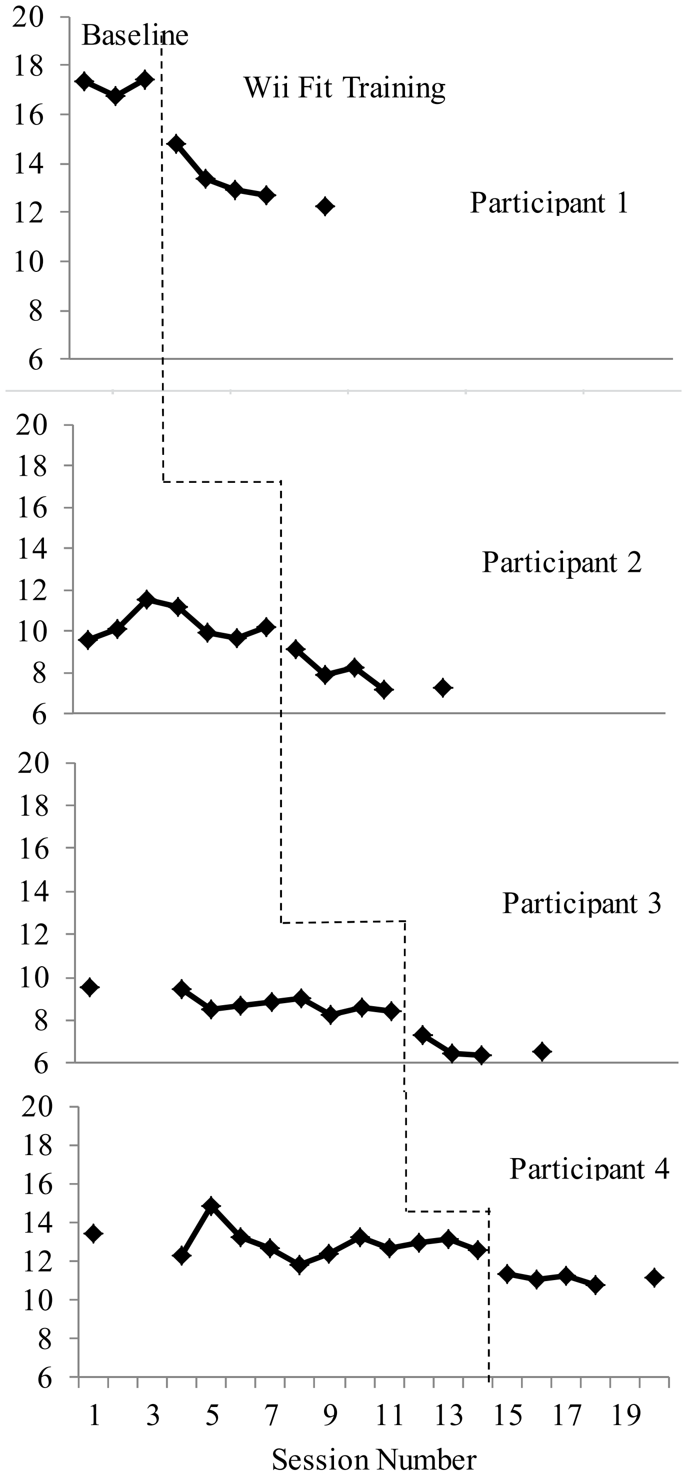


*Figure 2.* Timed Up and Go scores.

BBS and TUAG scores. Participants 3 and 4 continued in a stable baseline pattern for the entire intervention phase with Participant 2.

Participants 3 and 4 followed the pattern of the two previous participants by maintaining stable baselines followed by changing trends in both BBS (increasing) and TUAG (decreasing) scores. Participant 4 was similar to participant one in that the change in BBS scores was more dramatic than either Participant 2 or 3. However, all four participants followed the trend of stable baseline followed by score changes as intervention was introduced. Figures 1 and 2 visually demonstrate the changes in BBS (Figure 1) and TUAG (Figure 2) scores.

In addition to the results shown in the above graphs, research done by Donoghue and Stokes (2009) indicated that changes in the BBS scores were significant if they fall within the parameters shown in the methods section of this text. Based on this research, every participant demonstrated a significant change on the BBS assessment (see Table 6).

The second research question was, “To what extent does three times per week training on the Wii Fit gaming system increase or decrease the fear of falling, as measured by the ABC scale, in community dwelling seniors aged 65 years old or older”?

Table 6

*Level of Significance of Change*

| Participant # | Initial BBS score | Change needed for significance | Actual BBS change |
|---|---|---|---|
| 1 | 36 | 5 | 11[a] |
| 2 | 44 | 5 | 6[a] |
| 3 | 48 | 4 | 4[a] |
| 4 | 41 | 5 | 7[a] |

[a] Level of change indicates significance according to Donoghue and Stokes (2009).

A pretest/posttest assessment was taken and visual inspection was used to assess trends. Figure 3 shows the change in ABC scores for each participant. While all participants increased in their raw score, indicating increased balance confidence, those who scored lower initially demonstrated greater gains through the course of the intervention. Due to the minimal data points and small sample, the increase in balance confidence for all participants is useful only for identifying trends (see Table 7).

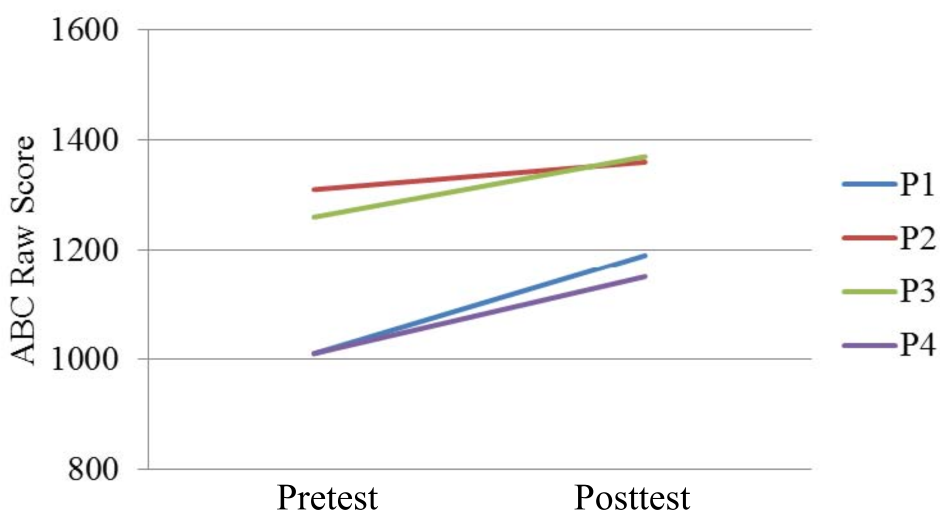


*Figure 3.* ABC raw score pretest versus posttest.

Table 7

*ABC Score Percentage Change*

| Participant | Initial ABC score | Final ABC score | Difference |
|---|---|---|---|
| 1 | 63.13% (1010/16) | 74.38% (1190/16) | 11.25%(180) |
| 2 | 81.88% (1310/16) | 85.00% (1360/16) | 3.12% (50) |
| 3 | 78.75% (1260/16) | 85.63% (1370/16) | 6.88% (110) |
| 4 | 63.13% (1010/16) | 71.88% (1150/16) | 8.75% (140) |

The third data set gathered was intended to assess the motivational qualities and ease of use of the Wii Fit gaming system. A brief informal interview was performed with each participant at the conclusion of the intervention. Following are some excerpts from the interview questions.

Question 1: What, if anything, did you find difficult about the physical operation of the Wii Fit game system?

Answer: "The only really hard part was remembering to use the white thing (Wii remote) to control the TV screen." Another participant noted, "It was pretty easy but I don't think that I would be able to set it up (initial set up of system). I don't know very much about technology." All four participants cited technology as the most difficult aspect of operation.

Question 2: What, if anything, did you find easy about the physical operation of the Wii Fit game system?

Answer: "I think it is easy to choose games once I have the screen on the games. I just have to put the finger (cursor) on the game I want and push the button." Another participant stated, "Since you wrote down the steps to turn the machine on, it is much easier to play." Yet another participant noted, "The way you can just stay on the platform and change games is a lot easier than having to go up to the TV to change games. It is like a remote control for the TV." Each participant noted different aspects of the gaming system that they felt made the system easy to operate.

Question 3: What, if anything, did you find motivating about the Wii Fit game system?

Answer: One participant said, "I like to try to get better on the bubble game each time. When I mess up I have to try again to get a better score." Another participant stated that he enjoyed trying to ski down the hill even though it, "…is nothing like real skiing because it is warm!" Three of four participants cited the desire to improve on previous scores as the most motivating aspect of their Wii Fit experience. The remaining participant noted that the opportunity to play with grandchildren motivated her.

Question 4: What, if anything, did you find least motivating about the Wii Fit game system?

Answer: The most common theme was regarding the monotony of the games. Comments such as, "I wish the ski course would change" were common. This lack of variety within the same game seemed to be the primary complaint. All four participants responded in this way.

Question 5: Which of the games that you played did you find most motivating and why?

Answer: Responses to this question varied across participants but all reported that they enjoyed the skiing game. Participant one noted that another favorite was the bubble game, participants two and three preferred the skiing game and participant four chose the penguin game as his favorite. While the choice of games for each participant was different, the motivational factor was the same. There was a desire to score better on each attempt. When asked what motivated them about the game, each participant indicated that the game was challenging not only physically but mentally as well. All participants indicated that they needed to focus acutely during participation.

Question 6: Which of the games that you played did you find least motivating and why?

Answer: As with the previous question, there was a variety of answers to which game, but the reasons that the games were not motivating were lack of change in the patterns of the games. This question required some time for participants to answer as the participants seemed to be fairly happy with the games overall.

Question 7: Would you consider continuation of training on the Wii Fit? If yes, what makes you want to continue? If not, what makes you not want to continue?

Answer: Three of the four participants expressed a desire to continue training and on follow up (2 weeks post intervention), three were still training at least "a couple times a week." The reasons given by these three were that the training helped improve balance (participant 1), made them more functional in their homes (participant 4) and allowed them to be able to engage with their grandkids because, "…grandma is cool. She plays video games with me" (Participant 3). The most consistent training post intervention came with participant one who had a stroke about a year prior to the study. She was using a cane at the time of the intervention and following the training intervention no longer needed a cane in the home. She felt that the continued training would help her be more independent. The lone participant who indicated that he wouldn't likely continue training was participant two. He regularly exercises at a local fitness facility and is active in outdoor activities. He felt that the training on the Wii Fit was fun but not as beneficial as his outdoor activities. He did note that in the winter when outdoor access is limited by weather he might "try it out again."

Question 8: What recommendations would you make to game or system developers wanting to improve the Wii Fit for seniors?

Answer: Most of the participant's responses centered on technology and monotony of some games. Participant four noted that if the system was easier to set up, there would be more seniors buying it. Participant one described the need for some sort of safety apparatus to keep seniors with poor balance from being afraid of trying it out or using it when no one else is around. As noted above, several participants noted the lack of change of course/sequence as a drawback.

# CHAPTER V

# DISCUSSION

## Primary Results

Balance has been identified as a major threat to seniors in this country. Authors report that more than one in three seniors will fall (Hausdorff et al., 2001) with an even higher incidence in those with secondary conditions (Finkelstein et al., 2007). Because of barriers such as availability, cost, and motivation, accessibility of balance training is limited. This study indicated significant improvement in functional balance for community dwelling seniors after training on the Wii Fit gaming system three times a week for 30 minutes each session. The participants all showed improvement in scores on measures that assess balance including the BBS and TUAG. Further, participant's scores on the ABC scale improved indicating increased balance confidence and a decreased fear of falling. Finally, participants had many comments during a semi-structured interview which indicated a positive experience in using the Wii Fit. This novel techniques shows promise in improving accessibility of effective balance training.

The primary research focus of this study was to assess the effect of training on the Wii Fit gaming system on functional balance in community dwelling seniors. Using the BBS and TUAG, each of the participant's initial scores on the BBS scores fell within the medium to low fall risk categories (0-20 = high risk, 21-40 = medium risk, 41-56 = low fall risk). Following training, each of the participant's BBS and TUAG scores improved significantly although the rate and magnitude of change varied among the participants.

Participant 1 demonstrated the largest gain in BBS score (11 points) while Participant 2 gained only 6 points in the same amount of time (4 weeks).This difference in rate and magnitude of improvement may be affected by a ceiling effect. Bainbridge and colleagues (2011) noted that a ceiling effect may be present as participants get nearer the 56-point limit. The ceiling effect, which may have been present in both Participant 2 and 3, would lead to an underestimation of actual improvement in these participants. Participant 1 had an initial score of 36/56 while Participant 2 began at 44/56. Figure 1 indicates the improvement made and rate by each participant. BBS scores were also assessed for significance using the research findings of Donoghue and Stokes (2009). Each of the participants improved by a sufficient amount to indicate significant change based on Donoghue and Stokes research. Similar results were noted when using the TUAG test to assess functional balance. The results from these two tests indicate that improvement in functional balance can be achieved following training on this accessible training system that can be used in one's own home.

While all of the participants demonstrated improvement in both the BBS and TUAG, there were three that warrant further explanation. First, Participant 2 showed an increase in his TUAG time on his third assessment in the intervention phase. This was a 0.36 second increase in his time. While his BBS score still improved for that evaluation, an additional week was added to intervention to ensure that the increase in time was an anomaly and not a trend. The following assessment indicated a 1.06 second drop in his TUAG time in reference to the previous week and a 0.70 second drop from the assessment two weeks previous. A second explanation is needed with Participant 4 and his lack of noticeable improvement in his TUAG time during the intervention phase. His TUAG time only decreased from 11.34 to 10.75 which was just over half a second. However, his score from the final baseline assessment to the final intervention assessment decreased by nearly two seconds. Close visual inspection of Figure 2 reveals that there was a large decrease in TUAG time during the interval between the last baseline and first intervention session assessment. The third issue needing discussion involves both the BBS and TUAG scores during the maintenance phase assessment. In each case, excepting Participant 1, the BBS score decreased or stayed the same and the TUAG time increased. During the final assessment and interview session, only three of the participants had continued using the Wii Fit system and of the three, only one (Participant 1) had continued at the three times per week or more rate of use. The others had only performed the Wii Fit exercises, “a couple of times a week.” This may explain some of the decreased performance on follow up in Participants 2, 3, and 4.

## Secondary Results

In addition to the primary purposes of the research, some secondary purposes were identified including assessment of balance confidence and general attitudes toward using the Wii Fit gaming system. These were deemed secondary due to the method of data collection. The ABAC assessment was only administered twice during the study. These times were on initial assessment and final assessment following maintenance phase. Because of the limited number of assessments completed, data from the ABC scales was used only to identify trends. The semistructured interview was included to identify what participants liked or disliked about the Wii Fit gaming system as well as whether this type of training was motivational.

The ABC scale is a highly regarded and researched tool used to assess balance confidence and fear of falling (Jorstad et al., 2005; Powell & Myers, 1995). The results in this study indicate that all participants improved in balance confidence over the course of the study. The infrequent administration of the test does not allow inference of significance but the results indicate that there is at least a trend of increased confidence/decreased fear of falling among community dwelling seniors who engage in regular training on the Wii Fit gaming system. The level of improvement on the ABC scales varied from 3.12% to 11.25%. Interestingly, the participant who was most physically active (Participant 2) was also the one who reported the least improvement on the ABC scales. Further, the least physically active participant (Participant 1) was the participant who reported the largest increase in score on the ABC Scales. Also, change in the scores on the ABC scales are fairly closely related to changes in the BBS and TUAG scores. Figure 4 demonstrates the comparison between BBS scores and ABC scores. This figure indicates that in all cases, excepting participant 3, the increase in balance confidence was similar to the improvement in functional balance as measured by the BBS. Also, the level of increase on each measure appeared to be related to the initial score on the BBS or ABC. Participant one, who started with the lowest scores on both the BBS and ABC showed the largest percentage increase on both tests. Participant 2 (highest initial ABC score) and Participant 3 (highest initial BBS score) showed the smallest gains on the ABC and BBS, respectively. This may indicate that the intervention

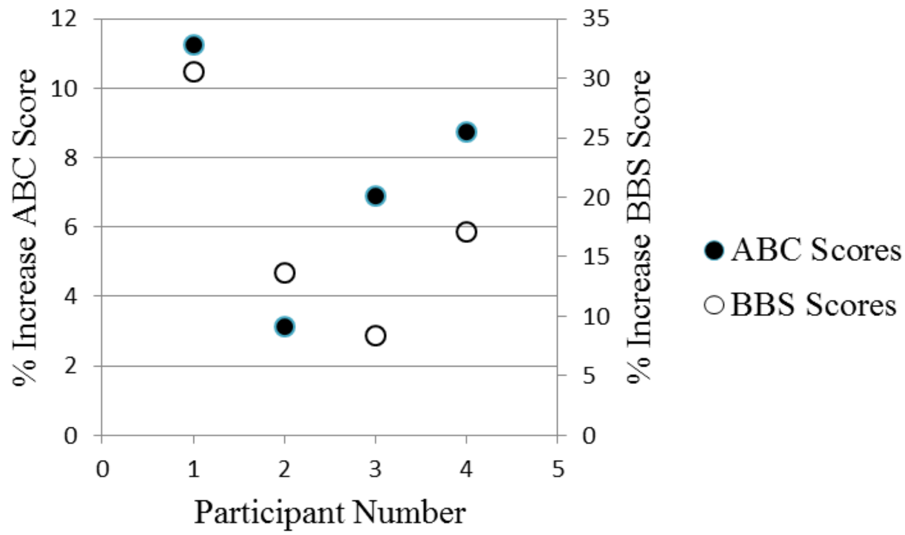


*Figure 4*. BBS and ABC score comparison.

performed is most effective for increasing the functional balance and balance confidence in people with medium risk of falls.

Finally, results from the semistructured interview revealed a generally positive attitude toward the Wii Fit gaming system as well as a positive attitude regarding the motivational qualities of the system. Technology seemed to consistently be one of the barriers to use of the system. Many would expect seniors to be less technologically savvy which was indicated by many of their remarks. They felt that initial set up was difficult but that operation of the system was easy once they learned the steps. Another concern voiced by all of the participants was that the games were mundane. They reported that the games should change routine in order to be more motivating. One example was a comment from participant who enjoyed the skiing game. He indicated that if there was a change in the course he “skied” he would enjoy it more. Generally, the participants felt that variety of games was limited. Three of the four participants did report that they planned on continuing use of the Wii Fit gaming system even after the research study was done. The one participant who did not plan on continuing on the system is a participant who is active in the outdoors and prefers outdoor activity to indoor training. He did say that during the winter when it got cold that he would consider using the system again as an alternative method to be physically active.

## Anecdotal Findings

In addition to the primary and secondary findings reported, several anecdotal findings were gathered during the course of the study. One interesting finding was that participants seemed to enjoy one or two particular games above the others. These games were different in almost every case. Skiing was popular with all participants but each participant also had at least one other “favorite” game. A second observation was that the participants were intensely competitive with themselves. While no participant had any knowledge of others who used the Wii Fit gaming system, it was common for participants to want to continue playing beyond the 30-minute session to “get a better score.” This competitive spirit was not anticipated during the formulation of this research project but definitely is an interesting byproduct of this study. This competitive nature in all four participants indicates that there may be an opportunity to use this as a method of motivation in future research.

## Future Research Directions

Results from this study lead to several potential future research directions. Further research to expand on the current study is warranted owing largely to the limited scope of the current study. While results were clear, a larger more comprehensive study may be more easily generalized to the population at large. The current study was done with primarily active seniors.

Another line of research would be in the area or looking at seniors with specific challenges such as neurological disorders, heart disease, neuropathy, recent joint replacement or loss of limb. The list is endless as one explores the many maladies that accompany advancing age. This may reveal some of the questions left unanswered regarding the effect of this balance training system with seniors who have secondary conditions.

A third area that may be explored is the use of the Wii Fit gaming device in different settings. These may include clinical settings, senior centers, cardiac rehabilitation or stroke rehabilitation. One of the purposes of the current study was to identify the effect in the home setting as that is the most accessible. However, use in any of the aforementioned settings may reveal an additional modality in combatting the infirmities of age.

Finally, research is needed on the effect of Wii Fit training in different age categories of people including the very frail as well as the more healthy older population. Prior research on strength training in frail elderly women has shown that strength can be improved even into the eighth and ninth decade of life (Yarasheski et al., 1999). Studies that explore the effect of balance training using the Wii Fit in this older demographic would be helpful in improving the knowledge base for helping the most frail in society.

## Limitations

While the results of this study are promising, there are limitations that affect the breadth of the effect. One limitation to this study is the length of intervention used with the chosen design. Typical single-subject designs are shorter in length; however, balance is a complex skill and requires an extended duration to show improvement. Further, typical single subject design studies record one or more data points per session where the current study documented only one data point per week (every three sessions). This was also because of the lack of immediate improvement shown with balance interventions. Most current research studies using the Wii Fit indicate several weeks to months before improvements in balance are measureable. An additional limitation is the use of a convenience sample. However, due to the limited scope of this project, the author concluded that a convenience sample was the only feasible choice. Finally, use of visual inspection for the ABC scale is not ideal due to the limited data points (one before baseline and one postintervention); however, parametric statistics are not feasible due to the small participant pool ($n = 4$). The visual inspection of so few data points did not allow credible statements on significance of change but did allow trends to be identified. The limitations noted have been assessed, and while present, study design, measurement choice and investigator training have been carefully considered to eliminate as much error as possible.

## Conclusions

The results of this study indicate that training consistently on the Wii Fit gaming system is beneficial in improving the functional balance in seniors, and potentially beneficial for decreasing a fear of falling and motivating seniors to activity. Based on these results, a regiment of training three times per week for 30 minutes on the Wii Fit gaming system may be considered as an effective way to improve functional balance in community dwelling seniors. These seniors reported that the system was motivational and generally easy to use but the repetitive and sometimes mundane nature of some of the games did cause concern in the participants. However, three of the four participants reported that they would continue to use the Wii Fit gaming system even after the research was done because in spite of the drawbacks noted, the benefits of improved balance were valuable to the participants. Even the fourth participant did indicate that he would use the system when the weather did not permit outdoor activity.

These findings support previous findings that indicate that computerized balance training is an effective modality for improving balance in seniors (Sihvonen, Sipila, & Era, 2004). The results of this study add to an expanding body of research on accessible balance training methods by demonstrating that a home-based, motivational, and inexpensive system can be used to improve the functional balance in community dwelling seniors. This finding has the potential to affect many seniors who have previously been unable to access balance training services.

The primary results from this study indicate significant improvement in functional balance in all participants when trained on the Wii Fit gaming system. Further, secondary results show trends which indicate that training can decrease fear of falling and increase balance confidence using a system that is considered generally motivating and easy to use. Additionally, anecdotal findings indicate that seniors enjoyed this training and are self-competitive which may drive them to be actively engaged in activities that may improve functional balance.

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# APPENDICES

# Appendix A

## Literature Review Summary Table

Table A1

*Literature Review Summary*

| Author | Year and type of publication | Number of participants | Interventions used | Functional balance measures/ assessments use | Results |
|---|---|---|---|---|---|
| Agmon et al. | 2011 Abstract only | 7 participants | Home based WF only with weekly calls. Asked to do 30 min, 3x/wk for 3 months. Self-report log for data collection | BBS, 4-meter timed walk test | Significant improvement in both measures. BBS mean score from 49-53 ($p$ = 0.017). 4-meter timed walk test with $p$ = 0.018. |
| Allen | 2009 Master's Thesis | 3 female participants | 20 min, 3x/wk for 8 wks., WF only | BBS | BBS results not significant ($p$ = 0.549) |
| Bainbridge et al. | 2011 | 8 participants | 30 min, 2x/wk for 6 wks., WF only | BBS, MDRT | BBS "approaching significance" ($p$= 0.066). One participant reached MDC threshold. 4 of 6 improved BBS score. MDRT not sig. |
| Bateni | 2011 | 18 participants age 53-9[a] | 3x/wk for 4 wks. Session time not noted. PT, PT+WF and WF only groups | BBS | Non-significant scores for WF only group. Other two groups met MDC for BBS. Positive trend for WF only group. |
| Bieryla & Dold | 2011 Conference Presentation | 11 total ($n$ = 5 exp, $n$ = 6 ctrl groups) | 30 min, 3x/wk for 3 wks; WF only for exp group | BBS, TUAG, FR | Significant improvement on BBS, non-significant for TUAG and FR (intrasubject); no diff between groups |
| Bomberger | 2010 Senior Thesis | 14 participants (no impair. $n$ = 7, mild/mod impair. $n$ = 7) | 20 min, 3x/wk for 4 wks (no impair grp);20 min, 3x/wk for 6 wks (mild/mod impair grp), WF only | BBS, Tinetti Balance score | Significant improvement in: no impair grp (BBS $p$ = 0.009, Tinetti total $p$ = 0.01, Tinetti gait $p$ = 0.02); mild/mod impair (BBS item #14(SLS) $p$ = 0.038, Tinetti $p$ =0.02) |
| Gardner | 2011Master's Thesis | Single subject design | Three phases (A-B-A-C-A-D-A reversal); phase one was walk (60 min) and WF (60 min) 5x/wk for 2 mos.; phase 2 was WF only 60 min, 5x/wk for 3 wks., phase three was walk only 60 min, 5x/wk for 3 wks | TUAG, FSST | FSST scores improved significantly ($p$ = 0.048). TUAG not significant pre to posttest, but pretest to end of phase 2 was significant. |
| Hermes et al. | 2010 Conference Presentation | 12 participants ($n$ = 4 each group); all female | 40 min, 2x/wk for 8 wks; WF only, trad phys. act, ctrl groups | No specific functional test. Measured "funct. Fitness" and CGB scores[b] | Funct. fitness defined as strength, CR endur. and flexibility. Trad. activity showed large gains, WF little change. CGB scores comparable on WF and Trad groups |
| Pigford & Andrews | 2010 | Single case study | 60 min, 5x/wk for 2 wks, WF+PT | BBS, TUAG, gait speed | BBS and TUAG met MDC, gait speed did not meet MDC but was improved |

(*table continues*)

| Author | Year and type of publication | Number of participants | Interventions used | Functional balance measures/ assessments use | Results |
|---|---|---|---|---|---|
| Pluchino | 2010 Dissertation | 40 participants (3 grps: Trad bal ex, Tai Chi, WF | 60 min, 2x/wk for 8 wks. (part exercised in supervised lab setting), trad., Tai Chi, & WF groups | TUAG, SLS, FR, POMA | No significant changes time or time x group interactions noted. Each treatment is equal in affecting balance. |
| Sugarman et al. | 2009—Conference Presentation | Single case study | 45 min. for 4 consecutive days of PT + WF | BBS, TUAG, FR, LR | Functional balance can be affected by PT + WF |
| Williams et al. | 2011 | 22 participants | 10 min WF balance &10 min WF aerobic, 3x/wk for 4 wks. | BBS | Significant improvement at $p < 0.01$ for pre vs. post BBS assessments |

*Note.* BBS = Berg Balance Scale; TUAG = Timed UP and Go test; FR = Functional Reach test; LR = Lateral Reach test; MDRT = Multi-Directional Reach Test; FSST = Four square step test; POMA=Tinetti Performance Oriented Mobility Assessment

[a]Typically older adults are considered to be 65 years-old or older, but because a number of participants in this group were older than 65 and due to the lack of available research, this study was included. Group mean age was 73 years old.

[b]While the measures in this study are not functional balance scores, it was included to show that the Wii Fit may not be effective in traditional measures of fitness but may be effective in balance improvement (as noted by no change in functional fitness and positive change in CGB scores.)

# Appendix B

## Informed Consent

# Informed Consent

**Introduction/ Purpose** Dr. Judith Holt in the Department of Special Education at Utah State University is conducting a research study to find out more about the effect of balance training in active seniors regularly using the Wii Fit gaming system. You have been asked to take part because meet the inclusion criteria. There will be up to six participants in this study. Curtis Phillips, physical therapist and doctoral student, will be assisting with this research project.

**Funding** No external funding will be used in this research project.

**Procedures** If you agree to be in this research study, you will be expected to continue with your current daily activities in addition to a research intervention involving three 30 minute balance training sessions each week using the Wii Fit game system. Each session will be in your home and be supervised by a licensed physical therapist with over 15 years' experience working with seniors. During each session, you will be asked to participate in balance training "games" using a balance force-plate. All materials for the study will be provided by the researcher. You will also have a five minute warm up and cool down supervised by the physical therapist. You will be expected to complete the research project, the duration of which will depend on progress made on balance assessments. The projected duration of active participation of the study is 3-6 weeks with weekly assessments for up to 16 weeks. You will be required to participate in two different balance tests while performing basic movements, an assessment of you fear of falling, a short survey and a brief interview that will be voice recorded. Your balance will be re-assessed each week during the duration of the study. For the safety of the participant, a signed note from your doctor will be necessary to ensure your health is sufficient to participate in the study. The only information needed from the doctor is whether your doctor feels that you can safely participate in the study.

**Alternative Procedures** Instead of participating in this research, an alternative for you to consider would be to seek out physical therapy or other research based treatment that is recommended by your physician.

**Risks** Participation in this research study may involve some added risks or discomforts. These include the possibility of injury during physical activity. However, measures will be taken to minimize the risk of a fall or other injury. As stated, all sessions will be supervised by a licensed physical therapist. Secondly, the participant will be wearing a safety belt during all phases of the research session to decrease the risk of injury.

**Research-Related Injuries** While the likelihood of injury is low, it is important that the participant understand that there is no explicit or implied responsibility on the part of the researcher for medical payment above that which is covered by the researcher's professional liability insurance.

**Benefits** The benefits of participation in this study include free balance training by a physical therapist, increased knowledge regarding the proper rehabilitation activities done to improve balance and assessments that identify areas of potential balance deficiencies in the participant. In addition to these benefits, the proposed study intervention, if successful, will improve the participant's balance and decrease the risk of falling and injury. At the conclusion of the study, you will be offered a Wii Fit balance training system for your continued use at no cost to you.

**Explanation & offer to answer questions** Curtis Phillips has explained this research study to you and answered your questions. If you have other questions or research-related problems, you may reach (PI) Judith Holt at (435) 797-7157 or Curt Phillips at (435) 797-7681.

**Extra Cost(s)** There will be no cost to the participant for this research.

**Voluntary nature of participation and right to withdraw without consequence** Participation in research is entirely voluntary. You may refuse to participate or withdraw at any time without consequence. You may be withdrawn from this study without your consent by the investigator based on health, injury or lack of consistent participation.

**Confidentiality** Research records will be kept confidential, consistent with federal and state regulations. Only the investigators will have access to the data which will be kept in a locked file cabinet or on a password protected computer in a locked room. To protect your privacy, personal, identifiable information will be removed from study documents and replaced with a study identifier. Identifying information will be stored separately from data and will be kept for a maximum of one year following the conclusion of the study after which it will be destroyed. Voice recordings will be transcribed within one week of interview and then deleted.

**IRB Approval Statement** The Institutional Review Board for the protection of human participants at Utah State University has approved this research study. If you have any questions or concerns about your rights or a research-related injury and would like to contact someone other than the research team, you may contact the IRB Administrator at (435) 797-0567 or email irb@usu.edu to obtain information or to offer input.

**Copy of consent** You have been given two copies of this Informed Consent. Please sign both copies and keep one copy for your files.

**Investigator Statement** "I certify that the research study has been explained to the individual, by me or my research staff, and that the individual understands the nature and purpose, the possible risks and benefits associated with taking part in this research study. Any questions that have been raised have been answered."

**Signature of Researcher(s)**

| | |
|---|---|
| ______________________________ | ______________________________ |
| *Judith M. Holt* | *Curtis Phillips* |
| Principal Investigator | Co-Principal Investigator |
| *(435)797-7157* | *(435)797-7681* |
| *judith.holt@usu.edu* | *curt@cpd2.usu.edu* |

**Signature of Participant** By signing below, I agree to participate.

| | |
|---|---|
| ______________________________ | ______________________________ |
| Participant's signature | Date |

Appendix C

List of Potential Wii Fit Games by Category

Table C1

*List of Potential Wii Fit Games by Category*

| Lower body only games | Upper and lower body games |
|---|---|
| Soccer Heading (LS) | Birds Eye Bulls-eye (LS, FB) |
| Ski Slalom (LS, FB) | Tilt City (LS, FB) |
| Tightrope Walk (LS, FB) | Snowball Fight (LS) |
| Segway Circuit (LS, FB) | Big Top Juggling (LS, FB) |
| Balance Bubble (LS, FB) | |
| Perfect 10 (LS, FB) | |
| Hula Hoop (LS, FB) | |
| Table Tilt (LS, FB) | |
| Penguin Slide (LS) | |

LB = Lower Body
UB = Upper Body
LS = Lateral Weight Shift
FB = Forward and Backward Weight Shift

# Appendix D

## Berg Balance Scale

# BERG BALANCE SCALE

The Berg Balance Scale (BBS) was developed to measure balance among older people with impairment in balance function by assessing the performance of functional tasks. It is a valid instrument used for evaluation of the effectiveness of interventions and for quantitative descriptions of function in clinical practice and research. The BBS has been evaluated in several reliability studies. A recent study of the BBS, which was completed in Finland, indicates that a change of eight (8) BBS points is required to reveal a genuine change in function between two assessments among older people who are dependent in ADL and living in residential care facilities (Conradsson et al., 2007).

**Description:**
14-item scale designed to measure balance of the older adult in a clinical setting.
Equipment needed: Ruler, two standard chairs (one with arm rests, one without), footstool or step, stopwatch or wristwatch, 15 ft. walkway

**Completion:**
Time: 15-20 minutes

**Scoring:**
A five-point scale, ranging from 0-4. “0” indicates the lowest level of function and “4” the highest level of function.
Total Score = 56

**Interpretation:**
41-56 = low fall risk
21-40 = medium fall risk
0 –20 = high fall risk
*****A change of 8 points is required to reveal a genuine change in function between 2 assessments.*****

*Berg Balance Scale*

Name: ________________________________ Date: __________________

Location: ______________________________ Rater: __________________

ITEM DESCRIPTION SCORE (0-4)
Sitting to standing ________
Standing unsupported ________
Sitting unsupported ________
Standing to sitting ________
Transfers ________
Standing with eyes closed ________
Standing with feet together ________
Reaching forward with outstretched arm ________
Retrieving object from floor ________
Turning to look behind ________
Turning 360 degrees ________
Placing alternate foot on stool ________
Standing with one foot in front ________
Standing on one foot ________
Total ________

**GENERAL INSTRUCTIONS**
Please document each task and/or give instructions as written. When scoring, please record the lowest response category that applies for each item.
In most items, the subject is asked to maintain a given position for a specific time.

Progressively more points are deducted if:
• the time or distance requirements are not met
• the subject's performance warrants supervision
• the subject touches an external support or receives assistance from the examiner

Subject should understand that they must maintain their balance while attempting the tasks. The choices of which leg to stand on or how far to reach are left to the subject. Poor judgment will adversely influence the performance and the scoring.
Equipment required for testing is a stopwatch or watch with a second hand, and a ruler or other indicator of 2, 5, and 10 inches. Chairs used during testing should be a reasonable height. Either a step or a stool of average step height may be used for item # 12.

**Berg Balance Scale**

SITTING TO STANDING
INSTRUCTIONS: Please stand up. Try not to use your hand for support.
( ) 4 able to stand without using hands and stabilize independently
( ) 3 able to stand independently using hands
( ) 2 able to stand using hands after several tries *(two or more tries)*
( ) 1 needs minimal aid to stand or stabilize *(25% - 50% assist)*
( ) 0 needs moderate or maximal assist to stand *(50% or more assist)*

STANDING UNSUPPORTED
INSTRUCTIONS: Please stand for two minutes without holding on.
( ) 4 able to stand safely for 2 minutes
( ) 3 able to stand 2 minutes with supervision
( ) 2 able to stand 30 seconds unsupported
( ) 1 needs several tries to stand 30 seconds unsupported *(two or more tries)*
( ) 0 unable to stand 30 seconds unsupported
If a subject is able to stand 2 minutes unsupported, score full points for sitting unsupported. Proceed to item #4.

SITTING WITH BACK UNSUPPORTED BUT FEET SUPPORTED ON FLOOR OR ON A STOOL
INSTRUCTIONS: Please sit with arms folded for 2 minutes.
( ) 4 able to sit safely and securely for 2 minutes
( ) 3 able to sit 2 minutes under supervision
( ) 2 able to able to sit 30 seconds
( ) 1 able to sit 10 seconds
( ) 0 unable to sit without support 10 seconds

STANDING TO SITTING
INSTRUCTIONS: Please sit down.
( ) 4 sits safely with minimal use of hands *(finger touch or less only)*
( ) 3 controls descent by using hands *(palms in contact with arm rests)*
( ) 2 uses back of legs against chair to control descent
( ) 1 sits independently but has uncontrolled descent
( ) 0 needs assist to sit *(therapist hands contact participant for assist)*

TRANSFERS
INSTRUCTIONS: Arrange chair(s) for pivot transfer. Ask subject to transfer one way toward a seat with armrests and one way toward a seat without armrests. You may use two chairs (one with and one without armrests) or a bed and a chair.
( ) 4 able to transfer safely with minor use of hands *(finger touch only)*
( ) 3 able to transfer safely definite need of hands *(palms of hands on arm rests)*
( ) 2 able to transfer with verbal cuing and/or supervision
( ) 1 needs one person to assist
( ) 0 needs two people to assist or supervise to be safe

STANDING UNSUPPORTED WITH EYES CLOSED
INSTRUCTIONS: Please close your eyes and stand still for 10 seconds.
( ) 4 able to stand 10 seconds safely
( ) 3 able to stand 10 seconds with supervision
( ) 2 able to stand 3 seconds *(followed by need for therapist hands on for safety)*
( ) 1 unable to keep eyes closed 3 seconds but stays safely
( ) 0 needs help to keep from falling

STANDING UNSUPPORTED WITH FEET TOGETHER *(movement of feet end trial)*
INSTRUCTIONS: Place your feet together and stand without holding on.
( ) 4 able to place feet together independently and stand 1 minute safely
( ) 3 able to place feet together independently and stand 1 minute with supervision
( ) 2 able to place feet together independently but unable to hold for 30 seconds
( ) 1 needs help to attain position but able to stand 15 seconds feet together
( ) 0 needs help to attain position and unable to hold for 15 seconds

REACHING FORWARD WITH OUTSTRETCHED ARM WHILE STANDING
INSTRUCTIONS: Lift arm to 90 degrees. Stretch out your fingers and reach forward as far as you can. (Examiner places a ruler at the end of fingertips when arm is at 90 degrees. Fingers should not touch the ruler while reaching forward.) The recorded measure is the distance forward that the fingers reach while the subject is in the most forward lean position. (When possible, ask subject to use both arms when reaching to avoid rotation of the trunk.) *(step forward ends trial)*
( ) 4 can reach forward confidently 25 cm (10 inches) *or more*
( ) 3 can reach forward 12 cm (5 inches) *but less than 10 inches*
( ) 2 can reach forward 5 cm (2 inches) *but less than 5 inches*
( ) 1 reaches forward but needs supervision
( ) 0 loses balance while trying/requires external support

PICK UP OBJECT FROM THE FLOOR FROM A STANDING POSITION
INSTRUCTIONS: Pick up the shoe/slipper, which is in front of your feet.
( ) 4 able to pick up slipper safely and easily
( ) 3 able to pick up slipper but needs supervision
( ) 2 unable to pick up but reaches 2-5 cm(1-2 inches) from slipper and keeps balance independently
( ) 1 unable to pick up and needs supervision while trying
( ) 0 unable to try/needs assist to keep from losing balance or falling
TURNING TO LOOK BEHIND OVER LEFT AND RIGHT SHOULDERS WHILE STANDING
INSTRUCTIONS: Turn to look directly behind you over toward the left shoulder. Repeat to the right. (Examiner may pick an object to look at directly behind the subject to encourage a better twist turn.)
( ) 4 looks behind from both sides and weight shifts well
( ) 3 looks behind one side only other side shows less weight shift
( ) 2 turns sideways only but maintains balance
( ) 1 needs supervision when turning
( ) 0 needs assist to keep from losing balance or falling *(hands on participant to prevent fall)*

TURN 360 DEGREES
INSTRUCTIONS: Turn completely around in a full circle. Pause. Then turn a full circle in the other direction.
( ) 4 able to turn 360 degrees safely in 4 seconds or less
( ) 3 able to turn 360 degrees safely one side only 4 seconds or less
( ) 2 able to turn 360 degrees safely but slowly *(> 4 seconds)*
( ) 1 needs close supervision or verbal cuing
( ) 0 needs assistance while turning *(hands on participant to prevent fall)*

PLACE ALTERNATE FOOT ON STEP OR STOOL WHILE STANDING UNSUPPORTED
INSTRUCTIONS: Place each foot alternately on the step/stool. Continue until each foot has touched the step/stool four times.
( ) 4 able to stand independently and safely and complete 8 steps in 20 seconds
( ) 3 able to stand independently and complete 8 steps in > 20 seconds
( ) 2 able to complete 4 steps without aid with supervision
( ) 1 able to complete > 2 steps needs minimal assist *(25% to 50 support)*
( ) 0 needs assistance to keep from falling / unable to try *(therapist hands on participant)*

STANDING UNSUPPORTED ONE FOOT IN FRONT

INSTRUCTIONS: (DEMONSTRATE TO SUBJECT) Place one foot directly in front of the other. If you feel that you cannot place your foot directly in front, try to step far enough ahead that the heel of your forward foot is ahead of the toes of the other foot. (To score 3 points, the length of the step should exceed the length of the other foot and the width of the stance should approximate the subject's normal stride width.)

( ) 4 able to place foot tandem *(directly in front)* independently and hold 30 seconds

( ) 3 able to place foot ahead *(width of normal stride width)* independently and hold 30 seconds

( ) 2 able to take small step independently and hold 30 seconds *(step to side but within typical stride width)*

( ) 1 needs help to step but can hold 15 seconds *(therapist must assist balance to place foot in typical stride width then participant can hold 15 seconds)*

( ) 0 loses balance while stepping or standing

STANDING ON ONE LEG

INSTRUCTIONS: Stand on one leg as long as you can without holding on.

( ) 4 able to lift leg independently and hold > 10 seconds

( ) 3 able to lift leg independently and hold 5-10 seconds

( ) 2 able to lift leg independently and hold < 3 seconds

( ) 1 tries to lift leg unable to hold 3 seconds but remains standing *(both feet in contact with the ground)* independently.

( ) 0 unable to try or needs assist to prevent fall

**( ) TOTAL SCORE (Maximum = 56)**

Appendix E

Timed Up and Go

# TIMED UP AND GO

*Directions*

The timed "Up and Go" test measures, in seconds, the time taken by an individual to stand up from a standard arm chair (approximate seat height of 46 cm [18in], arm height 65 cm [25.6 in]), walk a distance of 3 meters (118 inches, approximately 10 feet), turn, walk back to the chair, and sit down. The subject wears their regular footwear and uses their customary walking aid (none, cane, walker). No physical assistance is given. They start with their back against the chair, their arms resting on the armrests, and their walking aid at hand. They are instructed that, on the word "go" they are to get up and walk at a comfortable and safe pace to a line on the floor 3 meters away, turn, return to the chair and sit down again. The subject walks through the test once before being timed in order to become familiar with the test. Either a stopwatch or a wristwatch with a second hand can be used to time the trial.

*Instructions to the patient*

"When I say 'go' I want you to stand up and walk to the line, turn and then walk back to the chair and sit down again. Walk at your normal pace."

*Scoring*

Time for 'Up and Go' test _________sec.

Unstable on turning?

Walking aid used? Type of aid: ___________

Appendix F

Activities-Specific Balance Confidence Scale

# ACTIVITIES-SPECIFIC BALANCE CONFIDENCE SCALE

*Instructions to Participants*

For each of the following, please indicate your level of confidence in doing the activity without losing your balance or becoming unsteady from choosing one of the percentage points on the scale form 0% to 100%. If you do not currently do the activity in question, try and imagine how confident you would be if you had to do the activity. If you normally use a walking aid to do the activity or hold onto someone, rate your confidence as it you were using these supports. If you have any questions about answering any of these items, please ask the administrator.

*The Activities-specific Balance Confidence (ABC) Scale*

For each of the following activities, please indicate your level of self-confidence by choosing a corresponding number from the following rating scale:

0% 10 20 30 40 50 60 70 80 90 100%
no confidence completely confident

“How confident are you that you will not lose your balance or become unsteady when you…

1. …walk around the house? ____%
2. …walk up or down stairs? ____%
3. …bend over and pick up a slipper from the front of a closet floor ____%
4. …reach for a small can off a shelf at eye level? ____%
5. …stand on your tiptoes and reach for something above your head? ____%
6. …stand on a chair and reach for something? ____%
7. …sweep the floor? ____%
8. …walk outside the house to a car parked in the driveway? ____%
9. …get into or out of a car? ____%
10. …walk across a parking lot to the mall? ____%
11. …walk up or down a ramp? ____%
12. …walk in a crowded mall where people rapidly walk past you? ____%
13. …are bumped into by people as you walk through the mall?____%
14. … step onto or off an escalator while you are holding onto a railing? ____%
15. … step onto or off an escalator while holding onto parcels such that you cannot hold onto the railing? ____%
16. …walk outside on icy sidewalks? ____%

# Appendix G

## Ease of Use and Motivational Qualities Questions

EASE OF USE AND MOTIVATIONAL QUALITIES QUESTIONS

1. What, if anything, did you find difficult about the physical operation of the Wii Fit game system?
2. What, if anything, did you find easy about the physical operation of the Wii Fit game system?
3. What, if anything, did you find motivating about the Wii Fit game system?
4. What, if anything, did you find least motivating about the Wii Fit game system?
5. Which of the games which you played did you find most motivating and why?
6. Which of the games that you played did you find least motivating and why?
7. Would you consider continuation of training on the Wii Fit? If yes, what makes you want to continue? If not, what makes you not want to continue?
8. What recommendations would you make to game or system developers wanting to improve the Wii Fit for seniors?

# Appendix H

## Total Agreement Data

Table H1

*Total Agreement Data*

| Participant # | Session # | BL vs. I | Berg Balance Scale R1 | Berg Balance Scale R2 | Berg Balance Scale TA | Timed Up and Go R1 | Timed Up and Go R2 | Timed Up and Go TA |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 | BL | 36 | 37 | 97.3 | 17.38 | 17.74 | 97.97 |
| | 4 | BL | 39 | 37 | 94.87 | 14.81 | 15.11 | 98.01 |
| | 7 | I | 47 | 45 | 95.74 | 12.71 | 12.56 | 98.82 |
| | | | | | 95.97 | | | 98.26667 |
| 2 | 1 | BL | 44 | 44 | 100 | 9.62 | 9.79 | 98.26 |
| | 4 | BL | 45 | 43 | 95.56 | 11.21 | 10.74 | 95.81 |
| | 7 | BL | 43 | 45 | 95.56 | 10.24 | 10.49 | 97.62 |
| | 10 | I | 49 | 48 | 97.96 | 8.22 | 8.73 | 94.16 |
| | | | | | 97.27 | | | 96.4625 |
| 3 | 1 | BL | 48 | 49 | 97.96 | 9.57 | 9.16 | 95.72 |
| | 4 | BL | 47 | 49 | 95.92 | 9.44 | 9.77 | 96.62 |
| | 7 | BL | 48 | 48 | 100 | 8.84 | 8.61 | 97.4 |
| | 10 | BL | 47 | 49 | 95.92 | 8.59 | 8.94 | 96.01 |
| | 13 | I | 50 | 51 | 98.04 | 6.49 | 7.01 | 92.58 |
| | | | | | 97.568 | | | 95.666 |
| 4 | 1 | BL | 41 | 39 | 95.12 | 13.42 | 13.57 | 98.89 |
| | 4 | BL | 41 | 40 | 97.56 | 12.28 | 12.83 | 95.71 |
| | 7 | BL | 42 | 40 | 95.24 | 12.71 | 12.52 | 98.51 |
| | 10 | BL | 42 | 41 | 97.62 | 13.2 | 12.81 | 97.05 |
| | 13 | BL | 42 | 43 | 97.67 | 13.11 | 13.4 | 97.84 |
| | 16 | I | 45 | 46 | 97.83 | 11.11 | 11.27 | 98.58 |
| | | | | | 96.84 | | | 97.76333 |

Appendix I

Point-By-Point Data On Specific BBS Items Across Participants

Table I1

*Point-By-Point Data On Specific BBS Items Across Participants*

| Item # | Agreements | Agree + Disagree | Calculation | % Agreement |
|---|---|---|---|---|
| 1 | 16 | 18 | 16/18 x 100% | 88.89 |
| 2 | 14 | 18 | 14/18 x 100% | 77.78[a] |
| 3 | 18 | 18 | 18/18 x 100% | 100 |
| 4 | 14 | 18 | 14/18 x 100% | 77.78 [a] |
| 5 | 13 | 18 | 13/18 x 100% | 72.22 [a] |
| 6 | 13 | 18 | 13/18 x 100% | 72.22 [a] |
| 7 | 14 | 18 | 14/18 x 100% | 77.78 [a] |
| 8 | 18 | 18 | 18/18 x 100% | 100 |
| 9 | 16 | 18 | 16/18 x 100% | 88.89 |
| 10 | 15 | 18 | 15/18 x 100% | 83.33 |
| 11 | 11 | 18 | 11/18 x 100% | 61.11 [a] |
| 12 | 18 | 18 | 18/18 x 100% | 100 |
| 13 | 17 | 18 | 17/18 x 100% | 94.44 |
| 14 | 18 | 18 | 18/18 x 100% | 100 |

[a] Indicates less that 80% agreement

# VITA

## CURTIS N. PHILLIPS


| | |
|---|---|
| Address: | 1204 West 350 South<br>Logan, UT 84321 |
| Home Phone: | 435.787.8452 |
| Work Phone: | 435.797.7681 |
| Email: | curt@cpd2.usu.edu |


## I. EDUCATION

2013 Utah State University, Logan, UT, Ph.D., Disability Studies

1997 University of California, San Francisco, CA, MPT, Physical Therapy

1995 Brigham Young University, Provo, UT, BS Exercise Science

## II. PROFESSIONAL EXPERIENCE

| | |
|---|---|
| Physical Therapist—Community Nursing Services | 2012-present |
| Interim Director Utah Assistive Technology Program | 2008-2009 |
| Adjunct Lecturer in HPER Department at Utah State University (PEP 2020) | 2004-present |
| BabyWatch Early Intervention Motor Trainer | 2002-present |
| Supervising Physical Therapist—Up to 3 Early Intervention Program | 2002-present |
| Physical Therapist—Up to 3 Early Intervention Program | 2000-2002 |
| Physical Therapist—Beck and Cale Physical Therapy | 1997-2000 |

## III. PUBLICATIONS

Christensen, K. M., Holt, J. M., Collins, S., & Phillips, C. N. (2006). The relationship between the design of the built environment, collective egress behavior, and the ability to egress of individuals with disabilities. *Review of Disability Policy Studies*, *2*(3), 24-34.

## IV. PRESENTATIONS

Phillips, C. (April 2008). *TOPSports: Involvement Through Recreation.* Presented to participants at Pacific Rim International Conference on Disabilities.

## V. TEACHING EXPERIENCE

Lecturer in Health, Physical Education and Recreation Department at Utah State University: Teach Neurological, Pediatric and Assistive Technology lectures in PEP 2020 class (2004 to present).

## VI. FUNDED GRANTS

IOTI grant for Topsports
IOTI Grant: Handle With Care

## VII. AWARDS, HONORS AND AFFILIATIONS

ULEND Graduate