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Nintendo® Wii Fit™ Balance and Cognitive Function in Older Adults

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Nintendo® Wii Fit™ Balance and Cognitive Function in Older Adults

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Abstract

Nintendo® Wii Fit™ Balance and Cognitive Function in Older Adults

Fear of falling is highly prevalent among older adults. It is important to find ways to decrease the fear of falling and improve the confidence one has in their own balance when doing daily activities. **PURPOSE:** The purpose of this study was to evaluate the effects of a balance training intervention using the Nintendo Wii Fit on balance confidence and cognitive function, specifically executive function, in older adults. **METHODS:** Twelve adults over the age of 65 years were assigned to a treatment group or control group to complete an eight-week balance training intervention. Balance confidence was measured using the Activities-Specific Balance Confidence Scale. Cognitive function was evaluated with the Trail Making Test (TMT), Part A and Part B. Center of mass was measured using the Nintendo Wii Fit balance board. All assessments were taken at baseline and after eight weeks of training. The data were analyzed using an ANOVA with repeated measures for each outcome ($\alpha = .025$). **RESULTS:** No significant interaction or time effects were observed for any variable. The group effect for TMT Part A approached significance ($F = 7.034$, $p = 0.029$). **CONCLUSIONS:** It can be concluded that using the Nintendo Wii Fit as a balance training tool will not improve balance confidence or cognitive function, particularly executive function, in older adults. Future studies should look at testing other components of cognitive function to see if the Nintendo Wii Fit is a useful device for older adults. They should also consider combining balance training using the Nintendo Wii Fit with resistance training, to build the strength in the lower body.

Chapter One: Introduction

Significance

With increasing age there is a trend of falling, which is often due to balance problems. In 2000, approximately 2.6 million non-fatal fall injuries occurred with a total annual cost of $19 billion (Stevens, Corso, Finkelstein, & Miller, 2006). Also, in 2000, there were nearly 10,300 fatal fall injuries that cost around $179 million (Stevens et al., 2006). Injuries due to falls seem to be more prevalent in women. However, fatality rates for men exceeded those for woman (Stevens et al., 2006). The most common type of injury reports are fractures, mainly of the hip. One fourth of older adults, over the age of 70 years old, who sustain a hip fracture pass away within six months of the injury (Fuller, 2000). Most falls do not end in death; however, the psychological impact of a fall or near fall often results in a fear of falling and increasing self-restriction of activities (Fuller, 2000). When one has fear of future falls, this can lead to dependence and increasing immobility (Fuller, 2000). Determining the underlying cause of a fall can potentially return one to baseline function and reduce the risk of recurrent falls (Fuller, 2000). Interventions to decrease the number of fall related injuries are necessary to improve the quality of life among older adults, and reduce the cost of healthcare (Stevens et al., 2006). Individuals with high levels of fear of falling are more likely to have a poor quality of life (Fuzhong, Fisher, Harmer, McAuley, & Wilson, 2003). Providing interventions that target reducing falls and improving fear of falling will help improve the quality of life in older adults (Fuzhong et al., 2003).

Burrachiao et al. (2011) found that in adults with balance impairment, changes in cognitive function may play less of a role in preventing falls. Fall interventions should take into account both cognitive and balance domains (Buracchio et al., 2011). Cognitive training may only benefit those who do not have serious balance problems and those with balance problems are more likely to benefit from a balance or strength training program (Buracchio et al., 2011). Lower scores on executive function tests can be a risk factor for falls in participants with low balance impairment (Buracchio et al., 2011). Physical activity has been seen to improve cognitive outcomes for older adults (Lautenschlager, Almeida, Flicker, & Janca, 2004).

Background

Fear of falling is prevalent in at least 30% of older adults who do not have a history of falls and double that in those who have a history of falls (Legters, 2002). There are many factors that contribute to fear of falling in older adults. The fear of falling can often lead to dependence and immobility, thus leading to a greater fear. Fear of falling should be looked into separately from falling. Fear of falling interventions can provide education on falls, fall related injuries, and fear of falls to instill confidence in older adults abilities (Legters, 2002). Multiple interventions have been recommended, with the most important one being a cognitive-behavioral change in the older adult that yields strengthened self-confidence to perform daily activities (Legters, 2002). Older adults who had fallen in the past year or sustained a fall related injury had a lower score on the Activities-Specific Balance Confidence (ABC) Scale (Myers, Powell, Maki, Holliday, Brawley, & Sherk, 1996). Thus suggesting that those with a high fear of falling have lower confidence in doing every day activities.

Fallers tend to have a lower executive function score on cognitive tests. Basic physical function and poor balance lead to the effect of relatively minor changes in executive function with aging with respect to remaining upright during an event of falling (Buracchio et al., 2011). Older adults with discrepancies in attention and executive function may lead to a dissociation of higher-order gait and postural control and increase the risk for falls (Buracchio et al., 2011). The attention and concentration skills required by working memory may be important for things like transferring wheelchairs, which requires balance (Rapport, Hanks, Millis, & Deshpande, 1998). Measures of cognitive fluency and working memory are related to falls in older adults (Rapport et al., 1998).

Liu-Ambrose, Khan, Eng, Lord, & McKay (2004) found that fear of falling can lead to activity restriction that is self-imposed rather than due to actual physical impairments. One way to improve balance confidence is to have resistance or agility training interventions. Changes in balance confidence can directly be linked to general physical function. Participating in exercise alone may increase balance confidence in the void of improved physical abilities (Liu-Ambrose et al., 2004). In addition to improved balance confidence, one can have a better quality of life and be able to perform every day normal activities without having to worry about falling. Rehabilitation programs can be developed to improve balance confidence. There is a need to learn more about other predictors of balance confidence as well. This can include socioeconomic, psychological, and other psychosocial and health-related factors (Hatch, Hill-Body, & Portney, 2003). Executive function is improved from exercise interventions in both healthy older adults and frail older adults (Langlois, Vu, Chassé, Dupuis, Kergoat, & Bherer, 2012). From exercise training the biggest gains have been seen in executive control, processing speed, and working memory (Langlois et al., 2012).

Statement of Purpose

The purpose of this study was to evaluate the effect of a balance training program using the Nintendo Wii Fit on balance confidence in older adults. The secondary purpose was to assess the effect of a balance training intervention using the Nintendo Wii Fit on cognitive function, specifically executive function. The independent variables were time (pre and post) and group (treatment and control). The dependent variables were balance confidence and cognitive function.

Hypothesis

The researcher hypothesized the treatment group would improve balance confidence and executive function, while the control group would not change or decrease. A second hypothesis was there would be a significant difference between groups in time effect in balance confidence using the Activities-Specific Balance Confidence (ABC) Scale.

Operational Definitions

Balance can be defined as one controlling their center of mass with respect to its base of support (Rose, 2010). Dynamic balance is controlling the center of mass while moving, for example walking (Rose, 2010). Balance confidence is a person's level of confidence in the ability of performing daily activities while maintaining balance (Hatch et al., 2003). Executive functions are a variety of higher cognitive processes that use and alter information from sensory systems in the brain to produce behavior (Yogev-Seligmann, Hausdorff, & Giladi, 2008). The functions include cognitive and behavioral components, which are needed to help with independent activities of daily living (Yogev-Seligmann et al., 2008). Executive function can be divided into six major components: volition, planning, self-awareness, response inhibition, response monitoring and attention/dual tasking (Lezak, 1995). Activities of daily living can be things such as dressing/undressing oneself, standing up/sitting down by yourself, feeding oneself, bathing by yourself, socializing with others at ease, moving about indoors/outdoors independently, and doing things of recreational interests without help (Chiou & Burnett, 1985).

Assumptions

An assumption made about this study was that the participants would be honest in the self-reported survey used to test balance confidence. Another assumption is that the participants knew the correct guidelines for playing the games on the Wii. The participants would perform with their best effort as well as they would be compliant.

Limitations

- The inability to control outside physical activity influence or other health practices.
- The lack of interest in the study.
- The dropout rate from the study.

Delimitations

- All individuals were over the age of 65 years.
- All individuals were independent living.
- Participants only used the Wii Fit.
- The participants were limited to five specific games on the Wii Fit.
- The short length of the study (8 weeks).

Summary

The purpose of this study was to evaluate the effects of a balance training program using the Nintendo Wii Fit on balance confidence and cognitive function in older adults. Balance interventions formed to decrease the risk of falls are important. From the study, the researcher found the Nintendo Wii Fit to not be a useful tool to help aid in preventing falls and injuries due to falls because balance confidence levels did not improve.

Chapter Two: Literature Review

The purpose of this literature review is to gain further knowledge about balance, cognitive function, and how the Nintendo Wii Fit can be used as a training tool. Multiple areas related to balance and falls will be discussed. These include the risk of falls, dynamic balance, dual task balance, balance confidence, cognitive function, and the Nintendo Wii Fit as a training tool. These will be looked at in more detail to help understand the importance of balance training programs using the Nintendo Wii Fit in helping to decrease the risk of falls in older adults.

Risk of Falls

In the year 2003 over 1.8 million older adults had fall related injuries, and over 421,000 were hospitalized (Schiller, Kramarow, & Dey, 2007). The most common cause of fall injuries was slipping, tripping, or stumbling (Schiller et al., 2007). Nearly 60 percent of older adults who received a fall related injury visited the emergency room (Schiller et al., 2007). As a result of the injury, almost one-third of older adults needed help with activities of daily living, and over one-half expected to need help for at least six months (Schiller et al., 2007). As adults age, they are more at risk for falls. This can be due to many things such as: muscle weakness and diminished physical fitness, vision changes, physical disability, chronic and acute illness, and cognitive impairments (Scott, Peck, & Kendall, 2004). Other factors include: inattention to their surroundings, medication use, risk-taking behaviors, inappropriate footwear, inadequate diet/exercise, women carrying heavy handbags, and having a fear of falling (Scott et al., 2004). Falls can happen anywhere whether it is at home, in the community, or at an institution because there are many factors at these places that can cause one to fall (Scott et al., 2004).

Shumway-Cook, Baldwin, Polissar, and Gruber (1997) developed a model to quantify fall risk among community-dwelling older adults. This study used 44 independently living community-dwelling adults over the age of 65 years old. Participants were classified as a faller or nonfaller. A faller was one that had two or more falls within the past six months. All participants completed the Mini Mental Test to establish mental status. They also completed the Balance Self-Perception Test to examine their views regarding the level to which balance and perceived risk for falls restrict daily activities. The Berg Balance Scale was utilized to assess balance and mobility function. Having the participants walk 50 feet at their preferred speed and again at their fastest pace tested mobility. The Dynamic Gait Index was used to examine the ability to adjust gait changes in task demands. In order to analyze the data, *t* tests and cross tabulations with chi-square tests were used to determine which variables varied significantly between fallers and nonfallers. Spearman correlations among pairs for the variables were analyzed to conclude similar variables as well as those that had little correspondence (Shumway-Cook et al., 1997).

Results from this study revealed the highest correlations ($r = .76$) were found between Dynamic Gait Index and the Balance Self-Perceptions Test and between the Balance Self-Perceptions Test and the Berg Balance Scale. There were significant differences between the fallers and nonfallers in five risk factors. These risk factors were the Berg Balance Scale (p=.0001), use of assistive devices ($p = .05$), the Dynamic Gait Index ($p = .001$), the Balance Self-Perceptions Test ($p = .01$), and history of imbalance ($p = .0002$). Participants who score high on the Berg Balance Scale have a low fall risk, where as those who score below 40 have a high risk for falling and should be referred to a program intended to improve balance and mobility function and to reduce fall risk. Authors concluded that a predictive model based on two risk factors can be used by clinicians to measure fall risk in community-dwelling older adults (Shumway-Cook et al., 1997).

Burrachio et al. (2011) evaluated if executive function was associated with an increased risk of falling, to determine if the association is independent of balance. For this study 188 community-dwelling individuals were recruited to participate. Individuals with high risk of falling and significant cognitive impairment were excluded, as they wanted only independent, ambulatory, and non-demented participants. All subjects were tested at baseline on multiple factors. Health status was assessed using the modified Cumulative Illness Rating Scale (CIRS). To test for the presence of arthralgia and myalgia, the musculoskeletal sub score from the CIRS was utilized. Annual in-home clinical evaluations were made to check for any medications and physical examinations. The Geriatric Depression Scale was also used to test depressive symptoms. In addition to neurological assessments, tests for motor function were completed as well. To test for gait and balance the Performance-Oriented Assessment of Mobility was used. Gait speed was assessed by having the participant walk 15 feet, then turning around and walking back for a total of 30 feet. Participants were also assessed on neuropsychological testing at baseline using the National Alzheimer's Coordinating Center (NACC) protocol. Executive function was tested using the Trail Making Test (TMT) Part B and the Category Fluency Animals and Vegetables. Letter-Number Sequencing and Digit Span Backward were utilized to assess working memory. The Digit Span Backward, the Digit-Symbol Test, and Trail Making Test- Part A were used to evaluate attention/processing speed. Memory was assessed using the Logical Memory Delayed, Visual Reproduction II, and CERAD Word-List Recall. Block Design and Picture Completion were used to test Visuospatial Function. Participants were asked to report the incident of falls weekly using an online health form. In order to compare the characteristics between fallers and non-fallers a Wilcoxon Ranked Sum Test for continuous variables and Pearson Chi-Square test for categorical variables was run (Burrachio et al., 2011).

Results showed that twenty-four participants reported more than one fall. Fallers were found to have a lower CIRS score ($p = .03$), to perform worse on the Tinetti balance scale ($p<.01$) and to report prior history of falls ($p = .01$). The executive function z score was found to be significantly lower (-0.19 vs. 0.08) in fallers than non-fallers ($p = .03$). A higher executive function z score remained affiliated with lower number of falls ($p = .10$). Prior history of falls was not a significant predictor of expected falls in older adults with no balance impairment ($p=.28$). However, prior history of falls was a significant predictor of future falls in older adults with balance impairment ($p = .01$). It can be concluded that older adults that were fallers are more likely to have lower scores in executive function. These scores are not low enough to be classified as dementia or mild cognitive impairment. Physical or direct motor system factors might play a greater role in fall risk in individuals with poor balance. While low executive function can prove to be a risk factor for falls in adults with minimal balance impairment (Burrachio et al., 2011), important intrinsic factors associated with fall risk should also be assessed. Well-designed exercise programs that target these intrinsic risk factors associated with increased fall risk have been very effective in recent studies (Rose, 2011).

Rose (2011) developed The Fallproof Balance and Mobility Program. This program was designed in response to the need for effective community-based programs that target the important intrinsic factors associated with increased fall risk. If the intrinsic systems do not function properly, the older adults may fail to accomplish a simple task or goal. This study used 188 older adults who completed an eight-week version of the program. The standardized assessment package was used to test the participants. The tests included Fullerton Advanced

Balance scale or Berg Balance Scale, 30-feet walk at preferred speed, 30-second arm curl and chair stand, Balance Efficacy Scale, 8 foot up-and-go, and walkie-talkie test (which has recently changed to the walking while talking test). The program focuses on improving the motor, sensory, and cognitive systems. These systems are tested through four different components, which included: Center of Gravity (COG) Control Training, Postural-Strategy Training, Multisensory Training, and Gait Pattern Enhancement and Variation Training. Results from the study found that after the eight-week program there were improvements in balance, gait, upper and lower body strength, and balance-related confidence. This program is good for older adults that are at a moderate-to-high risk of falling and for health care professionals interested in sending their patients to programs that target balance and mobility skills (Rose, 2011).

One strong point found was the collection of falls on a weekly basis, which minimalized recall bias (Burrachio et al., 2011). The standardized measurements of motor and cognitive function and standardized definition of falls is another major strength of the study (Burrachio et al., 2011). It is important to have trained instructors and a standardized assessment and program delivery package (Rose, 2011). Shumway-Cook et al. (1997) used volunteers; if the subject were drawn at random the results may have been different. Using computer falls forms may not be an acceptable way to measure falls for the general population of older adults (Burrachio et al., 2011). While the study assessed falls risk factors, it was not an initial design, therefore some risk factors for falls were not included (Burrachio et al., 2011). Rose (2011) has found the program to be effective for short term; however, there is nothing to show for the long-term efficacy to lowering fall rates, fall-related injuries, and health care costs.

The most common cause of falls in older adults accounting for 30-50% is accidental or environmental related (Rubenstein, 2006). The next common cause of falls accounting for 10-

25% is gait problems and weakness (Rubenstein, 2006). The gait problems often occur as one ages in gait and balance following a period of inactivity (Rubenstein, 2006). The next major cause of falls is dizziness, which is often seen in older adults (Rubenstein, 2006). Most often, it is hard to pin point just one cause for falls in older adults because they have multiple risk factors (Rubenstein, 2006). The most important risk factors for falls in older adults are muscle weakness and problems with gait and balance (Rubenstein, 2006).

It can be concluded that older adults who have moderate-to-high risk of falling may need to participate in balance training sessions in order to decrease the risk. These balance training sessions should focus on improving balance and mobility function. It is important for older adults to improve cognitive function to avoid having the risk of falling.

Balance as a Risk for Falls

Balance is a very common measure of risks of falls. Dynamic balance, more specifically, since it deals with balance while moving. Desai, Goodman, Kapadia, Shay, & Szturm (2010) assessed center of pressure (COP) measurements on the Dynamic Balance Assessment (DAB) to see if it differentiated between fallers and nonfallers. Authors also determined if DAB COP measures were correlated to any functional balance tests. The subjects recruited for this study were 72 community-dwelling older adults over the age of 65 years old that were receiving rehabilitation from physical therapists for balance impairments. All participants were required to score a 24 or higher on the Mini Mental State Examination (MMSE) to participate. Fallers and nonfallers were based on self-report of one or more falls in the past year. The four clinical tests that all participants completed were the Berg Balance Scale (BBS), Timed Up & Go (TUG), 6-minute walk test (6MWT), and gait speed. After completing these, they performed the DAB on a separate day. There were six tasks involved in the DAB that took 20 seconds to complete each.

If a participant was not able to complete a task it was recorded as a loss of balance (LOB). A force sensor array (FSA) pressure-sensing mat was used to test vertical foot COP position on all tasks. Independent *t* tests were used on age, gait speed, and 6MWT score. Mann-Whitney *U* tests were used for TUG score, BBS score, LOB frequency, and composite DBA scores. Chi-square tests were used for sex, use of walking aids, and activity of walking 0.5 mile. A Spearman correlation was used to examine validity between DBA and clinical tests (Desai et al., 2010).

Results of this study showed that moderate to high (r = .58 - .83) correlations were found among performance-based test scores (BBS, 6MWT, TUG, and gait speed). Low correlations (r= .10 - .31) were found between the clinical tests and scores based on COP position and LOB. Composite DBA scores for the sponge surface discriminated between fallers and nonfallers. Whereas, composite DBA scores for a normal floor surface did not discriminate between fallers and nonfallers. Performance-based tests did not differentiate between the two groups, but the TUG did. There were no significant differences between groups for gait speed and 6MWT scores. An appropriate method to assess standing dynamic balance in older adults is by using the DBA to test COP displacements under different surface conditions and during certain tasks. Also, the DBA and the TUG are good measures to identify community-dwelling older adults who are at risk of falling (Desai et al., 2010).

Hiyamizu, Morioka, Shomoto, & Shimada (2011) evaluated dual task balance training and determined if it could not only improve standing postural control, but also improve the ability of elderly subjects in dual task performance. Forty-five healthy elderly adults over the age of 65 that had no neurological or musculoskeletal diagnosis, orthopedic involvement, or visual and auditory impairments were recruited for this study. Subjects were randomly assigned to a control group or a dual task balance-training (DT) group. All measurements were taken at baseline and at the end of the intervention for all participants. The measurements of physical performance used were the Chair Stand Test, Functional Reach Test, and Timed Up and Go Test. The Trail Making Test (TMT) was used to test cognitive function. The time difference between Part A and Part B (B-A) was used to control for the effect of motor speed on the TMT performance and to evaluate the ability of attention, rather than using the performance of Part B alone. The Stroop task was used while standing on the force platform for 30 seconds with eyes open and eyes closed to test for dual task. All participants participated in strength and balance training twice a week for three months for one hour a day, for a total of 24 sessions. The DT group received a calculation task, a visual search task, and a verbal fluency task to perform simultaneously with the balance training. A comparison of age and physical features between control group and DT group were made using the independent *t*-test or the chi-square test (Hiyamizu et al., 2011).

At baseline, the Functional Reach Test ($p = .91$), Timed Up and Go Test ($p = .53$), and Chair Stand Test ($p = .37$), showed no statistical difference between groups. The Trail Making Test Part A ($p = .07$), Trail Making Test Part B ($p = .10$), and Trail Making Test (B-A), $p = .23$, also showed no statistical difference between groups. The same results were found after the intervention for all physical tests and Trail Making Test parts. Muscle and balance training help maintain physical function and balance ability in older adults. Also, dual task balance training with a cognitive task maintained balance ability, and significantly improved the dual task performance compared to the normal balance training (Hiyamizu et al., 2011).

Balance can be tested multiple ways. One great way is to measure balance with dual task tests. Silsupadol, Siu, Shumway-Cook, & Woollacott (2006) described three approaches to training balance; single task, dual task with fixed-priority instructions, and dual task with variable-priority instructions in older adults with balance impairment. Three adults over the age of 80 were randomly assigned to one of the three interventions that were a total of 12 weeks. All participants were able to walk 30 feet without any assistance and their Mini Mental State Examination (MMSE) scores were above 24. In order to measure balance and mobility under single-task, the Berg Balance Scale (BBS), Dynamic Gait Index (DGI), and the Timed Up and Go Test (TUG) were used. The TUG was also repeated under dual-task. The BBS is a 14-item test using a 4-point scale, on tasks like standing up, standing with eyes closed, or standing with feet together. Scores can range from 0 to 56, where the higher the number means better balance. The DGI rates performance from 0 to 3 on eight different gait tasks. The scores range from 0 to 24. The time it takes to stand up from a 17-inch chair, walk 3 meters, turn, walk back, and sit down is recorded for the TUG test. Participants also completed the Activities-Specific Balance Confidence (ABC) Scale and the MMSE. The ABC Scale is used to measure self-determined confidence when performing 16 daily activities. In order to calculate body kinematics during the tasks, a three-dimensional motion analysis was used. Participant One was randomly selected to participate in the single-task training, which included balance activities. Participant Two was selected to participate in dual-task training under a fixed priority (FP) instructional set. This participant performed the same balance activities as Participant One, as well as performing auditory and visual discrimination tasks and also cognitive tasks. Participant Three participated in the same activities as Participant Two, but under dual-task training under a variable priority (Silsupadol et al., 2006).

After the training, balance had improved in all participants. The BBS score increased for all three participants, but was a significant increase for Participant Three. Participants Two and

Three increased their DGI scores, while Participant One already scored the most they could at baseline. TUG tasks were improved in all participants in both single- and dual-task conditions. The scores for the ABC Scale also improved for all three participants. Older adults might be able to improve balance under dual-task conditions under certain types of balance training (Silsupadol et al., 2006).

Another very important way to measure for people at risk of falling is the Sensory Organization Test (Judge, King, Whipple, Clive, & Wolfson, 1995). Authors evaluated the importance of visual and proprioceptive sensory input in performance using the Sensory Organization Test in older adults. Another purpose was to examine the effects of age and muscle strength on performance. The last purpose of this study was to test the concurrent validity of the EquiTest protocol. There were a total of 110 subjects recruited for this study. All subjects were required to be over the age of 75 and had the ability to walk without a device to assist them for eight meters. At baseline, all subjects completed a medical history, a physical examination, a depression questionnaire, and cognitive and functional status questionnaires.

Subjects were asked to stand on a force platform where they stood still to test center of force (COF) and shear force. There were six conditions used during the EquiTest Sensory Organization Test protocol. Also, subjects' postural responses were measured by analyzing the force platform data in order to determine the center of force displacement (COFD). Balance was measured using standing balance tests, gathering the best times of two 30-second tests. Gait velocity was measured by gathering the pace over an eight-meter course. In order to measure muscle strength, the isokinetic peak joint movement was measured at the knee, hip, and ankle. Isokinetic strength was measured on the right leg at two angular velocities: 60° and 180° s^{-1} at the knee and 30° and 60° s^{-1} at the hip and ankle. Flexion and extension were measured at all joints, and adduction and abduction at the hip. The number of falls in the previous year was recorded, as well as the frequency of recreational activities and the type of activity. Subjective physical function was measured using the Sickness Impact Profile mobility and ambulation subscales. Independence in activities in daily living (ADLs) and instrumental activities of daily living (IADLs) were measured as well. A MANOVA was used in order to determine the effects of the altered visual input and altered proprioception on COFD. A multi-variable logistic regression was run to determine the variables that influenced a subject's risk of losses of balance (LOBs). The relationship between performance on the Sensory Organization Test and subject characteristics were examined using the Mantel-Haenszel chi-square test. A multi-variable logistic regression was used in order to determine the variables that affect the risk of loss of balance (Judge et al., 1995).

Results from this study showed that there were moderate but significant inverse relationships between the number of LOBs and performance measures (r = .30-.37, p< .001). Meaning, the subjects who had a higher number of losses of balance on the Sensory Organization Test had impaired performances on strength, gait, and single stance balance tests. Balance performance was reduced by declines in visual and foot/ankle tactile/proprioceptive input. When subjects had their eyes closed or inaccurate vision the adaptation in repeated trials was reduced, this also included having proprioceptive and visual input decreased. Authors concluded that lower body strength must improve in order to reduce falls. Muscle strength in the hip, knee, and ankle joints is strongly associated with loss of balance in older adults (Judge et al., 1995).

Subjects were asked to recall their fall history, which proves to be a major limitation to the study (Desai et al., 2010). Another limitation is that the sample may not correctly represent the general older adult population because the subjects were in a rehabilitation program (Desai et al., 2010). Judge et al. (1995) found the data in the study not to be sufficient enough to test if the diminished adaptation in subjects who had multiple LOBs might represent age-associated reductions in the plasticity of the nervous system. Hiyamizu et al. (2011) found a limitation to the study to be the small sample size. Also, the participants were all healthy and active, which means the training did not affect physical function and performance. Silsupadol et al. (2006) also had a limitation of a small sample size. Larger sample size and understanding how long training benefits are sustained in older adults are important to consider. The ceiling effect on performance was a limitation using the BBS and DGI because it resulted in not detecting for change (Silsupadol et al., 2006). Task priority under dual task condition, meaning prioritizing one task determines the direction of attention to tasks, was different among subjects regarding their ability, which proved to be a limitation (Hiyamizu et al., 2011).

Overall, cognitive function plays a very important role in someone's ability to balance with multiple tasks involved. Balancing under dual task behaviors is not an easy task for older adults. This might be able to be improved with certain types of balance training. To summarize, dynamic balance should be tested in order to assess if someone is at risk of falling or not. Another important factor in assessing someone's risk of falling is testing his or her lower body strength. If lower body strength is low one will not be able to control their balance as well.

Cognitive Function as a Risk for Falls

Recent studies have not focused on the cognitive factors that are a part of risk for falls. Rapport, Hanks, Millis, & Deshpande (1998) examined the efficacy of executive function tests in prediction of falls among patients in a rehabilitation setting. This study used 90 patients in an urban rehabilitation hospital between the ages of 17 and 73 years. Incident reports of falls while the patient was in the hospital were utilized for measuring falls. The Functional Independent

Measure (FIM) is an 18-item test that measures two dimensions: motor functioning and cognition. Pre-injury intelligence was measured with the Reading subtest of the Wide-Range Achievement Test-Revised (WRAT-R). The Visual Form Discrimination Test (VFDT) was utilized to assess visuospatial functioning. Verbal memory was measured with the Logical Memory subtest of the Wechsler Memory Scale-Revised (WMS-R). The Wisconsin Card Sorting Test (WCST) was used to test cognitive flexibility. To measure response inhibition the Stroop Neuropsychologic Screening Test (Stroop) was used. The Letter-Number Span was utilized to test working memory. The last cognitive test, the Controlled Oral Word Association Test (COWAT), is one that measures cognitive initiation, productivity, and access speed. In order to analyze the contribution of executive function measures in the prediction of falls, a multiple regression was run. Another multiple regression was used to assess whether measures of executive function added to the prediction of falls (Rapport et al., 1998).

The strongest relationship to falls was seen with the preservative errors on the WCST, (r=.43, p< .001), followed by COWAT Fluency, (r = -.32, p< .001), and Letter-Number Span, (r= -.23, p< .05). Verbal memory was also associated with falls, (r = -.23, p< .05). Visuospatial functioning was a significant predictor combined with measures of executive functioning, although not directly related to falls. All variables accounted for 30.3% of the variance in falls. The WCST preservative errors (p< .002), Stroop Test (p = .040), and VFDT (p = .013) had significant contributions to the prediction of falls. Authors concluded that executive functioning controls the impact of motor and sensory impairments on falls. It may be of importance to have interventions for those with executive dysfunction. However, those with intact executive function are less likely to act in a way that could result in a fall (Rapport et al., 1998).

Cognitive impairment may be crucial to perform everyday activities in older adults. A study by Lamoth, van Duedekom, van Campen, Appels, de Vries, & Pijnappels (2011) evaluated gait stability and variability of elderly patients with and without cognitive impairments under normal and dual task walking conditions. For this study 26 older adults over the age of 70 that were able to walk without an assisted device were recruited. To assess dependency in daily life the Instrumental Activities of Daily Living (IADL) was used and the Charlson Comorbidity Index (CCI) was used to determine the presence of co-morbidity in the group. All participants took the Mini Mental State Examination (MMSE) and the Seven Minute Screen (SMS). The participants were divided into two groups, one group suffering from cognitive impairments and one group of cognitively unimpaired individuals. All subjects walked for three minutes at a self-selected speed. The walking was performed once without and once with a verbal dual task. During the dual task condition, the participants had to perform a letter fluency task where they were asked to name as many words starting with a predefined letter. Trunk accelerations in three directions during the walking trials were measured using a tri-axial ambulant accelerometer. The Mann-Whitney test and Wilcoxen signed rank test were used to test the significance between group effect and main condition effects. Spearman correlations were calculated to evaluate the relationships between MMSE, SMS scores and gait and trunk variables (Lamoth et al., 2011).

Results found that there were no significant differences in the number of words during walking between cognitively impaired and cognitively intact participants ($p = .19$). Walking speed significantly decreased (0.92 ± 0.24 m/sec), $p < .05$, during dual task, however stride time variability increased, and stability and regularity of lateral trunk accelerations decreased. The cognitively impaired participants showed significantly ($p < .05$) more changes in gait variability than the cognitively intact participants. Correlations between MMSE, SMS scores and gait and trunk acceleration measures were low ($r < .03$). Under dual task conditions differences in dynamic parameters between groups were more distinguished. Changes in cognitive functioning might contribute to an increased fall risk, especially in older adults when tasks such as walking requires more attention and are combined with cognitive tasks (Lamoth et al., 2011).

There has been little research done on people with mild cognitive function (MCI). Therefore not much is known of risk factors for falls or the incidence of falls in this population. Liu-Ambrose, Ashe, Graf, Beattie, & Khan, (2008) compared physiological and cognitive factors for risk of falls in older women with and without MCI. This study used 158 community-dwelling women between the age of 65-75 years and received a score of > 24 on the Mini-Mental State Examination (MMSE). In order to categorize participants as either having MCI or not, the Montreal Cognitive Assessment (MoCA) was utilized. The Physiological Profile Assessment (PPA) was used to assess participants fall risk profile. There were three central executive functions focused on during this study. These included set shifting using the Trail Making Test Part B, updating (working memory) using the Verbal Digits Backward Test, and response inhibition using the Stroop Colour-Word Test. Comparisons of group characteristics were analyzed using a chi-square test for differences in proportions and *t* tests for differences in means. A MANOVA was used to analyze the five key PPA components and also for performance of the executive functions (Liu-Ambrose et al., 2008).

Fifty-two participants reported one or more falls within the last year. The mean MoCA score for the whole sample was 25.2, which is just below the cutoff score of 26 for MCI. The total PPA score was significantly correlated with all of the executive functions ($p < .05$). There was a significant difference between the two groups on physiological fall risk profile ($p = .04$). The total PPA score and postural sway performance ($p < .03$) were significantly different between groups. There were no significant differences between the groups in any of the other four key PPA components ($p > .10$). Participants with MCI performed significantly worse on all three executive functions ($p < .04$). There was a significant difference between the groups on all three executive function tests ($p = .001$). Results from this study suggest that older adults with MCI have greater risk of falls. Therefore, fall risk screening may be important for older adults with mild cognitive function (Liu-Ambrose et al., 2008). Cognitive function can play an important role in balance and performances of simple tasks. This can be seen in the next study, which involves executive function and walking tasks with certain conditions.

Coppin et al. (2006) determined the relationship between executive function and performance of complex walking tasks among community-dwelling older adults whose cognitive function was untouched. This study used 737 males and females between 65-102 years old. Global cognitive status was assessed using the Mini-Mental State Examination (MMSE). Executive function was assessed using the Trail Making Test (TMT). Selected physiological impairments were assessed. Mobility was assessed using multiple walk tests that evaluated the participant's ability to walk under certain conditions and different distances. The different walking conditions included things like talking while walking, carrying a large package while walking, picking up an object from the ground while walking, walking over two obstacles at a fast pace, and walking with a weighted vest.

Results displayed that gait speed for the complex walk tests was much lower (0.9 s) among participants with poor executive function. The relationship between executive function and gait speed is task dependent and also varies based on the degree of locomotor and sensorial adaptation that is required for the performance of the complex walking tasks. Poor executive function may also be due to a decreased awareness of a risk factor in a task. Executive function has a significant effect on the older adult's ability to adapt to environmental challenges (Coppin et al., 2006).

Cognitive function involves one to be aware, perceive, or comprehend particular ideas or tasks. Research has shown that older adults may have impaired balance when performing tasks with cognitive conditions or after a cognitive training. Westlake and Culham (2007) determined the effects of sensory specific balance training on proprioceptive reintegration in older adults. For this study there were 36 adults over the age of 65 years recruited. Participants were randomly assigned to an exercise group or a falls prevention education group. All participants were tested at baseline and within one week after the intervention. The intervention included sensory-specific balance classes that were held three times a week, for one-hour sessions, for a total of eight weeks. The exercise protocol followed the Fallproof Program (Rose, 2011). This program involves static and dynamic balance exercises with transitions between different sensory conditions. A force platform was used to test the mean center of pressure (COP) velocity. COP velocity was measured under four different 45-second postural conditions. Functional limitations were measured with the Fullerton Advanced Balance (FAB) Scale. The Activities-Specific Balance Confidence (ABC) Scale was used to test the participants balance confidence. Physical activity level outside of the intervention was measured using the Physical Activity Scale for the Elderly (PASE). The isokinetic dynamometer was utilized in order to assess concentric isokinetic strength of the hip, knee, ankle flexor and extensor muscles of the dominant leg at a set velocity of 60 degrees/second. A 2 x 6 x 2 ANOVA was used to determine the effects of the intervention on the ability of the participants to regain postural stability with or without a secondary task. A 2 x 2 ANOVA with repeated measures was run to determine the changes in strength and clinical measures. The outcomes of the exercise group from baseline were compared to outcomes at post intervention using an analysis of variance with repeated measures (Westlake & Culham, 2007).

Results from this study showed no differences between groups at baseline or post intervention for PASE scores, however the exercise group had significantly lower scores at the 8-week follow up than post intervention ($p = .003$). A lower balance confidence score was found at post intervention for the education group ($p = .047$). There was less destabilization within the first five seconds following vibration with or without a secondary task at post intervention, $p=.002$ (Westlake & Culham, 2007).

Littbrand, Rosendahl, Lindelof, Lundin-Olsson, Gustafson, & Nyberg, (2006) evaluated a high-intensity exercise program pertaining to attendance, achieved intensity, and adverse events. The authors also explored whether or not cognitive function was associated with the program. This study used 91 subjects 68-100 years of age. These subjects were all dependent in daily living activities, were able to stand up from a chair with no armrests with help from one person or less, scored a 10 or higher on the Mini-Mental State Examination (MMSE), and received approval from their physician. All participants were tested at baseline on cognitive function using the MMSE, balance using the Berg Balance Scale, walking ability using the Functional Ambulation Categories (FAC), depressive symptoms using the Geriatric Depression Scale (GDS-15), and morale using the Philadelphia Geriatric Center Morale Scale (PGCM). The Mini Nutritional Assessment assessed nutritional status. The exercise intervention consisted of 45 minute long sessions, for a total of 29 sessions over a 13-week period. The exercises were based on the High-Intensity Functional Exercise Program (HIFE Program). The program consisted of balance exercises and lower limb strength, in both standing and walking, at a high intensity, if possible.

Results revealed that there was no significant correlation between applicability and MMSE scores. Also, there was no significant difference between those with dementia and those without dementia. A high-intensity functional weight-bearing exercise program may be useful among older adults who are dependent in activities of daily living, have an MMSE score of 10 or higher, and live in a residential care facility (Littbrand et al., 2006).

Ball et al. (2002) examined the effectiveness of three cognitive interventions in improving the performance of the older adult on measures of cognition and on measures of cognitively demanding daily activities. This study used 2832 participants ranging from 65 to 94 years old. Participants were excluded from the study if they were younger than 65; already experienced substantial cognitive decline; self-reported diagnosis of Alzheimer's Disease; experienced substantial functional decline; had medical dispositions that would expose them to functional decline or death; had recent cognitive training; was unable to attend testing and intervention phases of the study; or had severe loss of hearing, vision, or communication. Subjects were split up into a control group or one of three intervention groups. Each intervention group targeted a different cognitive function (memory training, reasoning training, and speed of processing training). Measurements were taken at baseline, immediately following the intervention, and two years post. The interventions were conducted over a 5- 6-week period where they met for 60 to 75 minute sessions. The tests used to measure memory were the Hopkins Verbal Learning Test, Auditory Verbal Learning Test, and the Rivermead Behavioral Memory Test. The tests used to measure reasoning were the Word Series, Letter series, and Letter sets. The only test used to measure speed of reasoning was the Useful Field of View. Other measures tested were everyday problem solving, everyday speed, activities of daily living and IADL functioning, and driving habits (Ball et al., 2002).

Results revealed that all intervention groups improved the cognitive ability compared with baseline ($p < .001$) for all. Immediately following the intervention, 87% of speed-trained, 74% of reasoning-trained, and 26% of memory-trained individuals improved cognitive composite. Cognitive interventions do help elderly adults to perform better on measures of cognitive ability. However, it did not prove that such interventions improve everyday performance, at least in the first two years (Ball et al., 2002).

It can be seen that balance and cognition can improve from not only balance training but also other forms of exercise, which may be helpful. Alpert et al. (2009) evaluated the impact of jazz dance class instruction on balance, cognition, and mood (specifically depression) in older women. This study used 13 healthy community-dwelling women over the age of 50 years old. All subjects participated in jazz dance class for a 15-week study period. Measurements were taken three times, at baseline (time 1), mid intervention (time 2), and after the intervention (time 3). The Mini Mental Status Examination (MMSE) was used to test mental status. The Geriatric Depression Scale (GDS) was utilized to test depression. Balance was measured by using the Sensory Organization Test (SOT) which uses the Balance Master to analyze balance by testing the three primary sensory systems; vision, proprioception, and motor receptors in older adults. A repeated-measures ANOVA was run to determine within-subject changes over time on balance, cognition, and depression. Spearman's rank correlation coefficient was used to relate the intervention to each outcome (Alpert et al., 2009).

Results indicated that balance measures improved throughout the study ($p< .001$). Significant increases in balance occurred from time 1 to time 2 ($p = .003$) and from time 2 to time 3 ($p < .001$). Age was negatively correlated to SOT-time 3 ($r^2= -.635$, $p = .020$) and with MMSE-time 3 ($r^2 = -.559$, $p = .047$) but was unrelated to GDS. There were no significant correlations when looking at SOT versus MMSE and SOT versus GDS. MMSE time 3 and GDS time 3 scores were negatively correlated (r^2 = -.597, p = .040). The balance scores showed significant improvements for all time intervals, stating that improvements occurred not only in the early phase but also throughout the program. Dance might be an effective alternative to exercise regimens for older adults that are working towards improving balance (Alpert et al., 2009). While dance is a great form of exercise, high-intensity exercise may also be important for those with high cognitive impairment.

Rapport et al. (1998) lacked patients older than 73 years, which limits the generalization of the results to the older adult population. Also, being in a rehabilitation center once a patient has had a fall, the risk for more falls is affected by the efforts made to prevent falls to reoccur. Lamoth et al. (2011) were limited by the very small group sizes. They also used cognitive intact elderly adults for their participants that attended the diagnostic geriatric outpatient clinic for multiple problems (Lamoth et al., 2011). Liu-Ambrose et al. (2008) noticed a limitation in their study to be the fact that they used the MoCA to categorize participants as with or without MCI instead of using a comprehensive neuropsychological test. They also compared key fall risk factors for women with and without MCI instead of the actual incidences of falls. Coppin et al. (2006) discovered a limitation to their study to be that the only test used to measure executive function was the TMT. Although this is a widely used test, other measures could be used that provide more comprehensive evaluations of executive functions. Westlake and Culham (2007) found a limitation to be that the participants were healthy adults that did not have balance impairment, and these people may have benefited more. Another limitation found was the education group did not get tested again at the 8-week follow up. Littbrand et al. (2006) used scales to evaluate the intensity of strength and balance exercises were not tested for interrater reliability. Another limitation to the study was they excluded people with an MMSE score of less than 10 or those that needed more help with more than one person getting out of a chair (Littbrand et al., 2006). Ball et al. (2002) was not able to find enough functional decline in all groups, therefore they were not able to observe training effects on everyday functions. Alpert et al. (2009) also found the small sample size to be a limitation. The subjects were senior adults that had a tendency to be involved in other healthy practices and socialization, causing a limitation to generalize to the elderly of all populations.

To sum it all up, older adults that have a higher cognitive function can benefit from different forms of exercise. When someone is asked to perform a task that involves attention to be focused on something else, this may increase his or her risk of falls. Older adults with mild cognitive function are the most at risk for falls, so balance training should be implemented into their daily activities.

Fear of Falling Impact on Decreasing Balance Confidence and Risk for Falls

Balance confidence is an important role in one's ability to balance. Without this confidence, the likelihood of falling increases. Hatch et al. (2003) examined the relationship between balance confidence, balance performance, and functional mobility. Another purpose was to explore the extent to which balance confidence can be defined by measures of balance and functional mobility. Balance confidence is important in older adults because fear of falling can have adverse effects on physical function. This study used 50 elderly adults between the ages of 65 and 95 years old. All participants performed two physical performance measures including The Berg Balance Scale (BBS) and the Timed Up & Go Test (TUG). The participants also completed the Activities-Specific Balance (ABC) Scale to assess balance confidence.

Results from this study revealed a strong association between ABC Scale and BBS scores (r = .752), between ABC Scale and TUG scores (r = .698), and between TUG and BBS scores (r= .810). The BBS score was associated with 60% of the variance in the ABC Scale scores and was the major determinant of balance confidence between all variables tested. Fear of falling also explained balance confidence, indicating that people who report reduced balance confidence, fear they are likely to fall due to the balance limitations. However, functional mobility and subject characteristics did not contribute to balance confidence. Balance impairments do appear in people with lower confidence in their balance ability and play an important role in determining balance confidence (Hatch et al., 2003).

This can also be seen in a study conducted by Cyarto, Brown, Marshall, & Trost (2008) that compared changes in balance confidence and balance ability resulting from three exercise interventions (home-based resistance and balance training (RBT); group-based RBT and group-based walking), and the concomitant relationships between change in balance confidence and change in balance ability. This study used 167 independent-living older adults over the age of 65 years old that were assigned to one of three exercise groups. Each group was asked to exercise two times a week for an hour in a 20-week program. The three exercise groups had different goals to work on. The first group was called the 'Have a Try' (HAT), which was the home-based program that was designed to enhance muscular strength, balance and flexibility. The second group was called the 'Come Have a Try' (CHAT), which performed the exercise program as the HAT group, just in a group format. The last group was called the 'Come Have a Try-Walking' (CHAT-W) which consisted of groups of 10 participants that walked outdoors at their own pace and did cool-down stretches indoors afterward. In order to test balance confidence on all participants the Activities-Specific Balance Confidence (ABC) Scale was used. Tandem and one-leg stands were used to measure static balance, while the 8-foot up and go test was used to measure dynamic balance and agility. All intervention effects were tested using a mixed model repeated measures ANOVA. Pearson correlation was used to determine the level of association between changes in the measures of objective balance and balance confidence (Cyarto et al., 2008).

Results unveiled there were significant between-group differences in the before to after change in ABC scores: HAT group improved more than CHAT ($p < .05$) and CHAT-W ($p < .05$). The median ABC score increased significantly in the HAT group ($p < .05$) but decreased in the CHAT-W group ($p < .05$) at the end of the program. The CHAT group showed more significant improvements in net change for one-leg stance than the HAT group ($p = .05$). The difference between the CHAT and HAT groups in tandem stance was close to significant ($p = .07$). Mean scores for the tandem and one-leg stand and timed up and go test improved significantly over time in the CHAT group, tandem ($p < .01$), one-leg ($p < .01$), up and go ($p < .01$). Change in ABC score was not significantly correlated with a change in tandem or one-leg balance test scores ($r = .04$, $p = -.01$). However, there was a weak but significant correlation between change in ABC score and change in up and go test score ($r = -.21$, $p < .01$). Authors found that the participants in the group-based resistance and balance training improved their static balance scores more than the home-based group. However, there was a greater improvement in balance confidence in the home-based group. The home-based group had increases in confidence to do everyday living activities, but still felt cautious in performing the balance testing. The group-based participants had more interaction with the instructors, which pushed them harder during the training and got encouragement, unlike the home-based group. Balance confidence was most improved in home-based resistance-training program. However, balance ability was most improved in the group-based resistance-training program (Cyarto et al., 2008).

Hatch et al. (2003) used a sample that was relatively healthy which may not represent the general older adult population. Another limitation was the way falls were defined. It did not differentiate among those that may experience instability and loss of balance during daily activities but did not fall to the ground. Cyarto et al. (2008) did not recruit a non-exercise control group causing the between-group differences not to be noticed. Field tests for balance were used, which may be limited by ceiling effects. Improvements in muscle strength and gait impairment could have resulted in an increase in confidence, but not an increase in balance ability (Cyarto et al., 2008).

It can be concluded that older adults with balance impairment are more likely to have lower balance confidence. Balance training interventions should be implemented in order to improve one's confidence. Balance confidence may also be able to be improved by improving muscle strength.

Wii Fit as a Way to Decrease Falls Risk

A new way to develop a balance training intervention is by using the Nintendo Wii Fit Balance Board. Research is starting to show that the Wii Fit may be a great tool for balance for older adults. Clark and Kraemer (2009) looked at outcomes from using the Wii bowling as an intervention with an elderly nursing home patient that has an unspecified balance disorder. For this case study an 89-year-old female that lived in a skilled nursing facility (SNF) was recruited to participate. Multiple assessments were used to measure balance and confidence before and after the intervention. These included the Berg Balance Scale (BBS), the Dynamic Gait Index (DGI), the Timed Up and Go Test (TUG), and the Activities-Specific Balance Confidence

(ABC) Scale. The Mini Mental State Examination (MMSE) was used only before the intervention. The intervention consisted of six Wii bowling sessions of 60 minutes each, for a total of six hours over a two-week period. The researchers chose this intervention because it involved the visual, somatosensory, and vestibular systems, which are involved in maintaining balance.

Results revealed that the participants BBS score improved by five after the intervention. The participant also increased the DGI by two points. The time to complete the TUG was improved by reducing the amount of time it took to complete by 4.4 seconds. Lastly, the participants ABC Scale score increased by 2%. The participant reported feeling like they had more spring in their step and also did not feel like they needed to shuffle their feet while walking anymore. It can be concluded that from this intervention improvements in balance have been seen. There is a possibility that with this type of intervention improvements in balance dysfunction and reduction in fall risks can be seen (Clark & Kraemer, 2009). Another thing the Wii Fit Balance Board may be good for is balance rehabilitation in older adults in place of physical therapy.

Lange et al. (2010) designed and assessed the usability of an interactive game focused on training weight shift in a controlled and customized manner. This study recruited four males over the age of 60 years who had a stroke. The participants played the Panda 3D game engine using the Nintendo Wii Balance Board. This game requires the participant to shift their weight on the balance board from one leg to the other to avoid falling rocks and collect falling stars by moving a balloon. The participants played the game for a total of four to ten minutes. Once the game was over the participant filled out a usability questionnaire, which also contained the Borg Scale of perceived exertion.

Results showed that the participants with stroke perceived that the game was engaging but just as strenuous as physical or occupational therapy for balance training. This research provides support for developing a game that caters specifically to key requirements for balance rehabilitation (Lange et al., 2010). Fall risk assessment is another measurement one can look at using the Wii Fit.

Yamada et al. (2011) determined if the Wii Fit program was an accurate tool to be used for fall risk assessment in healthy, community-dwelling older adults. Forty- five older women volunteered for this study. All participants had to meet the following criteria: 65 years or older in age, community-dwelling, independently ambulatory, visited a primary physician in the last three years, had a sum score of five on the Rapid Dementia Screening Test (RDST), and had minimal hearing and visual impairments. All participants played two games on the Wii Fit, which were the “Basic Step” and “Ski Slalom”, which were modified in order for the participants to be sitting while playing. Locomotive functions were tested in all subjects by the 10-m walk test under single task (ST) conditions, 10-m walk test under dual task (DT) conditions, Timed Up and Go (TUG) test under ST conditions, TUG test under DT conditions, DT lag of walking and TUG, and Functional Reach (FR) test. Falls were recorded using a questionnaire that reported the date, number, characteristics, and consequences of the fall.

Results revealed that the nonfaller group showed a significant difference in the Basic Step ($p < .001$) and a non-significant difference in the Ski Slalom ($p = .453$). The relationship between the Basic Step and physical function was not significant ($p > .05$), as well as the Ski Slalom ($p > .05$). There was also no significant relationship between the Basic Step and Ski Slalom. A score of 111 on the Basic Step was considered the fall-related cutoff point. Authors concluded that the Basic Step has a high generality and is useful in community-dwelling older adults as a fall risk assessment (Yamada et al., 2011).

Body balance is an important skill for all human beings and it decreases with increasing age. Body balance is especially important in the study by Kliem and Wiemeyer (2010) where they looked at the differences between a traditional training program and a training program on the Nintendo Wii Fit Balance Board. This study used 22 volunteer participants that were between 18 and 67 years old. They were split into two groups; one group went through a traditional balance program, while the other group trained using the Wii Fit Balance Board. Both groups participated in balance training exercises three days a week for three weeks. They were tested before and after the intervention. The variables tested were the Star Excursion Balance Test (SEBT), a single-leg balance test on the Posturomed device (ball handling), a dynamic balance test (DBT), and two game tests on the Wii (Ski Slalom and Balance Bubble). These tests were chosen in order to look at the transfer between virtual and real movements, and the transfer from exercise to non-exercise tests. The Wii group treatment consisted of three games (Ski Slalom, Table Tilt, and Tightrope Walk) that they played each time for about three minutes. The traditional group treatment consisted of four varying levels of balance exercises (Squat, Ball-handling, Rotary board, and Ball-cycling) that used specific training devices.

Results showed that both groups improved balance performance in four of five tests. The Wii group showed a significant improvement in the Ski Slalom ($p = .035$). The traditional group showed a significant improvement in the SEBT ($p = .007$) and ball handling ($p = .001$). The Nintendo Wii Fit could be a useful tool for training balance in prevention of falls for adults (Kliem & Wiemeyer, 2010).

The Wii Fit can also be a tool for many other things besides balance. Nitz, Kuys, Isles, & Fu (2010) evaluated the response to participation using the Wii Fit Program. The program was designed to improve balance, flexibility, strength, reaction time, and somatosensation. This study used eight healthy women between the ages of 30-58 years old. The intervention consisted of two 30-minute sessions per week for a 10-week period of time. The program consisted of yoga, aerobic, balance, and strength activities. The subjects were tested before and after the intervention. The tools used for measuring balance and functional mobility were the Timed Up & Go (TUG), Timed Up & Go cognitive (TUG_{cog}) and the step test. Balance was measured using the modified Clinical Test for Sensory Integration of Balance (mCTSIB) and limits of stability (LOS) program of the Basic Balance Master to measure reaction time, as well as balance. The 6-minute walk test was used to determine submaximal cardiorespiratory fitness. Flexibility was determined by measuring the ankle dorsiflexion range. Subjects self-reported their well being based on a 5-point Likert scale. The overall adherence to the program was 70%, which equaled out to be 112 sessions out of 160 (Nitz et al., 2010).

Following the Wii Fit intervention, results showed that TUG_{cog} improved ($p = .09$) unilateral stance for both limbs increased ($p < .05$) lower limb strength increased ($p < .02$) and body weight reduced ($p = .09$). Self-reported well being did not change over the intervention. The subjects walking 50 meters further in the 6-minute walk test improved fitness. The two things that improved the most after the Wii Fit intervention were balance and strength. It can be concluded that fitness, balance, reaction time, flexibility, strength, and somatosensation may not have improved, but they were impacted from the intervention (Nitz et al., 2010).

Clark and Kraemer (2009) found a few limitations due to the fact that it was a case study. One limitation was that only one physical therapist examined, provided the intervention, and re-tested which could cause bias in the outcomes. Another limitation is that the results cannot be generalized to other patients receiving physical therapy interventions. There were no conclusions about whether or not the intervention improved overall functional abilities in the subject (Clark & Kraemer, 2009). Lange et al. (2010) also found the small sample size to be a limitation because it cannot generalize to the large population of stroke survivors. The questionnaires used limited the feedback that participants were able to provide. Yamada et al. (2011) found the Basic Step game on the Wii Fit was not able to predict falls in older adults because the study was based on previous fall experiences. The fall experiences may have reported wrong due to the fact that participants were supposed to accurately recall them. This group of participants showed greater interest in health issues and risks of falls and were more motivated, making it hard to generalize to the general elderly population (Yamada et al., 2011). Kliem and Wiemeyer (2010) found a major limitation to the study to be the lack of motivation from the older adults to play the video games like younger adults have. A limitation in the study by Nitz et al. (2010) was the small sample size as well as the short length of the study and the lower intensity of training.

Considering all of this, the Wii Fit can potentially be used as an effective training method in order to improve balance in older adults. Studies should look at the long-term effects of training on the Wii Fit in order to assess if it is a true method. Balance may not be the only thing that can be improved from Wii Fit training, but also strength, flexibility, reaction time, and many others.

Summary

The purpose of this literature review was to further the knowledge of why balance plays an important role in older adults that have a high risk of falls. These topics were specifically examined because they help us understand why balance training programs need to be implemented in older adult's daily routines. It is very important to improve balance to decrease the risk of falls, as well as cognitive function. Also, with increased balance improved balance confidence can be seen.

Chapter Three: Methods

Participants

An application was filled out to receive Institutional Review Boards (IRB) approval from the University of Central Oklahoma (Appendix A). Independent living older adults over the age of 65 were recruited after a site was selected and approval from the IRB was received. Recruitment of subjects was conducted by posting flyers and contacting the activity director at a retirement community. In a study by Ullman, Williams, Hussey, Durstine, & McClenaghan, (2010) the calculated sample size for the Activities-Specific Balance Confidence Scale using a slightly different exercise was 140 subjects, $\alpha = .05$, $1 - \beta = .80$, Cohen's $d = .27$ (Cohen, 1988). There are no cited sample sizes for the Trail Making Test.

After the individuals signed an Informed Consent Form (Appendix B), they were required to take the Exercise Assessment and Screening for You (Appendix C). Participants were asked their age on the Participant Information Sheet (Appendix D).

The Exercise Assessment and Screening for You (EASY) is a pre participation medical screening tool. Any participant that has responses, which indicate a condition where medical clearance is needed, will be required to obtain written medical clearance before participating. The EASY form provides guidance in making this decision based on the answer the participants give for each question. For example, if a participant answers yes to question #1 and it is a new problem, they are instructed to speak with their health care provider (ie. medical clearance). If the person answers yes to question #1 and it is not a new problem, they are free to begin the exercise program. Each question provides guidance regarding medical clearance. Wherever the EASY form indicates that the person needs to speak to their health care provider, a written and signed medical clearance on whatever form is used by the primary physician was required. If the participant requires medical clearance and they fail to receive it, they were not allowed to participate in the study. There were no participants in the treatment group that required medical clearance. There were no participants that were not allowed to participate in the study due to not turning in a medical clearance from their physician.

Instrumentation

Activities-Specific Balance Confidence (ABC) Scale. The ABC Scale is a questionnaire developed to measure the psychological impact of balance impairment and/or falls (Appendix E). The subject is asked to rate their confidence on performing 16 activities on a scale of 0 to 100%. Zero is no confidence where 100 is complete confidence, without losing balance or falling (Pal, Hale, & Skinner, 2005). An average score of all 16 items is then calculated. The test-retest reliability is found to be very high, $r = 0.89$, over a 1-week period, and after a five-month period, $r = 0.80$ (Pal et al., 2005). Through the relationships found between the ABC Scale and other measures (Survey of Activities and Fear of Falling in the Elderly, Study 36-item Short-Form 36 Survey, and Geriatric Depression Scale), the ABC Scale showed evidence of concurrent validity with scores of $r = .65$, at baseline, and $r = .61$ after 12 weeks (Talley, Wyman, & Gross, 2008).

Trail Making Test (TMT). The TMT is a neuropsychological test of visual attention and task switching that consists of two parts (Appendix F). The subject must connect a set of 25 dots as fast as possible while maintaining accuracy. Part A consists of the subject connecting the numbers (1-25) in sequential order, while Part B consists of the subject switching between numbers (1-12) and letters (A-L). The time taken to complete the test is the primary performance measurement (Sanchez-Cubillo et. al, 2008). The TMT test did not show evidence of concurrent validity between Part A and Part B with a correlation of $r = .36$ (Sanchez-Cubillo et. al, 2008). This indicates that the parts do not measure the same cognitive function. Part A measures the participants' speed, where as Part B measures executive function. Stewart (1992) found the inter-rater reliability for Part A was high, r = .94, and Part B inter-rater reliability was high, r = .90.

Center of Mass (COM). The COM is a test to measure a person's mass in one location. This was tested using the Nintendo Wii Fit Body Test. The participant was asked to stand with their feet shoulder width apart and to release the tension in their shoulders while relaxing and standing still. The balance board calculated the participants' center of mass. It also traces the shift in the center of gravity of the participant. This then calculates the percentage of weight put on the right side and the left side. The test-retest reliability with-in device (r = .66- .94) and between-device (r = .77- .89) were close to excellent when tested against a laboratory-grade force platform (Clark, Bryant, Pua, McCroy, Bennell, & Hunt, 2009). The concurrent validity was excellent (r = .77- .89) across balance tasks and testing sessions (Clark et al., 2009).

Procedures

The primary investigator began the research study by developing a balance training program using the Nintendo Wii Fit. Participants were placed into a treatment group or a control group. The balance training program was developed for the treatment group. This program consisted of the participants playing five games on the Nintendo Wii Fit. These games included the Soccer Heading, Table Tilt, Ski Slalom, Balance Bubble, and Penguin Slide. For the Soccer Heading the participant was asked to shift their weight to the left and right in order for the character to hit the soccer balls. The participant tried to avoid shoes and panda bears, which deduct points if hit. The participant was asked to focus on shifting their weight through their feet. For the Table Tilt the participant was asked to shift their weight from left to right and back to front in order to roll the balls into the holes, without dropping them off the sides. For the Ski Slalom the participants were asked to shift their weight from left to right in order to make the character go in between the flags. Leaning forward caused the character to go faster, but they were asked focus on getting between the flags to get points. For the Balance Bubble the participants were asked to shift their weight on the balance board in order to move the bubble through a hazardous course. Leaning further made the bubble go faster. The participant worked on avoiding rocks, riverbanks, and bees, which caused a deduction in points if hit. For the Penguin Slide the participants was asked to shift their weight from left to right to have the penguin move on the iceberg. The participant wanted to try and keep the penguin on the iceberg and not let him slide off. The subject was asked to lean far enough to the side to get the penguin to the edge and flip him up to catch a fish, while staying on the iceberg.

The intervention was implemented for eight weeks. This comprised two 25-minute sessions per week. During the 25-minute session participants played the five games multiple times, where they trained alone. Also, during the session all results from each game were recorded on the Nintendo Wii Fit Balance Games Results Collection Sheet (Appendix G). The ABC Scale was utilized in order to test balance confidence. The Trail Making Test was used to test cognitive function. Testing was completed initially, at baseline, and again at the end of the study. The control group took part in pre- and post-testing. The primary investigator scored all tests completed by the subjects.

Design and Analysis

This study looked at whether a balance training program utilizing the Nintendo Wii Fit would improve balance confidence and cognitive function in older adults. The independent variables were time (pre and post) and group (treatment and control). The dependent variables were balance confidence and cognitive function. The PASW 18 system was used to analyze all collected data. A 2 X 2 ANOVA with repeated measures was conducted for the ABC Scale and the TMT test to determine if the balance training program had an effect on balance confidence and cognitive function. The level of significance (α) was .025, which was adjusted to reduce Type 1 error rate. The null hypothesis stated that the balance training program on the Nintendo Wii Fit will not affect balance confidence and cognitive function in older adults.

Chapter Four: Results

The purpose of this study was to evaluate the effects of a balance training program using the Nintendo Wii Fit on balance confidence and cognitive function in older adults. Descriptive statistics and effect sizes were calculated for ABC, TMT Part A, TMT Part B, COM and can be found in Table 1. There were two outliers found in the data set. Both of them (#1 and # 9, Figure 1) were removed because they were above the cut off time on the TMT Part A and Part B (Corrigan & Hinkeldey, 1987). Pre and post-testing were conducted for ABC, TMT Part A and Part B, COM, and Nintendo Wii Fit Balance Games.

The mean for ABC Scale at pre testing was a score of 81.56 ± 22.29% for the treatment group. The mean for the control group was a score of 85.82 ± 7.68%. Both means for ABC Scale at pre testing were higher than at post testing. At post-testing the treatment group had a mean score of 76.75 ± 25.60%. The control group had a mean score of 83.49 ± 11.94%.

The mean for TMT Part A at pre testing for the treatment group was 31.67 ± 7.94 seconds, while the mean for the control group was 20.50 ± 2.08 seconds. The mean time from pre to post went up indicating decreased performance. At post-testing the treatment group had a mean of 33.83 ± 12.09 seconds, and the control group had a mean of 19.75 ± 3.10 seconds for TMT Part A.

For TMT Part B the mean time at pre testing was 79.33 ± 37.92 seconds for the treatment group, and 53.00 ± 16.83 seconds for the control group. The mean time from pre testing to post testing went up. The treatment group had a mean time of 87.50 ± 33.60 seconds for the TMT Part B, whereas the control group had a mean time of 40.50 ± 13.33 seconds.

The mean for TMT difference between Part A and Part B at pre testing was 47.67 ± 34.22 seconds for the treatment group. The control group had a mean time of 32.5 ± 15.29 seconds at pre testing. The treatment group had an increase in time to complete the TMT from pre to post test, while the control group had a decrease in time to complete the TMT. The mean for the treatment group at post testing was 53.67 ± 23.51 seconds. The mean time for the control group at post testing was 20.75 ± 13.10 seconds.

The COM was measured at pre and post testing. COM was measured by giving a percentage for center of mass left side (COML) and center of mass right side (COMR). The mean for COML at pre testing in the treatment group was 54.95 ± 4.14%, where the mean for the control group was 47.95 ± 3.48%. The mean for COMR at pre testing for the treatment group was 45.05 ± 4.14%, while the control group had a mean of 52.05 ± 3.478%. There was a shift in COM from pre to post testing. The mean for the COML at post testing for the treatment group was 44.93 ± 4.70%, and the mean for the control group was 50.10 ± 3.95%. The mean at post testing for COMR for the treatment group was 55.07 ± 4.96%, with a mean of 49.90 ± 3.95% for the control group.

Independent *t*-tests were calculated to check for differences between groups at pre testing (Table 2). For all variables, the groups were not significantly different at pre-test.

Balance Confidence

It was predicted that those in the treatment group would improve balance confidence as assessed by the ABC Scale more than those in the control group. A 2 X 2 ANOVA with repeated measures showed no significant group by time interaction effect for balance confidence ($F = 1.16$, $p = 0.31$). Similarly, the time effect was non-significant ($F = 2.48$, $p = .146$). There was also a non-significant group effect ($F = 0.44$, $p = 0.52$). Results for these statistical analyses of ABC scale can be viewed in Table 3; the time effect can be viewed in Figure 2. Balance training using the Nintendo Wii Fit did not significantly change balance confidence. Both the treatment group and control group had small effect sizes (*d* = 0.22, *d* = 0.30, respectively), which decreased their balance confidence.

Cognitive Function

It was also predicted that those in the treatment group would improve cognitive function more than those in the control group. A 2 X 2 ANOVA with repeated measured revealed no significant group by time interaction effect for the TMT Part A test ($F = 0.38$, p=0.56). Also, the time effect was non-significant ($F = .09$, $p = .77$). The group effect approached significance (F=7.03, $p = 0.03$). Results for these statistical analyses of TMT Part A can be viewed in Table 4; the time effect can be viewed in Figure 3. Balance training with the Nintendo Wii Fit did not significantly change time to complete the TMT Part A. The treatment group had a small effect size (*d* = -0.27), which had an increase in time to complete TMT Part A. The control group also had a small effect size (*d* = 0.36) with a slight decrease in time to complete TMT Part A.

Another 2 X 2 ANOVA with repeated measures indicated no significant group by time interaction effect for the TMT Part B test ($F = 2.58$, p= 0.15). Similarly, there was a non-significant time effect ($F = .11$, $p = .75$). The group effect was also non-significant (F=4.09, p=0.08). Results for these statistical analyses of TMT Part B can be viewed in Table 5; the time effect can be viewed in Figure 4. Using the Nintendo Wii Fit for balance training did not significantly change executive function. The strongest effect size (TMT Part B) was seen in the control group (*d* = 0.74), which decreased their time to complete TMT Part B. There was a small effect size in the treatment group (*d* = -0.22) with an increased completion time for TMT Part B.

The difference between TMT Part A and TMT Part B was calculated by subtracting the time in seconds to complete TMT Part B from the time to complete TMT Part A. A 2 X 2 ANOVA with repeated measures was then used and showed no significant group by time interaction effect ($F = 1.94$, $p = 0.20$). Likewise, the time effect was non-significant ($F = .20$, $p=.66$). There was also a non-significant group effect ($F = 2.68$, $p = 0.14$). Results for these statistical analyses of TMT difference can be viewed in Table 6; the time effect can be viewed in Figure 5. The treatment group had a small effect size ($d= -0.18$), which was an increased time to complete the TMT. There was a large effect seen in the control group ($d = 0.77$) with a large decrease in time to complete the TMT.

Center of Mass

Center of mass was measured on the Nintendo Wii Fit. A 2 X 2 ANOVA with repeated measures revealed a group by time interaction effect that approached significance for COML ($F=5.64$, $p=0.04$). Also, there was a non-significant time effect ($F = 4.01$, $p = .07$). Additionally, the group effect was non-significant ($F = 0$, $p = 0.99$). The treatment group had a shift in their weight from the left to right side. The control group did not change their COM. Results for these statistical analyses of COML can be viewed in Table 7; the time effect can be viewed in Figure 6. Balance training on the Nintendo Wii Fit did not significantly change center of mass for the left side.

COMR was calculated with a 2 X 2 ANOVA with repeated measures as well and showed a group by time interaction time effect that approached significance ($F = 5.64$, $p=0.04$). There was also a non-significant time effect ($F = .07$, $p = .07$). A non-significant effect for group was seen as well ($F = 0$, $p = 0.99$). The control group had a slight decrease in weight on the right side. The treatment group had a major shift from the left side to the right side. Results for these statistical analyses of COMR can be viewed in Table 8; the time effect can be viewed in Figure 7. Using the Nintendo Wii Fit for balance training did not significantly change center of mass for the right side.

Nintendo Wii Fit Balance Games

The results from each game the participants played were recorded from every session. The means from the first week and the last week are reported in Table 9. These results were then analyzed using a dependent *t*-test to observe if there were any differences from the beginning of the intervention to the end of the intervention. The games played were the Balance Bubble (BB), Table Tilt (TT), Soccer Heading (SH), Penguin Slide (PS), Ski Slalom-misses (SSmisses), and Ski Slalom-time (SStime). There was a significant improvement in BB scores from the beginning and end of the intervention ($p = .006$). There was a significant increase in SH scores from the beginning and end of the intervention ($p = .040$). SSmisses had a significant decrease in how many flags were missed from the beginning and the end of the intervention ($p = .001$). SStime had a significant decrease in the time to complete the course from the beginning and the end of the intervention ($p = .001$). Although not all of the games had significant differences, there were improvements were made in each.

Chapter Five: Discussion

Balance confidence and cognitive function were investigated with a balance training program using the Nintendo Wii Fit. Results from the study show that using the Nintendo Wii Fit is not a good training method to improve balance confidence or cognitive function in older adults. However, there were improvements in the scores on the games played by the participants. It is believed that the ABC Scale is a reliable way to test balance confidence in older adults (Pal et al., 2005). It is also believed that the TMT is a valid way to test cognitive function, more specifically speed and executive function, in older adults (Stewart, 1992). The Nintendo Wii Fit balance training did not improve balance confidence or cognitive function.

Balance

There are multiple risk factors for falls in older adults. These can be aspects such as gait problems, dizziness, muscle weakness, and balance problems (Rubenstein, 2006). These risk factors need to be improved before one can gain confidence in their balance. Balance, more specifically dynamic balance, should be targeted first. Since dynamic balance is controlling the center of mass while in motion (Rose, 2010), it is essential to improve this skill to reduce the risk of falls. Providing balance training programs that target more than standing balance would be ideal for one with a high fear of falling. Increasing dynamic balance could increase the person's balance confidence as well, because they would have to move while training balance. Another way to reduce falls is by improving strength in the lower body (Judge et al., 1995). Increasing lower body strength can be done with resistance training, or simple tasks like chair stands and walking. These exercises are simple things that can be added to a balance training program. Adding in lower body exercises could increase balance confidence in an individual because they are able to walk better with improved lower body strength. This study did not target training dynamic balance with the games played. Also, this study did not train strength in the lower body. However, for this study, it was important to measure balance to see if there were improvements because it can be related to one's balance confidence.

Balance Confidence

It was believed that balance confidence would improve following a balance training program using the Nintendo Wii Fit. Statistically both of the groups had the same ABC Scale scores; however, the control group (85.82%) had a slightly higher score than the treatment group (81.56%). After the intervention, both groups lowered their confidence, the treatment group (76.75%) more than the control group (83.49%). Nitz et al. (2010) found from a study using the Nintendo Wii Fit intervention that the most improvements were seen in balance and strength. Other variables did not improve, but everything was impacted by the intervention (Nitz et al., 2010). This can be a true statement about this study, as well. Balance confidence and cognitive function may not have improved, but they were impacted. The participants standing on a balance board for the games may have caused their confidence to decline. They might have become more aware of their balance and possibly how poor it is from standing on the balance board. Becoming more aware of their balance could be a potential reason as to why balance confidence declined for most of the treatment group in the study. Also, some games required a lot of attention and could have caused the participants to lose confidence. Older adults that are given a task that requires more attention and combine it with cognitive tasks are more likely to have a greater fear of falling (Lamoth et al., 2011).

Hatch et al. (2003) found that those who report a lower balance confidence fear they are likely to fall due to balance limitations. Standing on the balance board could have posed as a limitation to this group of participants because they were not used to it. All participants were allowed to have a walker in front of them while playing the games. Speculatively, this would make the participants feel more confident in their balance. Most of the participants did not use the walker unless they needed to. The participants commented that they felt like it was in the way most of the time and it helped them to “cheat” on certain games because they were able to lean on it so much. The participants could have gotten too comfortable with having the walker in front of them, which could have caused a decrease in balance confidence. Cyarto et al. (2008) found that balance confidence to complete everyday living activities has improved after a resistance training program. Adding in resistance training with balance training may certainly improve one’s balance confidence. The resistance training could improve the strength of the hips, knees, and legs, which is important to target when trying to improve someone’s balance. Improving the persons balance would then in turn improve their balance confidence. Even though this study did not include resistance training, there were improvements seen in the balance of participants without the corresponding increases of balance confidence.

Cognitive Function

It was believed that cognitive function would improve after an eight-week balance training program with the Nintendo Wii Fit. The control group had a shorter time to complete Part A of the TMT than the treatment group at pre- and post-testing. The control group also had a much shorter time to complete Part B of the TMT than the treatment group at pre-and post-testing. This could have been due to the fact that the control group was higher functioning than those in the treatment group. Those in the treatment group (80.57 ± 10.89 years of age) were slightly older than those in the control group (71.80 ± 6.57 years of age), which could also have contributed to the results.

Cognitive function requires one to be aware of or comprehend tasks. The game called Soccer Heading on the Nintendo Wii Fit presented the most challenge. The participants had a hard time understanding they were only supposed to shift the weight in their feet and not the upper half of their body. The participants noted throughout the program they thought there was a delay in the character when they shifted their weight. This game trained the participants' cognitive function because they were trying to focus on objects and determine which one to hit and which ones to avoid. Older adults that have a task that requires more attention and are combined with cognitive tasks are more likely to have a higher fear of falling (Lamoth et al., 2011). Rapport et al., (1998) found that people with high executive function are less likely to act in a way that could potentially result in a fall. Most of the participants in this study did not have poor executive function; however, they still did not feel confident they would not lose balance when doing daily activities. Since they all had relatively high executive function scores, they were not likely to act in a way that would cause them to fall.

Cognitive function has multiple characteristics, with one of them being executive function. These characteristics are things like memory, reasoning, perception, and thinking. Executive function was the only aspect of cognitive function that was tested, as well as speed. Other tests of cognitive function, unlike the TMT, may test these aspects, which could be an important variable to assess in older adults. As a person ages, they tend to decrease or lose these characteristics. This could also lead to the fear of falling many older adults have. Testing their memory or reaction time might have led to significant results. These two components of cognitive function were constantly trained when playing the Nintendo Wii Fit games. Since memory and reaction time were trained throughout the eight weeks, this might have led to greater improvements from pre- to post-testing. These aspects could be affected more easily from a short-term program.

Center of Mass

Center of mass was measured on the Nintendo Wii Fit balance board in order to get a measure of balance. This was important in order to see any changes in balance. Most participants in the treatment group at pre testing stood slightly to their left (COML= 54.95%, COMR= 45.05%). At post testing they shifted their weight to the right side (COML= 44.93%, COMR= 55.07%). There was no obvious reason for why this happened. The control group did not have any major shifts from pre testing (COML= 47.95%, COMR= 52.05%) to post testing (COML= 50.10%, COMR= 49.90%). The fact that the treatment group became more aware of their balance because of playing games on the balance board, which might have caused them to overcompensate, is the reason that makes the most sense for the shift. The control group did not change any outside activities they were already participating in; this might have contributed to the fact that they did not have a major shift.

Dynamic Balance Versus Weight Shifting Balance

When playing the games on the Nintendo Wii Fit the participants were working on balance by weight shifting. Dynamic balance was not trained while playing the games. Slipping, tripping, or stumbling are seen as the most common cause of fall injuries (Schiller et al., 2007). These are all done while in motion and not when standing still. Therefore, both static and dynamic balance would be important to measure when using the Nintendo Wii Fit as a balance training tool. Dynamic balance must be improved in order to reduce the number of falls in older adults. While the Nintendo Wii Fit trains balance, it trains balance through weight shifting in a stationary position, which would not be considered dynamic balance.

Nintendo Wii Fit Balance Games

A major improvement in the games played from Week One to Week Eight was seen in all of the participants. The largest improvements were seen in the Balance Bubble, Soccer Heading, and Ski Slalom. These three games seemed to be the most challenging for the participants. Balance Bubble required that they keep their weight in the middle and to not shift too much to the right or left, which was difficult. Ski Slalom required the participants to make it through flags while maintaining a steady speed in order to complete the course with the least amount of misses. The participants were very determined to beat their highest scores each time they played. Dependent *t*-tests revealed the Balance Bubble ($p = .006$), Soccer Heading ($p = .040$), and Ski Slalom flag misses ($p = .032$) to have a significant difference from the beginning of the study compared to the end of the study. Although the participants did not improve in balance confidence or cognitive function, there were improvements still seen over the eight weeks. The participants felt more comfortable with the games because they understood how to play each of them. Playing two times a week for 25 minutes allowed them to play each game multiple times in a session. This helped them become more confident in playing the games.

Strengths

The main strength of this study was the improvement in the performances of the Nintendo Wii Fit games seen in the participants. Once they felt comfortable playing the games, they challenged themselves to get better each time. Each time the participants came in for their session they were determined to improve from the previous visit. All participants were able to walk on their own without an assisted device, so they did not have to rely heavily on the walker in front of them while they played the games. Sometimes, however, the walker proved to be an extra piece of equipment to help them get a better score on certain games. The participants tried not to use the walker because they did not like knowing it helped them get increases in their scores.

Another strength was having good compliance from the participants. The group of participants was consistent with attending each session scheduled, or making it up if they were not able to make their scheduled time. One participant missed four sessions because of an injured back. A couple of participants went out of town, but were able to make up the session they missed. All other participants made every session. Word of mouth feedback from the participants about the program indicated that they enjoyed playing the games, which could have influenced compliance. With the program being eight weeks, it was not too long for them to commit their time. This group of participants was also motivated to improve in all of the games and to improve their balance. This could have also been a factor for good compliance.

Another strength to note is the fact that the participants were enjoying themselves throughout the study. The participants had fun cheering each other on to get a good score. All of the participants were great motivators of each other. Seeing the participants laugh and have a good time showed that they were enjoying the intervention. This could be important to note for future studies that the participants enjoyed playing the balance games on the Nintendo Wii Fit. The Nintendo Wii Fit might be a valuable tool to improve balance or other factors for older adults and deserves further study.

Limitations

Multiple limitations exist in this study. The first is that the sample size was very small. This could be due to the fact that recruitment for participants could only be completed at one independent living center. The researcher was not able to recruit from any other sites, making it difficult to recruit sufficient participants. Other studies with a Nintendo Wii Fit intervention have also had a small sample size (Nitz et al., 2010). This could be because older adults are not familiar with how to use the Nintendo Wii Fit. If there were training sessions on how to use the Nintendo Wii Fit, additional older adults might be willing to participate in research studies. One participant in the treatment group had an injury and had to drop the study. One participant in the control group was not able to complete post testing. These two participants also contributed to the small sample size.

The second is that the intervention was only eight weeks long. There might have been improvements seen if the study could have been longer. Nitz et al. (2010) created a 10-week program using the Nintendo Wii Fit where they found improvements in balance and strength after completion of the balance training. It can be difficult to get an older adult to commit their time for that long. Many older adults are retired, which means they like to travel or participate in activities within the community. Sometimes older adults are afraid to commit to something that is long term because they do not know what they will be doing down the road. It might be easier to recruit participants that are already committed to another program that is multiple weeks long, or someone that just completed a program because they might be more willing to commit their time if already done once.

During the intervention, one participant had a hard time seeing the television making it hard to play the games to the best of her ability. The participant also had a hard time with the TMT because it requires vision, which resulted in the researcher having to remove the data. This contributed to the smaller sample size. In future studies it would be important to make sure participants do not have any eye impairments because of how much eye sight is needed while playing the games.

Another limitation to note is that the participants were willing to play all of the games, but not all of them enjoyed each game. They were required to play each game at least one time during the 25-minute session. This was always accomplished and some games were played five or six times depending on how they felt about the game on that day. Some games were more difficult than others, causing the participants to not want to play each multiple times in a session.

Another limitation to this study is the participants not being able to complete a full 25-minute session. They were not always able to complete the full session because of being ill, needing to be somewhere else or having pain in the back, legs, or feet. Participants were allowed to take breaks throughout the 25-minute session if they needed it and they were allowed to stop early if they asked. Twenty-five-minute sessions seem to be a good amount of time to play, however it might be more beneficial to have two participants to a television to take turns playing so that they can have breaks. It may even progress the learning curve by watching each other.

Future Directions

Future studies should determine other components of cognitive function to test that might improve after an intervention on the Nintendo Wii Fit. Components like reaction time, processing speed, or memory may be better variables to test. These are skills that are used while playing the games on the Nintendo Wii Fit, meaning they could potentially improve over time. These skills might be better to test because as one ages, he/she tends to lose these things first (Park, Polk, Mikels, Taylor, & Marshuetz, 2001). If using the Nintendo Wii Fit as a tool improves these components, it should be used more often when working with older adults. Balance, more specifically dynamic balance, should also be tested to evaluate if the Nintendo Wii Fit is a good tool to improve balance in older adults. Functional balance could be a good way of measuring balance during a Nintendo Wii Fit balance training intervention. Functional balance tests might have better improvements after a balance training program with the Nintendo Wii Fit. Future studies should also consider combining the Nintendo Wii Fit balance games with resistance training to determine if that improves balance confidence. The combination of resistance training with balance training can help an older adult feel more comfortable with daily functioning activities.

Practical Applications

The Nintendo Wii Fit can be beneficial in different ways for older adults. If there is one in a senior center or independent living center it should not be overlooked. It is not a gaming system just for the younger population to play on. It would be good if someone that works in the senior center or independent living center were able to hold multiple training sessions on how to use the Nintendo Wii Fit. This would allow the older adults to become familiar with how to turn the console on and how to navigate through the games. The Nintendo Wii Fit could also be incorporated into social events at a senior center. It would be a good tool to keep older adults active as well as actively engaging their brains. Engaging one's brain is important for older adults to keep up with because quality of life tends to decline with aging (Campbell, Crews, Moriarty, Zack, & Blackman, 1999). Playing on the Nintendo Wii Fit can be a good way for older adults to have fun and socialize with each other.

Upon completion of this study, it is now known by the researcher that it is important to have supervision around when older adults are using the balance board to play the games on the Nintendo Wii Fit. Having supervision helps to prevent any injuries or falls from occurring while one is playing a game. Since one would be standing on the balance board while playing the balance games, it would be important to have supervision at all times to make sure no one stepped off the wrong way or leaned too far backwards or forwards causing them to fall off the board. The supervision also helps if someone is not aware of how to navigate through the games. Having the supervision during each session throughout this study also helped most participants improve on the games. This was because the supervisors were able to help explain the games while the participants were playing. A case study with an 89-year-old female that played bowling on the Wii for 60-minute sessions used the researchers as supervision during each session (Clark & Kraemer, 2009). This was important to make sure she did not sustain any injuries as well as being able to coach the participant on proper form and technique for the game being played.

While having the walkers in front of each participant during the whole session was good for safety reasons, it was not necessary for most. For some participants this might be an important piece of equipment to have available at all times depending on if they have any disabilities or if they are not able to stand without an assisted device. The main reason to not have the walker for most older adults, is because it can be used to help them get better scores on games. If they are able to lean on the walker it helps them control their movements much easier than having to control their balance without a walker in front of them. Therefore, it would not be necessary to have a walker at all times.

Using the Nintendo Wii Fit as a balance training tool would be worthwhile for the older adult population. This was seen in a study by Kliem and Wiemeyer (2010) that used 22 participants who completed either a traditional balance training program or a balance training program with the Nintendo Wii Fit. Both groups had improvements on four of five balance tests, indicating that the Nintendo Wii Fit can be a useful tool for older adults to improve balance (Kliem & Wiemeyer, 2010). If older adults can get over the phase of learning how to use the system, it could potentially be a very beneficial tool.

Conclusions

It can be concluded that the TMT might not be the best way to test executive function changes in older adults. While the Nintendo Wii Fit did not improve balance confidence or cognitive function, it does not mean that it is not a good tool for older adults to use. With the prevalence of the Nintendo Wii Fit being higher in nursing homes and independent living communities for a training tool, older adults should use the system. There are multiple games to play and it is a great way for older adults to socialize. The Nintendo Wii Fit can also be a fun way to improve the balance of older adults.

References

Alpert, P., Miller, S., Havey, H., Cross, R., Chevalia, C., Gills, C., & Kodandapari, K. (2009). The effect of modified jazz dance on balance, cognition, and mood in older adults. *Journal of the American Academy of Nurse Practitioners, 21,* 108-115. doi: 10.1111/j.1745-7599.2008.00392.x

Ball, K., Berch, D., Helmers, K., Jobe, J., Leveck, M., Marsiske, M., … Willis, S. (2002). Effects of cognitive training interventions with older adults. *Journal of American Medical Association, 288*(18) 2271-2281. Retrieved from www.jama.ama-assn.org

Burrachio, T., Mattek, N., Dodge, H., Hayes, T., Pavel, M., Howieson, D., & Kaye, J. (2011). Executive function predicts risk of falls in older adults with balance impairment. *BioMed Central Geriatrics, 11*(74), 1-7. Retrieved from www.biomedcentral.com/journals

Campbell, V., Crews, J., Moriarty, D., Zack, M., & Blackman, D. (1999). Surveillance for sensory impairment, activity limitation, and health-related quality of life among older adults – United States, 1993-1997. *Center for Disease Control MMWR Surveillance Summaries, 48*(SS08), 131-156. Retrieved from www.cdc.gov

Chiou, I-I. and Burnett, C. (1985). Values of activities of daily living: A survey of stroke patients and their home therapists. *Journal of the American Physical Therapy Association, 65*, 901-906. Retrieved from www.apta.org

Clark, R., Bryant, A., Pua, Y., McCroy, P., Bennell, K., & Hunt, M. (2009). Validity and reliability of the Nintendo Wii balance board for assessment of standing balance. *Gait & Posture, 31*, 307-310. Retrieved from www.elsevier.com/locate/gaitpost

Clark, R., & Kraemer, T. (2009). Clinical use of the Nintendo Wii bowling simulation to decrease fall risk in an elderly resident of a nursing home: A case report. *Journal of*

Geriatric Physical Therapy, 32(4),174-180. Retrieved from www.journals.lww.com/jgpt/pages/default.aspx

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences.* New York, NY: Lawrence Erlbaum Associates.

Coppin, A., Shumway-Cook, A., Saczynski, J., Patel, K., Ble, A., Ferrucci, L., & Guralnik, J. (2006). Association of executive function and performance of dual-task physical tests among older adults: Analyses from the inchianti study. *Age and Ageing, 35,* 619-624. doi: 10.1093/ageing/afl107

Corrigan, J., & Hinkeldey, M. (1987). Relationships between parts A and B of the Trail Making Test. *Journal of Clinical Psychology, 43*(4), 402–409. Retrieved from www.onlinelibrary.wiley.com/journal

Cyarto, E., Brown, W., Marshall, A., & Trost, S. (2008). Comparative effects of home- and group-based exercise on balance confidence and balance ability in older adults: Cluster randomized trial. *Gerontology, 54*, 272-280. doi: 10.1159/000155653

Desai, A., Goodman, V., Kapadia, N., Shay, B. L., & Szturm, T. (2010). Relationship between dynamic balance measures and functional performance in community-dwelling elderly people. *Physical Therapy*, *90*(5), 748-760. Retrieved from www.apta.org/

Fuller, G. (2000). Falls in the elderly. *American Academy of Family Physicians, 61*(7), 2159-2168. Retrieved from http://www.aafp.org/online/en/home.html

Fuzhong, L., Fisher, J., Harmer, P., McAuley, E., & Wilson, N. (2003). Fear of falling in elderly persons: Association with falls, functional ability, and quality of life. *Journal of Gerentology: Physcological Sciences, 58B*(5) 283-290. Retrieved from www.biomedgerentology.oxfordjournals.org

Hatch, J., Gill-Body, K., & Portney, L. (2003). Determinants of balance confidence in community-dwelling elderly people. *Journal of the American Physical Therapy Association, 83*, 1072-1079. Retrieved from http://www.apta.org/

Hiyamizu, M., Morioka, S., Shomoto, K., & Shimada, T. (2011). Effects of dual task balance training on dual task performance in elderly people: A randomized controlled trial. *Clinical Rehabilitation, 26*(1), 58-67. doi: 10.1177/0269215510394222

Judge, J., King, M., Whipple, R., Clive, J., & Wolfson, L. (1995). Dynamic balance in older persons: Effects of reduced visual and proprioceptive input. *Journal of Gerontology, 50*(5), 263-270. Retrieved from www.biomedgerentology.oxfordjournals.org

Kliem, K & Wiemeyer, J. (2010). Comparison of a traditional and a video game based balance-training program. *International Journal of Computer Science in Sport, 9,* 80-91. Retrieved from www.iacss.org

Lamoth, C., van Duedekom, F., van Campen, J., Appels, B., de Vries, O., & Pijnappels, M. (2011). Gait stability and variability measures show effects of impaired cognition and dual tasking in frail people. *Journal of Neuroengineering and Rehabilitation, 8*(2), 1-9. Retrieved from http://www.jneuroengrehab.com

Lange, B., Physio, B., Flynn, S., Proffitt, R., Chang, C., Meng, & Rizzo, A. (2010). Development of an interactive game-based rehabilitation tool for dynamic balance training. *Topics in Stroke Rehabilitation, 17*(5), 345-352. doi: 10.1310/tsr1705-345

Langlois, F., Vu, T.T.M., Chassé, K., Dupuis, G., Kergoat, M.J., & Bherer, L., (2012). Benefits of physical exercise training on cognition and quality of life in frail older adults. *Journals of Gerontology Series B: Psychological Sciences and Social Sciences,* 1-5. doi:10.1093/geronb/gbs069

Lautenschlager, N., Almeida, O., Flicker, L., & Janca, A. (2004). Can physical activity improve the mental health of older adults? *Annals of General Hospital Psychiatry, 3*(12), 1-5. doi: 10.1186/1475-2832-3-12

Legters, K. (2002). Fear of falling. *Journal of American Physical Therapy Association, 82,* 264-272. Retrieved from http://www.apta.org/

Lezak, M. (1995). *Neuropsychological assessment*. New York: Oxford University Press, Inc.

Littbrand, H., Rosendahl, E., Lindelof, N., Lundin-Olsson, L., Gustafson, Y., & Nyberg, L. (2006). A high-intensity functional weight-bearing exercise program for older people dependent in activities of daily living and living in residential care facilities: Evaluation of the applicability with focus on cognitive function. *Journal of American Physical Therapy Association, 86,* 489-498. Retrieved from www.ptjournal.apta.org

Liu-Ambrose, T., Ashe, M., Graf, P., Beattie, L., & Khan, K. (2008). Increased risk of falling in older community-dwelling women with mild cognitive impairment. *Journal of American Physical Therapy Association, 88*(12),1482-1491. Retrieved from www.apta.org

Liu-Ambrose, T., Khan, K., Eng, J., Lord, S., & McKay, H. (2004). Balance confidence improves with resistance or agility training. Increase is not correlated with objective changes in fall risk and physical abilities. *Gerontology, 50*(6), 373-382. doi: 10.1159/000080175

Myers, A., Powell, L., Maki, B., Holliday, P., Brawley, L., & Sherk, W. (1996). Physchological indicators of balance confidence: Relationship to actual and perceived abilities. *Journal of Gerontology: Medical Sciences, 51A*(1), M37-M43. Retrieved from www.biomedgerontology.oxfordjournals.org

Nitz, J., Kuys, S., Isles, R., & Fu, S. (2010). Is the Wii Fit[tm] a new generation tool for improving balance, health and well being? A pilot study. *International Menopause Society, 13,* 487-491. doi: 10.3109/13090395193

Park, D., Polk, T., Mikels, J., Taylor, S., & Marshuetz, C. (2001). Cerebral aging: Integration of brain and behavioral models of cognitive function. *Dialogues in Clinical Neuroscience, 3*(3), 151-165. Retrieved from www.dialogues-cns.org

Pal, J., Hale, L., & Skinner, M. (2005). Investigating the reliability and validity of two balance measures in adults with stroke. *International Journal of Therapy and Rehabilitation, 12*(7), 308-314. Retrieved from http://www.iljtr.co.uk

Rapport, L., Hanks, R., Millis, S., & Deshpande, S. (1998). Executive functioning and predictor of falls in the rehabilitation setting. *Archives of Physical Medicine and Rehabilitation, 79*, 629-633. Retrieved from www.archives-pmr.org

Rose, D. (2010). *Fallproof!: A comprehensive balance and mobility training program.* Champaign, IL: Human Kinetics.

Rose, D. (2011). Reducing the risk of falls among older adults: The fallproof balance and mobility program. *Current Sports Medicine Reports, 10*(3),151-156. Retrieved from www.acsm-csmr.org

Rubenstein, L. (2006). Falls in older people: Epidemiology, risk factors, and strategies for prevention. *Age and Ageing, 35*(S2), ii37-ii41. doi: 10.1093/ageing/afl084

Sanchez-Cubillo, I., Perianez, J., Adrover-Roig, D., Rodriguez-Sanchez, J., Rios-Lago, M., Tirapu, J., & Barcelo, F. (2008). Construct validity of the trail making test: Role of task-switching, working memory, inhibition/interference control, and visuomotor abilities.

Journal of the International Neuropsychological Society, 15, 438-450. doi: 10.1017/S1355617709090626

Schiller, J., Kramarow, E., & Dey, A. (2007). Fall injury episodes among noninsitutionalized older adults: United States, 2001-2003. *Advance Data, 392*, 1-16. Retrieved from www.cdc.gov/nchs/nhis/nhis_ad.htm

Scott, V., Peck, S., & Kendall, W. (2004). Prevention of falls and injuries among the elderly: A special report from the office of the provincial health officer. *Office of the Provincial Officer, British Columbia Ministry of Health Planning*, 1-96. Retrieved from http://www.health.gov.bc.ca/pho/reports/special.html

Shumway-Cook, A., Baldwin, M., Polissar, N., & Gruber, W. (1997). Predicting the probability for falls in community-dwelling older adults. *Journal of the American Physical Therapy Association, 77*, 812-819. Retrieved from www.apta.org

Silsupadol, P., Siu, K., Shumway-Cook, A., & Woollacott, M. (2006). Training of balance under single- and dual-task conditions in older adults with balance impairment. *American Physical Therapy Association, 86*(2),269- 281. Retrieved from www.apta.org

Stevens, J., Corso, P., Finkelstein, E., & Miller, T. (2006). The costs of fatal and non-fatal falls among older adults. *Injury Prevention, 12*, 290-295. doi: 10.1136/ip.2005.011015

Stewart, W. (1992). An interrater reliability study of the trail making test (parts a and b). *Perceptual and Motor Skills, 74,* 39-42. Retrieved from http://www.amsciepub.com/loi/pms

Talley, K., Wyman, J., & Gross, C. (2008). Psychometric properties of the activities-specific balance confidence scale and the survey of activities and fear of falling in older women.

Journal of the American Geriatrics Society, 56, 328-333. doi: 10.1111/j.1532-5415.2007.01550.x

Ullman, G., Williams, H., Hussey, J., Durstine, J.L. & McClenaghan, B. (2010). Effects of feldenkrais exercises on balance, mobility, balance confidence, and gait performance in community-dwelling adults age 65 and older. *The Journal of Alternative and Complementary Medicine, 16*(1), 97-105. doi: 10.1089/acm.2008.0612

Westlake, K & Culham, E. (2007). Sensory-specific balance training in older adults: Effect on proprioceptive reintegration and cognitive demands. *American Physical Therapy Association, 87*(10), 1274-1283. Retrieved from www.apta.org

Yamada, M., Aoyama, T., Nakamura, M., Tanaka, B., Nagai, K., Tatematsu N., … Ichihashi, N. (2011). The reliability and preliminary validity of game-based fall risk assessment in community-dwelling older adults. *Geriatric Nursing, 32*, 188-194. Retrieved from www.gnjournals.com

Yogev-Seligmann, G., Hausdorff, J., & Giladi, N. (2008). The role of executive function and attention in gait. *Movement Disorders, 23*(3), 329-342. Retrieved from http://www.movementdisorders.org

Tables

Table 1

Descriptive Statistics and Effect Sizes of Balance Confidence, Cognitive Function, and Center of Mass.

		Pre-Testing		Post-Testing			
		Mean	SD	Mean	SD	Mean Diff	ES
ABC (%)							
	Treatment	81.56	22.29	76.75	25.60	4.81	0.22
	Control	85.82	7.69	83.49	11.94	2.33	0.30
TMT-A (sec)							
	Treatment	31.67	7.94	33.83	12.09	-2.16	-0.27
	Control	20.5	2.08	19.75	3.10	0.75	0.36
TMT-B (sec)							
	Treatment	79.33	37.92	87.5	33.60	-8.17	-0.22
	Control	53	16.83	40.5	13.33	12.5	0.74
TMT-Diff (sec)							
	Treatment	47.67	34.22	53.67	23.51	-6	-0.18
	Control	32.5	15.29	20.75	13.10	11.75	0.77
COM-R (%)							
	Treatment	45.05	4.18	55.07	4.96	-10.02	
	Control	52.05	3.48	49.9	3.95	2.15	
COM-L (%)							
	Treatment	54.95	4.14	44.93	4.96	10.02	
	Control	47.95	3.48	50.1	3.95	-2.15	

Note. ABC= Activities-Specific Balance Confidence Scale used to measure balance confidence, TMT-A= Trail Making Test Part A used to measure cognitive function, TMT-B= Trail Making Test Part B used to measure cognitive function, COM-L= Center of Mass for the left side used to measure center of mass, COM-R= Center of mass for the right side used to measure center of mass, TMT-Diff= Trail Making Test difference between Part A and Part B, sec= the seconds it took to complete the test, ES= univariate effect size calculated as mean at pre-test minus mean at post-test divided by the SD at pre-test.

Table 2

Independent Samples T-Test for Balance Confidence, Cognitive Function, and Center of Mass.

	t	df	Significance
ABC (%)	-0.58	7.84	0.58
TMT-A (sec)	2.7	8	0.03
TMT-B (sec)	1.29	8	0.23
COM-L (%)	2.02	10	0.07
COM-R (%)	-2.02	10	0.07

Note. ABC= Activities-Specific Balance Confidence Scale used to measure balance confidence, TMT-A= Trail Making Test Part A used to measure cognitive function, TMT-B= Trail Making Test Part B used to measure cognitive function, COM-L= Center of Mass for the left side used to measure center of mass, COM-R= Center of mass for the right side used to measure center of mass, sec= the seconds it took to complete the test.

Table 3

ANOVA with Repeated Measures for the Activities-Specific Balance Confidence Scale.

	Between Subjects		
	df	F	p
Group	1	0.44	0.52
Error	10		

	Within Subjects		
	df	F	p
Time	1	2.48	0.17
Time * Group	1	1.16	0.31
Error	10		

Table 4

ANOVA with Repeated Measures for the Trail Making Test Part A.

	Between Subjects		
	df	F	p
Group	1	7.03	0.03
Error	8		
	Within Subjects		
	df	F	p
Time	1	0.09	0.77
Time * Group	1	0.38	0.56
Error	8		

Table 5

ANOVA with Repeated Measures for the Trail Making Test Part B.

	Between Subjects		
	df	F	p
Group	1	4.09	0.08
Error	8		

	Within Subjects		
	df	F	p
Time	1	0.11	0.74
Time * Group	1	2.58	0.15
Error	8		

Table 6

ANOVA with Repeated Measures for Trail Making Test Difference Between Part A and Part B.

	Between Subjects		
	df	F	p
Group	1	2.68	0.14
Error	8		

	Within Subjects		
	df	F	p
Time	1	0.20	0.66
Time * Group	1	1.94	0.20
Error	8		

Table 7

ANOVA with Repeated Measures for Center of Mass for the Left Side.

	Between Subjects		
	df	F	p
Group	1	0	0.99
Error	10		

	Within Subjects		
	df	F	p
Time	1	4.01	0.07
Time * Group	1	5.64	0.04
Error	10		

Table 8

ANOVA with Repeated Measures for Center of Mass for the Right Side.

	Between Subjects		
	df	F	p
Group	1	0	0.99
Error	10		

	Within Subjects		
	df	F	p
Time	1	4.01	0.07
Time * Group	1	5.64	0.04
Error	10		

Table 9

Dependent T-Test for Nintendo Wii Fit Balance Games.

		Mean	t	df	Significance
Balance Bubble (yards)			-4.11	6	0.006*
	Pre	598			
	Post	906.86			
Table Tilt (points)			-1.23	6	0.27
	Pre	41.43			
	Post	51.43			
Soccer Heading (points)			-2.61	6	0.04*
	Pre	6.86			
	Post	17			
Penguin Slide (points)			-0.09	6	0.93
	Pre	48.86			
	Post	49.29			
Ski Slalom-Misses (flags missed)			5.62	6	0.001*
	Pre	7.29			
	Post	3.14			
Ski Slalom-Time (minutes,seconds)			6.74	6	0.001*
	Pre	01:30.4			
	Post	01:05.3			

*$p < .05$.

Figures

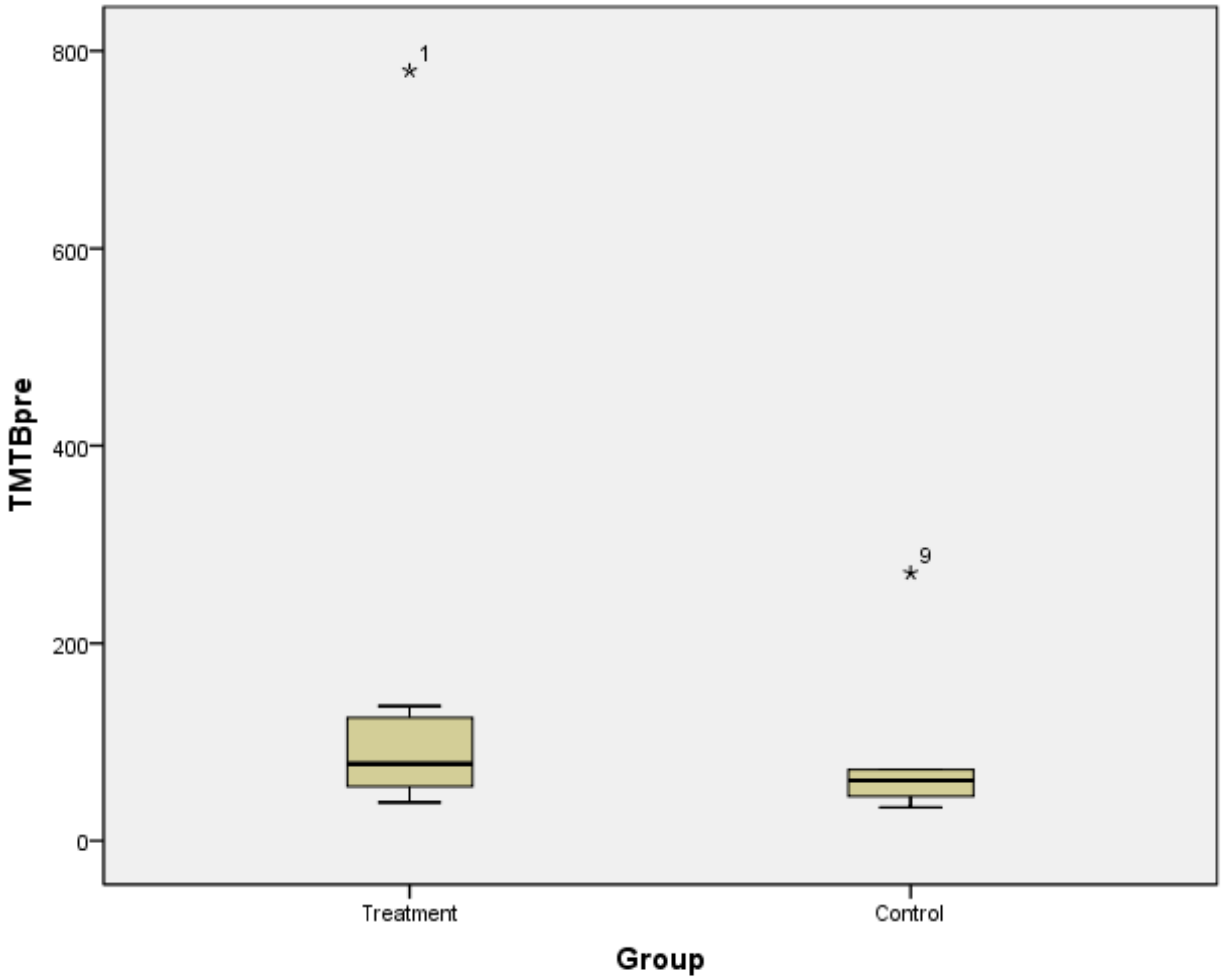


Figure 1. Boxplot with Outliers Removed.

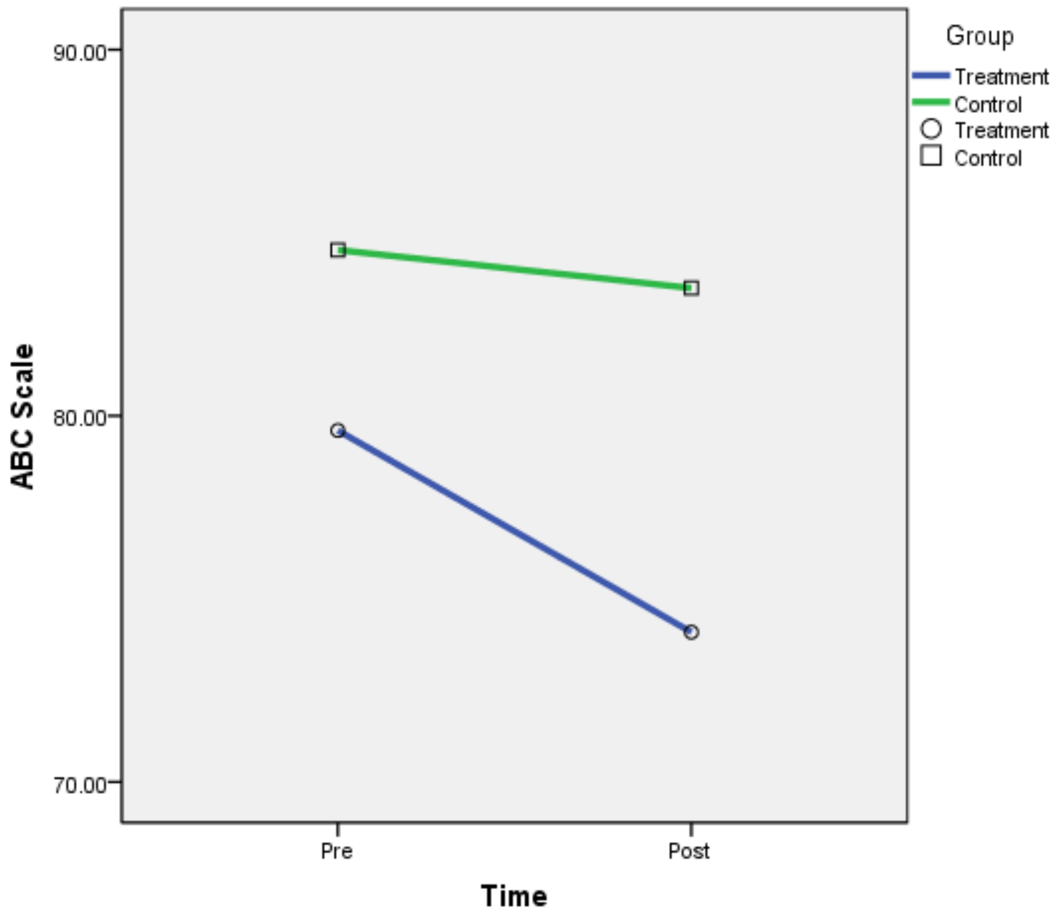


Figure 2. Changes in Activities-Specific Balance Confidence Scale, used to measure balance confidence, from Pre- to Post-Test.

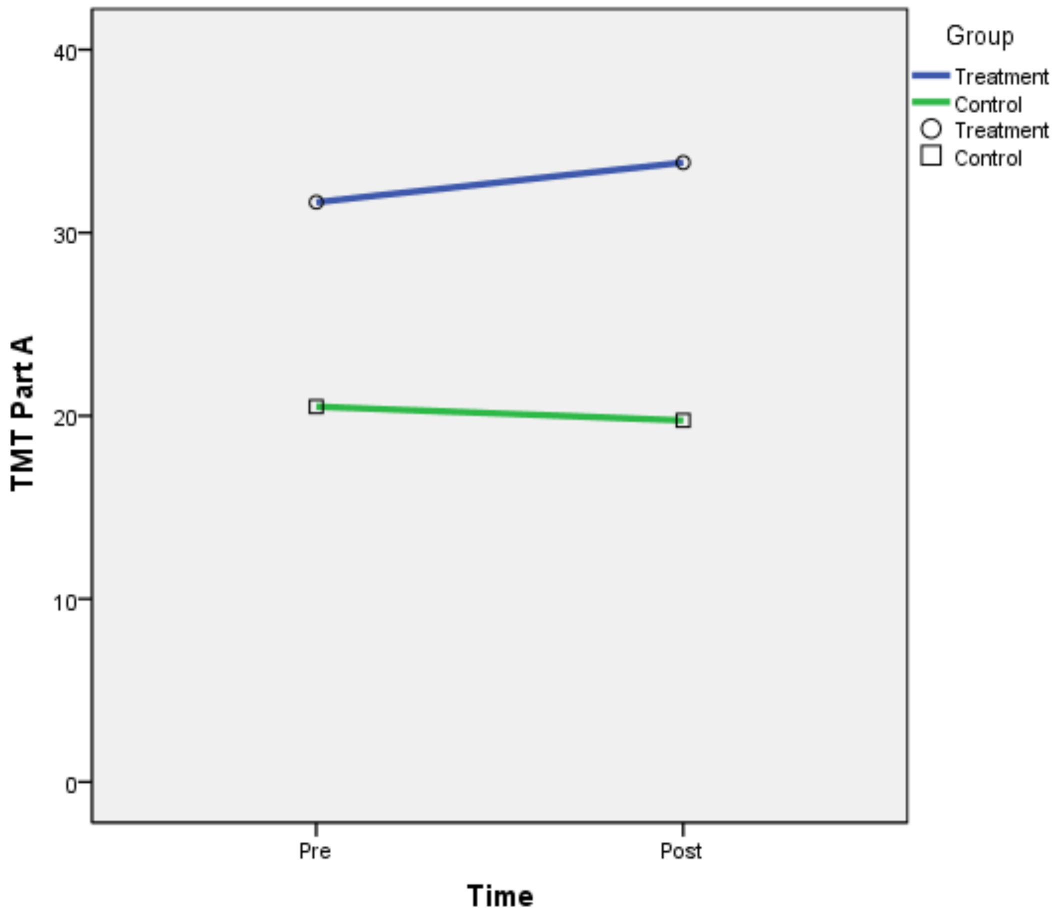


Figure 3. Changes in Trail Making Test Part A, used to measure cognitive function, from Pre- to Post-Test.

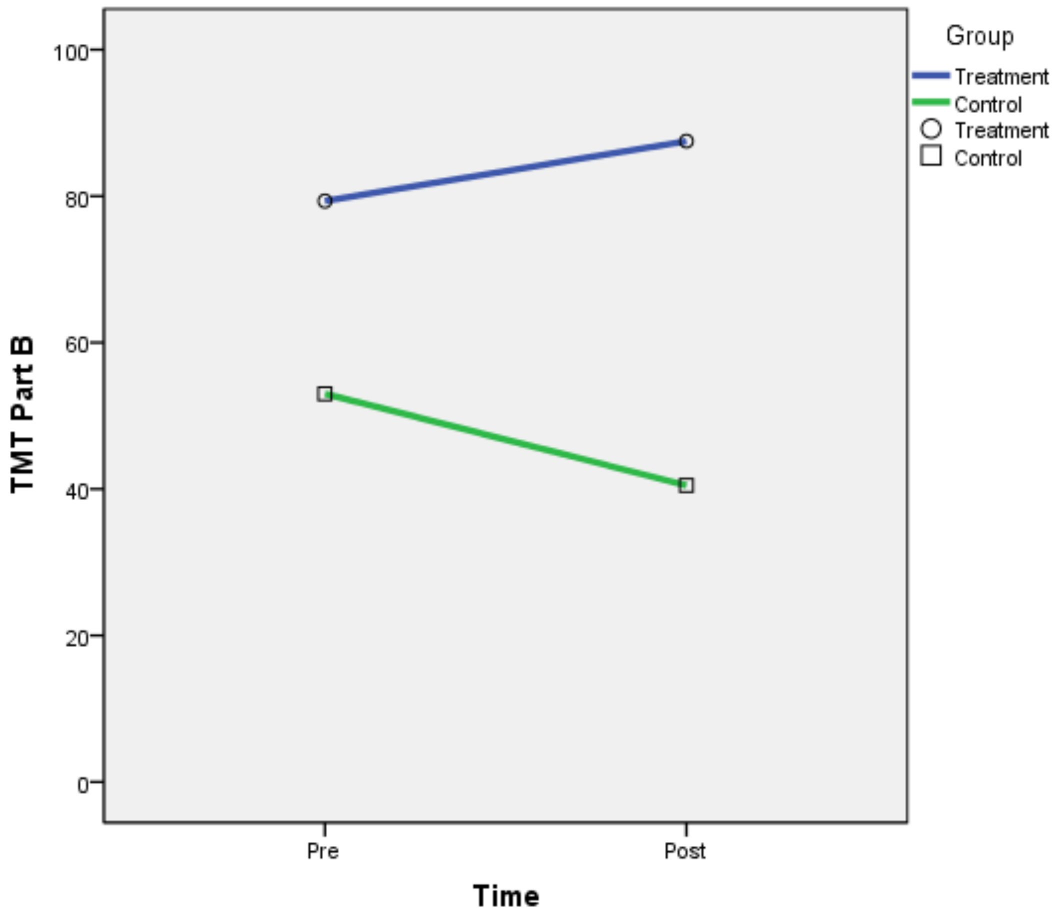


Figure 4. Changes in Trail Making Test Part B, used to measure executive function, from Pre- to Post-Test.

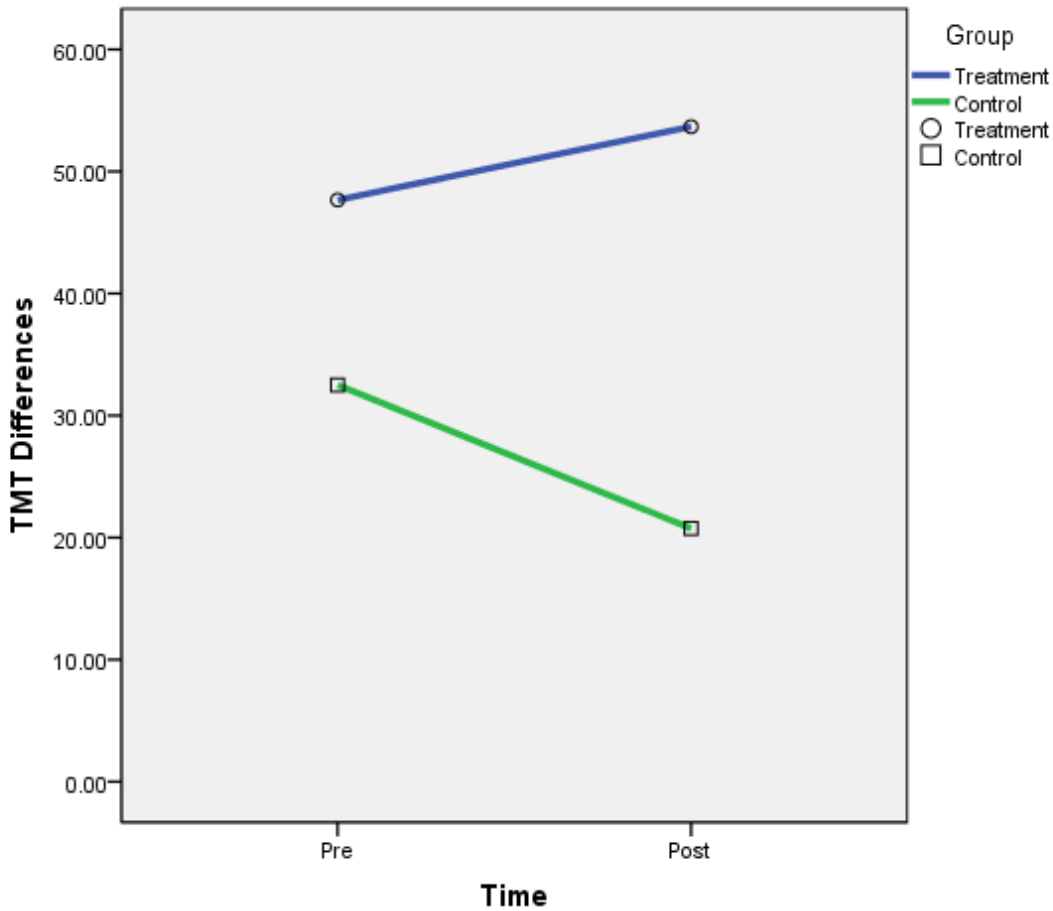


Figure 5. Changes in Trail Making Test Difference Between Part A and Part B from Pre- to Post-Test.

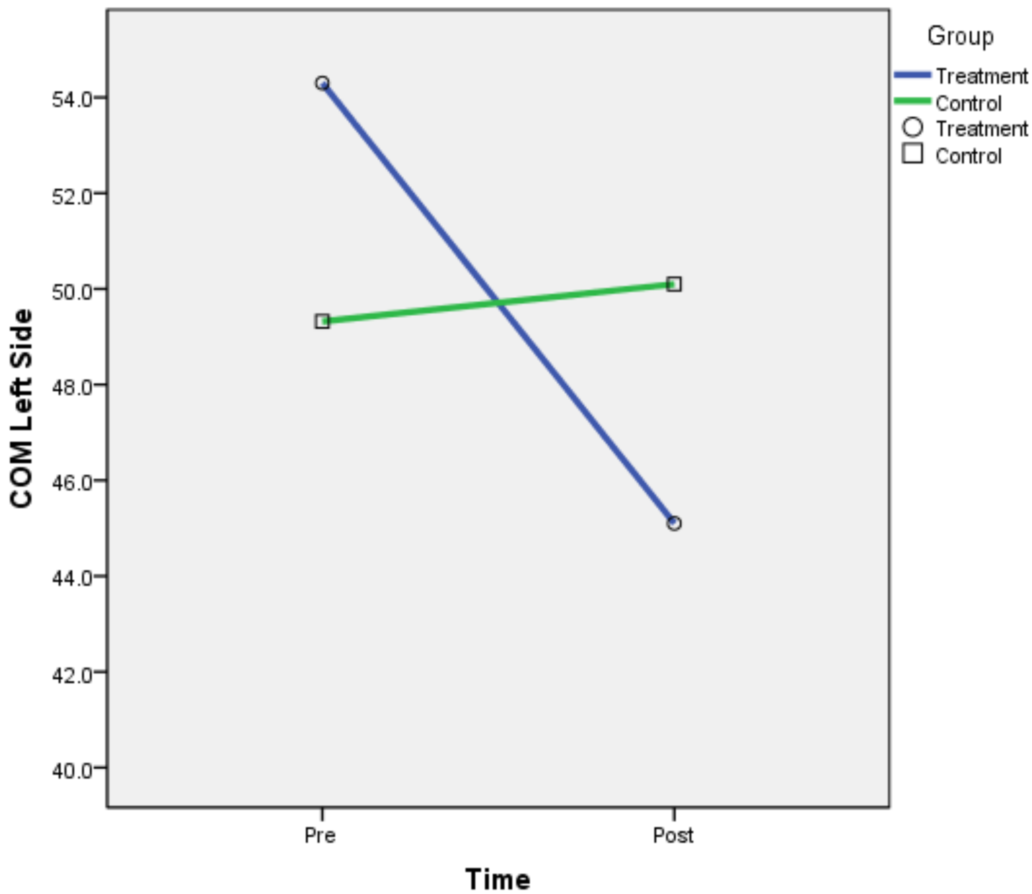


Figure 6. Changes in Center of Mass on the Left Side from Pre- to Post-Test.

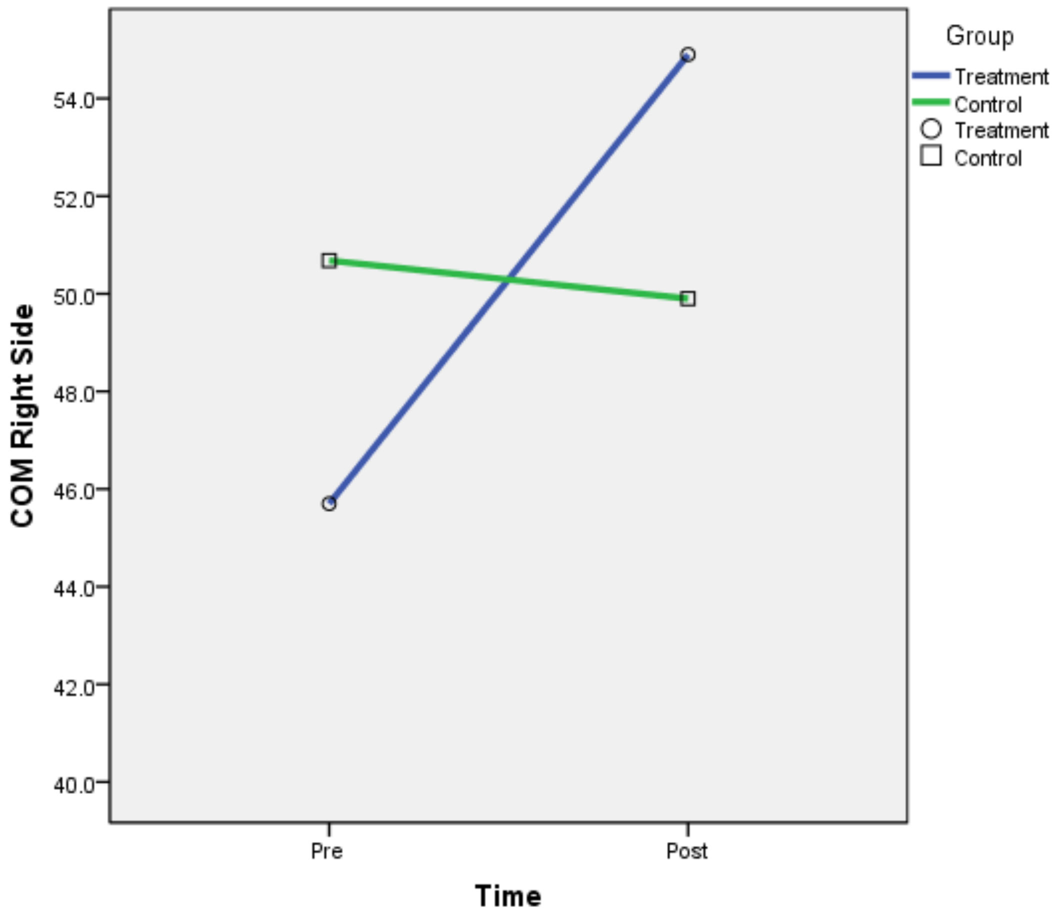


Figure 7. Changes in Center of Mass on the Right Side from Pre- to Post-Test.

Appendix A

Institutionalized Review Board Approval Letter

October 11, 2012 IRB Application #: 12091

Proposal Title: Nintendo Wii Fit™ Balance and Cognitive Function in Older Adults

Type of Review: Full Board

Investigators:

Ms. Kristin Bogda

Dr. Melissa Powers

Department of Kinesiology and Health Studies

College of Education & Professional Studies

Campus Box 189

University of Central Oklahoma

Edmond, OK 73034

Dear Ms. Bogda and Dr. Powers:

Re: Application for IRB Review of Research Involving Human Subjects

We have received your revised materials for your application. The UCO IRB has determined that the above named application is APPROVED BY FULL BOARD REVIEW.

Date of Approval: 10/11/2012

Date of Approval Expiration: 10/10/2013

If applicable, informed consent (and HIPAA authorization) must be obtained from subjects or their legally authorized representatives and documented prior to research involvement. A stamped, approved copy of the informed consent form will be sent to you via campus mail. The IRB-approved consent form and process must be used. While this project is approved for the period noted above, any modification to the procedures and/or consent form must be approved prior to incorporation into the study. A written request is needed to initiate the amendment process. You will be contacted in writing prior to the approval expiration to determine if a continuing review is needed, which must be obtained before the anniversary date. Notification of the completion of the project must be sent to the IRB office in writing and all records must be retained and available for audit for at least 3 years after the research has ended.

It is the responsibility of the investigators to promptly report to the IRB any serious or unexpected adverse events or unanticipated problems that may be a risk to the subjects.

On behalf of the UCO IRB, I wish you the best of luck with your research project. If our office can be of any further assistance, please do not hesitate to contact us.

Sincerely,

Jill A. Devenport, Ph.D.
Chair, Institutional Review Board
Director of Research Compliance, Academic Affairs
Campus Box 159
University of Central Oklahoma
Edmond, OK 73034
405-974-5479
jdevenport@uco.edu

Appendix B

Informed Consent Form

UNIVERSITY OF CENTRAL OKLAHOMA
INFORMED CONSENT FORM

Research Project Title: Nintendo® Wii Fit™ Balance and Cognitive Function in Older Adults.
Researcher (s): Kristin Bogda

A. Purpose of this research: You are being asked to participate in a research study designed to look at balance confidence and cognitive function in older adults. This study will give a balance-training program using the Wii Fit. Balance confidence and cognitive function will be tested before and after the eight weeks.

B. Procedures/treatments involved: After signing this form you will be asked to answer questions about your health status. You will be medically screened with the Exercise and Screening for You (EASY) tool. If need be, you may be asked to receive a written medical release from your primary care physician. You will also be asked to complete a Participant Information Form with personal and emergency contact information. You will be asked to complete a test and a survey, The Activities-specific Balance Confidence Scale and the Trail Making Test. The Activities-Specific Balance Confidence Scale asks questions that may make you feel embarrassed or stressed. It is not the goal of the survey to make you feel this way, but it is possible it may occur. These two assessments will be given before and after the Wii training. The first test assesses your confidence in your ability to perform certain tasks without losing your balance. The second survey assesses your cognitive function, specifically the speed in which you can complete a task. After completing the assessments, you will be randomly assigned to Group 1 or Group 2. Both groups will receive the Wii training. Group 1 will receive it in the first eight weeks; Group 2 will receive it in the second eight weeks. Group 1 will meet two times a week for 25-minute sessions for the first eight weeks and Group 2 will meet two times a week for 25-minute sessions during the second eight weeks where you will complete 5 games on the Nintendo Wii Fit. The researchers who are trained on using the Wii will supervise each training session. You will receive instructions about how to play each game. You are asked to not change your current activities. This means not adding a new activity class or doing anything that will increase or decrease your current activity level.

C. Expected length of participation: This experiment has two groups; you will be randomly assigned to one of these groups. Expected length of participation for both groups will be approximately ten consecutive weeks. All participants will be tested during weeks 1 and 10. Group 1 will meet 2 times per week for 25 minutes through week 10. Group 2 will meet two times per week for 25 minutes from week 11 through 20.

D. Potential benefits: The results of this study may add to past and present knowledge of the impact of balance training on balance confidence and cognitive function. This can lead to better balance and therefore decrease the number of falls. Another potential benefit is to gain more balance confidence.

E. Potential risks or discomforts: Balance training has been shown to be safe for all adults. Risks associated with balance training include muscle soreness, muscle tiredness, and rarely, muscle or joint injury. These injuries usually occur when exercises are not performed correctly. You will have a walker in front of you when standing on the Balance Board and research assistants around you to help prevent falls. These risks are very minimal and very unlikely to occur. You will be taught to recognize the signs and symptoms that increase your risk of injury. In addition, the exercise leader will watch for these signs. If these signs are reported or observed, you may be asked to rest or reduce your training intensity. The researchers may remove any participant from the study at any time, if needed, due to injury or any other reason. If you are injured, you will be responsible for all costs associated with the treatment of the injury. By signing this form, you indicate that you understand that UCO is not liable for any injuries that may occur during your participation in this study.

F. Contact information for researchers: For questions about the study or an injury related to the study, please contact the principal investigator:

Kristin Bogda	Melissa Powers
(314) 952-6372	(405) 974-5309
kbogda@uco.edu	mpowers3@uco.edu

G. Contact information for UCO IRB: For questions about your rights as a research participant, please contact:

Dr. Jill A. Devenport, Chair
UCO Institutional Review Board
100 University Drive # 159,
Edmond, OK 73034
(405) 974-5479
irb@uco.edu

H. Explanation of confidentiality and privacy: All information regarding your participation will be kept completely confidential. You will be assigned a code number that will be used on all data collection and analysis. Only the researcher will know your name, but will not share your answers with anyone. All information will be kept on a password-protected computer. This study may result in scientific presentations and publications; however, your identity will be kept confidential.

I. Assurance of voluntary participation: Participation in this study is voluntary. You may refuse to participate or withdraw from this study at any time. If you choose to refuse or withdraw there will be no penalty, just a loss of any benefits from balance training. If you withdraw from the study you will not be allowed to participate in the Wii training.

AFFIRMATION BY RESEARCH SUBJECT

I hereby voluntarily agree to participate in the above listed research project and further understand the above listed explanations and descriptions of the research project. I also understand that there is no penalty for refusal to participate, and that I am free to withdraw my consent and participation in this project at any time without penalty. I acknowledge that I am at least 18 years old. I have read and fully understand this Informed Consent Form. I sign it freely and voluntarily. I acknowledge that a copy of this Informed Consent Form has been given to me to keep.

Research Subject's Name: ____

Signature: ___________________________ Date: _______________

Appendix C

Exercise Assessment and Screening for You

Answering the Six Easy Questions:

EASY QUESTIONS (Circle Response):

1) Do you have pains, tightness or pressure in your chest during physical activity (walking, climbing stairs, household chores, similar activities)?	Yes	No
2) Do you currently experience dizziness or lightheadedness?	Yes	No
3) Have you ever been told you have high blood pressure?	Yes	No
4) Do you have pain, stiffness or swelling that limits or prevents you from doing what you want or need to do?	Yes	No
5) Do you fall, feel unsteady, or use assistive device device while standing or walking?	Yes	No
6) Is there a health reason not mentioned why you would be concerned about starting an exercise program?	Yes	No

Answering Yes to any of the EASY Questions:

Question	YES
1. Do you have pain, tightness or pressure in your chest during physical activity (walking, climbing stairs, household chores, similar activities)?	If you answered yes to this question and this is a NEW problem, see your health care provider first before starting any exercises. Ask your health care provider "Are there any exercises that I can not do"? Work with your doctor to identify activities that are appropriate for you. If it is not new, or has already been evaluated, begin or continue your exercise program. American Heart Association 1-800-242-8721 http://www.americanheart.org
2. Do you currently experience dizziness or lightheadedness?	If you answered yes, it is recommended that you talk with your health care provider before initiating a new activity program. Ask if there are any exercises you cannot do. Work with your provider to identify exercises good for you. NIH SeniorHealth 1-800-222-2225 http://seniorhealth.gov/exercise/toc.html

Question	Helpful Tips
3. Have you ever been told you have high blood pressure?	**If your blood pressure has not been checked in the last 6 months, get it checked by a healthcare provider.** **If you answered yes, you may continue to exercise to improve your overall heart health and prevent disease.** **American Heart Association 1-800-242-8721** **http://www.americanheart.org**
4. Do you have pain, stiffness or swelling that limits or prevents you from doing what you want or need to do?	**If you answered yes, continue to enjoy your exercise to prevent worsening of your arthritis and help manage your pain. If you have osteoporosis always avoid stretches that flex your spine or cause you to bend at the waist, and avoid making jerky, rapid movements.** **Call the Arthritis Foundation 1-800-283-7800 for the local office number and for specific exercises for people who have arthritis.** **Arthritis Foundation 1-800-283-7800** **http://www.arthritis.org**

5. Do you fall, feel unsteady, or use an assistive device while standing or walking?	**If you answered yes, it is recommended that you talk with your health care provider before initiating a new activity program.** **Ask if there are any exercises you cannot do. Work with your provider to identify exercises good for you.** **NIH SeniorHealth 1-800-222-2225** **http://seniorhealth.gov/exercise/toc.html**
6. Is there a health reason not mentioned why you would be concerned about starting an exercise program?	**If you answered yes, SHARE this information with your health care provider** **Most reasons can be addressed and you can begin an exercise program that will improve your overall health and well-being.**

Appendix D

Participant Information Form

Participant Information Form

We are excited to have you participate in our study! Please fill out the following contact information and questions.

Name:___________________________ Age:____________
Address:____
City:____________________________ Zip Code:__________________
Home Phone:_____________________ Cell Phone:_______________________
Email:______________________________________
Gender: M F

1. Have you used the Nintendo Wii? (Check one) ___Yes ______No

2. Have you used the Nintendo Wii Fit with the balance board?

   (Check one) _____Yes _____No

Appendix E

Activities-Specific Balance Confidence Scale

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...

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

*Powell, LE & Myers AM. The Activities-specific Balance Confidence (ABC) Scale. *J Gerontol Med Sci* 1995; 50(1): M28-34

Appendix F

Trail Making Test

Trail Making Test (TMT) Parts A & B

Instructions:

Both parts of the Trail Making Test consist of 25 circles distributed over a sheet of paper. In Part A, the circles are numbered 1 – 25, and the patient should draw lines to connect the numbers in ascending order. In Part B, the circles include both numbers (1 – 13) and letters (A – L); as in Part A, the patient draws lines to connect the circles in an ascending pattern, but with the added task of alternating between the numbers and letters (i.e., 1-A-2-B-3-C, etc.). The patient should be instructed to connect the circles as quickly as possible, without lifting the pen or pencil from the paper. Time the patient as he or she connects the "trail." If the patient makes an error, point it out immediately and allow the patient to correct it. Errors affect the patient's score only in that the correction of errors is included in the completion time for the task. It is unnecessary to continue the test if the patient has not completed both parts after five minutes has elapsed.

Step 1: Give the patient a copy of the Trail Making Test Part A worksheet and a pen or pencil.

Step 2: Demonstrate the test to the patient using the sample sheet (Trail Making Part A – *SAMPLE)*.

Step 3: Time the patient as he or she follows the “trail” made by the numbers on the test.

Step 4: Record the time.

Step 5: Repeat the procedure for Trail Making Test Part B.

Scoring:

Results for both TMT A and B are reported as the number of seconds required to complete the task; therefore, higher scores reveal greater impairment.

	Average	**Deficient**	**Rule of Thumb**
Trail A	29 seconds	> 78 seconds	Most in 90 seconds
Trail B	75 seconds	> 273 seconds	Most in 3 minutes

Sources:

- Corrigan JD, Hinkeldey MS. Relationships between parts A and B of the Trail Making Test. *J Clin Psychol.* 1987;43(4):402–409.

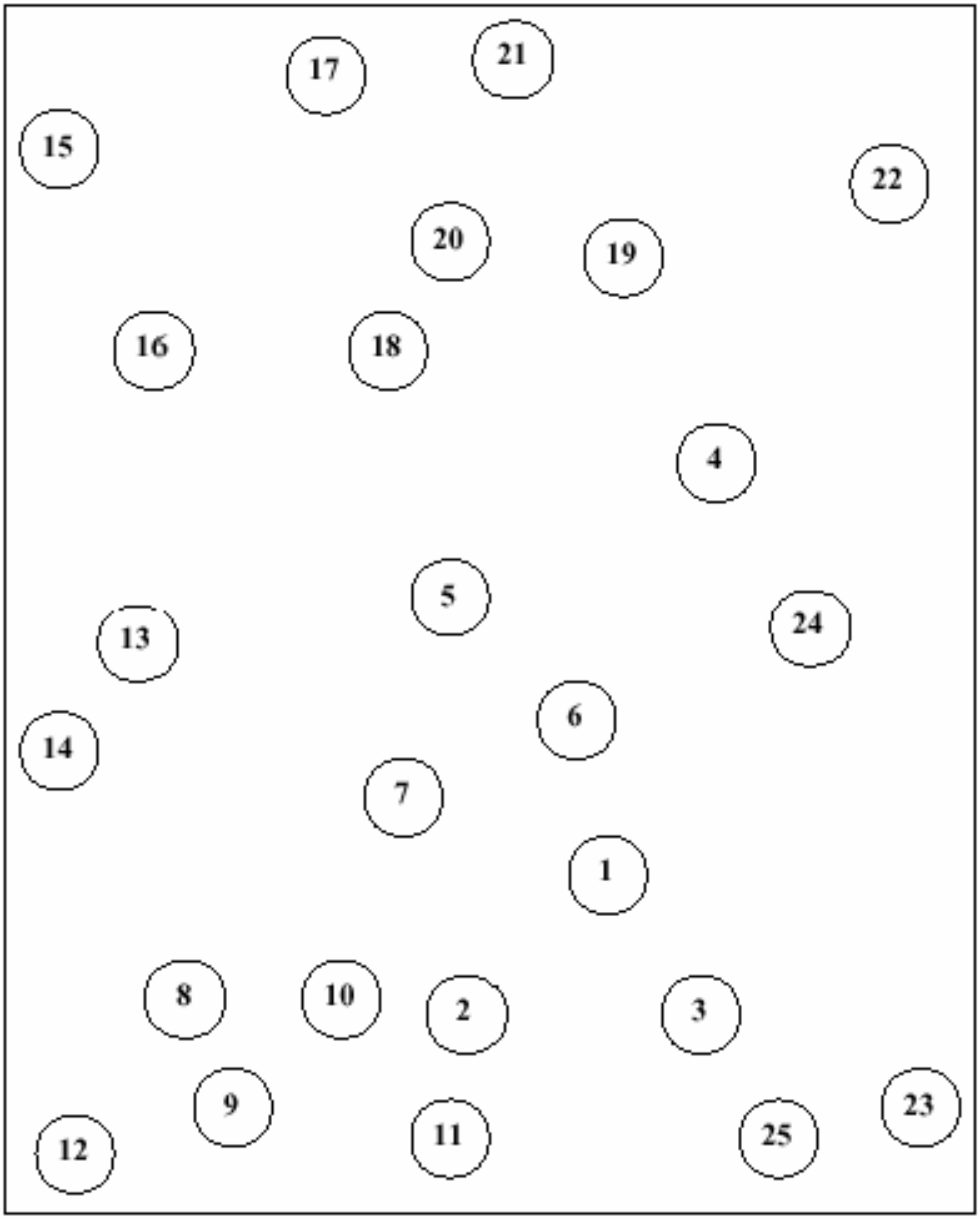
- Gaudino EA, Geisler MW, Squires NK. Construct validity in the Trail Making Test: what makes Part B harder? *J Clin Exp Neuropsychol.* 1995;17(4): 529-535.

- Lezak MD, Howieson DB, Loring DW. *Neuropsychological Assessment.* 4th ed. New York: Oxford University Press; 2004.

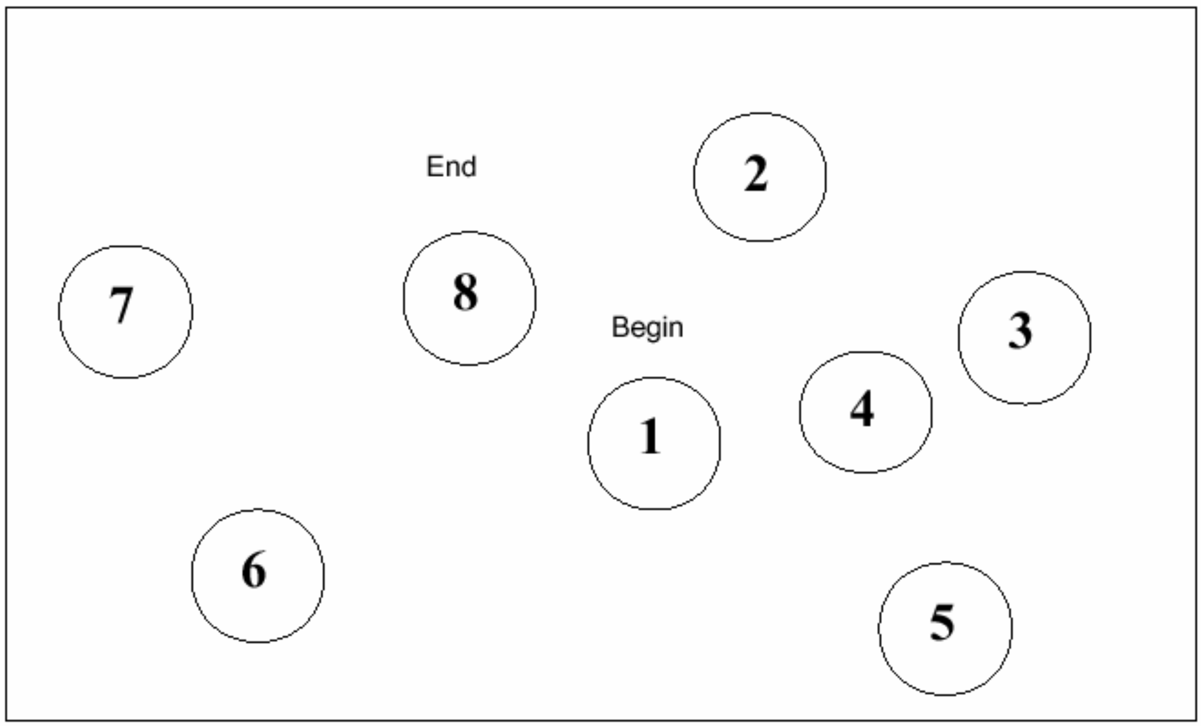
- Reitan RM. Validity of the Trail Making test as an indicator of organic brain damage. *Percept Mot Skills.* 1958;8: 271-276.

Trail Making Test Part A

Patient's Name______________________ Date:__________________

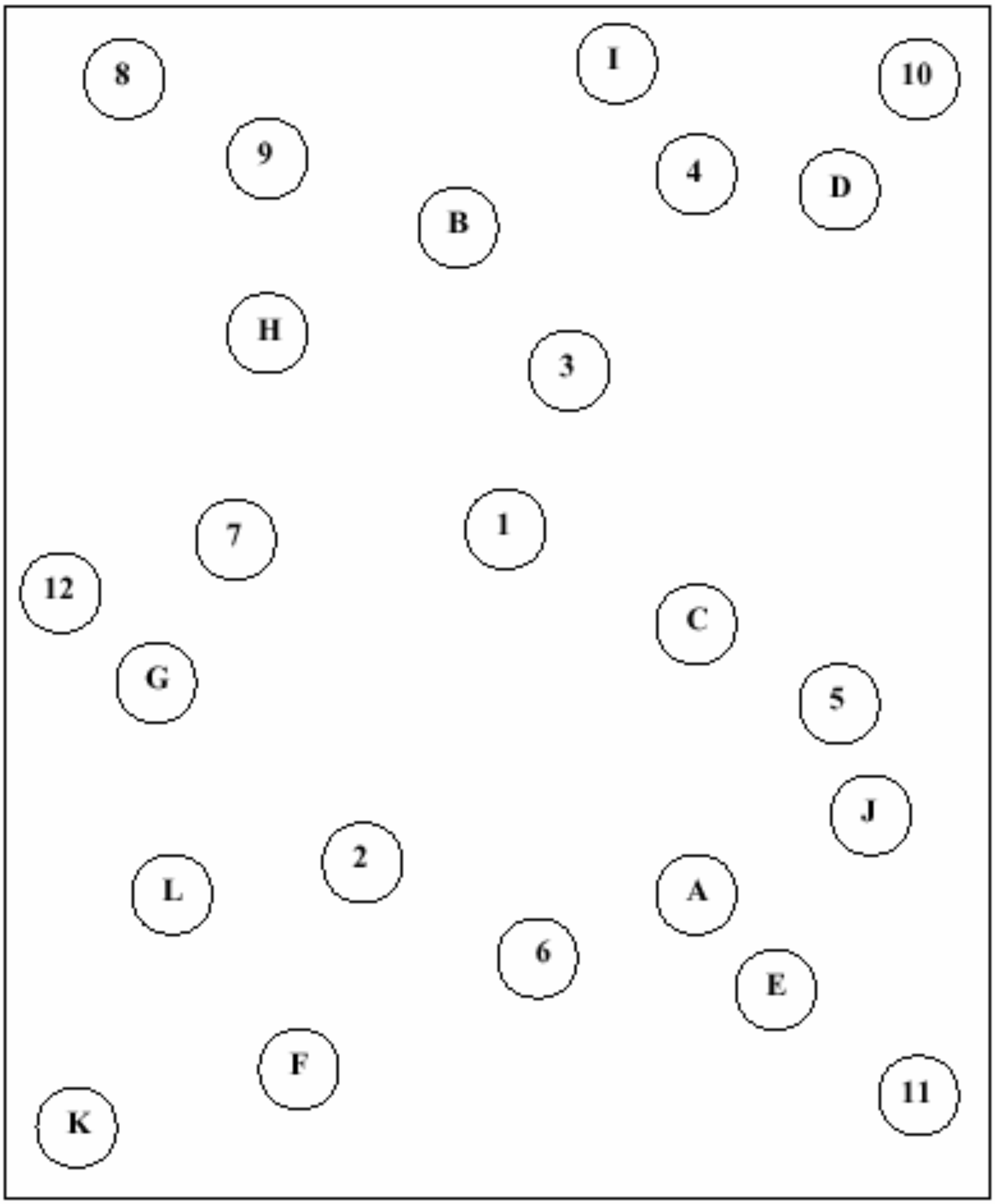


Trail Making Test Part A – *SAMPLE*

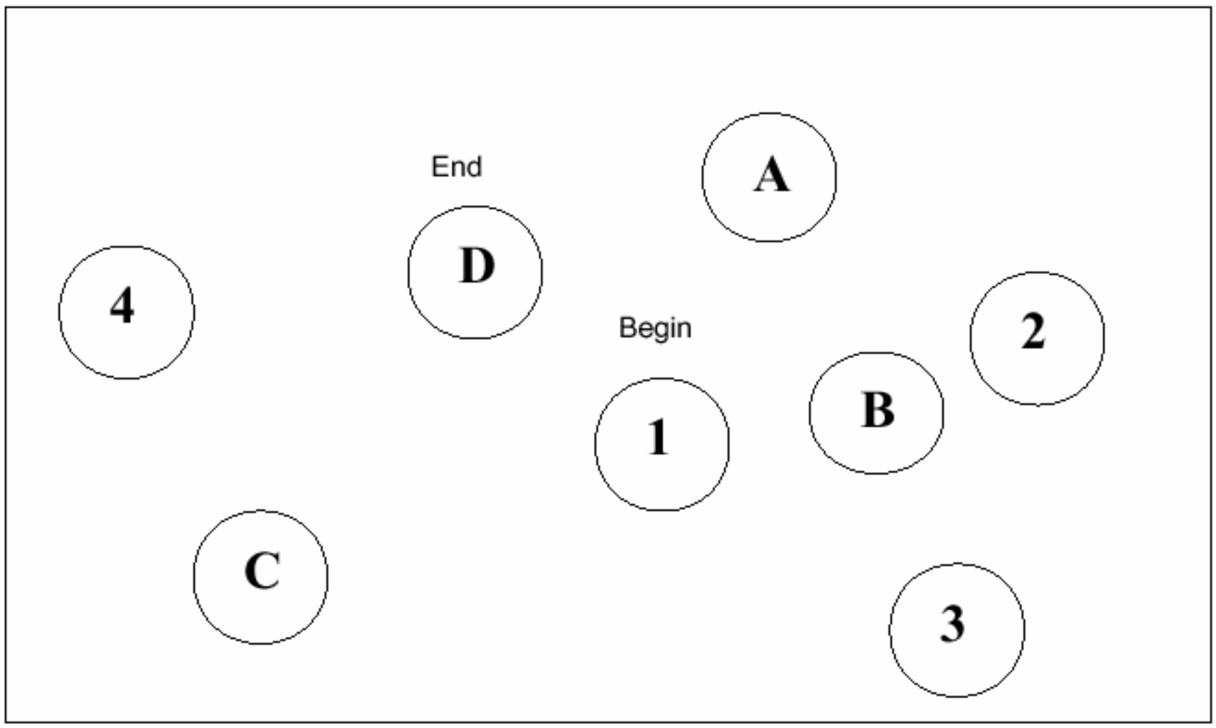


Trail Making Test Part B

Patient's Name:________________________ Date:__________________



Trail Making Test Part B – *SAMPLE*



Appendix G

Nintendo Wii Fit Balance Games Results Log Sheet

Log Sheet

Name:______________________________ Date:___________________
Time:__________________

1. Balance Bubble:____________________

2. Table Tilt:__________________________

3. Soccer Heading:____________________

4. Penguin Slide:______________________

5. Ski Slalom:_________________________