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Effect of Nintendo® Wii Fit™ Balance Games on Postural Control and Balance Among Adults with Down Syndrome

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Effect of Nintendo® Wii Fit™ Balance Games on Postural Control and Balance Among Adults with Down Syndrome

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Abstract

A Nintendo Wii Fit gaming device may eliminate several barriers to exercise and promote participation in balance training among adults with Down syndrome (DS). This study seeks to determine if a Nintendo Wii balance exercise regimen will improve postural control and balance among adults with DS over the age of 18. Nine participants were randomly divided into a treatment (TR) and control (CR) group. A TekScan HR mat was used to measure the following variables: anterior/posterior sway (AP), medial/lateral sway (ML), area (A), distance (D), and variability (V) in two feet eyes open (EO) and two feet eyes closed (EC) stances. A 2X2 RM ANOVA was utilized to analyze results as well as Cohen's *d* for effect size calculations. There were no significant differences found within group-by-time interaction, time, and group effects for any dependent variable (p>.05). Effect sizes were calculated for EOTR: AP (d = -.44), ML (d = -.03), A (d = -.47), D (d = -.48), and V (d = -.29. Values for the EOCR saw a larger effect among all variables: AP (d = -.84), ML (d = -.17), area (d = -.73), D (d = -.78), and V (d = -.67). ECTR values were as follows: AP (d = -.91), ML (d = -.53), A (d = -.76), D (d = -.69), and V (d = -.71). Values for ECCR are as follows: AP (d = -.41), ML (d = +2.81), A (d = -.48), D (d = -.42), and V (d = -.21). Although there were not statistically significant improvements in postural control between groups or over time, based on effect size calculations either of these training methods may still be an effective mode of improving postural control.

Chapter One: Introduction

Significance

The prevalence of Down syndrome (DS) births every year in the United States has significantly increased ($p<.05$) from year 1979 to 2003 from 9.0 per 10,000 live births to 11.8 per 10,000 live births (Shin et al., 2009). It must also be noted that DS prevalence at birth among older mothers was 38.6 per 10,000 live births and 7.8 per 10,000 live births among younger mothers (Shin et al., 2009). Due to the increasing prevalence of DS births every year in the United States, it is imperative to find innovative ways to improve this population's health, safety, and quality of life (Shin et al., 2009). Literature suggests the importance of improving balance among the DS population is driven by their increased life expectancy and their need to carry out every day functional activities (Carmeli, Kessel, Merrick, & Bar-Chad, 2004; Mendonca, Pereira, & Fernhall, 2010). Traditional balance training has been shown to be an effective way of improving strength and balance among children with DS however; the possibility that using virtual reality gaming can produce equivalent balance improvements may promote better long term exercise adherence among adults with DS (Berg, Becker, Martian, Primrose, & Wingen, 2012; Gupta, Bhagway, Rao, & Kumaran, 2011; Mahy, Shields, Taylor, & Dodd, 2010). Implementing a Nintendo Wii Fit balance regimen may be one way to improve balance; however, there is a lack of literature on the effects of using the Wii to improve postural control and balance among adults with DS over the age of 18.

Major barriers to exercise seen among those with DS include lack of equipment, cost, not knowing where or how to exercise, and lack of transportation (Heller, Hsieh, & Rimmer, 2002). More specific exercise barriers to those with DS include lack of time and interest and the program is boring or too difficult (Heller et al., 2002). Yet, it has been suggested that feasible exercise programs, which can be easily maintained, entertaining, affordable, and provide a social aspect of the regimen may produce the greatest improvements among those with DS (Mahy et al., 2010).

Recent studies have indicated that using virtual reality gaming systems, such as the Nintendo Wii, significantly improve motor proficiency, visual-integrative abilities, and sensory integrative functions of children with DS (Wuang, Chiang, Su, & Wang, 2011). A study conducted utilizing children with DS showed an improvement in the child's internal feedback and self-evaluation of performance (Wuang et al., 2011). Those enhancements may be related to the exercise characteristics required to successfully complete a Nintendo Wii program such as maintaining equilibrium, jumping, and striking balls (Wuang et al., 2011). Virtual reality gaming has also helped children with DS see virtual progression and goals met on the Nintendo Wii, which may serve as an entertaining motivator. Nintendo Wii games are progressive, requiring the user to successfully complete one goal to move on to the next, which may promote exercise adherence. The Nintendo Wii gaming device seems to be an innovative, exciting, and challenging game that may ultimately help a child develop cognitively and physically. It would be beneficial to see if those same results can be seen in adults with DS.

Significant lack of postural control among adults with DS appears to be an inhibitor for impaired balance, which may negatively affect the ability to carry out everyday functional activities such as putting on clothes, carrying in groceries, and walking up stairs (Galli et al., 2008). Due to the decreased equilibrium, generally caused from hypotonia and ligament laxity in adults with DS, postural control is important (Rigoldi, Galli, Mainardi, Crivellini, & Albertini, 2011b). There is a significant difference between those with DS and control groups of all ages; this is important when considering how those with DS perform throughout adulthood (Rigoldi et al. 2011b). Vuillerme, Marin, and Debu (2001) have determined that there is an increased postural sway during rest in teenagers with DS, which indicates there may be an increased postural sway during rest in children and adults with DS. Suggestions to decrease postural sway and increase postural control consist of therapeutic remediation of balance and enhancing motor coordination by improving multiple muscle groups that act together to establish posture (Rigoldi et al. 2011b). This may be achieved by the implementation of Nintendo Wii balance games as a routine therapeutic type regimen.

The Nintendo Wii balance board games have served as an efficient and effective way to improve balance in populations other than adults with DS (Byrne, Roberts, Squires, & Rohr, 2012; Harvey & Ada, 2012). Due to the incorporation of combination movements such as a consistent center of mass in frontal and sagittal planes and the medio/lateral and anterior/posterior movements, the games were utilized to improve balance among rehabilitating stroke patients

(Harvey & Ada, 2012). It was concluded that not every game in the Nintendo Wii balance program could be effective in improving balance among different populations (Byrne et al., 2012; Harvey & Ada, 2012). Byrne et al. (2012) determined that a Nintendo Wii balance program does positively affect dynamic balance among healthy young adults and suggested it would be beneficial for future research to be conducted in different populations. These findings provide enough support to explore if the researchers' hypothesis of incorporating a Nintendo Wii balance regimen among adults with DS over the age of 18 years old would be beneficial.

Implementing this Nintendo Wii Fit balance gaming exercise regimen may help reduce several barriers to exercise such as being unentertained, which directly effects attention span and willingness to participate in the activity. It may also aid in eliminating the lack of motivation some may have in regards to exercising. Studies providing scientific evidence that support the overall benefits of implementing Nintendo Wii Fit balance games among children with DS are prominent; however, there is a lack of literature regarding the effect of Nintendo Wii Fit balance games among adults with DS over the age of 18 years old. Virtual reality Wii gaming technology has been shown to significantly improve motor proficiency, visual-integrative abilities, and sensory integrative functions among children with DS (Wuang et al., 2012). These findings may suggest similar improvements among adults over the age of 18 years old.

The prevalence of DS at birth is increasing, as well as the average age of death for persons with DS (Shin et al. 2009). Starting from infancy, individuals with DS are hypotonic, which continues into their adulthood (Shumway-Cook & Woolacott, 1985). Children with DS have been found to function both physically and cognitively up to 18 to 24 months behind their age level, indicating decreased physical performance in both static and dynamic balance tests (Shumway & Woolacott, 1985). Literature suggests that because of the increased average age of individuals with DS it can be concluded there will be an increased amount of health care needed to help them maintain health and quality of life. This could range anywhere from controlling congenital heart defects to the improvement of balance and postural control. It is important to understand the increased demand of health services needed to help individual's with DS maintain a high quality of life and functionality (Shin et al., 2009).

Some of the most common cognitive and physical characteristics of those with DS are intellectual disabilities and poor dynamic and static balance (Boswell, 1991). Literature suggests that because the lack of balance seen among individuals with DS has been established as an inhibitor for efficiently performing functional daily tasks, it is important to identify and develop effective programs not just for children and adolescents with DS but also adults with DS, especially due to the growing average age.

Purpose

The purpose of this study is to determine if implementing a Nintendo Wii balance exercise regimen would improve postural control and balance among adults with DS over the age of 18 years.

Hypotheses

The researcher's first hypothesis is that implementing a Nintendo Wii balance session two times per week for 30 minutes a session for five weeks would show a significant improvement in postural control in adults with DS over the age of 18 years old (Berg, et al., 2012).

The researcher's second hypothesis is that implementing a Nintendo Wii balance session two times per week for 30 minutes a session for five weeks would show a significant improvement in balance among adults with DS over the age of 18 (Byrne et al., 2012; Young, Ferguson, Brault, & Craig, 2011).

Assumptions

- Participants would attend every session.
- Participants would be able to understand the rules and guidelines to the games after the primary researcher verbally explains what to do.
- Participants would perform with their best effort.
- Participants of both comparison and experimental groups would be interested in participating and completing this study.

Limitations

- The inability to have the comparison group participate in generic exercises, due to fairness,
- Having both experimental and comparison groups at the same facility,
- The dropout rate from the study, and
- Participants missing intervention days for miscellaneous reasons.

Delimitations

- All individuals were over the age of 18 years old.
- Participants would only use the Nintendo Wii.
- Experimental group was limited to three specific games on the Nintendo Wii Fit.
- The comparison group was limited to two Nintendo Wii Sport games.

Summary

Wii sports active gaming sessions may be a beneficial and feasible therapeutic regimen for those with DS to improve balance and independent daily living tasks (Berg et al., 2012). Lack of easy access to exercise facilities and equipment for adults with DS poses as an exercise barrier (Heller et al., 2002). The purpose of this study was to determine if a Nintendo Wii Fit balance program would improve balance and postural control among adults with DS over the age of 18.

Definitions

- Down syndrome – Known as 'trisomy 21' DS is one of the most common causes of intellectual disabilities and is a chromosomal disorder resulting in 47 chromosomes instead of 46 (Bertoti & Smith, 2008).
- Hypotonic – congenital disease prevalent among those with DS; low muscle tone, reduced muscle strength, motor skills delay, and motor delays seen with increasing age (Bertoti & Smith, 2008).

- Ligament laxity – is thought to be a result of collagen deficit and loose ligaments, which may ultimately cause chronic body pain (Bertoti & Smith, 2008).
- Postural control – integration of somatosensory, visual/vestibular sensory information regarding body position and motion with the ability to generate forces to control body position (Vuillerme et al., 2001).
- Balance – equal distribution of weight allowing a person to maintain a steady upright position (Villamonte et al., 2010).

Chapter Two: Literature Review

The purpose of this literature review was to gain further knowledge about balance and postural control among individuals with DS and how the Nintendo Wii Fit could be implemented into an exercise regimen. This review went into depth on topics discussing the idea that a Nintendo Wii Fit may be a beneficial tool to utilize for increasing balance and postural control among adults with DS. Literature not supporting this idea was also reviewed. Exercise barriers seen among adults with DS are immense; this review will help the reader understand the importance for adults with DS to have good balance and postural control.

Background on Down Syndrome

Life expectancy for a person with DS has significantly increased by approximately 40 years, with an average expectancy of 25 in 1983 to now 60 years old (National Down Syndrome Society, 2014a). Individuals with DS have an increased risk for medical conditions ranging from congenital heart defects, thyroid conditions, and musculoskeletal deficiencies (National Down Syndrome Society, 2014c). Although normal aging in individuals with DS is still being researched, it can be stated that this population generally experiences accelerated aging, ranging from decreased physical/functional abilities to worsening medical conditions, such as congenital heart disease (National Down Syndrome Society, 2014a). It is important to understand there are different severities of the syndrome ranging from mild, moderate, and severe; most individuals who have the syndrome are considered mild to moderate (National Down Syndrome Society, 2014c). Bertoti and Smith (2008) stated that approximately 3% of the population in the United States has some form of intellectual disability, with DS being one of the most common forms. In 2002, one out of every 971 children and adolescents between the ages of zero to 19 were diagnosed with DS at birth (Shin et al., 2009). Shin et al. (2009) also determined there was a significant increase in percentage of DS births from the year 1990 to 2009 ($p < 0.05$). The prevalence of DS may differ depending on the region, race/ethnicity, and gender (Shin et al., 2009). This is important when reviewing how the societal treatment of this population has progressed throughout the decades. The growth and understanding of society's perception of individuals with intellectual disabilities has progressed from originally being excluded, tolerated, and accepted to finally a full inclusion lifestyle (Bertoti & Smith, 2008).

When looking at the fitness aspect among the DS population the full inclusion concept has not been implemented (Bertoti & Smith, 2008; Heller et al., 2002; Mahy et al., 2010; McGrath, Stransky, Cooley, & Moeschler, 2011). The most prominent musculoskeletal differences among the DS population consist of atlantoaxial hyperextension, ligament laxity and hypotonia (Bertoti & Smith, 2008). These differences may be a contributor to poor strength in the extremities, which serves as an element contributing to poor balance (Bertoti & Smith, 2008; Galli et al., 2008).

McGrath et al. (2011) analyzed a national survey to determine co-morbidities that are associated with children with DS and compared that to the needs of the generally healthy child. This study determined that children with DS had a significantly greater number of co-morbidity conditions and were less likely to have their needs met, such as home medical access ($p < 0.05$). This may support the idea that although society is making an effort at providing full inclusion for this population, people may still benefit from increased awareness and education in order to continue the movement into full inclusion. If the proper balance regimen was incorporated for this population, the balance regimen itself may have the ability to decrease several of co-morbidities and help promote awareness. Due to children and adults with disabilities having a significantly higher prevalence of preventable diseases it may be beneficial to determine if self-help, like a Nintendo Wii balance program, could serve as a productive way to improve functionality and medical issues.

Balance and Postural Control

Postural control can be defined as the integration of somatosensory, visual, and vestibular sensory information regarding body position and motion with the ability to generate forces to control body position (Vuillerme et al., 2001). Balance can be defined as equal distribution of weight allowing a person to maintain a steady upright position (Villamonte et al., 2010). It may be stated that children with DS often have orthopedic and biomechanical disadvantages, however, there has been less research in regard to analyzing balance and postural control among this population (Galli et al., 2008). Li, Chen, How, and Zhang (2013) determined via a systematic review that interventions including treadmill walking, weight bearing exercises, and specific traditional balance exercises improved balance and postural control among the DS population.

Galli et al. (2008) assessed postural control in patients with DS to quantify abnormalities within the automatic postural control system. This study used 60 participants with DS between the ages of 16 to 22 years, and ten non-DS individuals for a control group between the ages of 19 to 25 years old. A Kistler force platform was used for postural evaluation to analyze center of pressure (COP) displacement by looking at sway oscillation in anterior/posterior and medio/lateral directions. Results indicated that between groups, the group with DS saw greater COP displacement for medial/lateral sway ($p<.05$) but not anterior/posterior sway ($p>.05$) in the eyes open stance. Trajectory length of the COP displacement was also significantly greater among the DS group in the eyes open stance ($p<.05$). The same results were found in the eyes closed stances with greater COP displacement of medial/lateral sway ($p<.05$) found among the group with DS, but not anterior/posterior sway ($p>.05$). Trajectory length of the COP displacement was also significantly greater among the group with DS when compared to the control group in the eyes closed stance ($p<.05$). The authors concluded that subjects with DS have greater deficits in postural control when compared to individuals who do not have DS (Galli et al., 2008).

Wang, Long, and Liu (2012) conducted a similar study that tested whether individuals with DS have greater postural sway in quiet stance and insufficient motor ability by determining the relationship between task-oriented postural control and motor ability among adolescents with DS. There were 23 adolescents with DS in the experimental group and 18 non-DS age and gender matched participants in the control group. Measurements were taken looking at center of pressure (COP) utilizing force plates and looking at the differences between quiet standing with eyes open and with eyes closed. Results indicated that participants with DS had a higher velocity of COP sway during quiet standing ($p < 0.05$). Shumway-Cook and Woollacott (1985) had similar findings, stating that children with DS had greater body oscillation and saw greater loss in balance compared to the non-DS control group. Wang and Ju (2002) determined that walking, running, jumping, and muscle strength had a significant contribution to the heightened velocity of postural sway during voluntary movement among DS participants ($p < 0.05$). Wang et al. (2002) concluded the DS participants showed a significantly lower postural control and motor ability than the control group and that future research may look at the underlying causes of the postural sway during movement.

Rigoldi et al. (2011b) analyzed postural control in three different groups of subjects. Participants consisted of 37 children with DS, 58 teenagers with DS, and 45 adults with DS. There were also age matched control groups to compare data to consisting of 10 children, 15 teenagers, and 16 adults, all without DS. Participants and parents were required to sign an informed consent. Force platforms were used to measure center of pressure (COP) displacement values and two TV cameras were utilized to record participants on the force platform. Data were collected during two consecutive trials; time-domain parameters were normalized to prevent the influence of the participant’s height on results. The anterior/posterior COP displacement and medio/lateral COP displacement were analyzed looking at the difference between absolute maximum and minimum sway while also analyzing the trajectory length of COP. Results showed that sway is greatest among children with DS, followed by teenagers with DS, with the smallest amount of sway observed among adults with DS. Results also indicated a significant difference between the group with DS and the group without DS with larger COP displacement seen among the DS group ($p<.05$).

Based on these results, it may be concluded that individuals with DS have more COP displacement than individuals without DS (Rigoldi et al., 2011b). Rigoldi et al. (2011b) also concluded that individuals in the DS group had less postural control as children than they did when compared to the teenage and adult groups. Likewise, the adult group had the greatest amount of postural control when compared to the teenage and child group.

It may be concluded that people with DS have deficits in postural control and balance when compared to people without DS disease. It can also be concluded that people with DS may benefit from participating in balance training sessions in order to increase postural control and balance (Li et al., 2013). Balance-training sessions should focus on the anterior/posterior and medio/lateral sway in center of pressure while balancing. It is important for those with DS to improve balance in order to enhance balance and postural control. Li et al. (2013) had similar conclusions stating the numerous positive outcomes ranging from overall improvements in quality of life to improvement in performing activities of daily living came from implementing exercise programs among the DS population. The common balance problems found among the DS population may stem specifically from the inability to maintain a stable and consistent postural control, which indicates there is a need for improvement in this domain.

Benefits from Exercise and Balance Training

Li et al. (2013) determined that in all areas of physical fitness, balance is the most overlooked among the DS population. According to Angelopoulou et al. (2000) persons with DS are more likely to experience lower bone mineral density and muscle strength, which can directly affect their functional balance abilities. Heller et al. (2002) concluded individuals with DS of all ages experience fewer opportunities to participate in exercise and balance training, so it may also be beneficial to determine the most efficient and effective way to improve balance.

Gupta et al. (2011) analyzed the effect of exercise on the strength and balance of children with DS. Twenty-eight children were utilized in this study over a six-week intervention with training sessions occurring three times per week. Three test trials were utilized, using the best performance from all three. The Bruinicks-Oseretsky Test of Motor Proficiency (BOTMP) was used to measure balance. After baseline measurements were taken, the children were randomly separated into experimental and control groups. The children in the experimental group took part in an exercise training program that used resistance-training exercises for the lower limbs while also focusing on balance exercises. Instructional procedures were first demonstrated in order to familiarize the subjects with the exercise tasks. The control group continued daily activities in the school, which generally consisted of classroom setting learning and generic physical activity. Results indicated that post program assessments were significantly different than baseline assessments ($p < 0.05$) between the experimental and control group, when analyzing strength of all the muscle groups. When analyzing pre and post scores from the balance intervention, there was a statistical difference between the intervention and control group with the intervention group improving more ($p < 0.05$); excluding three components: walking on a line, standing on a balance beam with eyes closed, and stepping over a response stick on a balance beam. The author's were able to conclude that a six-week intervention time period was long enough to produce significant results. They were also able to conclude that the intervention program was able to improve the overall lower limb strength and balance in children with DS.

Boswell (1991) aimed to determine the most efficient way of improving balance among the DS population by utilizing 26 subjects with mild to moderate cognitive disabilities. The first group incorporated a creative dance technique (n=13), which consisted of exploring the different elements of dance such as space, time, and effort. The second group incorporated a movement exploration technique (n=13), which consisted of activities specifically targeting locomotor, manipulative, and balance skills and methods used ranged from voice commands to hula-hoops. There were only two participants in the creative dance group with DS and in the movement exploration group there were no DS participants; however, all participants were considered to have cognitive disabilities. Instruments utilized were the balance beam and stabilometer to measure dynamic balance pre and post intervention (eight weeks, three sessions per week, 30 minutes per session). Boswell (1991) determined that both the creative dance group and the movement exploration group provided similar results post-testing in regards to dynamic balance. The creative dance group showed greater increase in means from pre and posttest scores than the movement exploration group, although there were no significant differences between the two groups ($p > 0.05$). It may be suggested that the creative dance group had better posttest scores because it was a more fun and exciting environment that was purposeful and made the activity appealing, ultimately eliminating exercise barriers (Heller et al., 2002; Mahy et al., 2010). Author's concluded both groups were similarly effective programs in regards to improving dynamic balance among children with intellectual disabilities.

Rigoldi, Galli, and Albertini (2011a) conducted a research study to determine the effects of aging among a group of individuals with DS, by analyzing their gait. This study is beneficial in understanding several other factors that are affected when analyzing balance and postural control among the DS population (Galli et al., 2008; Wang et al., 2012). The experimental group consisted of 32 individuals with DS and the control group consisted of 36 cognitively healthy subjects. Results determined that step length (SL), step width (SW), and velocity (V) are all significantly different between the DS group and the control group ($p < 0.05$), with the control group having greater step length, width, and velocity. There was not a significant difference between the different classifications (children, teenagers, and adults) for SL, SW, and V among the control group ($p > 0.05$). There was a significant difference between children, teenagers, and adults with DS looking at SL, SW, and V, over time ($p < 0.05$)

with children having the better scores. These results support Rigoldi et al. (2011b) previous research analyzing postural control among individuals with DS. It may be concluded that early intervention for improvement of ligament laxity and motor coordination may be an effective way to prevent decrease in gait development among individuals with DS (Rigoldi et al., 2011a).

It may be concluded that people with DS may benefit from strength and balance training programs (Boswell, 1991; Gupta et al., 2011). Literature suggests the importance of implementing exercise regimens that focus on strength, balance, and gait can increase daily functional living among adults with DS (Rigoldi et al., 2011a). It also may be concluded that many children, adolescents, teenagers, and young adults with DS do not have the same opportunities as non-DS individuals to participate in a balance program (Heller et al., 2002). It may be beneficial to see if there can be improvements in balance, postural control, and center of pressure among individuals with DS.

Exercise Barriers

According to Barr and Shields (2011), the percentage of children with DS who do not meet the recommended physical activity guidelines is lower when compared to children who do not have DS. Literature suggests that individuals of all ages with DS have less postural control and balance when compared to non-DS populations (Galli et al., 2008). Heller et al. (2002) examined the impact of exercise barriers and caregivers attitudes on exercise participation in adults with DS. Participants included 44 adults with mild to moderate DS ranging between the ages of 30 to 57 years old. Exercise participation consisted of aerobic, strength, and flexibility and the frequency consisted of the number of days per week the adults with DS exercised. Duration was determined by the minutes per day the adults with DS exercised. Health of the DS adult was rated on a 5 point Likert scale, 1 being excellent and 5 being poor. Instrumental Activities of Daily Activities and Activities of Daily Living scales were utilized to report adaptive behavior and were measured on a Likert scale, 1 meaning with total help and 3 meaning without help. An Exercise Perceptions Scale was utilized to determine the caregiver's perception of health benefits from exercise and DS perceptions of the health benefits from exercise. A Likert scale was utilized for the caregivers and was based on a scale from 1 to 3, 1 being strongly disagree and 3 being strongly agree. The Likert scale utilized for the persons with DS and was based on a scale from 1 to 5, 1 being strongly disagree and 5 being strongly agree. An Exercise Barriers Scale was utilized to determine whether caregivers and adults with DS considered 18 difference items a barrier to exercise. This was based on a 3-point Likert scale, 1 being not a barrier and 3 being a barrier.

Results indicated that the 59% of adults with DS participated in some type of physical activity ranging from walking to jump roping with an average frequency of 3 days per week. Adults with DS and the caregivers perceived exercise expectations differently ($p < 0.05$). Adults with DS perceived the benefits of exercise as feeling better emotionally and looking better while the caregivers perceived benefits of exercise as improving overall health and getting in shape. Paired samples *t*-test was utilized to determine the difference in caregiver's self-ratings on cognitive-emotional barriers. Adults with DS reported higher barriers of lack of time ($p < 0.05$), higher barriers of difficulty ($p < 0.001$), and health concerns ($p < 0.01$). However, access barriers were not perceived differently between carers and adults with DS ($p > 0.05$). The access barriers reported included transportation, too expensive, does not know how to exercise and fitness centers are not easily accessible. Heller et al. (2002) concluded that the low physical activity rates among adults with DS may be caused by socio-environmental factors, which include both attitudinal factors of caregivers, environmental access barriers, and exercise expectations in regards to the health benefits.

A similar study supporting Heller et al. (2002) was conducted by Mahy et al. (2010) to determine facilitators and barriers to physical activity among adults with DS. Interviews were conducted with 18 participants between the ages of 21 to 44, 12 support people consisting of four mothers of the adults with DS and eight staff members from the day programs who have had experience working with adults with DS for a minimum of six years. Inclusion criteria for adults with DS was the ability to communicate verbally, experience with physical activity, and engaging in physical activity more than once a week. Written informed consents were required from both the DS adult and the guardian. All interviews were recorded and transcribed verbatim to ensure accurate interpretations of answers and conversations.

There were three main themes to the results of the interviews: support from others, fun and/or exciting activity, and routine and/or familiarity to exercises. Almost all of the interviews with the adults with DS preferred a fun, exciting environment full of music and encouragement. Authors were able to draw conclusions from the interviews that incorporating a social aspect of the games and creating a routine for the exercises would also serve as motivation to participate in physical activity. It may be concluded that exercise barriers significantly hinder the DS population in more ways than one. This is why incorporating a Nintendo Wii balance program may be beneficial in promoting exercise program adherence (Berg et al., 2012).

Nintendo Wii Fit for Non-Down Syndrome Population

It may be beneficial to understand if the Nintendo Wii Fit can be effective in increasing balance among other populations aside from DS. Bieryla and Dold (2013) determined using virtual reality gaming, such as the Nintendo Wii Fit was a beneficial way to improve balance among older adults. Bieryla and Dold (2013) concluded that utilizing the Nintendo Wii Fit may encourage older adults to continue the regimen after the research intervention ceases. It may be assumed that a person will be more likely to continue doing something they enjoy (Bieryla & Dold., 2013). Byrne et al. (2012) conducted a study to determine if the Wii Fit balance games can improve dynamic balance among healthy young adults. A quasi-experimental design looking at pre and post testing effects during a three week intervention (total of eight sessions) established a significant difference between scores over time. Nineteen participants were recruited and the Star Excursion Balance Test was utilized to determine balance measurements pre and post intervention (Byrne et al., 2012). The participants played the game in a quiet laboratory to eliminate any encouragement or direct feedback to the participants.

Results showed a significant increase of the Star Excursion Balance Test scores with the exclusion of posterolateral and anteromedial ($p < 0.05$). Byrne et al. (2012) concluded that the Nintendo Wii Fit balance training program did significantly improve dynamic balance among young adults over an intervention period of three weeks (eight total sessions).

Rendon et al. (2012) conducted a study to look at the effects of virtual reality balance programs on dynamic balance among older adults (n=40). This was a randomized controlled six-week intervention that had an experimental and control group. The control group only received pre and post measurements while the experimental group received virtual reality gaming utilizing the Nintendo Wii balance board and also had pre and post measurements. The 8-foot up-and-go and Activities-specific Balance Confidence Scale were utilized to measure balance. Rendon et al. (2012) found results that showed significant improvements among the experimental group in both the 8-foot up-and-go and the Activities-specific Balance Confidence Scale ($p < 0.05$). Based on these results, it may be concluded that the Nintendo Wii fit balance games are a beneficial tool for improving balance and postural stability among older adults (Bieryla & Dold., 2013; Rendon et al., 2012).

Looking specifically at individuals improving their ability to stand after a stroke, Harvey and Ada (2012) conducted a study to determine which Nintendo Wii Fit Plus games were the most effective as a form of rehabilitation therapy. A total of 75 Nintendo Wii Fit Plus games were assessed; however, only 20 games were kept for critical review. It was concluded that a total of five games were effective at improving standing abilities among individuals with severe standing impairment; those games included Basic Balance Test, Agility Test, Stillness Test, Table Tilt, and Judgement Test. There were a total of four games effective for improving standing abilities among individuals with moderate standing impairment; those games consisted of Balance Bubble, Prediction Test, Peripheral Vision Test, and Dual Balance Test. Lastly, eleven games were effective at improving standing abilities among individuals with mild standing impairment; the games consisted of Table Tilt Plus, Balance Bubble Plus, Ski Slalom, Penguin Slide, Snowboard Slalom, Heading, Segway Circuit, Snowball Fight, Tilt City, Birds-Eye Bulls-Eye, and Big Top Juggling. All of these games include training specifically aimed at developing greater control of center of mass (Harvey & Ada, 2012). Harvey and Ada (2012) concluded that a total of 20 games were an effective mode of rehabilitation for improving standing among individuals who have had a stroke.

In summary, literature supports that Nintendo Wii Fit balance games have been effective in improving balance and postural control among other populations aside from DS (Byrne et al., 2012; Harvey & Ada., 2012; Rendon et al., 2012). It may also be assumed that due to the significant improvements in balance seen among the non-DS population, implementing a Nintendo Wii Fit balance regimen may be beneficial for improving balance among adults with DS (Byrne et al. 2012; Rendon et al., 2012).

Nintendo Wii Fit for Down Syndrome Population

To the researchers knowledge there is no current literature specifically on the effects of a Nintendo Wii balance program for the improvement of postural control and balance among adults with DS. There have been a few studies conducted to determine if implementing a Nintendo Wii balance program for the improvement of postural control and balance among children with DS (Berg et al., 2012). Berg et al. (2012) conducted a case study to determine if motor outcomes would improve following an 8-week intervention utilizing the Nintendo Wii and encouraging family support in a child with DS. A self-efficacy questionnaire was utilized, the Perceived Ability Questionnaire and the Bruinicks-Oseretsky Test of Motor Proficiency, 2nd Edition, was utilized to measure fine motor skills, and the Test of Visual Perception Skills, 3rd Edition was utilized to measure nonmotor visual perceptions. The Biodex BioSway Balance System, was utilized to measure center of mass during both stable and unstable conditions. The intervention was 8-weeks long and the child was instructed to participate in the Wii game at least four times per week for no less than 20 minutes per session.

Similar to the results seen among non-DS population, Berg et al. (2012) found results indicating that the child demonstrated improvements in manual dexterity, postural stability, upper-limb coordination, balance, and running speed and agility. After the intervention the testing for postural stability indicated a decreased sway in anterior/posterior sway and an increase in medial/lateral sway. Overall stability index changed from 1.39 (week 1) to 1.00 (week 8) looking at degree of sway (the lower the number indicates the less sway). Degree of sway anterior/posterior was at 1.39 (week 1) and changed to 0.64 (week 8). Finally, degree of sway medial/lateral index went from 0.53 (week 1) to 0.94 (week 8) showing no improvement or a regression. Author's concluded that with use of a Nintendo Wii Fit gaming device and the encouragement from family and/or friends improved upper-limb coordination, manual dexterity, balance, and postural stability (Berg et al., 2012).

Wuang et al. (2011) conducted a similar study utilizing a larger sample size (n=105) to determine if virtual reality using Wii gaming technology (VRWii) can enhance sensorimotor functions in comparison to standard occupational therapy (SOT) among children with DS. The Bruinicks-Osteretsky Test of Motor Proficiency, 2nd Edition was utilized to measure motor proficiency among the children and the Developmental Test of Visual Motor Integration was utilized to test visual perception and motor coordination. This was a 24-week program that consisted of two sessions per week for one hour per session. Results indicated that the VRWii group performed significantly better than the SOT group in regards to fine motor integration, upper-limb coordination, and running speed and agility ($p < 0.03$). Wuang et al. (2011) concluded that the VRWii provided a larger increase than the SOT group in post intervention scores when looking at the Bruinicks-Osteresky Test of Motor Proficient, 2nd Edition. This measure specifically looked at fine motor integration, upper-limb coordination, and running speed and agility. The idea that virtual reality gaming, such as a Nintendo Wii Fit balance regimen may be an efficient way of improving balance by decreasing postural sway among individuals should be further explored and researched.

Summary

The purpose of this literature review was to further the knowledge of why implementing a Nintendo Wii fit balance regimen among adults with DS over the age of 18 years old will be beneficial. Educating and promoting awareness is imperative for finding new and innovative ways to more efficiently improve balance and postural control among individuals with DS (Galli et al., 2008; Wang et al., 2012). According to Tanaka, Takeda, Izumi, Ino, and Ifukube (1997) balance is substantive for performing daily functional activities, which may contribute to maintaining stable postural control. Hirabayashi and Iwasaki (1995) concluded the two main variables that effect postural control are the sensory organizational process and the musculoskeletal response to motor adjustment process. Both of these variables are targeted with the utilization of the Nintendo Wii Fit balance board games (Wuang et al., 2011). Literature suggests a greater improvement in sensorimotor functions when utilizing the Nintendo Wii Fit compared to more traditional balance regimens (Wuang et al., 2011), as well as an improvement in motor functions (Berg et al., 2012). Villamonte et al. (2010) determined there is major variability between cognitive and physical function among individuals with DS. Due to this it is nonconclusive as to the most reliable balance test to utilize among the DS population (Villamonte et al., 2010). Villamonte et al. (2010) recommended to those conducting research, use more than one balance test. According to results and intraclass correlation coefficient (ICC) scores it may be assumed that out of the 16 balance tests analyzed the highest ICC score (0.94) was seen utilizing a static test measuring length of time (in seconds) standing on preferred leg on the floor. Functional balance tests such as the timed get-up and go may have been inconsistent due to the participant's fear of falling and their cognitive inability to understand the concept of the tests (Villamonte et al., 2010). TekScan systems may serve as a reliable and valid addition to measuring balance by quantifying postural sway, contact area, force, and pressure applications (Bachus, DeMarco, Horwitz, & Brodke, 2006; Nomura et al., 2009). It may be assumed that utilizing the TekScan mat while conducting traditional static balance tests would produce reliable results (Coda, Carline, & Santos., 2014; Rule et al., 2012; Tekscan, Inc., 2014).

In conclusion, there is a lack of literature on the effects of utilizing a Nintendo Wii balance program to improve postural control and balance among adults with (DS) over the age of 18 years old. Due to the increasing prevalence in DS births every year in the United States, it is important to find innovative ways to increase their health, safety, and quality of life (Shin et al., 2009).

Chapter Three: Methodology

The purpose of this study was to determine if implementing a Nintendo Wii balance exercise regimen would improve postural control and balance among adults with DS over the age of 18 years old. The researcher hypothesized that implementing a Nintendo Wii balance session two times per week, 30 minutes a session, for five weeks, would show a significant improvement in postural control and balance when compared to a group who participated in general Nintendo Wii Sport games two times per week, 30 minutes per session, for five weeks.

Participants

Recruitment of subjects began in the spring semester (2015) at the Wings facility (a special needs community) located in Edmond, Oklahoma. Adults with DS over the age of 18 who met the Wings criteria for participation were recruited. Participants had to be over the age of 18 years old, communicate effectively and efficiently, be able to understand general rules and guidelines, and function independently (i.e., go to the bathroom by themselves, eat by themselves, walk and move around by themselves). The youngest participant was 23 years old and the oldest participant was 60 years old. Participants ranged in weight from 83 pounds to 194.5 pounds. A letter was sent home to the parent/guardian of the potential participants describing the project as well as the risks and benefits associated with participating in the project (Appendix D). The primary researcher's name and contact information was also provided. Within the letter there was also one informed consent (Appendix B) for the parent/guardian, one assent form for the potential participant (Appendix C), and one medical release form (Appendix E) for primary care physician approval to participate in the study. Based on previous research by Wuang et al. (2011), univariate effect size for change in postural control was estimated to be (d = 2.58) requiring a sample size of 12 per group to find statistical significance, $\alpha = .05$, $1 - \beta = .80$ (Cohen, 1988). Wuang et al. (2011) measured change in postural control by utilizing the Bruininks-Oseretsky Test of Motor Proficiency-Second Edition (BOT-2). This is a motor proficiency test utilized by clinicians, researchers, and educators to evaluate four motor areas to determine a total motor composite score. The primary researcher utilized the TekScan HR Mat to measure postural control and balance within this study, details of the TekScan HR Mat will be provided in the section below titled, Instrumentation.

Once informed consents were received from the parent/guardian and the assent form was received from the adults with DS prescreening began. Prescreening required a medical release from the participant's primary care physician. The medical release form (Appendix E) was sent to the parent/guardian at the time of recruitment to request permission to contact the primary care physician and get primary care physician name and contact information. Once permission was received to contact the participant's primary care physician, the medical release form was faxed to the primary care physician for medical release. Participants were required to have medical release prior to the intervention. These procedures followed American College of Sports Medicine health screening guidelines for individuals with DS (Pescatello, 2014).

Instrumentation

TekScan HR-Mat™. This device is commonly used to measure foot function, gait, pressure differences between feet, asymmetries during regular stance, balance, and etc. (Nomura et al., 2009; Rule et al., 2012). Rule et al. (2012) concluded the TekScan HR Mat test is both reliable and valid. It was utilized to accurately measure center of force (COF) and postural sway, which is an indicator of poor balance (Nomura et al., 2009; Bachus et al., 2006). More specifically, the TekScan HR Mat was used to specifically measure sway path length from medio/lateral, anterior/posterior, area, distance, and variability to analyze postural control and balance. Each game utilized is described below.

Nintendo Wii Fit balance board and games. This is a virtual reality gaming system. The games utilized within the intervention included Penguin Slide, Snow board Slalom, Candle Light, Ski Slalom, Balance Bubble, and Table Tilt. Each game utilized is described below.

Penguin slide. The participant was asked to shift his/her weight from medial to lateral to make the penguin move on the iceberg. The participants goal was to try and keep the penguin on the iceberg and not let him slide off, focusing on shifting weight to obtain this goal. The subject was also asked to lean far enough to one side to get the penguin to the edge and flip him up to catch a fish, while staying on the iceberg, the more fish the penguin catches, the higher the score received.

Snowboard Slalom. The participant was asked to shift his/her weight from anterior to posterior in order for the character in the game to go between the flags posted in the ground while snowboarding down the mountain. The main goal of this game was to make it through each flag, the more flags the participant made it through the better the score.

Candle Light. The participant was asked to maintain balance while standing as still as possible on the Wii Fit board; the more movement the participant experienced the more likely the candle was to go out. The goal was to keep the candle lit as long as possible.

Table Tilt. The participant was asked to shift his/her weight from medial to lateral and anterior to posterior in order to roll the balls into the holes. The goal of this game was for the participant to roll as many balls into the holes as possible before the time ran out; the longer the participant did this the better their score.

Ski Slalom. The participant was asked to shift his/her weight from medial to lateral in order to make the game character go in between flags posted in the ground while skiing down the mountain. The main goal of this game was to make it through each flag, the more flags the participant made it through the better their score.

Balance Bubble. The participant was asked to shift his/her weight from anterior to posterior to medial and lateral on the balance board in order to move the bubble through a hazardous course (riverbanks, rocks, etc.) and if the bubble hit any hazardous objects it popped, ending the game. The goal of this game was to continue down the river as long as possible.

Nintendo Wii Sports Games. This is a virtual reality gaming system. The games included were baseball, golf, bowling, and tennis. The participant used the remote in simulation for the "equipment" used in each game, such as a baseball bat, tennis racket, bowling ball, and a golf club. It must be noted, each game was played in a standard play mode.

Baseball. The participant played a 3-inning game and got to simulate a baseball swing as well as pitch the ball via the remote control.

Golf. Participants played either a 3-hole or 9-hole course and simulated a golf swing via the remote control.

Bowling. The participant played a total of a 10-frame game and simulated a bowling rotation motion with his/her arm via the remote control.

Tennis. The participant played a doubles match and simulated a swinging motion with the tennis racket via the remote control

Procedures

Institutional Review Board (IRB) approval from the University of Central Oklahoma was requested and received. Once the researcher obtained IRB approval, recruitment began. Those with completed informed consent forms by the parent/guardian and assent form by the participant began prescreening which included a medical release form from the participant's primary care physician. Baseline assessments were administered to those participants who received primary care physician medical release. Baseline assessments included measuring postural control utilizing the TekScan HR-Mat. Participants were asked to balance on the TekScan HR Mat for 30 seconds on both feet with eyes open, both feet with eyes closed, left foot with eyes open, left foot with eyes closed, right foot with eyes open, and right foot with eyes closed. The participants were unable to balance in the following stances: left foot eyes open, left foot eyes closed, right foot eyes open, and right food eyes closed. The stances utilized for analyses were standing on two feet eyes open and standing on two feet eyes closed. The following dependent variables were measured via TekScan HR Mat, anterior/posterior sway, medial/lateral sway, area, distance, and variability. Measurements were taken before and after the five week intervention. The comparison group (n = 4) was allowed to use up to four Nintendo Wii Sport games. The experimental group (n = 5) was allowed to use four to six different balance games for 30 minute sessions, two days per week. During the 30 minute sessions participants in both groups would take turns playing the games in order to implement appropriate rest periods. Due to the research project being held at the Wings facility, both comparison and experimental groups used the Nintendo Wii game. This was done because it was believed that the participants' intellectual impairments did not allow them to fully comprehend why half the class would be allowed to play the Nintendo game and the other half not. They started with one game, as the other games served as an incentive for them to perform well. The control group ended up only using two out of the four games (bowling and tennis) due to various reasons such as refusing to play a certain game. The treatment group also only ended up playing three balance games (Penguin Slide, Ski Slalom, and Candle Lotus) due to refusal of playing a different one and some games being too difficult. There was one television hooked up to one Nintendo Wii. The participants took turns playing games in both groups.

Statistical Analysis

This study examined whether a balance-training program utilizing the Nintendo Wii Fit improved balance and postural control in adults with DS over the age of 18 years old. The null hypothesis stated that the Nintendo Wii Fit balance exercise regimen would not show an improvement in postural control and balance among adults with DS. The research hypothesis stated that the Nintendo Wii Fit balance exercise regimen would show an improvement in postural control and balance among adults with DS.

The independent variables were time (pre and post) and group (treatment and control). There were a total of 10 dependent variables that measured postural control and balance. The dependent variables were measured in two stances, two feet eyes open and two feet eyes closed and will be listed below:

- Anterior/Posterior sway (cm)
- Medial/Lateral sway (cm)
- Area (cm^2)
- Distance (cm)
- Variability (cm)

A software package used for statistical analysis, *Statistical Package for the Social Sciences*, or more commonly referred to as *SPSS* was utilized to analyze all collected data. A 2 x 2 Repeated Measures ANOVA was utilized to test the null hypotheses for each dependent variable (α = .05). Due to the small sample size, univariate effect sizes and percent change were calculated to examine non-significant, but potentially meaningful changes within each group. Independent samples *t* tests were conducted to examine baseline differences between groups. Descriptive statistics including examination of outliers and normality were conducted for each variable.

Chapter Four: Results

Purpose

Due to the increase in prevalence of DS births every year in the United States, it is important to discover the most efficient and realistic modes of exercise to improve their health, safety, and quality of life (Shin et al., 2009). In order to improve activities of daily living among this population, Nintendo Wii Fit gaming sessions may serve as a beneficial exercise regimen (Berg et al., 2012). The primary purpose of this study was to determine if a Nintendo Wii Fit balance program would improve balance and postural control among adults with DS over the age of 18. This section will include, in full detail, the statistical analyses from the implemented intervention. Total participants for this study were 11 with two dropouts, split by group there were five in the treatment and four in control. The two participants dropped out due to temporary uncontrollable seizures and back pain (likely caused by the rods in her back).

Descriptive Statistics

There were a total of six females and 3 males that participated in this research study. In the treatment group there were three females and two males. In the control group there were four females and one male. The mean and standard deviation for the ages of all nine participants were as follows: 35.22±13.58 years old. The mean and standard deviation for the weight of all nine participants were as follows: 136.94±35.17. Descriptive statistics were calculated for anterior/posterior, medial/lateral, area, distance, and variability sway (Table 1 & 2). When the data were split into treatment and control groups, one outlier was found in the treatment group in pretests (Figures 1 & 2) and two outliers were found in the treatment group during post tests (Figures 3, 4, 5, 6, & 7). These outliers were not removed because they were true measures and were important for the accuracy of the results as well as maintenance of sample size.

Anterior/Posterior – Eyes Open. Anterior/posterior sway can be described as the distance traveled by the participant's center of force from front to back (Tekscan Inc, 2014). Descriptive statistics were calculated for this variable for pre and post testing analyses in the eyes open two feet stance.

Treatment. Pre testing numbers for the treatment group included a mean and standard deviation of 7.26±4.23 cm with a range of 10.87 cm. This variable was normally distributed looking at skewness and kurtosis. Post testing numbers for anterior/posterior sway with the eyes open included a mean and standard deviation of 5.39±1.82 cm with a range of 5.02 cm. There were two outliers found within the post testing measurements of the treatment group (Figure 3). Anterior/posterior sway with eyes open at post test was also normally distributed.

Control. Pre testing data for anterior/posterior sway of the control group included a mean and standard deviation of 8.09±4.15 cm with a range of 8.05 cm. Anterior/posterior sway of the control group at pretest was platykurtic with normal skewness. Post testing data for the control group consisted of a mean and standard deviation of 4.6±1.08 cm with a range of 2.63 cm. The distributions of these data were leptokurtic and normally skewed.

Anterior/Posterior – Eyes Closed. Descriptive statistics were also calculated for anterior/posterior sway for pre and post testing analyses in the eyes closed two feet stance.

Treatment. Pre testing numbers for the treatment group included a mean and standard deviation of 9.19±5.58 cm with a range of 13.31 cm. Anterior/posterior sway with eyes closed in the treatment group at pretest was platykurtic with normal skewness. Post testing numbers for anterior/posterior sway included a mean and standard deviation of 4.09±2.43 cm with a range of 5.70 cm. This variable was normally distributed.

Control. Pre testing data for anterior/posterior sway of the control group included a mean and standard deviation of 7.74±6.94 cm with a range of 15.36 cm. Anterior/posterior sway of control group was leptokurtic and positively skewed. Post testing data for the control group consisted of a mean and standard deviation of 4.92±1.99 cm with a range of 3.88 cm. The distributions of these data were platykurtic and normally skewed.

Medial/Lateral – Eyes Open. Medial/lateral sway can be described as the distance traveled by the participant's center of force from right to left (Tekscan Inc, 2014). Descriptive statistics were calculated for medial/lateral sway for pre and post testing analyses in the eyes open two feet stance.

Treatment. Pre testing numbers for the treatment group included a mean and standard deviation of 8.34±6.11 cm with a range of 12.98 cm. This variable was platykurtic with normal skewness. Post testing numbers for medial/lateral sway of treatment group included a mean and standard deviation of 8.13±9.20 cm with a range of 22.41 cm. Medial/lateral sway of treatment group at post testing was leptokurtic and positively skewed.

Control. Pre testing data for medial/lateral sway of the control group included a mean and standard deviation of 7.95±2.76 cm with a range of 5.57 cm. Medial/lateral sway of control group at pretest was platykurtic and normally skewed. Post testing data for the control group consisted of a mean and standard deviation of 7.45±9.69 cm with a range of 19.72 cm. The distributions of these data were leptokurtic and positively skewed. There was one outlier found within the post testing data in the treatment group (Figure 4).

Medial/Lateral – Eyes Closed. Descriptive statistics for medial/lateral sway in the eyes closed group for pre and post testing analyses were also calculated.

Treatment. Pre testing numbers for the treatment group included a mean and standard deviation of 9.60±7.96 cm with a range of 19.25 cm. Medial/lateral sway with eyes closed for pretests in the treatment group was normally distributed. Post testing numbers for this variable included a mean and standard deviation of 5.38±5.94 cm with a range of 13.95 cm. Medial/lateral sway was for eyes closed post tests in the treatment group was leptokurtic and positively skewed.

Control. Pre testing data for medial/lateral sway of the control group included a mean and standard deviation of 4.83±1.94 cm with a range of 4.03 cm. Medial/lateral sway of control group was platykurtic and normally skewed. Post testing data for the control group at pre test consisted of a mean and standard deviation of 10.28±10.32 cm with a range of 22.81 cm. The distributions of these data were normal.

Area – Eyes Open. Area can be described as the region in which the participant's center of force traveled during the measurement on the TekScan HR Mat (Tekscan Inc, 2014). Descriptive statistics were calculated for area sway for pre and post testing analyses in the eyes open two feet stance.

Treatment. Pre testing numbers for the treatment group included a mean and standard deviation of 38.99±44.20 cm^2 with a range of 100.57 cm^2. Area sway for the treatment group during pretests was slightly platykurtic and normally skewed. Post testing numbers for this variable included a mean and standard deviation of 18.26±26.39 cm^2 with a range of 62.78 cm^2. Area sway for post testing of the treatment group was leptokurtic and positively skewed. One outlier was also found within the post testing assessment in the treatment group of the variable area (Figure 5).

Control. Pre testing data for area sway of the control group included a mean and standard deviation of 25.68±12.62 cm^2 with a range of 29.23 cm^2. Area sway with eyes open of control group during pre testing was leptokurtic and slightly positively skewed. Post testing data for the control group consisted of a mean and standard deviation of 16.45±21.71 cm^2 with a range of 44.15 cm^2. The distribution of this data was leptokurtic and positively skewed.

Area – Eyes Closed. Descriptive statistics for area sway in the eyes closed group for pre and post testing analyses were calculated.

Treatment. Pre testing numbers for the treatment group included a mean and standard deviation of 47.90±46.53 cm^2 with a range of 110.46 cm^2. Area sway with eyes open during pre tests of the treatment group was platykurtic and normally skewed. Post testing numbers for this variable included a mean and standard deviation of 12.66±15.63 cm^2 with a range of 32.86 cm^2. Area sway with eyes closed of post tests was platykurtic and normally skewed.

Control. Pre testing data area sway of the control group included a mean and standard deviation of 15.31±14.80 cm^2 with a range of 33.34 cm^2. Area sway with eyes closed in the control group during pre tests was leptokurtic and slightly positively skewed. Post testing data for the control group consisted of a mean and standard deviation of 8.14±6.52 cm^2 with a range of 15.53 cm^2. The distributions of these data were slightly leptokurtic and normally skewed.

Distance – Eyes Open. The dependent variable distance can be described as the total length traveled by the participant's center of force during the measurement (Tekscan Inc, 2014). For example, if the distance recording were to be unraveled and brought out to a straight line this would be the measurement for total distance (Tekscan Inc, 2014). Descriptive statistics were calculated for distance sway for pre and post testing analyses in the eyes open two feet stance.

Treatment. Pre testing numbers for the treatment group included a mean and standard deviation of 138.54±93.83 cm with a range of 238.95 cm. Distance sway for treatment group in eyes open stance during pretests was slightly leptokurtic and slightly positively skewed. One outlier was found within this group (Figure 1). Post testing numbers for distance sway in the treatment group with eyes open during pretests included a mean and standard deviation of 93.84±43.90 cm with a range of 106.89 cm. Distance sway for treatment group was leptokurtic and positively skewed. There was one outlier found among the treatment group for post testing of the dependent variable, distance (Figure 6).

Control. Pre testing data for distance sway of the control group included a mean and standard deviation of 172.48±114.23 cm with a range of 259.28 cm. Distance sway with eyes open in the control group for pretests was leptokurtic and slightly positively skewed. Post testing data for the control group consisted of a mean and standard deviation of 85.97±29.36 cm with a range of 53.77 cm. The distributions of these data were platykurtic and normally skewed.

Distance – Eyes Closed. Descriptive statistics for distance sway in the eyes closed group for pre and post testing analyses were calculated.

Treatment. Pre testing numbers for the treatment group included a mean and standard deviation of 164.02±120.68 cm with a range of 299.83 cm. Distance sway with eyes closed in the treatment group during pretests was slightly leptokurtic and slightly positively skewed. Post testing numbers for distance sway eyes closed included a mean and standard deviation of 79.77±83.96 cm with a range of 83.96 cm. Distance sway with eyes closed the treatment group was platykurtic and normally skewed.

Control. Pre testing data distance sway of the control group included a mean and standard deviation of 210.43±274.10 cm with a range of 566.63 cm. Distance sway with eyes closed for pretests was platykurtic and positively skewed. Post testing data for the control group consisted of a mean and standard deviation of 94.76±69.64 cm with a range of 149.26 cm. The distributions of these data were leptokurtic and positively skewed.

Variability – Eyes Open. Variability is distance or also known as length of the center of force traveled by the participant during the measurement, per frame (Tekscan Inc, 2014). Essentially, it is the standard deviation of individual distances recorded on the TekScan HR Mat (Tekscan Inc, 2014). Descriptive statistics were calculated for this variable for pre and post testing analyses in the eyes open two feet stance.

Treatment. Pre testing numbers for the treatment group included a mean and standard deviation of .12±.07 cm with a range of .17 cm. Variability in the eyes open stance during pretests for the treatment group was platykurtic and normally skewed. Post testing numbers pretests of the treatment group for variability included a mean and standard deviation of .10±.08 cm with a range of .20 cm. Variability in the eyes open stance for post tests was leptokurtic and positively skewed. One outlier was present among the treatment group during post testing (Figure 7).

Control. Pre testing data for variability of sway for the control group included a mean and standard deviation of .16±.09 cm with a range of .21 cm. Variability with eyes open was platykurtic and normally skewed. Post testing data for the control group consisted of a mean and standard deviation of .10±.09 cm with a range of .20 cm. The distribution of this data was leptokurtic and positively skewed.

Variability – Eyes Closed. Descriptive statistics for variability of sway in the eyes closed group for pre and post testing analyses were calculated.

Treatment. Pre testing numbers for the treatment group included a mean and standard deviation of .17±.14 cm with a range of .35 cm. Variability with eyes closed during pretests in the treatment group was slightly leptokurtic and slightly positively skewed. There was one outlier found within this group (Figure 2). Post testing numbers for variability with eyes closed included a mean and standard deviation of .07±.05 cm with a range of .11 cm. Variability had normal kurtosis and was slightly positively skewed.

Control. Pre testing data variability sway of the control group included a mean and standard deviation of .17±.24 cm with a range of .48 cm. Variability in the control group for post testing with eyes closed was leptokurtic and positively skewed. Post testing data for the control group consisted of a mean and standard deviation of .12±.10 cm with a range of .22 cm. The distributions of these data were platykurtic and normally skewed.

Baseline Differences

Independent *t*-Tests. Independent *t*-tests were calculated to determine if there were significant differences between the treatment group and control group at baseline during both stances, eyes open and eyes closed standing on two feet. Statistical analyses determined there were no significant differences between groups in respect to all variables; anterior/posterior sway, medial lateral sway, area sway, distance, and variability in either the eyes open or eyes closed conditions ($p>.05$, Table 3).

Repeated Measures Analysis of variance

The hypothesis stated that the Nintendo Wii fit balance games would significantly improve balance over time. It was also predicted there would be a significant difference between groups at post testing. The variables anterior/posterior sway, medial/lateral sway, area, distance, and variability are all indicators of balance and postural control.

Anterior/Posterior – Eyes Open. A 2 X 2 repeated measures ANOVA was calculated to examine the effects of a Nintendo Wii fit balance intervention on the participant's balance pre and post intervention (Table 4). No significant main effects or interactions were found for anterior/posterior sway with eyes open. The time * group interaction, $F(1,7) = 0.222$, $p = .652$, the main effect for time, $F(1,7) = 2.4$, $p = .165$, and the main effect for the group, $F(1,7) = 0.0$, $p = .988$, were not significant (Table 4); anterior/posterior sway was not influenced by either time or group. Even though these results are not statistically significant, they are still meaningful based on effect size and percent change. In the treatment group, analyzing anterior/posterior sway in the eyes open stance Cohen's effect size was calculated as approaching moderate effect ($d = -.44$) and percent change being a 25.76% decrease. Not as suspected, in the control group for the same dependent variable, Cohen's effect size had a large effect ($d = -.84$) and percent change was calculated as a 43.14% decrease (Table 1 & 2).

Anterior/Posterior – Eyes Closed. A 2 X 2 repeated measures ANOVA was also calculated to examine the effects of a Nintendo Wii fit balance intervention on anterior/posterior sway in the two feet eyes closed stance (Table

4). No significant main effects of interactions were found for the variable, anterior/posterior sway with eyes closed. The time * group interaction, $F(1,7) = 0.356$, $p = .57$, the main effect for time, $F(1,7) = 4.299$, $p = .077$, and the main effect for the group, $F(1,7) = 0.015$, $p = .905$ were not significant (Table 3); balance was not influenced by either time or group. Even though these results are not statistically significant, they are still meaningful based on effect size and percent change. In the treatment group, analyzing anterior/posterior sway in the eyes closed stance Cohen's effect size was calculated as having a large effect ($d = -.91$) and percent change being a 55.50% decrease. As suspected, in the control group for the same dependent variable, Cohen's effect size had a small effect but was approaching a moderate effect ($d = -.41$) and percent change was calculated as a 43.14% decrease (Table 1).

Medial/Lateral – Eyes Open. A 2 X 2 repeated measures ANOVA was calculated to examine the effects of a Nintendo Wii fit balance intervention on the participant's balance pre and post intervention (Table 5). No significant main effects of interactions were found for the variable medial/lateral sway with eyes open. The time * group interaction $F(1,7) = 0.002$, $p = .969$, the main effect for time $F(1,7) = 0.009$, $p = .927$, and the main effect for the group $F(1,7) = 0.024$, $p = .881$ were not significant (Table 5); balance was not influenced by either time or group. Based on effect size calculations these results may not be very meaningful, the magnitude of the effect for the treatment group in the eyes open stance for medial/lateral sway had a small effect (d=-.03) and percent change was 2.40%. In the control group for the same dependent variable, Cohen's effect size also had a small effect (*d* = -.17) and percent change was calculated to 5.82% decrease (Table 1 & 2).

Medial/Lateral – Eyes Closed. A 2 X 2 repeated measures ANOVA was then calculated to examine the effects of a Nintendo Wii fit balance intervention on the medial/lateral sway of the participant with eyes closed (Table 5). No significant main effects of interactions were found for the variable medial/lateral sway with eyes closed. The time * group interaction, F(1,7) = 2.337, *p* = .17, the main effect for time, F(1,7) = 0.038, *p* = .852, and the main effect for the group, F(1,7) = 0.0, *p* = .987 were not significant (Table 4); medial/lateral sway was not influenced by either time or group. Even though these results are not statistically significant, they may still be meaningful based on effect size and percent change. In the treatment group, analyzing medial/lateral sway in the eyes closed stance Cohen's effect size was calculated as having a moderate effect (*d* = -.53) and percent change being 44.06% decrease. However, in the control group for the same dependent variable, Cohen's effect size had a large effect (*d* = +2.81), but the change was in the wrong direction; percent change was calculated to 112.84% increase (Table 1 & 2).

Area – Eyes Open. A 2 X 2 repeated measures ANOVA was calculated to examine the effects of a Nintendo Wii fit balance intervention on the participant's balance pre and post intervention (Table 6). No significant main effects of interactions were found for the variable area with eyes open. The time * group interaction, F(1,7) = 0.128, *p* = .731, the main effect for time, F(1,7) = 0.872, *p* = .381, and the main effect for the group, F(1,7) = 0.397, *p* = .549 were not significant (Table 6); area was not influenced by either time or group. Even though these results are not statistically significant, they are still meaningful based on effect size and percent change. In the treatment group, analyzing area sway in the eyes open stance Cohen's effect size was calculated as having a small effect (*d* = -.47) and percent change being 53.17% decrease. In the control group for the same dependent variable, Cohen's effect size had a moderate effect (*d* = -.73) and percent change was calculated to 35.94% decrease (Table 1 & 2).

Area – Eyes Closed. A 2 X 2 repeated measures ANOVA was then calculated to examine the effects of a Nintendo Wii fit balance intervention on the area sway of the participant with eyes closed (Table 6). No significant main effects of interactions were found for the variable, area sway with eyes closed. The time * group interaction, $F(1,7) = 1.434$, $p = .27$, the main effect for time, $F(1,7) = 3.274$, $p = .113$, and the main effect for the group, $F(1,7) = 1.743$, $p = .228$ were not significant (Table 6); area sway was not influenced by either time or group. Even though these results are not statistically significant, they are still meaningful based on effect size and percent change. In the treatment group, analyzing area sway in the eyes closed stance Cohen's effect size was calculated as having a moderate effect (*d* = -.76) and percent change being 73.57% decrease. In the control group for the same dependent variable, Cohen's effect size had a small effect (*d* = -.48) and percent change was calculated to 54.97% decrease (Table 1 & 2).

Distance – Eyes Open. A 2 X 2 repeated measures ANOVA was calculated to examine the effects of a Nintendo Wii fit balance intervention on the participant's balance pre and post intervention (Table 7). No significant main effects of interactions were found for the variable, distance with eyes open. The time * group interaction, $F(1,7) = 0.348$, $p = .574$, the main effect for time, $F(1,7) = 3.423$, $p = .107$, and the main effect for the group, $F(1,7) = 0.116$, $p = .743$ were not significant (Table 7); distance was not influenced by either time or group. Even though these results are not statistically significant, they are still meaningful based on effect size and percent change. In the treatment group, analyzing distance sway in the eyes open stance Cohen's effect size was calculated as having a small effect ($d = -.48$) and percent change being 32.26% decrease. In the control group for the same dependent variable, Cohen's effect size had a moderate effect ($d = -.78$) and percent change was calculated to 50.16% decrease (Table 1 & 2).

Distance – Eyes Closed. A 2 X 2 repeated measures ANOVA was then calculated to examine the effects of a Nintendo Wii fit balance intervention on the distance sway of the participant with eyes closed (Table 7). No significant main effects of interactions were found for the variable, distance with eyes closed. The time * group interaction, $F(1,7) = 0.081$, $p = .785$, the main effect for time, $F(1,7) = 3.266$, $p = .107$, and the main effect for the group, $F(1,7) = 0.14$, $p = .719$ were not significant (Table 7); distance was not influenced by either time or group. Even though these results are not statistically significant, they are still meaningful based on effect size and percent change. In the treatment group, analyzing distance sway in the eyes closed stance Cohen's effect size was calculated as having a moderate effect ($d = -.69$) and percent change being 51.37% decrease. In the control group for the same dependent variable, Cohen's effect size had a small effect (*d* = -.42) and percent change was calculated to 54.97% decrease (Table 1 & 2).

Variability – Eyes Open. A 2 X 2 repeated measures ANOVA was calculated to examine the effects of a Nintendo Wii fit balance intervention on the participants' balance pre and post intervention (Table 8). No significant main effects of interactions were found for the variable, variability with eyes open. The time * group interaction F(1,7) = 0.27 *p* = .619, the main effect for time, F(1,7) = 0.783, *p* = .406, and the main effect for the group, F(1,7) = 0.335, *p* = .581, were not significant (Table 8); variability was not influenced by either time or group. Even though these results are not statistically significant, they are still meaningful based on effect size and percent change. In the treatment group, analyzing the variable variability in the eyes open stance Cohen's effect size was calculated as having a small effect (*d* = -.29) and percent change being 16.67% decrease. In the control group for the same dependent variable, Cohen's effect size had a moderate effect (*d* = -.67) and percent change was calculated to 37.50% decrease (Table 1 & 2).

Variability – Eyes Closed. A 2 X 2 repeated measures ANOVA was then calculated to examine the effects of a Nintendo Wii fit balance intervention on the variable, variability of the participant with eyes closed (Table 8). No significant main effects of interactions were found for the variable, variability with eyes closed. The time * group interaction, F(1,7) = 0.224, *p* = .651, the main effect for time, F(1,7) = 2.236, *p* = .178, and the main effect for the group, F(1,7) = 0.107, *p*

= .753 were not significant (Table 8); variability was not influenced by either time or group. Even though these results are not statistically significant, they are still meaningful based on effect size and percent change. In the treatment group, analyzing variability in the eyes closed stance Cohen's effect size was calculated as having a moderate effect (d = -.71) and percent change being 58.82% decrease. In the control group for the same dependent variable, Cohen's effect size had a small effect (d = -.21) and percent change was calculated to 29.41% decrease (Table 1 & 2).

Summary

There were no significant differences in group-by-time interaction, time, and group effects. Based on these results, the primary researcher failed to reject the null hypothesis. A Nintendo Wii Fit balance regimen was not able to improve balance and postural control among adults with DS over the age of 18 years old after five weeks of intervention. However, based on effect sizes, it may be concluded that with a larger sample size and longer intervention period, there could have been a significant improvement among the treatment group as well as the control group (Figure 8 & 9).

Chapter Five: Discussion

Purpose/Hypotheses

The purpose of this study was to determine if implementing three games of the Nintendo Wii Fit balance program would improve postural control and balance among adults with DS over the age of 18 years when compared to the control group, who played Nintendo Wii Sports games. The primary researcher hypothesized that implementing a Nintendo Wii balance session two times per week for 30 minutes a session for five weeks, would show significant improvements in balance and postural control among adults with DS over the age of 18 years old (Berg et al., 2012; Byrne et al., 2012; Young et al., 2011).

Significance

Shin et al. (2009) stated the prevalence of DS at birth in the United States is increasing every year. Boswell (1991) stated that cognitive and physical impairments among individuals with DS are most commonly seen as intellectual disabilities and poor static/dynamic balance. Literature suggests because the lack of balance seen among individuals with DS has been established as an inhibitor for efficiently performing activities of daily living it is imperative to identify and improve balance programs for adults with DS. Recent studies have shown that implementing virtual reality gaming systems such as the Nintendo Wii significantly improve motor proficiency, visual-integrative abilities, and sensory integrative functions among children with DS (Wuang et al., 2011). The Nintendo Wii gaming device seems to be an innovative, exciting, and challenging game that ultimately helps a child with DS develop physically. This is what makes the current research study unique and important because to the primary researcher's knowledge it is the first of its kind.

Restatement of Results

There were no significant differences found within group-by-time interaction, time, and group effects for all variables: anterior/posterior sway, medial/lateral sway, area, distance, and variability ($p > .05$). Due to these statistically insignificant results, the primary researcher's hypotheses were not supported. A Nintendo Wii Fit balance regimen was not able to improve balance and postural control among adults with DS over the age of 18 years old. However it is note worthy, this study may still provide meaningful results due to effect size calculations despite the small sample size, short intervention period, and outliers (Figures 8 & 9; Table 1 & 2).

In regard to the two feet eyes open stance in the treatment group, Cohen's effect size value's for over-time results are as follows, anterior/posterior sway ($d = -.44$), medial/lateral sway ($d = -.03$), area ($d = -.47$), distance ($d = -.48$), and variability ($d = -.29$). Interestingly, Cohen's effect size values for the control group were higher during the two feet eyes open stance among all variables, anterior/posterior sway ($d = -.84$), medial/lateral sway ($d = -.17$), area ($d = -.73$), distance ($d = -.78$), and variability ($d = -.67$). One possible explanation for the greater effect among the control group could be due to the major outlier found in all dependent variables for post testing among the treatment group (Figures 3, 4, 5, 6, & 7).

In regard to effect sizes for the two feet eyes closed treatment group, Cohen's effect size value's were as follows, anterior/posterior sway (d = -.91), medial/lateral sway (d = -.53), area (d = -.76), distance (d = -.69), and variability (d = -.71). As suspected, Cohen's effect size values for the control group during two feet eyes closed stance had smaller effect sizes when compared to the treatment group, respectively, anterior/posterior sway (d = -.41), medial/lateral sway (d = +2.81), area (d = -.48), distance (d = -.42), and variability (d = -.21).

Comparison of Literature

Nintendo Wii Fit Balance Games. This research study is significant and beneficial to the field because to the primary researcher's knowledge it is the first of its kind. This is the first study designed focusing on adults with DS over the age of 18 years old and a Nintendo Wii Fit balance regimen for improvement of balance and postural control.

There were no statistically significant differences among the variables anterior/posterior sway, medial/lateral sway, area, distance, and variability between intervention and control groups (p>.05). Originally, the intervention group was going to play between four to six games but due to the difficulty level of the games, they were limited to three games, Penguin Slide, Ski Slalom, and Candle Lotus. It may be speculated that with more time via intervention period, the participants may have been able to progressively improve and play the more advanced games. Wuang et al. (2011) conducted a similar study to determine if virtual reality using Wii gaming technology could improve sensorimotor functions when compared to standard occupational therapy among children with

DS. Fine motor integration, upper-limb coordination, and running speed and agility improved among the intervention group when compared to the control ($p<.05$). Wuang et al. (2011) had a larger sample size (n=105) and a longer intervention period (24 weeks) when compared to this research study (n=11, 5 weeks).

Similarly, Berg et al. (2012) conducted an eight week long case study to determine if motor outcomes would improve following a Nintendo Wii intervention for a child with DS. Objective measurements similar to what was used in this study, the TekScan HR Mat, Berg et al. (2012) utilized the Biodex BioSway Balance system to measure center of mass during stable and unstable conditions for pre and post measurements. It should also be noted that Berg et al. (2012) was able to implement the intervention four times per week for eight weeks (32 sessions) as compared to this research design that was only twice per week for five weeks (ten sessions). Berg et al. (2012) found that anterior/posterior sway improved as medial/lateral sway got worse. These findings support the findings of this research study; when looking at percent change decrease among variables, medial/lateral sway saw the smallest change when compared to all other variables. Also, Berg et al. (2012) calculated minimum important difference (MID) for balance to find meaningful results and found that mean change score did exceed the MID (1.61 to .57), with lower numbers meaning an improvement. Similarly, for this research study effect size was calculated to determine potentially meaningful results and even though the treatment effects were not better than the control effects in the eyes open stance, the eyes closed provided larger effects in the treatment group for the variable anterior/posterior sway (d = .91) which showed 55.50% decrease in sway.

Due to lack of literature on the effects of a Nintendo Wii Fit balance program on postural control and balance among adults with DS research utilizing the Wii Fit balance games on other populations were analyzed. Byrne et al. (2012) conducted a study to determine if a three week intervention (total of eight sessions) using Wii Fit balance games was capable of improving dynamic balance among healthy young adults (n=19). All variables improved with the exclusion of posterolateral and anteromedial (p<.05). These variables are similar to the medial/lateral sway measured within this research study which were also found not to be significant along with small to moderate effect sizes (p>.05, EO d=.03, EC d=.53), as well as research by Berg et al. (2012) who found that medial/lateral sway got worse after the intervention. It should be noted that Byrne et al. (2012) conducted their intervention in a laboratory setting with a research investigator present at all times, and this research study was done in a community setting with many distractions. It may be suspected that if participants of this study were taken into a laboratory setting along with an increased sample size there may have been statistically significant differences at post testing measures. However, the study by Byrne et al. (2012) had a smaller external validity and less practicality because individuals with DS are more likely to perform the Nintendo Wii Fit balance games with friends or in a community setting as opposed to a laboratory setting (Bar & Shields, 2011).

Young et al. (2011) found similar results to this research study as well as the aforementioned research (Berg et al. 2012; Byrne et al. 2011). Young et al. (2011) designed a study to analyze the effects of a Nintendo Wii Fit balance regimen among healthy older adults (n=6). Similar to this research study, there were significant improvements found among the variable anterior/posterior sway ($p < .05$) and non-significant improvements among medial/lateral sway ($p > .05$). The intervention was over a four week period for a total of ten sessions; comparable to this research study, which consisted of a five week intervention for a total of ten sessions. Relatedly, Rendon et al. (2012) conducted a virtual reality balance intervention among older adults (n=40) to improve dynamic balance for a total of six weeks. Rendon et al. (2012) utilized the 8-foot up and go to measure dynamic balance and found a significant improvement ($p < .05$). Direct comparisons cannot be made between this study and Rendon et al. (2012) because different modes of pre and post assessments were utilized.

Previous literature supports the idea that Nintendo Wii Fit balance games have been effective for improving static/dynamic balance and postural control among several different populations (Byrne et al., 2012; Rendon et al., 2012; Young et al., 2011). It may be acceptable to conclude that with a larger sample size, longer intervention period, removal of any major outliers, and a greater amount of internal validity, statistically significant results could have potentially been gained and that further research will be beneficial for a definitive conclusion.

Additional Balance Exercises. Gupta et al. (2011) conducted a six week intervention (total 18 sessions) to improve strength and balance among children with DS (n=28). When compared to this research study, Gupta et al. (2011) had 17 more participants and eight more sessions. Gupta et al. (2011) found statistically significant improvements among all balance variables with the exclusion of three within the BOTMP (p<.05). These balance variables ranged from dynamic balance tests such as walking forward on a line to static balance tests such as standing on one leg on a balance beam. The results from Gupta et al. (2011) were contradictory to this research study when comparing only the static balance measurements. Gupta et al. (2011) did not mention a researcher to participant ratio however it was mentioned that participants had consistent positive reinforcement during the entire training period to encourage the greatest amount of effort from the participant. The participant/researcher ratio for this research study consisted of 5:1 in the treatment group and 4:1 in the control group, which made it difficult to elicit the participants' maximum effort throughout the span of the intervention period; possibly having an affect on the outcomes. It should also be stated again that the Gupta et al. (2011) had a longer intervention time, more participants, and a larger sample size.

It should also be noted that Boswell (1991), conducted an eight week long study, three sessions per week, for 30 minute sessions utilizing dance and movement exploration techniques to improve balance among individuals with DS (n=26). Although Boswell (1991) had 17 more participants than this research study, the session times were laid out the same. This research study was five weeks long, two sessions per week, and 30 minutes per session. While this intervention did not use traditional exercises or the Nintendo Wii balance games to improve balance, this technique along with the intervention length was enough to find statistically significant improvements at post testing measurements over time ($p<.05$) but not between groups ($p>.05$). These findings are consistent with this research as having no significant differences between groups ($p>.05$), but not consistent with differences over time among this research study, which were not significant ($p>.05$).

Due to the lack of literature regarding this topic and within this population, research utilizing the Nintendo Wii Fit balance games among individuals who have experienced a stroke were reviewed. Harvey and Ada (2012) determined that not every Nintendo Wii game would be efficient for improving standing/postural control after a stroke. After review of this article, it was reasoned that the only games shown to be efficient among this population were Ski Slalom and Penguin Slide for improving balance and postural control (Harvey & Ada, 2012). It may be concluded within the current research study that the reason the control group improved more than the treatment group in the eyes open stances may not only be a product of the major outliers but could be due to the differences in visual feedback between balance games (Harvey & Ada, 2012). Based on a study by Harvey and Ada (2012), several games utilized in this research study were not the most efficient for targeting an individual's visual, vestibular, and proprioception senses based on the relative amplitude excursion of each game. Based on further research from Harvey and Ada (2012), within this research study the games Ski Slalom and Penguin Slide required a large relative amplitude of excursion. Based on this it may be concluded that due to the large relative amplitude of excursion participants may not have been required to maintain as much control over their anterior/posterior and medial/lateral sway as they would have if they played games that required a small relative amplitude of excursion. It should also be noted that because of the difficulty level, participants within this research study were restricted to the games with large relative amplitude (Ski Slalom and Penguin Slide). Therefore, if the intervention length would have been longer, participants may have been able to progress to the more advanced games with the smaller relative amplitude excursions. This may also provide an explanation for why the eyes closed stance treatment group improved more than the control group when compared to the eyes open stance.

Limitations

The main limitation to this study was the small sample size (n=9). Based on previous research by Wuang et al. (2011), univariate effect size for change in postural control was estimated to be (d = 2.58) requiring a sample size of 12 per group to find statistical significance, $\alpha = .05$, $1 - \beta = .80$ (Cohen, 1988). The small sample size could be attributed to recruitment being confined to one community center for individual's with special needs as well as not having enough time to make sure all participants had their informed consents, assent forms, and medical release forms signed and returned. If there would have been a longer time frame for recruitment, the sample size may have been greater. With already a small sample size, the dropout of two participants midway through the study due to back pain and seizures further enhanced this limitation. The broad age range of participants in both the treatment and control group may also be a limitation for this study.

This intervention was relatively short, being only five weeks long. The short intervention length could be attributed to various reasons such as time frame allotted as well as snow days. The study was originally scheduled to be six weeks long however the last week of the intervention consisted of two snow days, which did not allow for participants to come to Wings, the special needs community where the intervention was held. Literature suggests the intervention needed to be approximately six to 24 weeks long to find statistically significant improvements (Berg et al., 2012; Rendon et al., 2012; Wuang et al., 2011).

Another limitation that must be noted is that several of the Nintendo Wii Balance and Sport games were too advanced for the participants to play. If the intervention period would have been longer there may have been time for the participants to progress to the more advanced games in both treatment and control groups. Doing this may have engaged more of the vision, vestibular, and proprioception senses that occur from playing the more advanced games (Harvey & Ada, 2012). It might also be noted that a possible reason the control group improved more than the experimental group in the eyes open stance is because of the treatment group's limited movement during the intervention sessions, due to being confined to the balance board. Because the control group was able to move dynamically in and out of the saggital and coronal planes, this may have served as an advantage and extra challenge to their balance.

Lastly, the National DS Association (2014b) states that individuals with DS typically have shorter attention spans than the general population, and can even been seen as a behavioral problem. The average attention span of an individual with DS has not been quantified however it should be noted that the National Center for Biotechnology Information (2015) has been able to quantify the attention span of a healthy adult to approximately eight seconds. Considering the average attention span for healthy adults, it may be speculated the total time for participants of this research study to hold pre and post assessment stances was to long (30 seconds for EO and EC stances). If the time had been cut in half the results may have been a more accurate measurement because participants could maintain focus throughout the entire amount of time as opposed to getting distracted towards the last 10 to 15 seconds.

Thurlow, Ysseldyke, and Wotruba (1993) conducted a study to determine the best student-teacher ratio for special education and determined that the smaller ratios, 1:1 and 3:1, were more efficient in academic responding time and academic engaged time as well as better for managing behavioral issues and keeping students on task when compared to the higher ratios of 6:1, 9:1, and 12:1. The researcher/participant ratio for this research study was approximately 5:1; which made it difficult to get the participants to focus and play the games for the entire 30 minutes. It may have been helpful for the primary researcher to have trained help conducting the intervention as well as pre and post assessments to ensure a greater amount of attention provided to the participants. With the above facts considered, a major limitation to this study would have to be the researcher/participant ratio as well as time chosen for participants to hold each stance during pre and post testing. The time chosen was 30 seconds for eyes open and eyes closed stances, however the participants would become distracted the last 10-15 seconds of the stance and lose focus. This may have hindered a true measurement of balance and postural sway via the TekScan HR Mat due to the lack of focus and larger margins of sway throughout the last 10-15 seconds of the analysis.

Strengths

An important strength to this study was the amount of enjoyment and excitement expressed by the participants to participate in both the control and treatment groups. According to Heller at al. (2002) major barriers to exercise seen among individuals with DS included lack of equipment, cost, transportations, and enjoyment. Utilizing the Nintendo Wii Fit/Sports games within this research study eliminated lack of equipment, cost, transportation, and little enjoyment. The group settings in both the comparison and experimental group enhanced a sense of social wellness and created a competitive atmosphere, encouraging improved performance. To the primary researcher's knowledge the participants appeared to show a great amount of enjoyment during the game and even looked forward to playing them on a weekly basis. Mahy et al. (2010) also contributed research on exercise barriers to this population and stated that it may be beneficial to implement entertaining, affordable, and provide a social aspect to see the greatest improvements. This research study did all of the above by being held in a community setting, by utilizing the Nintendo Wii Fit games, avoiding personal trainers/expensive gym memberships, and also providing an entertaining factor.

Future Directions

Based on the findings of this research study and literature by Heller at al. (2002), it may be beneficial to add a qualitative dependent variable that measured enjoyment as well as adding in a dependent variable that measures the participant's parent/guardian perception on the Nintendo Wii Fit games. Importantly, future studies should also focus on gathering a larger sample size and to increase the length of the intervention. It would be beneficial to include a true control group that only continues the activities the participants were already participating in, a comparison group utilizing games such as the Nintendo Wii Sports games, and an experimental group that utilizes the Nintendo Wii Balance games. Future studies may also consider implementing a smaller participant to researcher ratio, due to those with DS having shorter attention span than the general population (National Down Syndrome Society, 2014b). It may also be speculated that adding a familiarization period will help eliminate any test learning effects that could have occurred between the pre and post testing of this research study. As well, adding in functional balance testing to see the more practical improvements and having an objective measure such as the TekScan HR Mat or Biodex Sway would be useful.

Practical Implications

The Nintendo Wii Fit balance games can be easily implemented as well as an enjoyable mode of exercise for adults with DS. Based on previous literature and meaningful effect size calculations of this study, it may be determined this is one possible method for improving balance among adults with DS. Specifically implementing this game into special needs communities similar to Wings would be an easy and efficient way to incorporate training for improvement of quality of life by working on improving balance, while also allowing them to have fun doing so. It should also be addressed that within this research study there were greater improvements in the comparison group, who used the Nintendo Wii Sports games, only in the eyes open stances. This may also be an indicator that if the Nintendo Wii Sports and/or the Nintendo Wii Fit balance games are implemented in a special needs community setting, they would elicit better balance, more fun, and greater quality of life.

Conclusion

It may be concluded that although there were not statistically significant improvements in balance among adults with DS after completion of a Nintendo Wii Fit balance intervention, this mode of balance training still may be efficient in improving balance due to meaningful effect sizes. The adults with DS who played both the balance and sports games appeared to enjoy the games and looked forward to playing the games every session; this information in itself is important for exercise adherence. The Nintendo Wii Fit may be an innovative and exciting mode of improving balance among adults with DS.

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Tables/Figures

Table 1

Descriptive Statistics, Effect Size, and Percent Change of Postural Control for Eyes Open Measures

		Pre-Testing	Post-Testing			
	N	Mean±SD	Mean±SD	Mean Diff	ES	%Δ
EO_A/P (cm)						
Treatment	5	7.26 ± 4.23	5.39±1.82	1.87	-0.44	-25.76%
Control	4	8.09 ± 4.15	4.6±1.08	3.49	-0.84	-43.14%
Total	9	7.63 ± 3.95	5.04±1.51	2.59	-0.66	-33.94%
EO_M/L (cm)						
Treatment	5	8.34 ± 6.11	8.14±9.21	0.2	-0.03	-2.40%
Control	4	7.91 ± 2.76	7.45±9.69	0.46	-0.17	-44.06%
Total	9	8.17 ± 4.64	7.83±8.82	0.34	-0.07	-5.82%
EO_Area (cm^2)						
Treatment	5	38.99 ± 44.2	18.26±26.39	20.73	-0.47	-53.17%
Control	4	25.68 ± 12.62	16.45±21.71	9.23	-0.73	-35.94%
Total	9	33.08 ± 32.95	17.46±22.93	15.62	-0.47	-47.22%
EO_Dist (cm)						
Treatment	5	138.53 ± 93.83	93.84±43.9	44.69	-0.48	-32.26%
Control	4	172.48 ± 114.23	85.97 ± 29.36	86.51	-0.78	-50.16%
Total	9	153.62 ± 98.06	90.34±36.11	63.28	-0.65	-41.19%
EO_Var (cm)						
Treatment	5	0.12 ± 0.07	0.1±0.08	0.02	-0.29	-16.67%
Control	4	0.16 ± 0.09	0.1±0.09	0.06	-0.67	-37.50%
Total	9	0.14 ± 0.08	0.1±0.08	0.04	-0.5	-28.57%

Note. EO = eyes open, A/P = anterior/posterior, M/L = medial/lateral, Area = area, Dist = distance, Var = variability

Table 2

Descriptive Statistics, Effect Size, and Percent Change of Postural Control for Eyes Closed Measures

		Pre-Testing	Post-Testing			
	N	Mean±SD	Mean±SD	Mean Diff	ES	%Δ
EC_A/P (cm)						
Treatment	5	9.19±5.58	4.09±2.43	5.1	-0.91	-55.50%
Control	4	7.74±6.94	4.92±1.99	2.82	-0.41	-43.14%
Total	9	8.55±5.85	4.46±2.15	4.09	-0.7	-47.84%
EC_M/L (cm)	0					
Treatment	5	9.6±7.96	5.37±5.94	4.23	-0.53	-44.06%
Control	4	4.83±1.94	10.28±10.32	5.45	+2.81	+112.84%
Total	9	7.48±6.28	7.56±8.01	0.08	+0.01	+1.07%
EC_Area (cm^2)						
Treatment	5	47.9±46.53	12.66±15.63	35.24	-0.76	-73.57%
Control	4	15.31±14.8	8.14±6.52	7.17	-0.48	-54.97%
Total	9	33.42±38.21	10.65±11.99	22.77	-0.6	-68.13%
EC_Dist (cm)						
Treatment	5	164.02±120.69	79.77±38.23	84.25	-0.69	-51.37%
Control	4	210.433±274.1	94.76±69.64	114.67	-0.42	-54.97%
Total	9	184.65±189.88	86.43±51.12	98.22	-0.52	-53.19%
EC_Var (cm)						
Treatment	5	0.17±0.14	0.07±0.05	0.1	-0.71	-58.82%
Control	4	0.17±0.24	0.12±0.05	0.05	-0.21	-29.41%
Total	9	0.17±0.18	0.09±0.08	0.08	-0.44	-47.06%

Note. EC = eyes closed, A/P = anterior/posterior, M/L = medial/lateral, Area = area, Dist = distance, Var = variability

Table 3

Independent t-Test of Baseline Comparison of Treatment and Control Groups

		t	df	Significance
Eyes Open				
	A/P (cm)	-0.296	7	0.776
	M/L (cm)	0.116	7	0.911
	Area (cm^2)	0.577	7	0.582
	Dist (cm)	-0.491	7	0.638
	Var (cm)	-0.8	7	0.45
Eyes Closed				
	A/P (cm)	0.347	7	0.285
	M/L (cm)	1.157	7	0.285
	Area (cm^2)	1.332	7	0.225
	Dist (cm)	-0.344	7	0.741
	Var (cm)	-0.024	7	0.739

Note. EO = eyes open, EC = eyes closed, A/P = anterior/posterior M/L = medial/lateral, Area = area, Dist = distance, Var =variability

Table 4

Results of Repeated Measures Analysis of Variance for Sway Anterior/Posterior (cm) with Eyes Open and Eyes Closed

		Between Subjects Effects		
		df	F	p
EO_AP				
	Group	1	0	0.988
	Error	7		
EC_AP				
	Group	1	0.015	0.905
	Error	7		
		Within Subjects Effects		
		df	F	p
EO_AP				
	Time	1	2.4	0.165
	Time*Group	1	0.222	0.652
	Error	7		
EC_AP				
	Time	1	4.299	0.077
	Time*Group	1	0.356	0.57
	Error	7		

Note. EO = eyes open, EC = eyes closed, A/P = anterior/posterior

Table 5

Results of Repeated Measures Analysis of Variance for Sway Medial/Lateral (cm) with Eyes Open and Eyes Closed

		Between Subjects Effects		
		df	F	p
EO_ML				
	Group	1	0.024	0.881
	Error	7		
EC_ML				
	Group	1	0	0.987
	Error	7		
		Within Subjects Effects		
		df	F	p
EO_ML				
	Time	1	0.009	0.927
	Time*Group	1	0.002	0.969
	Error	7		
EC_ML				
	Time	1	0.038	0.852
	Time*Group	1	2.337	0.17
	Error	7		

Note. EO = eyes open, EC = eyes closed, M/L = medial/lateral

Table 6

Results of Repeated Measures Analysis of Variance for Sway Area (cm^2) with Eyes Open and Eyes Closed

		Between Subjects Effects		
		df	F	p
EO_Area				
	Group	1	0.397	0.549
	Error	7		
EC_Area				
	Group	1	1.743	0.228
	Error	7		
		Within Subjects Effects		
		df	F	p
EO_Area				
	Time	1	0.872	0.381
	Time*Group	1	0.128	0.731
	Error	7		
EC_Area				
	Time	1	3.274	0.113
	Time*Group	1	1.434	0.27
	Error	7		

Note. EO = eyes open, EC = eyes closed, Area = area

Table 7

Results of Repeated Measures Analysis of Variance for Sway Distance (cm) with Eyes Open and Eyes Closed

		Between Subjects Effects		
		df	F	p
EO_Dist				
	Group	1	0.116	0.743
	Error	7		
EC_Dist				
	Group	1	0.14	0.719
	Error	7		
		Within Subjects Effects		
		df	F	p
EO_Dist				
	Time	1	3.423	0.107
	Time*Group	1	0.348	0.574
	Error	7		
EC_Dist				
	Time	1	3.266	0.114
	Time*Group	1	0.081	0.785
	Error	7		

Note. EO = eyes ope, EC = eyes closed, Dist = distance

Table 8

Results of Repeated Measures Analysis of Variance for Sway Variability (cm) with Eyes Open and Eyes Closed

		Between Subjects Effects		
		df	F	p
EO_Var				
	Group	1	0.335	0.581
	Error	7		
EC_Var				
	Group	1	0.107	0.753
	Error	7		
		Within Subjects Effects		
		df	F	p
EO_Var				
	Time	1	0.783	0.406
	Times*Group	1	0.27	0.619
	Error	7		
EC_Var				
	Time	1	2.236	0.178
	Time*Group	1	0.224	0.651
	Error	7		

Note. EO = eyes open, EC = eyes closed, Var = variability

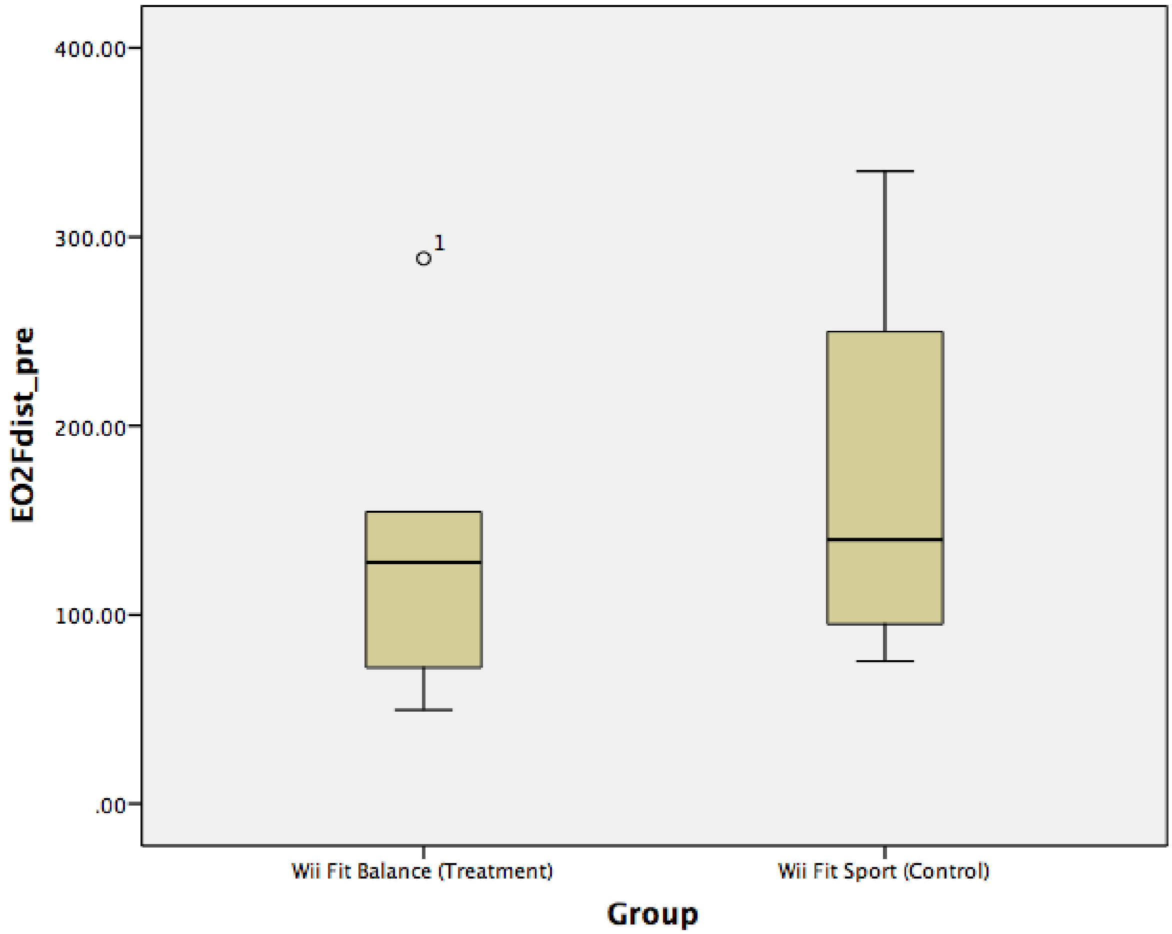

Figure 1. Boxplot of outliers in distance sway during pre testing assessments, with outliers included.

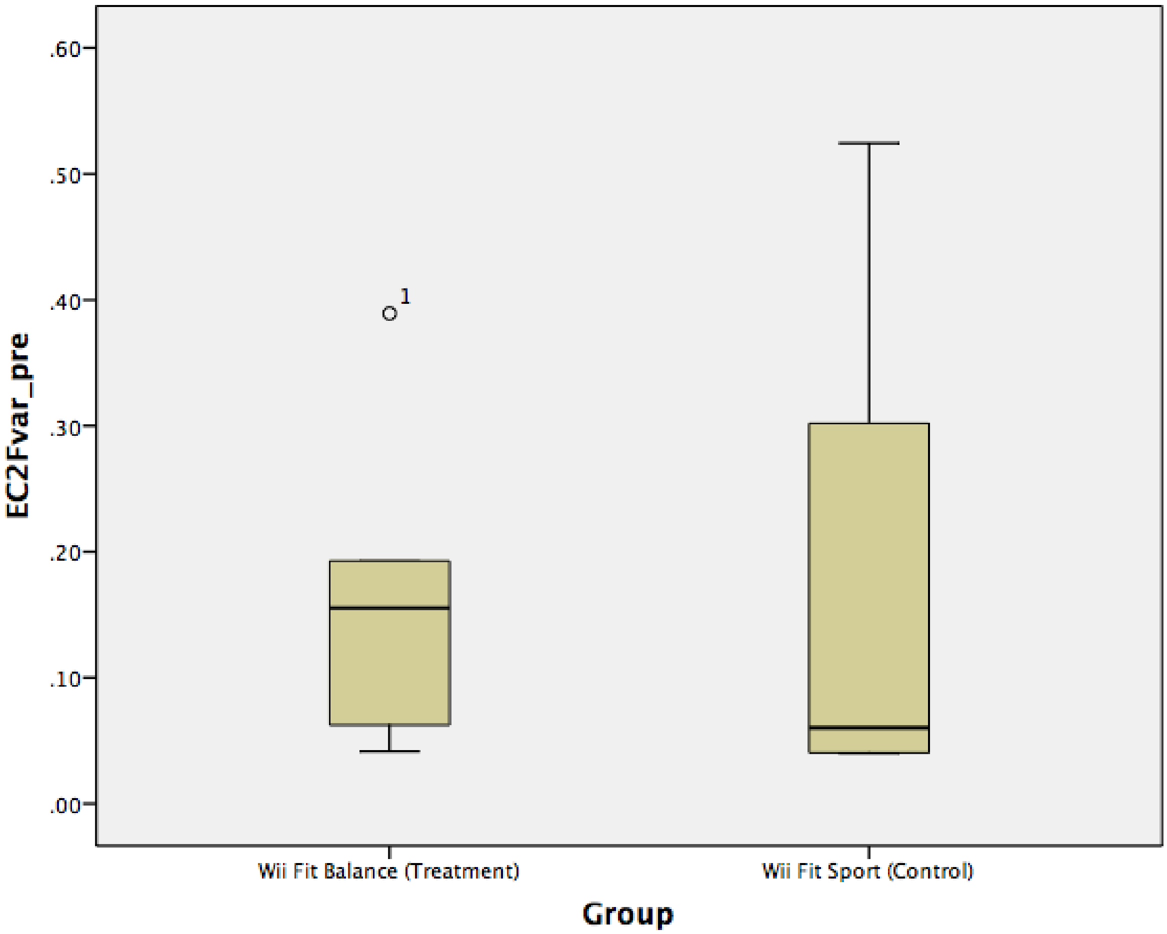

Figure 2. Boxplot of outliers in variability sway during pre testing assessments, with outliers included.

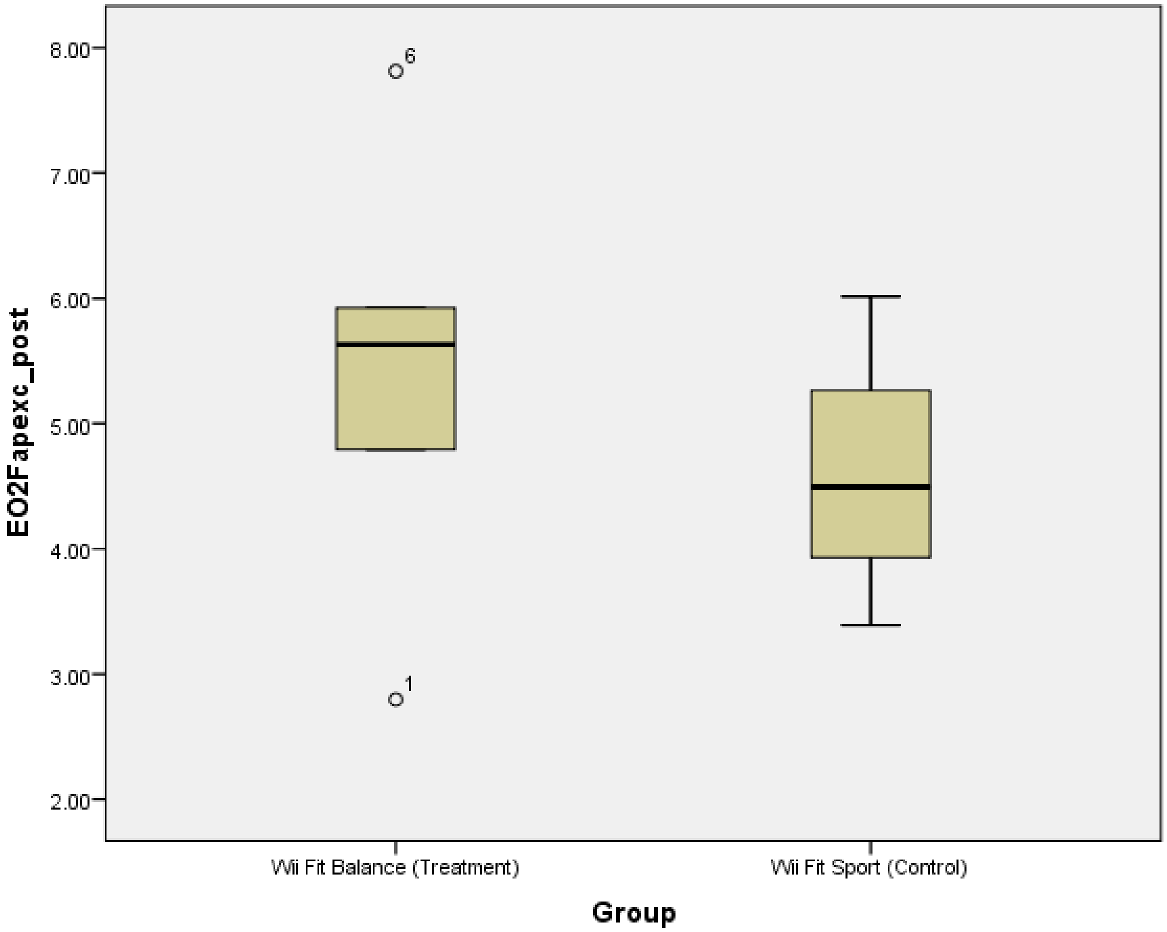

Figure 3. Boxplot of outliers in anterior/posterior sway during post testing assessments, with outliers included.

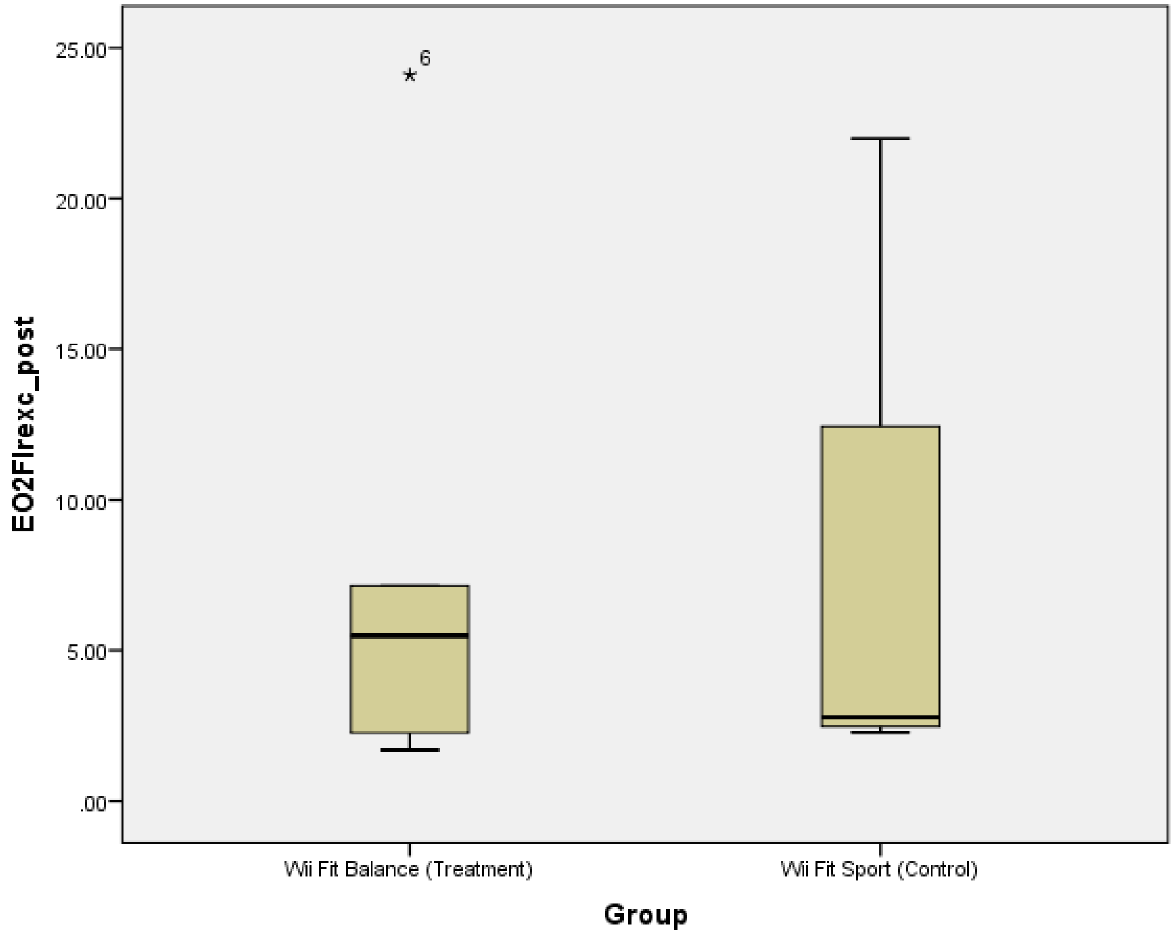

Figure 4. Boxplot of outliers in medial/lateral sway during post testing assessments, with outliers included.

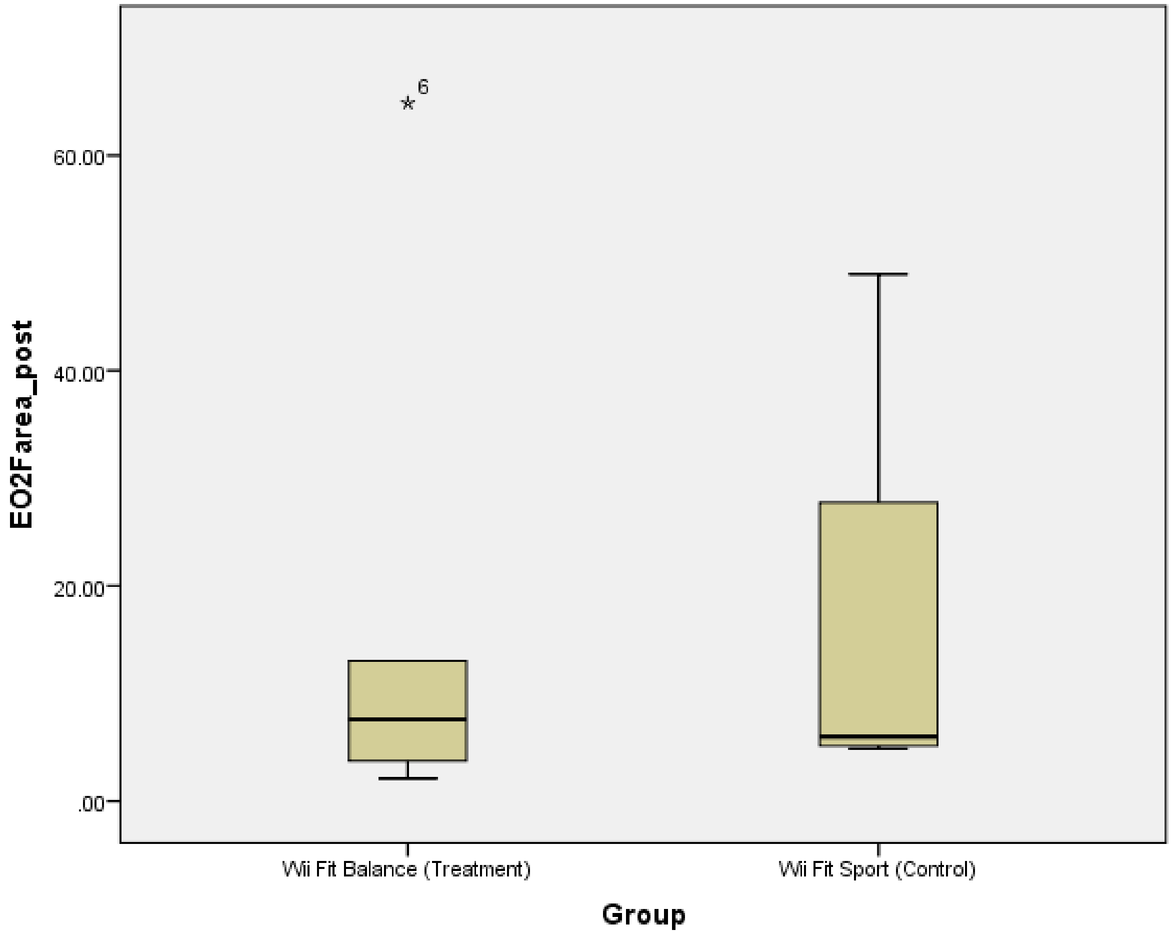

Figure 5. Boxplot of outliers in area sway during post testing assessments, with outliers included.

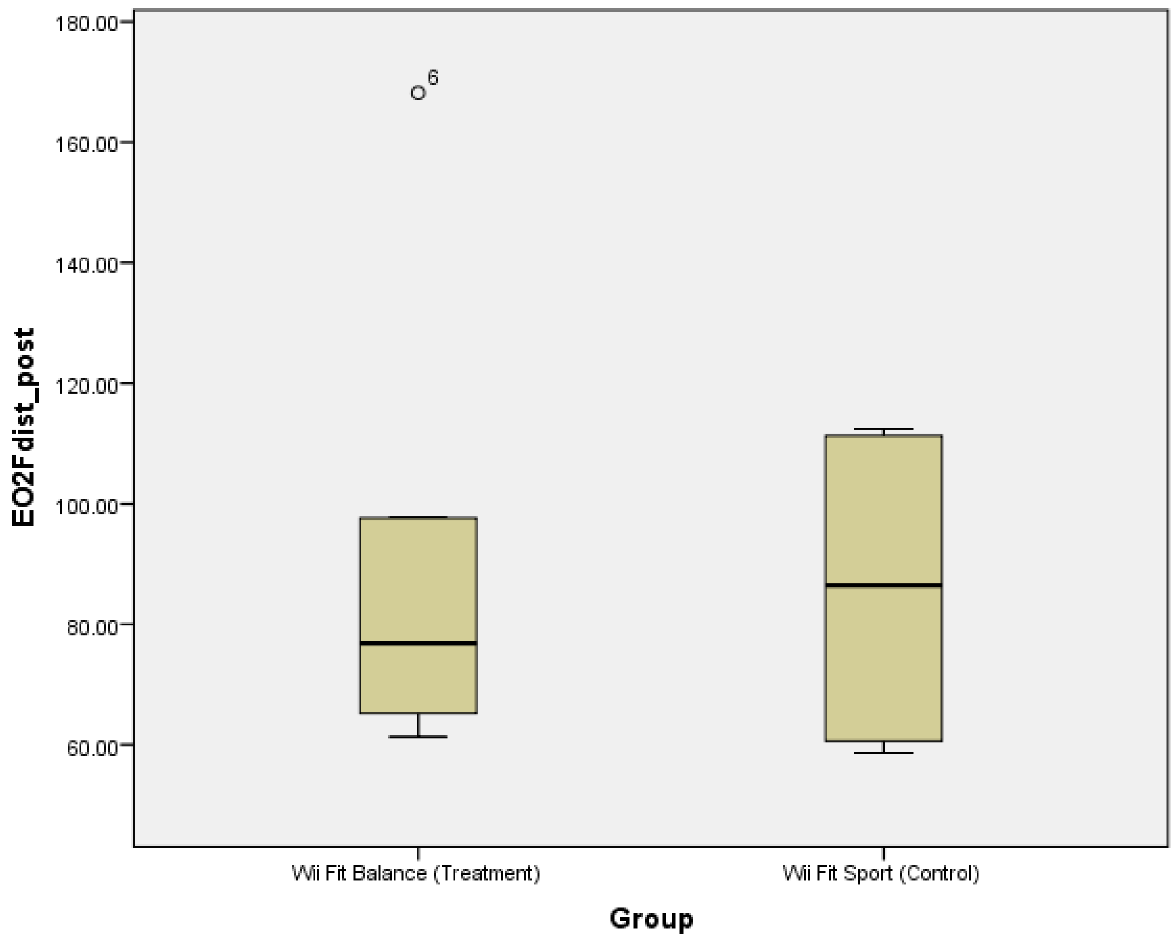

Figure 6. Boxplot of outliers in distance sway during post testing assessments, with outliers included.

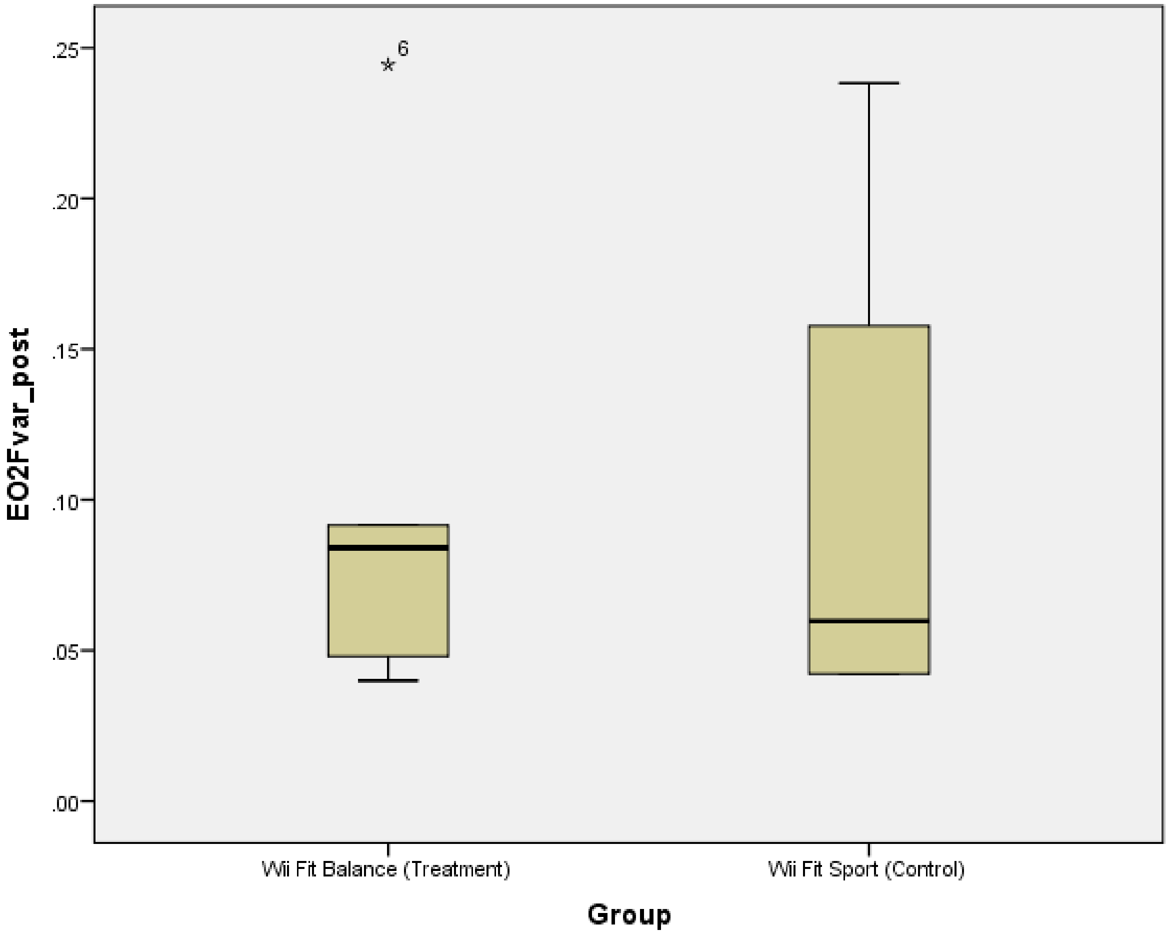

Figure 7. Boxplot of outliers in variability sway during post testing assessments, with outliers included.

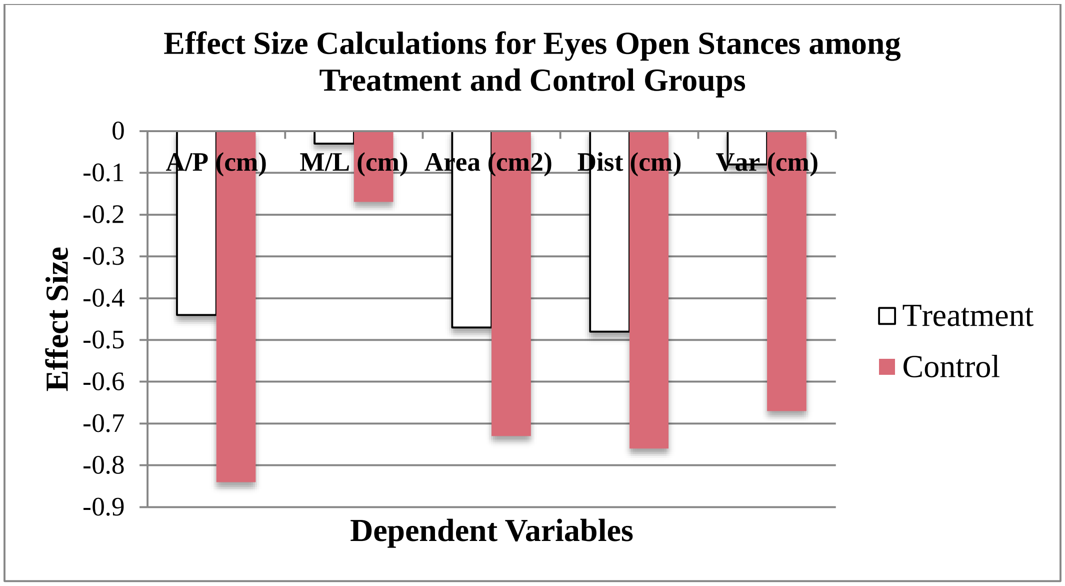

Figure 8. Bar graph of effect size calculations for all dependent variables in eyes open stance among both treatment and control groups.

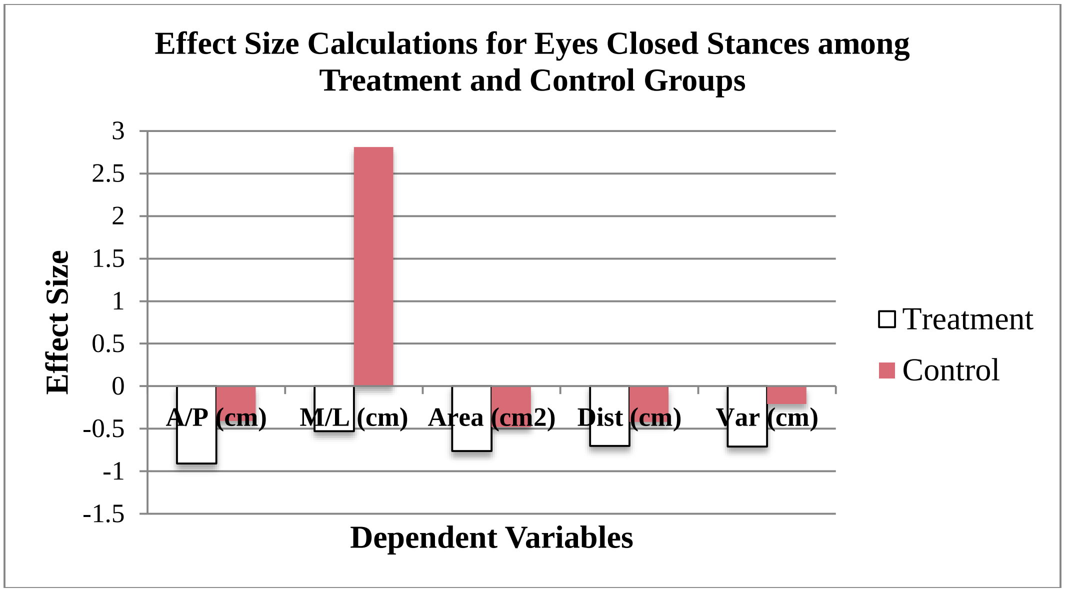

Figure 9. Bar graph of effect size calculations for all dependent variables in eyes closed stance among both treatment and control groups.

Appendix A

Institutionalized Review Board Approval Letter

UNIVERSITY OF
Central Oklahoma

November 12, 2014

IRB Application #: 14121-FB

Proposal Title: Effects Of Nintendo Wii Fit Balance Program Among Adults With Down Syndrome

Type of Review: Full Board

Investigators:

Ms. Michelle Miller
Dr. Melissa Powers
Department of Kinesiology & Health Studies
College of Education & Professional Studies
Campus Box 189
University of Central Oklahoma
Edmond, OK 73034

Dear Ms. Miller 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: 11/12/2014
Date of Approval Expiration: 11/11/2015

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,

Robert D. Mather, Ph.D.
Chair, Institutional Review Board
Campus Box 159
University of Central Oklahoma
Edmond, OK 73034
405-974-5479
irb@uco.edu

Office of Research Compliance, Academic Affairs
100 North University Drive · Edmond, Oklahoma 73034 · Phone (405) 974-5497 · Fax (405) 974-3825 · www.uco.edu

Appendix B

Informed Consent Form

Research project Title: Effects of Nintendo Wii Fit Balance Games on Postural Control and Balance Among Adults with Down Syndrome

Researcher: Ms. Michelle Miller

A. **Purpose of this research:** The purpose of this study is to determine if implementing a Nintendo Wii balance exercise regimen will improve postural control and balance among adults with DS over the age of 18 years old. Postural control is defined as the body position and motion with the ability to generate forces to control body position. Balance is defined as equal distribution of weight allowing a person to maintain a steady upright position.
B. **Procedures/treatments involved:** A medical release will be required for the participant from their primary care physician. With your permission (on the form), we will take care of this for you. The medical release will be faxed to the doctor by the primary researcher (Michelle Miller). Following baseline assessments the participant will be randomly placed in to the comparison or intervention group. If put into the comparison group the participant will play in non-balance Nintendo Wii Sports games, 2-days per week for 30 minute sessions. If put in to the intervention group the participant will play balance games on the Nintendo Wii fit balance board. These sessions will also be 2-days per week for 30 minute sessions. If the participant is able to progress they will move to a more challenging game, this will happen in both groups. Before and after the 6 weeks of Wii play, participants will complete tests of postural control and balance. For these pre and post tests, the participant will stand on a TekScan HR-mat that measures the movement of his/her body. The TekScan HR-mat will specifically measure foot pressure while standing on the mat in the different foot positions that are listed below. We will ask the participant to stand in six different foot positions on the mat: standing on both feet with eyes open, standing on both feet eyes closed, standing on left foot eyes open, standing on left foot eyes closed, standing on right foot eyes open, and standing on right foot eyes closed. We will also record how long the participants stand in each foot position. Each foot position will be tested two times for a total of 12 tests. The testing and Wii play will take place at the Wings facility.
C. **Expected length of participation:** The length of participation is 8 weeks. This includes 6 weeks of Wii play with one week before and after for testing. Each session is expected to take about 30 minutes. We will hold sessions 2 days per week for a total of 16 sessions during the 8 weeks.
D. **Potential benefits:** The primary research suspects the participant will gain improved balance and postural control, ultimately improving daily functional living tasks.
E. **Potential risks or discomforts:** Potential discomforts associated with participation in this study are low because it is a low-intensity game. There is a slight risk of muscle soreness and/or muscle/joint injury from a fall during Wii play or testing. We will minimize this risk by monitoring participants during Wii play and testing. The primary researcher will be assisted by Wings staff for this monitoring. By signing this form, you indicate that you understand that the

University of Central Oklahoma is not liable for any injuries that may occur during participation in this study.

F. **Medical/mental health contact information:** In the unlikely event that medical assistance is needed, the participant will be referred to their primary care physician.

G. **Contact information for researchers**: For questions about the study or an injury related to the study, please contact the principal investigator, and/or the faculty supervisor:

Michelle Miller	Dr. Melissa Powers
(254) 405-1040	(405) 974-5309
mmiller87@uco.edu	mpowers3@uco.edu

H. **Contact information for UCO IRB**: For questions about your rights as a research participant, please contact:
UCO Office of Research Compliance, 405-974-5497, irb@uco.edu

Explanation of confidentiality and privacy: All data collected will be labeled with a code number that will not be identifiable to the participant. Information regarding participation will be kept completely confidential and stored in a locked file cabinet. The electronic information will be kept on a password protected computer. In no way will the participants data be tied to their name. This study may result in scientific presentations and publications; however, any data will be reported as a group, not individual.

I. **Assurance of voluntary participation:** Participation in this study is entirely voluntary and participants are free to withdraw from the study at any time without penalty.

AFFIRMATION BY RESEARCH SUBJECT

I hereby voluntarily agree to allow my child to participate in the above listed research project and further understand the above listed explanatinos and descriptions of the research project. I also understand that there is no penalty for refusal of my child to participate, and that my child is free to withdraw their consent and participation in this project at any time without penalty. I ackknowledge that I am the parent/guardian of my child. 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 and my child to keep.

Research participants Parent/Guardian Name:________________________________

Research participants Parent/Guardian Signature: ____________________________

Date: __________________

Appendix C

Informed Assent Form

APPROVED
NOV 12 2014
UCO IRB

APPROVAL
NOV 11 2015
EXPIRES

University of Central Oklahoma

Effects of Implementing a Nintendo Wii Fit Balance Regimen Among Adults with Down Syndrome

Assent Form

My name is Michelle Miller. I am here to talk to you about a research project we are doing. The purpose of this research project is to understand what fun games and activities will be the best for making it easier for you to balance.

If you agree to participate in the project, you will play either a balance or non-balance game on the Nintendo Wii. Even if you choose not to participate, you will still be allowed to play the exact same games as those who choose to participate. You will play these games with a group, taking turns, for a total of 30 minutes playing the games. You will get to play these games on both Monday and Wednesday for a total of 6 weeks. One week before you get to start playing the games I will also test your balance on a mat, this will also happen one week directly following the last week of games. If you choose not to participate there will be no penalties. You will still get to play the games with the other students we just won't keep track of your progress.

At the end of the research project, we will be presenting or publishing the results of the study but the data will be reported as a group, which means that no names or other personal information will be used. At the conclusion of the study, we will destroy all of the data.

There are low risks of participation in this study; however, there is still a very small risk of falling. The information we learn from the study will help to understand what activities and games will be the safest and most efficient to help you better your balance. This will help not only you but also other people in the world like you.

Your parent or guardian must also give permission for you to participate but no information will be shared with anyone outside of the study. You have the right to refuse to answer any questions or to withdraw from the study at any time without penalty. If you choose to participate and your parent or guardian also gives permission for you to participate, a medical release form will be faxed to your doctor by the primary researcher (Michelle Miller) to ensure it is safe for you to participate.

My telephone number is 254-405-1040. You can call me if you have questions about the project or if you decide you don't want to continue in the study any more. If you have any questions regarding your rights as a participant, you may contact the UCO Institutional Review Board at irb@uco.edu or 405-974-5497. Do you have any questions?

Your signature below will indicate your understanding of this form and agreement to participate. You will be given a copy of this consent form to keep for future reference. If you do not wish to participate you should not sign your name below.

Signature ______________________________ Date__________

Print name ______________________________

Signature of person obtaining consent ______________________ Date __________

Print name of person obtaining consent ______________________________

Appendix D

Recruitment Letter

Dear Wings student parent/guardian,

My name is Michelle Miller and I am a graduate student in the field of Wellness Management - Exercise Science at the University of Central Oklahoma. Wings has given me authorization to use their facility as well as recruit participants for my graduate research study.

I am conducting a research study targeting adults over the age of 18 years old that have been diagnosed with Down syndrome. The purpose of my study is to determine if playing Nintendo Wii Fit balance games improves balance and postural control. You can read additional details of my study in the attached forms.

Along with this letter, you have received three forms:

- Participant Assent Form – This form should be signed by the research study participant if he or she agrees to participate in my study.

- Informed Consent Form – This form should be signed by the participant's parent or guardian if he or she agrees to allow the participant to participate in my study.

- Medical Clearance Form – Medical release is required to participate in my study because it involves physical activity. Please complete the top of the form which includes the participant's name and date of birth, the physician's name and phone number, and your printed name and signature.

If you agree to allow your student to participate in my study, all three forms should be completed, signed, and returned to Wings by <insert date>,

If you have questions regarding this study, I will be available to speak with you at Wings on <Insert date and time> and <insert date and time>. You may also call me at (254) 405-1040.

Participation in this study is completely voluntary. The participant may also choose to drop out of the study at any time during the intervention with no penalties. My project has been reviewed and approved by the Institutional Review Board of the University of Central Oklahoma. This Board is responsible for the ethical treatment of research participants.

Thank you for your time and I look forward to speaking with you.

Sincerely,
Michelle Miller
Email: mmiller87@uco.edu
Phone: (254) 405-1040

Appendix E

Medical Release Form

Medical Clearance by Personal Physician

Patient Name: ______________________ Date of Birth: ______________________

Physician's Name: ______________________ Physician's Phone Number: ______________

Parent/Guardian Name: ________________ Signature: _________________________

The patient listed above has expressed an interest in participating in a research study being conducted by researchers in the Department of Kinesiology & Health Studies at the University of Central Oklahoma. The purpose of this study is to determine if implementing a Nintendo Wii Fit balance regimen will improve postural control and balance among adults with Down syndrome over the age of 18 years old. We appreciate your medical opinion and recommendation concerning this individual's participation in the balance training program.

Assessments: This study requires the completion of postural control and balance tests via the TekScan HR-mat. Postural sway and balance will be measured in six foot stances: standing on both feet with eyes open, standing on both feet eyes closed, standing on left foot eyes open, standing on left foot eyes closed, standing on right foot eyes open, and standing on right foot eyes closed.

Exercise Program: Participants will be asked to participate in balance training and regular non-balance games via the Nintendo Wii fit and Nintendo Wii Sport games for 30 minute sessions, 2 days per week, for 6 weeks. All activities are of low intensity. Exercise sessions will be scheduled 2 days per week on non-consecutive days. Each exercise session will be supervised by the primary researcher and faculty and staff at Wings (a special needs community). ***This project has been approved by the Institutional Review Board of the University of Central Oklahoma.***

Special Considerations for Individuals with Down Syndrome with Precautions Included in this Study (taken from ACSM's Guidelines for Exercise Testing & Prescription)

- Congenital heart disease
  - This program is a low intensity, balance activity program that is not expected to increase heart rate or oxygen consumption.
- Atlantoaxial instability – avoid hyperflexion and hyperextension of the neck
  - We have not included any Wii games that require these contraindicated movement (ie. soccer heading).
- Hypotonia & joint laxity – avoid contact sports
  - While individuals will play Wii games in a group, there will be no contact during the activities.

Contacts: Please call Michelle Miller, PI (254) 405-1040, if you have any questions concerning this research.

Please check one

☐ My patient, ________________________, ***is*** medically cleared to participate in this research study being conducted by the University of Central Oklahoma.

Please list any special considerations or instructions for this patient ________________________
____

☐ My patient, ________________________, ***is not*** medically cleared to participate in this research study being conducted by the University of Central Oklahoma.

If not, please explain____

________________________ ________________________ ________________
Signature of Physician Printed name of physician Date

Please return to the University of Central Oklahoma, Attn: Michelle Miller/Melissa Powers, Fax: (405) 974-3805

Appendix F

Wings Use of Facility Approval Letter

Melissa Powers

From: Michelle Miller <mmiller87@uco.edu>
Sent: Tuesday, September 16, 2014 11:36 AM
To: Melissa Powers
Subject: Fwd: IRB application

---------- Forwarded message ----------
From: **UCO** <mmiller87@uco.edu>
Date: Mon, Sep 8, 2014 at 4:31 PM
Subject: Re: IRB application
To: Marshall Ottinger <marshall.ottinger@wingsok.org>

Mr. Ottinger,

Thanks so much. I am looking forward to this project!

Sincerely,
Michelle Miller

Sent from my iPhone

On Sep 8, 2014, at 4:16 PM, Marshall Ottinger <marshall.ottinger@wingsok.org> wrote:

Michelle,

Thank you for the information. Please consider this email as confirmation of Wings and my approval for you to conduct and complete your research intervention for the school term of 2014-15.

Marshall Ottinger

Program Director

<image001.jpg>

13700 N. Eastern Ave.

Edmond, OK 73013

405.242.4646

marshall.ottinger@wingsok.org