THE USE OF THE NINTENDO WII FIT BALANCE PROGRAM COMPARED TO A TRADITIONAL BALANCE PROGRAM IN PHYSICALLY ACTIVE INDIVIDUALS

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ABSTRACT

THE USE OF THE NINTENDO WII FIT BALANCE PROGRAM COMPARED TO A TRADITIONAL BALANCE PROGRAM IN PHYSICALLY ACTIVE INDIVIDUALS

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CONTEXT: Dynamic balance is a critical aspect of everyday life that can be affected by a variety of factors including age and injury. When training to improve balance, traditional (TRAD) balance exercises or the Nintendo Wii Fit balance training exercises can be utilized. **OBJECTIVE:** The purpose of this study is to examine if the Nintendo Wii Fit balance training program is more enjoyable and improves dynamic balance to the same degree as a TRAD balance training program. **SUBJECTS:** 60 female and 29 male participants began the study with 52 females and 20 males finishing the study. The control group comprised 25 participants, the TRAD group comprised 25 participants, and the Wii group included 22 participants. **METHODS:** The star excursion balance test (SEBT) was utilized to test dynamic balance before and after intervention. The TRAD and WII groups performed their training three times a week for 12-15 minutes for four weeks. Following each intervention the participants completed an enjoyment questionnaire. **RESULTS:** There were no significance differences on total SEBT scores on either leg for time by group (right leg p=.518;left leg p=.647). When examining enjoyment the WII group was significantly higher than the TRAD group after 4 weeks (p=.000) of balance training. **CONCLUSIONS:** The results indicated that there were similar balance improvements among the WII and TRAD group, therefore, both programs can be used interchangeably for balance training exercises in young physically active adults

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CHAPTER 1

INTRODUCTION

1.1 OVERVIEW OF THE PROBLEM

Balance is targeted in rehabilitation because of the role it plays in decreasing the risk of re-injury in patients. Balance is more than simply being able to stand; it is a task that requires a solid base of support with timely control of position and motion (Betker, 2007). There are three components of balance: the vestibular system, visual inputs, and the somatosensory system. Each aspect is critical and must be present to achieve a state of stability. The vestibular system provides the central nervous system with information about the position of the head in regards to the rest of the body. Visual input is given based on the movement of the head in relation to the supporting surface. The somatosensory system is used to give information regarding the position of body segments in relation to each other (Winser, 2011).

There are two types of cognitive controls that are used during balance. Feed-forward cognitive controls are where preparatory controls are initiated in order to keep balance during anticipated disturbances (Betker, 2006; Kuo, 1995; Peterka, 2002; Shepard, 1992). Whereas feedback control is used to keep balance when there are unexpected disturbances (Betker, 2006; Kuo, 1995; Peterka, 2002; Shepard, 1992). Feedback control is used more in the active population and less in the elderly population (Betker, 2006).

In order to measure dynamic balance the Star Excursion Balance Test is used. The star excursion balance test (SEBT) is a simple test that causes the patient to disrupt his or her equilibrium (Cohen, Blatchly, & Gombash, 1993; Hertel et al., 2000; Olmsted, Carcia, Hertel, & Shultz, 2002; Rasool, 2007). The subject is positioned on one leg and asked to touch his or her opposite toe as far as possible in several different directions. The SEBT provides a total score as well as independent directional scores. The SEBT is a valid and reliable approach to measuring balance in collegiate students (Hertel, 2000).

The most commonly used form of balance rehabilitation is traditional exercise. Traditional balance exercises (TRAD) have been used for years in clinics in order to rehabilitate and improve balance in a variety of patients. The goals of traditional balance rehabilitation in a clinic usually include improving the patient's functional balance (especially during ambulation), decreasing fall risk, improving the patient's ability to see clearly with head movement, and reducing the patients disequilibrium (Herdman, 2001). TRAD has been found to be an effective tool for increasing static and dynamic balance in previous research (Heitkamp, 2001; Pluchino, 2010; Rasool, 2007; Rothermel, 2004). In one study, which used a single leg balance protocol to improve balance post-injury, researchers saw improvements in dynamic balance (Rasool, 2007). Despite TRAD leading to improvements in balance, it is not always enjoyable for the patients.

Although research has shown improvements in balance using traditional programs, there has been an underutilization of this type of rehabilitation due to the limited enjoyment and motivation shown by the patient as the training program progresses (Pluchino, 2008). These rehabilitation programs can be uninteresting for patients. Due to this, boredom and loss of interest are obstacles that health-care provider must overcome during the rehabilitation process. A patient who has lost interest in the mundane exercises associated with a lengthy rehabilitation process also loses motivation. This makes it extremely difficult to reach the results desired by both the injured athlete and the health-care professional (Cramer, 2001; Piercy, 2007).

Another form of balance rehabilitation that is being investigated is virtual reality (VR). VR is defined as an immersive, interactive, three-dimensional computer experience occurring in real time. The benefit of virtual reality is that it gives the patient a sense of real-life situations and events and allows a variety of senses to be targeted (Deutsch, 2008). VR has been shown to be valid and applicable to the real world, along with having motivational qualities. This form of gaming is currently under examination around the world in order to help improve patient's enjoyment throughout their return to function rehabilitation programs. The Nintendo Wii is one of the most common VR based games being investigated, and has sold over 75 million units worldwide. The basic idea behind the Wii system is that it requires the patient to use their own physical movements in order to control the player (Mii) on the game. The player uses either the Wii remote or the Wii balance board to control their player. The balance board uses pressure sensors, which translate the movement of the player's center of gravity (Taylor, 2011). The balance board is a unique tool that captures slight movements in order to measure foot position and weight distribution (Shih, 2011).

Recently, a variety of studies have been conducted assessing the extent to which the Nintendo Wii fit balance program affects balance. Toulotte, Olivier, and Toursel (2012) found that when working with elderly adult participants in Wii fit balance training, there was an increase not only in static balance, but also an improvement in their center of gravity. In similar studies improvements were also shown in static balance in older adult patients (Allen, 2008; Bainbridge, 2011). Other studies comparing efficacy between traditional balance programs and video game based balance programs reported that patients performing video game based rehabilitation are more enjoyable, less difficult, and more engaging (Agmon, 2011). In addition to the overall increase in enjoyment of rehabilitation, improvements in postural sway from patients who used the Wii was noted (Brumels, 2008). Although a few studies have examined the Nintendo Wii as a balance training tool, more research is warranted to determine its effectiveness on static and dynamic balance.

In order to combat the issues noted with traditional balance exercises**,** athletic trainers and other health care professionals have begun to incorporate interactive gaming systems into injury therapy (Wikstrom, 2012). The purpose of using VR is to provide the patient with a different, interactive form of rehabilitation. Patients are playing competitive games, while still reaching the desired goals of rehabilitation. Studies have been done assessing the enjoyment and ability of Virtual Reality balance programs to improve balance in elderly adults, but few studies have investigated the college-aged physically active population (Brumels, 2006).

The population of people who might benefit from balance training is potentially quite large—including children, younger and older adults, and rehabilitation patients. In this initial phase of research, however, I have focused my attention on healthy, physically active young adults (college students) who volunteered for the study. If the results of this initial research are promising, future research can be pursued to examine other physically active populations for whom a balance training program would serve a therapeutic function (e.g., athletic rehabilitation patients).

1.2 PURPOSE OF THE STUDY

The purpose of this study was to examine if the Nintendo Wii Fit balance training program is more enjoyable and improves dynamic balance to the same degree as a traditional balance training program.

1.3 HYPOTHESES

This study examined the following hypotheses:

H1: The TRAD group and the WII group will show significantly increased dynamic balance compared to the control group based on the total star excursion balance test score.

H2: The TRAD group will show significantly greater improvements than the WII group for total star excursion balance test scores.

H3: The TRAD group and the WII group will show significantly increased dynamic balance compared to the control group according to independent star direction scores.

H4: TRAD group will show significantly greater improvements than the WII group for independent star direction scores.

H5: The WII group will have a significantly higher enjoyment level than TRAD group for the first 2 weeks.

H6: There will be no difference in the enjoyment levels after 4 weeks of balance training between the WII group and the TRAD group.

1.4 OPERATIONAL DEFINITION OF TERMS

Dynamic balance: The ability to maintain an upright position while the body is moving as measured by the star excursion balance test.

Enjoyment: The amount of happiness the subject felt while performing the exercises as measured by a five item Physical Activity Enjoyment Scale.

Independent Star Direction Scores: This is found by isolating each of the directions utilized in the Star Excursion Balance Test, which includes anterior, posteromedial, and posterolateral.

Nintendo Wii Fit balance training: The use of four Nintendo Wii Fit balance games which includes table tilt, balance bubble, ski slalom, or penguin slide to improve balance.

Table Tilt- Wii Fit Balance training game in which the object is to control the balance board by leaning in all directions in order to drop a ball into the hole.

Balance Bubble- Wii Fit Balance training game in which the object is to control the bubble down the river without hitting the sides of the river or any obstacles which would pop the bubble.

Ski Slalom- Wii Fit Balance training game in which the object is to move between gates down the ski hill. Time is added at the end to the participants score if gates are missed.

Penguin Slide- Wii Fit Balance training game where the object is to keep the penguin on the iceberg and collect as many fish in the air as possible by timing up the weight shift medial and laterally.

Physically Active: As defined by the American College of Sports Medicine is completing at least 150 minutes of moderate intensity exercise or 75 minutes of vigorous intensity exercise per week (ACSM, 2011).

Star Excursion Balance Test: A measure of dynamic stability by standing on one leg while reaching with the other leg in three directions. The three directions being used are: anterior, posteromedial, and posterolateral.

Traditional balance training: A series of exercises done in a clinical setting to improve balance, which involves a progression from simple exercises to more advanced exercises. The progression is as follows: solid ground with eyes open, solid ground with eyes closed, solid ground with eyes open and perturbation, and solid ground with eyes closed and perturbation. This sequence is then performed on foam.

CHAPTER 2

REVIEW OF LITERATURE

2.1 INTRODUCTION

For people of all ages balance is an important aspect of life. Proprioception and balance can be altered for a variety of reasons, such as injury, neurological disorders, being on unstable surfaces, and/or having an unexpected disturbance. Due to the significant role balance plays in quality of life, balance rehabilitation has been offered within many settings to a variety of individuals. The following chapter will highlight what components make up balance and two types of balance protocols that are offered: traditional balance rehabilitation and Wii Fit balance rehabilitation. Explanations of what each of these protocols entail, along with previous research regarding how both of these forms of rehabilitation affect balance, will be examined. Some attention will also be given to the enjoyment associated with performing each of these rehabilitation protocols.

2.2 BALANCE

Balance is defined as an even distribution of weight enabling someone or something to remain upright and steady. It is an important part of life due to the risk of injury that can occur when balance is disturbed. Balance is more than simply being able to stand; it is a holistic idea that requires a solid base of support with timely control of position and motion (Betker, 2007; Huxam, 2001). Balance is a function that requires exact muscle and joint movements to keep the center of gravity in accordance with the body’s base of support (Hassan, 2002; Kovacs, 2004; O’Connell, 1998; Subasi, 2008). There are two types of cognitive controls that are used for different types of balance. Feed-forward cognitive controls are where preparatory controls are initiated in order to keep balance during anticipated disturbances (Betker, 2006; Kuo, 1995;

Peterka, 2002; Shepard, 1992). Whereas feedback control is used to keep balance when there are unexpected disturbances (Betker, 2006; Kuo, 1995; Peterka, 2002; Shepard, 1992). Feedback control is used more in the active population where more opportunities for spontaneous perturbations are present. Feed-forward control is more easily planned for and is used during rehabilitation.

2.2.1 Three system control

There are three components that control whether a person is able to stay balanced: the vestibular system, sensory input, and the somatosensory system. Each aspect is critical in achieving the precise control to remain balanced. The vestibular system provides the central nervous system (CNS) with information about the position of the head in regards to the rest of the body (The Human Balance, 2013). This system is made up of the following structures within the ear: the utricle, saccule, and three semicircular canals. Linear and vertical movements are detected by the utricle and saccule. Rotational movements are monitored by the semicircular canals. These canals are filled with endolymph fluid which puts pressure on sensory receptors during rotational movement (Hanes, 2006; Shumway-Cook, 2001; The Human Balance, 2013).

Sensory input from the surrounding area is given based on the movement of the head in relation to the supporting surface (Mancini, 2010). This can be in the form of visual inputs, muscle and joint inputs, and vestibular organ inputs. These sensory receptors send information to the brain, which is then used to sustain balance (Horak, 1987; Horak, 1996; Horak, 1997; Macpherson, 2012; Mancini, 2010).

The somatosensory system is used to give information regarding the segments of the body in relation to each other (Shumway-Cook, 1986; Winser, 2011). Through the incorporation of information gained through touch and joint movement the bodies ability to remain balanced increases. The somatosensory system also gains information regarding temperature. These three systems work hand-in-hand to integrate the information they receive in order to keep the body upright (Tsuchitani, 1997).

2.2.2 Proprioception

Proprioception, although often thought as interchangeable with balance, is a separate facet of bodily position. It does contribute to being able to stay balanced and having good postural control, but it requires different controls (Bouet, 2000; Kovacs, 2004; Latazio, 1998; Lawkoverski, 2000; Pincivero, 2001; Riemann, 2002; Subasi, 2008). Proprioception is the term used to describe the sensory aspect of balance in both conscious and unconscious states. In order to improve balance, this must be an area of focus within rehabilitation. During complex movements conscious proprioception is used in order to maintain complex activities, whereas unconscious proprioception control occurs during basic movements such as sitting and walking. Proprioception is controlled by two different sensations. The first being static limb position during which the body is aware of where the limbs are in relation to the rest of the body in space. The second involves the body recognizing the rate at which the limbs are moving through space, which is termed kinesthesia (Johnson, 2013; Johnson 2008). Proprioception is challenging to measure and target, therefore it will not be a point of emphasis throughout this study.

2.2.3 Role in Athletics

Balance is the backbone to many functional movements not only done in everyday life, but also in sports. One of the most important aspects of an injury prevention program is a focus on improving the patient’s balance and proprioception. With increases in these skills, fewer injuries are likely to occur during physical activities (Troop, 1984). Decreased proprioception can result in different motor patterns of joints that can lead to unstable positioning and increased injury (Kidgell, 2007). Improving balance is not only useful in injury prevention, but is also an important part of injury rehabilitation, especially in the case of long term injuries (Kidgell, 2007). Varying activities for the athlete to perform each day can be challenging, so finding multiple balance rehabilitation options may increase their enjoyment of the rehabilitation process.

2.3 TRADITIONAL BALANCE TRAINING

In situations where balance and proprioception has decreased, balance training is required. Traditional balance training involves the repetition of specific movements (Burdea, 2003; Gil-Gomez, 2011; Teasell, 2009). These rehabilitation programs can be tedious, and costly depending on the equipment used. Based on the rehabilitation program exercises and the time frame the person has to complete their rehabilitation, the exercises can become repetitive overtime. Boredom and loss of interest are obstacles that health-care providers must overcome during the traditional rehabilitation process. A patient loses motivation when they become unengaged with the exercises associated with a lengthy rehabilitation process. This makes it difficult to reach the results desired by both the injured individual and the healthcare professional (Cramer, 2001).

Traditional balance exercises have been used for years in clinics in order to rehabilitate and improve proprioception. The goals of traditional balance rehabilitation in a clinical setting usually include: improving the patient's functional balance (especially during ambulation), decreasing fall risk, improving the patient's ability to see clearly with head movement, and reducing the patients disequilibrium (Herdman, 2001). Although research has shown improvements in balance using traditional programs, there has been an underutilization of this type of rehabilitation due to the limited enjoyment and motivation shown by the patient as the training program progressed. (Pluchino, 2008) The exercises used in this form of rehabilitation can be anything from basic strength training such as calf raises or mini squats to having the patient stand with their eyes closed in a variety of stances. There are also a variety of surfaces that people can stand on while performing balance training such as the ground, dynadisk, or a foam surface.

Pluchino (2010) compared using a standardized balance training program, a Tai Chi program, and a Wii Fit balance program over 8 weeks on 40 healthy older adults. The Wii Fit balance program consisted of playing any of the balance games. The games that were played were based off of the scores the participant received playing the games the previous training session. The Tai Chi program required the participant to perform 12 skills with an instructor's aid that required different movement patterns requiring balance. The standardized balance training program had 14 different exercises involving small steps, moving objects off shelves, and other walking activities.

In order to improve patient balance post-injury, clinicians have them perform exercises targeting proprioception. One study focused on improving dynamic stability through the completion of one leg dynamic balance activities on a variety of surfaces with 30 male athletes (Rasool, 2007). Each participant did three sets of five repetitions of one minute single leg balance with 30 second rest in between. The three sets all included balance on both the gymnasium floor and a soft mat with eyes open and closed. The difference in the three sets was the first set involved a relaxed position of the contra-lateral leg, the second set involved the participant performing trunk rotation while the contra-lateral leg was relaxed, and the last set had the knee and hip flexed on the contra-lateral leg to 90 degrees with trunk rotation. They performed the exercises five times a week for four weeks and were tested using the star excursion balance test (SEBT). After two weeks of training significant improvements were noted in all eight directions of the SEBT, whereas after four weeks significant increases were seen in six of the eight directions. The authors concluded that this simplified balance training protocol and measurement can be transferred into a clinical setting due to the ease of both the protocol and the testing measurements (Rasool, 2007).

Another study by Rothermel and colleagues (2004) used 45 healthy college students to determine if changing foot positioning can aid in improving balance. Three groups were utilized. The first group performed traditional balance training, the second performed traditional balance training with emphasized foot positioning, and the third was a control group. The intervention groups completed 12 ten-minute sessions of traditional balance training or balance training with a specific foot position over a four week time period. Each balance training session consisted of ten minutes of balance training with the eyes open and closed. Each exercise lasted 30 seconds followed by 30 seconds of rest and included a progression from the floor to a foam surface with hands placed on the subjects hips and straight out. The foot position group performed the exercises while trying to elevate their medial longitudinal arch while keeping their forefoot and rearfoot on the floor. Results indicated that the traditional balance group had a significant group by time improvement, whereas foot position showed less improvements than that of the traditional group. The researchers concluded that traditional balance training without focusing on foot position improved postural control more than if the focus was placed on foot position (Rothermel, 2004).

Heitkamp (2011) examined 30 physically active adults, divided into a balance group and a strength group, to determine whether balance training can also improve strength and muscle imbalances. Each participant performed 12 training sessions over six weeks for 25 minutes per session. The strength group performed leg curls and leg press, where the balance group performed activities on unstable surfaces. Results found that balance and strength did improve with traditional balance exercises. Researchers also noted that muscular development does occur through balance training (Heitkamp, 2001).

2.4 NINTENDO WII FIT BALANCE TRAINING

Health care professionals have begun to turn to interactive gaming systems in order to assist in balance rehabilitation (Brumels, 2006; Deutsch, 2008; Dixon, 2008, Wikstrom, 2012; Wuang, 2011). The goal of using virtual reality rehabilitation is to allow the patient a different form of rehabilitation, which involves the use of competitive games while still reaching the desired goals of rehabilitation. This allows the rehabilitation process to move away from traditional and often repetitive rehabilitation exercises.

Virtual reality (VR) is defined as an immersive, interactive, three-dimensional computer experience occurring in real time (Deutsch, 2011; Reid, 2004). The benefit of virtual reality is that it gives the patient a sense of real-life situations and events, allowing for a variety of senses to be targeted (Deutsch, 2011). VR is applicable to the real world and has motivational qualities. The efficacy of this form of gaming is currently under investigation as to whether it actually improves balance and patient enjoyment during their progression to functional activities (Agmon, 2011; Bainbridge 2011; Betker, 2007; Daniel, 2011; Deutsch, 2011; Toulotte et al. 2012). The Wii is one of the common VR based games being investigated.

The Wii has sold over 75 million units worldwide. The basic idea behind the Wii system is to control the Mii player on the screen through a person's physical movements outside of the game. The individual uses a Wii remote to control their player unless they are using the Wii Fit program, in which they will use the Wii balance board. The Wii balance board uses four pressure sensors, one in each corner, which tracks movement of the player's weight distribution and foot position (Nintendo, 2010; Shih, 2010; Taylor, 2011). The Wii balance board is mobile and includes a Bluetooth wireless connectivity run by batteries, making it user friendly. There are a variety of exercises that can be done using the Wii Fit software. The available categories or exercise include: yoga, strength training, aerobics, and balance.

This study will focus solely on the balance games. There are four main balance exercises that involve medial to lateral balance, anterior to posterior balance, and a combination of multi-directional balance. The first balance exercise, table tilt, involves trying to drop a marble into a small hole while controlling the movement of the board on which the marble sits. Second, during the balance bubble game, the participant floats down a river in a bubble and attempts to avoid hitting the sides of the river or the variety of disturbances that get in the way. Third, ski slalom involves skiing down a hill, and requires a combination of forward leaning to increase speed, along with side to side leaning to get around all of the gates. The last game is penguin slide where a penguin slides on an ice berg. The objective of this game is to not only keep the penguin from going into the water, but also change direction with enough force for the penguin to jump and catch fish. All of these games are scored with either time or points and incorporate multiple levels of difficulty.

In recent years, a variety of studies have been conducted assessing the extent to which the Wii fit balance games effect balance (Agmon, 2011; Bainbridge 2011; Betker, 2007; Daniel, 2011; Deutsch, 2011; Toulette, 2012). Toulotte et al. conducted a study that assessed balance in 36 elderly adults using four different interventions: adapted physical activities, Wii fit balance, a combination of physical activities and Wii fit balance, and no training. All participants trained once a week for 20 weeks for a one-hour training session. Their pre-test and post-test results were assessed using the Tinetti test, unipedal tests, and Wii fit tests. They found that after 20 weeks of interventions once a week, all groups demonstrated significant improvement in static balance using the Tinetti test which assessed seated static balance, along with center of gravity improvements using the Wii Fit balance test. This study established that adaptive physical activity training can decrease the loss of sensory functions often noted in the elderly (Toulotte, 2012).

In one pilot study, Bainbridge (2011) investigated six patients over the age of 65 with self-reported balance deficits in order to determine whether the Nintendo Wii Fit balance board could improve balance. The intervention was done for six weeks, two times a week for for 30 minutes each session. The testing used the Berg Balance Scale, activities-specific balance confidence scale, and multi-directional reach test. Although researchers found no statistically significant changes, clinically significant changes on the Berg Balance Scale as noted with a decreased fall risk, a test which is designed for the use in elderly adults to assess functional activities, in two-thirds of the subjects was seen (Bainbridge, 2011).

Deutsch (2011) completed a case study that investigated the feasibility and outcomes of using the Nintendo Wii Fit for rehabilitation with a patient who had cerebral palsy. The patient participated in 11 training sessions lasting anywhere from 60 to 90 minutes. The games played included boxing, tennis, golf, and bowling. Following the training sessions the outcomes measured were visual-perceptual processing, postural stability, and functional mobility. The patient improved in all of these categories, and the Wii was found to be easy to use for rehabilitation in a school setting.

Studies utilizing the Wii Fit not only examined improvement in balance, but also the enjoyment level of the patients. Studies which looked at efficacy between traditional balance programs and video game based balance programs proved that patients found video game based rehabilitation to be more enjoyable, less difficult, and more engaging (Agmon, 2011, Brumels, 2008). Brumels et al. investigated the efficacy in traditional balance exercises compared to video game based balance exercises in improving balance measures and compliance. Twenty-five college aged students were divided into a control group, Dance Dance Revolution Group, Wii Fit group, or traditional balance exercise group. Each participant was tested using the SEBT and forceplate measures. After 4-weeks of training three times per week, improvements were noted in the star excursion balance test. Increases in patient enjoyment and engagement were also noted (Brumels, 2008).

2.5 NINTENDO WII FIT REHABILITATION VS TRADITIONAL REHABILITATION

The Nintendo Wii Fit Balance Program offers a unique approach to balance training. Not only has it been proven to be more enjoyable, but it also offers a variety of different games to play throughout each session (Agmon, 2011; Brumels 2008). This VR game play involves multiple movements all in different directions at differing speeds. This keeps the player guessing when the next movement will be, which requires the patients to change their center of gravity while playing in an interactive environment. A score is kept for each of the different games so a motivation factor to improve every time they play is present. Positive feedback is seen throughout the game with crowds that cheer on the player. The problems with using the Wii Fit include equipment costs, being able to navigate the menu in order to get to the games that need to be played, and a predetermined amount of time that is not adjustable between each round of each game. The player can always pause the game, but there is no way to speed up the time between each game. The Wii fit does not have a lot of previous research done on its improvements in balance, therefore it has not proven to be reliable yet.

Traditional balance on the other hand is reliable. When it comes to traditional balance exercises there are often similar exercises that are either done with eyes open or closed on different surfaces along with minimal strength training when appropriate. This requires minimal if any equipment making it cost-effective for the clinic and patient. Some patients find this form of rehabilitation tedious (Piercy, 2007). Another drawback is that improvements may be varied based on how well the patient trusts his/her clinician, and unlike the Wii Fit Balance Training there is no immediate feedback, unless a clinician is standing by their side watching every exercise in detail.

One study compared these two forms of rehabilitation using 32 undergraduate students who were divided into a traditional and a Wii based gaming program. The students performed exercises two times a week for 8 weeks for 24-minute sessions. The traditional group performed single leg balance exercises on both the hard surface of the bosu ball and flat surface along with a mini trampoline. For some of the exercises a ball was tossed to the participant to try and alter their balance. The Wii group performed both Wii balance exercises and Wii yoga exercises. The authors found that the Nintendo Wii Fit Balance Training is effective for improving balance as measured using a single leg stance on the Biodex stability system. (Vernadakis et al., 2012).

In older adults, a similar preliminary study was done on eight females and nine males to improve their balance (Bateni, 2012). One group consisted of Wii fit training only and the participants performed table tilt, ski slalom, and ski jump. Another group consisted of traditional exercises only and the participants performed exercises to improve strength, posture, and balance. The final group performed a combination of both of the other two intervention groups. The exercises were performed three times per week for 4 weeks and improvements were noted in all groups, although the most improvements were seen in the traditional exercised only and the traditional exercised and Wii training group. These results found that some form of Nintendo Wii Fit training along with traditional balance training can be useful in improving balance in elderly adults. Also, despite the Wii not improving balance as much as the other two groups, it may still be utilized in situations where traditional balance is not feasible (Bateni, 2012).

Finally, Toulette and colleagues (2012) assessed balance in elderly adults using four groups. One consisted of adapted physical activities, the second group trained on the Wii fit, the third group used a combination of both training types, and the fourth group did no training. Toulotte et al. found that after 20 weeks of training once weekly, all training groups had significant improvement in static balance along with center of gravity (Toulotte, 2012). Using the Nintendo Wii Fit to gain balance improvements is a relatively new-found tool. Although, as seen in the previous paragraphs, there are a variety of studies that show it is capable of making improvements similar to traditional balance rehabilitation.

2.6 ENJOYMENT AND BALANCE TRAINING

An individual's enjoyment has been found to increase motivation to complete more tasks (Agmon 2011; Betker et al. 2007). Betker et al. used a center of pressure controlled video game system in order to improve dynamic balance in three patients with brain tumors and traumatic brain injuries. Researchers focused on this form of rehabilitation to see if motivation increased because of the challenge of the game. Dynamic balance was assessed with four trials of 20 seconds standing on foam, on the floor, and standing with a variety of head and arm movements. A decrease in fall rates were shown by the subjects, along with enjoyment noted through increased motivation of the participants to complete the balance exercises (Betker, 2006).

Agmon (2011) also found high enjoyment levels with patients using the Wii Fit for balance rehabilitation. He examined five elderly adults who played the Wii at home three times a week for 30 minutes for three months. They were asked to complete charts of their game play along with an enjoyment log immediately following game play. Balance was measured using the Berg Balance Scale, four meter timed walk test, and physical activity enjoyment scale. Both walking speed and Berg Balance Scale scores increased, along with participants expressing increased balance. This study not only demonstrated improvements in balance with the Wii Fit balance program, but also high enjoyment and usability levels for the patient (Agmon, 2011). Daniels et al. (2011) had volunteer, pre-frail older adults participate in two different forms of rehabilitation. The volunteers were organized into three groups: a control group, a seated exercise group, and a Wii rehabilitation group. The outcomes examined included: Senior Fitness Test, Body Weight, Balance Efficacy Scale, CHAMPS, Late-Life Function and Disability Index, and MOS SF-36. In pre-frail older adults, researchers noted an increase in balance confidence over 15-weeks of game play, along with high enjoyment levels throughout the game play period. Improvements in the outcome measures were seen in both the seated exercise group and the Wii group over the control group.

2.7 BALANCE MEASURMENT TOOLS

2.7.1 Balance Error Scoring System

The balance error scoring system (BESS) test was designed to provide a portable, cost effective, and objective measures of assessing postural stability (Riemann, 1999). The BESS test has moderate to good reliability (alpha > .72) (Bell, 2011). The test involves the subject standing in three different stances (feet together, tandem stance, and single leg stance) on both a firm surface and a foam surface. While the subject is performing the six stances, errors are counted.

Errors are tallied if the subject moves their hands off of their iliac crests, opens their eyes, steps stumble or falls, abductions or flexes their hip beyond 30 degrees in single leg stance, lifts the forefoot or heel off of the testing surface, or remains out of the proper testing position for greater than 5 seconds (Bell, 2011). The average number of errors for 20-39 year old individuals and healthy control groups was 10.93 errors for the BESS test (Bell, 2011). Although the BESS test itself will not be utilized throughout this study, the error scoring system will be used throughout the TRAD progression.

2.7.2 Star Excursion Balance Test

The star excursion balance test (SEBT) offers a simple, reliable, and low cost option for investigating dynamic balance when compared to other more expensive tools that are used (Rasool, 2007; Cohen, Blatchly, & Gombash, 1993; Hertel et al., 2000; Olmsted, Carcia, Hertel, & Shultz, 2002). The SEBT forces the subject to disrupt their equilibrium to the maximal amount. The SEBT is a functional test that positions the patient on one leg. The subject stands at the center of a grid and reaches in eight directions that all extend in 45 degree increments from the center of the grid. Anterolateral, anterior, anteromedial, medial, posteromedial, posterior, posterolateral and lateral are the directions the subjects are asked to reach. In one study, subjects were given a visual and verbal demonstration of the test and allowed six practice trials in each direction before data collection in order to reduce the learning effect (Hertel, 2000). After further research into the number of practice trials, Robinson et al. (2008), found that the number of practice trials can be moved from 6 to 4 with no change in validity of the test. During testing, they were told to touch lightly as far as they could along the line with their toe while keeping the heel of the opposite foot firmly planted in the center of the grid and their hands on their iliac crests. The subjects were allowed three touches along each line and the farthest touch was recorded. After each reach there is a 15 second rest period. If the subject did not follow protocol the measurement was discarded (Rasool, 2007). The intra-class correlation coefficients show reliability for the SEBT is anywhere from .67-.87 depending on which direction the subject reaches. The intra-tester values (intraclass correlation coefficients) calculated for each direction were as follows: Anterior = .96, Anteromedial = .95, Medial = .97, Posteromedial = .97, Posterior = .98, Posterolateral = .97, L = .96, and Anterolateral = .94 according to Hardy. (Hardy, 2008)

One study used the SEBT to assess improvements in single leg dynamic stability in 30 adult males. The participants were divided into a control and traditional balance training group and were evaluated at baseline, 2 weeks, and 4 weeks. Their protocol for the SEBT consisted of eight reach directions with 15 seconds rest in between each reach and three chances at each reach. If there was a mistake by the participant the score was discarded. This study concluded that a progressive single leg dynamic balance program can improve balance in a short amount of time (Rasool, 2007).

Another study which assessed SEBT scores between adult-aged and middle-aged women in order to determine dynamic balance differences found that the younger women were able to reach farther by seven centimeters (Bouillon, 2007). The SEBT was the only measure that was used. The protocol that was followed included a visual and verbal demonstration of three reach directions that were measured (anteromedial, medial, and posteromedial). Each participant warmed up for five minutes on an exercise bike. They then practiced the reach four times in each of the three directions. After a rest, the three directions were put in a randomized order and the participant performed three trials in each direction with 10 seconds between trials and 20 seconds between directions. If the participant lost balance the trial was repeated (Bouillon, 2007).

Gribble performed a systematic review regarding the SEBT and its role in determining dynamic stability (Gribble, 2012). Gribble found that it should be considered a highly representative, non-instrumented dynamic balance test for physically active individuals. The SEBT has been shown to be both valid and reliable and should be used in the clinical setting as a lower extremity functional test (Gribble, 2012).

One of the issues with using the SEBT is in regards to how many times the subject should reach in each direction. A study by Demura and Yamada (2011) examined the SEBT, but condensed it down to four directions with three reaches in each direction. The reach directions were anterior, medial, posterior, and lateral. They found that with this shortened version there was the same intra-tester and inter-tester reliability as the original version and that this made the testing much more practical. Kinzey et al. (1998) also performed a study to assess reliability of the SEBT. Participants performed a pretest and a posttest seven days apart. Participants were instructed to put both of their feet in the center box and reach with their right leg anterior and posterior and with the left leg anterior and posterior. Five consecutive trials were done in each direction before the participant moved to the next direction. Although they did not find high reliability the study concluded with practice tests the SEBT may be more reliable (Kinzey, 1998).

2.8 ENJOYMENT SCALE

Enjoyment plays a huge role in not only the amount of exercise a subject will do, but at the level he or she will complete the task. The Physical Activity Enjoyment scale (PACES: Kendzierski & DeCarlo, 1991) is a single factor, multiple-item scale used to assess enjoyment of physical activity in adults across varying types of exercise. Kendzierski and DeCarlo found the PACES to have acceptable internal consistency and test-retest reliability in college students (2009). A variety of researchers have developed similar scales to evaluate enjoyment at varying age levels. Raedeke (2013) developed a five item enjoyment measure and found it to show evidence of factorial validity. This five item questionnaire is easier and takes less time for the subject to fill out. This questionnaire includes 5 statements that the participant must rate on a scale of 1 to 7. The statements are as follows:

1. I enjoy it to I hate it
2. I feel bored to I feel interested
3. I dislike it to I like it
4. I find it pleasurable to I find it unpleasurable
5. It is no fun at all to it is a lot of fun

2.9 SUMMARY

Balance is a function that affects people of all ages. Clinicians are always trying to find more enjoyable and interactive ways for the patients to improve their balance rather than the traditional exercises. Few studies have addressed whether a Nintendo Wii Fit balance training program is just as effective and more enjoyable in college-aged individuals compared to a traditional balance protocol.

CHAPTER 3

METHODS

3.1 PURPOSE

This section discusses the methodology used to determine whether the Nintendo Wii Fit balance training program and a traditional balance training program demonstrate improvements in dynamic balance when compared to a control group. This study also addressed whether the Nintendo Wii Fit balance training program is more enjoyable than a traditional balance program.

3.2 RESEARCH DESIGN

A randomized convenience pre- and post- test research design was used to determine whether the Nintendo Wii Fit balance training program improved balance as much as a traditional balance training program. It also addressed which training protocol subjects found more enjoyable. The independent variables in this study were the two interventions groups (Nintendo Wii Fit balance training and the traditional balance training) and a control group. The dependent variables included dynamic balance (total SEBT and individual SEBT scores) and enjoyment level.

3.3 SAMPLE POPULATION AND PARTICIPANT SELECTION

This study's sample population was composed of 90 physically active, college students between the ages of 18-28 who volunteered for the study. Individuals were selected if they were physically active in accordance with the American College of Sports Medicine (ACSM) guidelines of completing at least 150 minutes of moderate intensity exercise or 75 minutes of vigorous intensity exercise per week (ACSM, 2011). Volunteers were excluded if they had sustained an acute injury or concussion within six months of data collection or if they had been previously diagnosed with a vestibular dysfunction or neurological disorder.

3.4 INSTRUMENTATION

The Star Excursion Balance Test (SEBT) was used to measure dynamic balance in this study. The SEBT offers a simple, reliable, and cost-effective method for examining dynamic balance when compared to other balance measurement tools, such as forceplates, the Berg Balance Scale, and other clinical balance measures (Cohen, Blatchly, & Gombash, 1993; Hertel et al., 2000; Olmsted, Carcia, Hertel, & Shultz, 2002; Rasool, 2007;). The SEBT is a functional test that positions the patient in a single-leg stance at the center of a grid with eight lines extending outward at 45-degree angles from one another. Subjects were instructed to do a single-leg squat motion, lightly touch the line with the most distal part of their foot, and then return to the start position (see Figure 1). Reach distance was measured in centimeter increments that were marked on the lines (Bouillin, 2011). In the event that the reach was in-between two measurements, the trial was recorded as the lesser distance. In order to be a countable attempt, the balance-leg heel must have stayed in contact with the floor and the hands must have remained on the subject's iliac crests at all times. For this study, only the anterior, posteromedial, and posterolateral directions were used due to evidence from Hertel suggesting these three directions are the most reliable (Hertel, 2008). A total SEBT score was determined by averaging the three individual direction trials and adding each direction together. The intratester values (intraclass correlation coefficients) calculated for each direction are as follows: Anterior = .96, Posteromedial = .97, Posterolateral = .97 according to Hardy (2008).

Figure 1 3 Direction Star Excursion Balance Test

3.4.1 Balance Training Programs

3.4.1.1Nintendo Wii Fit Balance Protocol

The two balance interventions being used were the Nintendo Wii Fit balance training (WII) program and the traditional balance training (TRAD) program. The WII training utilized the Wii Fit software and the Nintendo Wii Fit balance board. There were four main balance exercises that involved medial to lateral balance, anterior to posterior balance, and a combination of multi-directional balance. The first balance exercise, table tilt, involved trying to drop a marble into a small hole while controlling the movement of the board on which the marble sits. The second game was the balance bubble game where participants floated down a river in a bubble and attempted to avoid hitting the sides of the river and a variety of other disturbances. Ski slalom was the third game that involved skiing down a hill and guiding the character between a series of gates. This game utilized a combination of forward leaning to increase speed and side-to-side leaning to pass through all of the gates. The last game was penguin slide where a penguin slides on an iceberg. The objectives of this game were to control the iceberg's movement to both keep the penguin from going into the water and to also forcefully change directions to make the penguin jump and catch fish. All of these games were scored by time or points and incorporate multiple levels of difficulty for the participant so they can advance.

3.4.1.2 Traditional Balance Training Protocol

The subjects performing traditional exercises were asked to perform two exercises bilaterally. The first exercise was standing tandem (See Figure 2) and the second was standing on one leg (See Figure 3). All exercises were done on both the left and right leg. Errors were counted throughout the entire intervention time and the participant progresses when 10 or less errors were counted. Errors were accounted for using the following criteria as used by the balance error scoring system test: moving the hands off of the iliac crests, opening the eyes, step, stumble or fall, abduction or flexion of the hip beyond 30° in single leg stance, lifting the forefoot or heel off the testing surface, or remaining out of the proper testing position for greater than 5 seconds. After the subject completed the exercise with 10 or less errors the following progression was used for both the tandem and single leg exercise. Solid ground with eyes open solid ground with eyes closed, solid ground with eyes open and perturbation, solid ground with eyes closed and perturbation. If a participant reached the highest level of progression prior to the twelfth intervention training session he/she remained on that level for the duration of the training. The same progression levels were then done on foam once they completed all solid ground progressions with less than 10 errors. A researcher always worked with the traditional group in order to progress the participant at the proper time.

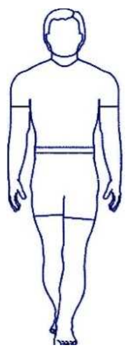

Figure 2 Tandem Stance

Figure 3 Single Leg Stance

3.4.1.3 Enjoyment Questionnaire

A 5 item enjoyment questionnaire was administered to the participants after each intervention session. This 5 item scale was adapted from Kendzierski andDeCarlo's (1991) Physical Activity Enjoyment Scale (PACES) by Raedeke and Amorose (2013). Raedeke and Amorose showed factorial validity using a confirmatory factor analysis using maximum likelihood estimation procedures. The original PACES was shown to have high internal consistency along with moderate to high test-retest reliability (Kendzierski, 1991). In the validation studies Kendzierski utilized one study containing a group who rode an exercise bike under control and external focus conditions. The other study consisted of participants riding a bike and jogging. The participant was then given the option for what to do for their third exercise. The questionnaire utilized in this study instructed the subject to rate the following 5 statements based on the workout they just completed. They had to rate on a scale of 1 to 7. An overall enjoyment score was determined by adding the scores from all five items and then dividing by five. They rated based on the following statements:

1. I enjoy it to I hate it
2. I feel bored to I feel interested
3. I dislike it to I like it
4. I find it pleasurable to I find it unpleasurable
5. It is no fun at all to it is a lot of fun

They then rated the following two questions on the same seven point scale from very important to not important.

1. How important is doing well on this task to you?
2. How important is it for you to improve your balance?

3.5 DATA COLLECTION AND MANAGEMENT

Participants were recruited through word of mouth in kinesiology classes along with flyers posted around campus and in each athletic training room. Participants was asked to contact the researcher via e-mail with a copy of their normal weekly schedule. E-mails were sent to all volunteers establishing an initial meeting for informed consent and SEBT pre-testing. At the first meeting, the study was described and informed consent was obtained from all participants. The participants were given the opportunity to ask questions and discuss the details of the study at this time. Individuals then completed a health-history form and an ACSM physical activity questionnaire to determine inclusion. Subjects were randomly numbered in order to conceal their identities during the testing process.

Once subject inclusion was confirmed by the lead researcher, SEBT pre-testing was conducted. Prior to the SEBT all participants warmed up on a bike for five minutes and then removed their shoes and socks. Each participant followed the same protocol with a randomized direction order when performing the SEBT. Each direction (anterior, posteromedial, and posterolateral) was done bilaterally before moving onto the next direction. Prior to starting each reach direction, a visual and verbal demonstration of the test was given and the participant completed 3 practice trials. Following the practice trials, subjects performed three recorded trials in accordance with the SEBT protocol with 15 seconds rest in between. They followed the same protocol for their bilateral leg before moving onto the other directions. A mean of the three trials was calculated and normalized by subject leg-length to determine an individual average reach distance for the anterior, posteromedial, and posterolateral directions. Leg length was determined by measuring from the subject's anterior superior iliac spine to the distal tip of the medial malleolus. Leg length was used to normalize excursion distances by taking the distance reached and dividing by leg length then multiplying by 100 (Gribble & Hertel, 2003; Munro, 2010). For statistical analysis purposes, a total SEBT score was also calculated by taking the sum of the average scores from all three directions.

All SEBT measurements were done by two research assistants who were blinded to the intervention groups. The first research assistant explained the procedure, demonstrated it, and measured reach distances. The second research assistant took the leg-length measurements, watched for the SEBT errors, and recorded the reach distances as reported by the first researcher. Following the completion of SEBT pre-testing, subjects were randomly assigned to the WII group (n=30), the TRAD group (n=30), or the control (CONTROL) group (n=30). Subjects were instructed to conceal their group assignments from the SEBT research assistants.

The TRAD group and WII group met three times a week for 4 weeks. Each session took between 12 and 15 minutes. For all balance training the participants removed their shoes and socks. Each WII subject was randomly assigned to two of the four games to play at each session. The games were played on a 46 inch TV with the balance board set up 6 feet from the screen. They played the two randomized games two times each then alternated between the two games until the completion of the 12-minute intervention session. If they were in the middle of a game when time elapsed, subjects were allowed to complete the game they were currently playing and it was recorded how many minutes they went over. The TRAD group performed their exercises in one room with a research assistant tallying the number of errors per training session. The participant progressed to the next level when they reached less than 10 errors per intervention session. Errors were not counted during the perturbation stage. After each intervention the participants completed the enjoyment questionnaire. An average enjoyment score was calculated for Week 1, 2, 3, and 4, of the intervention to be used for statistical analysis.

Following the final intervention, each participant returned for SEBT post-testing. The same protocol was used as the pre-test. They also completed a final enjoyment questionnaire regarding their experience as a whole with the balance training intervention.

3.6 DATA ANALYSIS

Descriptive and inferential statistics were used to analyze the data for this study. A 3 Group (CON, WII, TRAD) x 2 Time (pre, post) analysis of variance (ANOVA) with repeated-measures on the Time factor was performed to assess differences on total SEBT scores. Additionally, a 3 Group (CON, WII, TRAD) x 2 Time (pre, post) multivariate analysis of variance (MANOVA) with repeated measures on Time was completed to determine individual SEBT test scores in the direction of anterior, posteromedial, and posterolateral. A 2 Group (WII, TRAD) x 2 Time (two, and four weeks) ANOVA with repeated-measures on Time was used to determine the difference in average enjoyment scores. Data were analyzed using Statistical Package for Social Sciences (SPSS) version 19.0. Significance level for all analyses was set at prior to $p < 0.05$.

CHAPTER 4

RESULTS

4.1 OVERVIEW

This research was conducted to investigate whether a Nintendo Wii Fit balance training program is more effective and enjoyable than a traditional balance program in improving dynamic balance. This chapter describes the demographics of the sample and discusses results of a 4 week Nintendo Wii Fit balance training program, a traditional balance training program, and a control program. The results section is described in terms of Group (TRAD, WII, control) and Time (pre-test, post-test). It also discusses the differences in enjoyment between the two balance training groups.

4.2 DEMOGRAPHIC DATA

4.2.1 General Demographics.

A total of 89 (60 females, 29 males) participants began the study with 72 (52 females, 20 males) finishing the study. A participant was considered to finish the study by completing the post test and attending at least 10 out of 12 balance training sessions. The participants who opted out of finishing the study all had scheduling conflicts that caused them to not be able to attend intervention sessions or show up at the testing. The control group consisted of 25 participants, the traditional group consisted of 25 participants, and the Wii group consisted of 22 participants. The average age of the participants was 19.2+/-1.25 years old. The average weight was 66+/-1.24 kilograms and the average height was 168.5+/-11.97 centimeters.

4.3 ASSESMENT OF HYPOTHESIS

H1: The TRAD group and the WII group will show significantly increased dynamic balance compared to the control group based on the total star excursion balance test score.

H2: The TRAD group will show significantly greater improvements than the WII group for total star excursion balance test scores. These hypotheses were not supported as there were no significant improvements in total SEBT scores on the right leg for the interaction between Time by Group [Wilks=.981, $f_{(1.69)}$=.665, p=.518]. The left leg was also not statistically significant forTime by Group [Wilks=.988, $f_{(1,69)}$=.438, p=.647] for total SEBT. However, there was a significant difference for the main effect of time for the right leg [Wilks = .765, $f_{(1,69)}$=21.17, p=.000], and a significant difference for the left leg [Wilks=.885, $f_{(1,69)}$=9.09, p=.000] for time. Subjects scored lower post intervention compared to pre intervention on both the left and right leg. There was a statistically significant difference for the main effect for group [$f_{(2,69)}$=5.43, p=.006] with the TRAD group being higher balance scores than the control group. However, the control group started at a lower SEBT score (see Table 4.1).

Table 4.1 Total Star Direction Scores for the WII, TRAD, and Control Groups (Distance in cm)

Intervention	Mean (Pre L)	SD (Pre L)	Mean (Pre R)	SD (Pre R)	Mean (Post L)	SD (Post L)	Mean (Post R)	SD (Post R)
Control	239.09	16.91	258.28	21.84	243.52	19.68	243.97	21.99
TRAD	255.92	17.85	272.06	19.96	265.58	23.37	263.56	18.62
WII	248.97	22.2	266.12	20.62	255.74	21.55	257.10	19.83

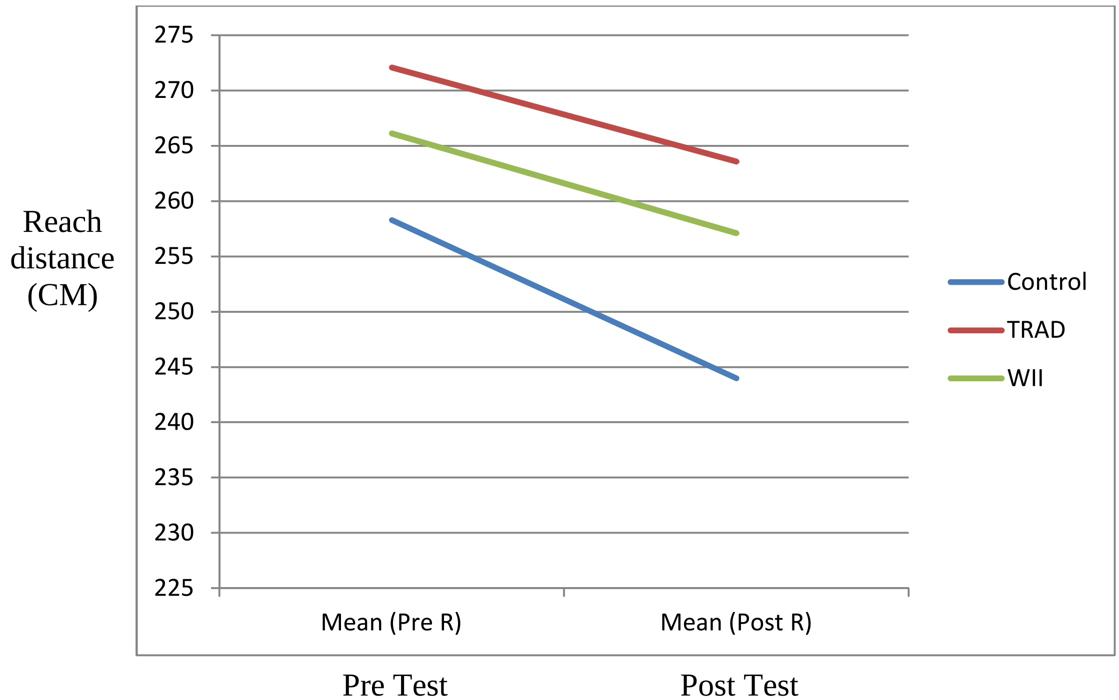

Figure 4 Total Star Excursion scores on the right leg for the WII, TRAD, and control group

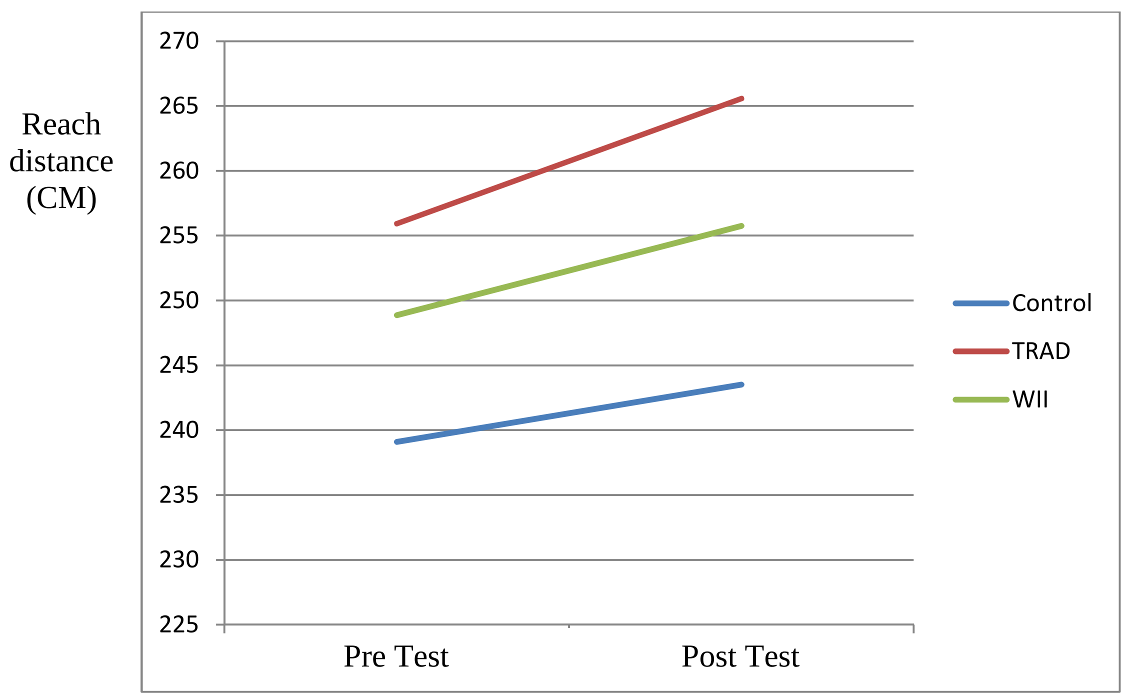

Figure 5 Total star excursion scores on the left leg for the WII, TRAD, and control group

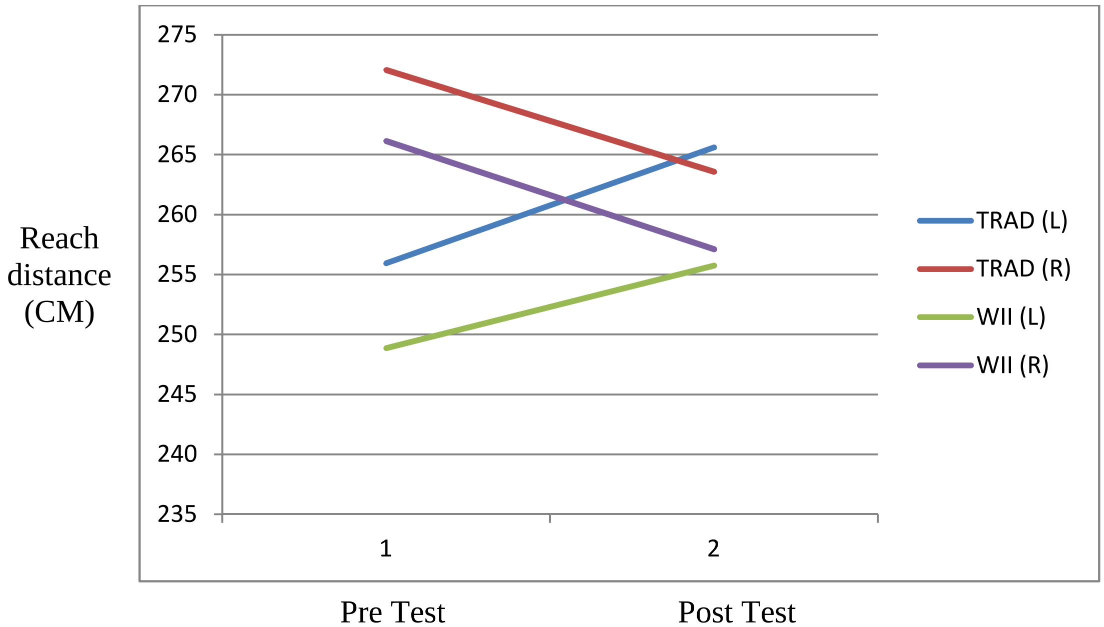

Figure 6 Total star excursion scores on the left and right leg for the TRAD and WII groups.

H3: The TRAD group and the WII group will show significantly increased dynamic balance compared to the control group according to independent star direction scores.

H4: TRAD group will show significantly greater improvements than the WII group for independent star direction scores.

Both these hypotheses were not supported as there were no significant time by group interactions. Specifically, in the direction of anterior, both the right [Wilks'=.988, $f_{(1,69)}$=.431, p=.65] and left leg [Wilks=.996, $f_{(1,69)}$=.13, p=.88] did not reveal statistical differences for the time by group interaction (see table 4.2). In addition, there were also no between group differences for the right [$f_{(2,69)}$=1.42, p=.25] and left [$f_{(2,69)}$=2.73, p=.072] leg in the anterior direction. In regards to the posterior medial direction, there were no significant differences for the interaction between time and group for the right [Wilks=.983 $f_{(2,69)}$=.60, p=.552] and left leg [Wilks=.986 $f_{(2,69)}$=.49, p=.614] . There was a significant difference for the right leg between groups with the TRAD group being higher than the control group [$f_{(2,69)}$=4.59, p=.013] for the posterior medial direction. Results revealed a trend towards significance for the left leg for posterior medial direction [$f_{(2,69)}$=3.03, p=.054]. Finally, the only interaction to indicate a significant difference was in the posterior lateral direction for the right leg [Wilks=.918 $f_{(2,69)}$=3.13, p=.05]. Specifically, the TRAD group was higher than the control group; however, both groups were lower at the post-test compared to the pre-test. There was no significant difference in the posterior lateral direction for the left leg [Wilks=.992 $f_{(2,69)}$=.287, p=.75]. Finally, there was a significant difference between groups for both the right [$f_{(2,69)}$= 6.79, p=.002] and left leg [$f_{(2,69)}$=6.37, p=.003] in the posterior lateral direction. Participants in the TRAD group were higher than the control group for both the right and left leg.

Table 4.2 Individual Star Direction Scores for the WII, TRAD, and Control Groups

Intervention	Direction	Mean	SD
Control (Pre)	Ant	89.19	8.83
Control (Post)	Ant	91.41	6.47
Control (Pre)	PM	79.51	9.20
Control (Post)	PM	82.52	10.31
Control (Pre)	PL	89.56	5.45
Control (Post)	PL	70.02	8.58
TRAD (Pre)	Ant	92.86	8.26
TRAD(Post)	Ant	93.57	6.71
TRAD (Pre)	PM	86.18	9.40
TRAD (Pre)	PL	93.01	4.99
TRAD (Post)	PL	78.66	9.18

Table 4.2 (cont'd)

WII (Pre)	Ant	93.05	7.88
WII (Post)	Ant	93.15	9.49
WII (Pre)	PM	81.54	11.80
WII (Post)	PM	87.61	9.22
WII (Pre)	PL	91.53	5.15
WII (Post)	PL	76.33	7.71

H5: The WII group will have a significantly higher enjoyment level than TRAD group for the first 2 weeks. This hypothesis was supported as the enjoyment of the WII group (M=5.50$\pm$.59) was significantly higher than the TRAD group (M=4.12$\pm$.68) after two weeks of their balance training [$f_{(1,49)}$=59.01, p=.000].

H6: There will be no difference in the enjoyment levels after 4 weeks of balance training between the WII group and the TRAD group. This hypothesis was not supported as there was a significant difference between the two groups. The WII group (M=5.38$\pm$.53) reported significantly higher enjoyment scores than the TRAD group (M=3.37$\pm$.60) after four weeks of balance training [$f_{(1,49)}$=155.33, p=.000].

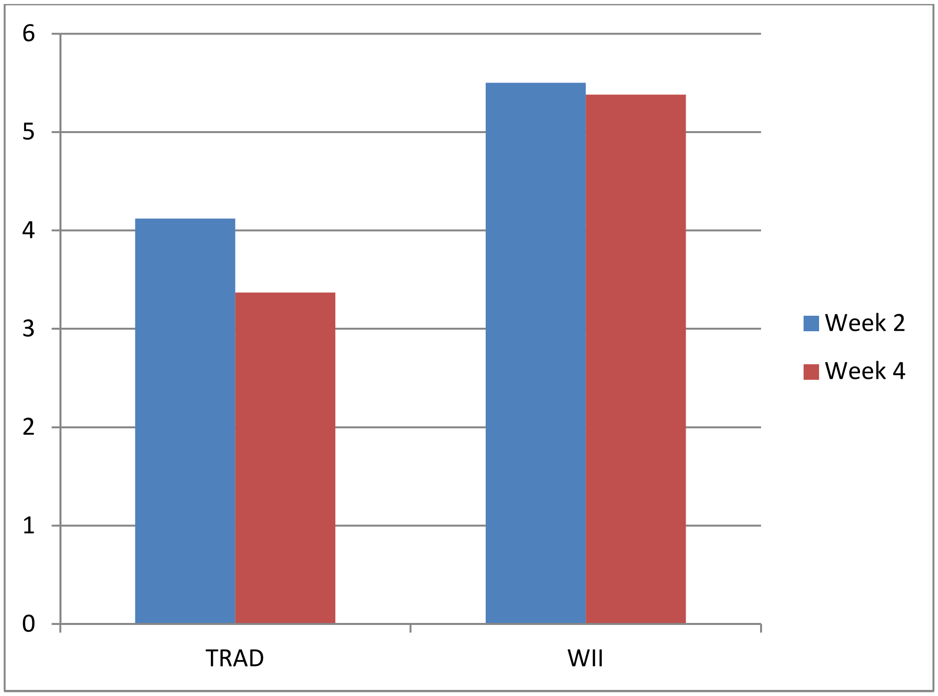

Figure 7 Average enjoyment scores for the TRAD and WII groups at 2 and 4 weeks.

CHAPTER 5

DISCUSSION

5.1 OVERVIEW

This study found that there were no significant improvements in the star excursion balance test (SEBT) between the WII and traditional (TRAD) group after a four week balance training program. However, participants in the WII balance program reported greater enjoyment performing their balancing exercises than those in the TRAD balance program at two and four weeks. This chapter discusses the relevant findings of the SEBT scores and enjoyment levels between the WII, TRAD, and control groups.

5.2 STAR EXCURSION BALANCE TEST

Overall the SEBT results from the present study indicate that there were no differences between the WII, TRAD and control groups after a four week balance program. These results were similar to Vernadakis and colleagues (2012) who reported no differences between a Nintendo Wii Fit balance group and TRAD balance group performing exercises twice a week over eight weeks. Bateni (2012) also reported no significant improvements between a physical therapy and Wii Fit group, a physical therapy only group, and a Wii Fit only group. Similar to this study the participants performed three sessions per week for four weeks. However, these results are in contrast to other researchers who reported improvements in balance after a training program (Bieryla & Dold, 2013; Brumels, 2008). Brumels (2008) found improvements in the TRAD group compared to the Dance Dance Revolution and TRAD group in the anteromedial and medial directions. While other researchers found improvements after three weeks of three times a week Nintendo Wii Fit training compared to a control group (Bieryla & Dold., 2013). These contrasting results could be attributed to the different methodologies used and sample population. Brumels used the SEBT as an intervention exercise which may have resulted in greater improvements in participants SEBT scores, while this study utilized different exercises for the TRAD group. Bieryla and Dold utilized a similar format in the frequency of game play, but their patient population was drastically different with all participants being over the age of 70.

In regards to individual SEBT scores, there were no significant increases from pre to post balance training between groups; however, overall participants did demonstrate increases in their scores clinically. Specifically, the right leg in the posteromedial direction of the WII indicated a 6.93% increase in SEBT score and the TRAD indicated a 5.63% increase. The left leg posteromedial direction for the WII indicated a 10.57% increase in balance whereas the TRAD indicated a 11.2%. These high percentage increases could demonstrate dynamic balance improvements that would be noticeable to the patient when performing activities on one leg or in a compromised position such as the SEBT.

The present study's findings demonstrated significant increases in the main effect for time on total SEBT scores for the WII, TRAD, and control group on both the left and the right leg. These results are also similar to Gil-Gomez and colleagues (2011) who reported significant differences over time when participants performed either TRAD exercises or virtual reality exercises for 21 one hour sessions. These sessions were completed no more than five times a week and no less than three times a week. In a similar study, Baltaci and colleagues (2012) had patients perform conventional balance training exercises or Nintendo Wii Fit balance training exercises after ACL reconstruction surgery. Although there were no significance between groups, over a period of 12 weeks, patients SEBT scores indicated significant improvements. A study done by Bainbridge (2011) utilized patients over the age of 65 performing Wii Fit balance training exercises two times a week for six weeks. Each session was 30 minutes in length. No statistically significant changes were indicated at the end of six weeks of training, but clinically significant improvements were seen in four of the participants (Bainbridge, 2011). Despite a lack of significant results the Nintendo Wii Fit balance training program may be clinically relevant.

5.3 ENJOYMENT

The current study found that college students significantly enjoyed the WII balance training program over the TRAD balance training program. These results are similar to other studies that found participants enjoyed the WII balance or fit training over TRAD or exercise programs (Brumels, 2008; Graves et al., 2010). Specifically, Graves et al. (2010) had patients perform Wii Fit games, handheld video games, jogging, and brisk walking and found that the highest group enjoyment was seen in the Wii Fit group. Another study focused on virtual reality balance training and found that participants enjoyed utilizing the WII more than TRAD (Brumels, 2008). Therefore, it appears that utilizing the Nintendo Wii Fit results in greater enjoyment. There are several reasons why participants could find the WII Fit more enjoyable than a TRAD balance program. First the participants may feel as if they are playing a game rather than performing exercises to benefit their balance or work out. Due to the Wii Fit exercises not typically being associated with physical therapy the participants may have a more positive attitude towards Wii Fit exercises. The Nintendo Wii Fit is also set up in a way where scores are kept and after playing each game the top ten scores are shown on the screen. This could create a competitive environment for the participants leading them to set goals which could increase their enjoyment or make the game more competitive for them.

5.4 CLINICAL IMPLICATIONS

Despite there being no statistical significance found when examining the balance interventions, clinicians should still consider using both the TRAD and Nintendo Wii Fit to increase balance. Clinically, college students increased their percent SEBT total scores after performing four weeks of both the TRAD and WII balance protocols. Typical current clinical protocols are to use a TRAD balance program; however, the Wii program could be interchanged with a TRAD program and still obtain similar results. Or in some cases both types of balance training could be utilized together to give the patients variety.

The high levels of enjoyment when playing the Nintendo Wii Fit noted in this study and other studies suggest that clinicians should utilize Wii Fit games for balance training. As stated above, if Nintendo Wii Fit exercises and TRAD exercises show the same levels of improvement in dynamic balance the Wii Fit may be more beneficial to use due to the patient's enjoyment. Moreover, researchers have found that a higher enjoyment has been associated with participants performing more tasks (Betker, 2007).

Very few studies have been performed to examine the effect of Nintendo Wii Fit balance training on young physically active adults. The results of this study indicate that the movements done on the WII and the TRAD may not be difficult enough to significantly enhance dynamic balance in this patient population. Therefore harder exercises need to be utilized in order to see improvements with an active population.

5.5 LIMITATIONS

The interpretation of the findings from the present study is bound by certain limitations. The main limitation was the small sample size for each group. Although the total sample size was large enough, it had to be divided into three separate groups leaving less than 30 participants in each group. This may have attributed to the lack of significant findings in this study.

Another limitation was that the researchers had to assume that every time a participant came to complete their balance training and testing they were performing at the best of their ability. This is not always realistic with a college aged population that is very busy and has a wide range of variables that can affect their training, especially when the training occurred at night or in the morning.

When performing the traditional balance exercises errors were counted in order to determine when to progress each participant. Due to the subjectivity of the errors and utilizing different research assistants there was not consistency between participants. This could have led to some subjects being progressed faster or slower than the other subjects.

Having self-reported enjoyment levels could also be another source of limitation. The participants may have not been honest each time they completed their enjoyment questionnaire and may have changed it based on outside factors. It may have been possible that the participants may have also attributed positive events to the actual training, but the negative events to outside factors. This can lead to bias when completing the enjoyment survey.

One last limitation was due to class schedules and extracurricular activities the participants could not come at the same time every day. This resulted in varying times for completing the exercises and testing. Some participants may have come right from sleeping, where others came right from working out. This could have resulted in differing levels of balance depending on how tired they were.

5.6 FUTURE RESEARCH CONSIDERATIONS

This research was performed on physically active college aged individuals, but in the future it would be worthwhile to perform a similar study utilizing injured athletes. Utilizing a similar study, but having a longer intervention period also warrants further research. Typically in a rehabilitation setting athletes perform rehabilitation for more than four weeks at a time, in some cases they can be doing rehabilitation for six to eight months. With a longer intervention session the training would better resemble that of a clinical setting. This would also demonstrate if the improved balance continues throughout the entire balance training or if it plateaus after a certain number of weeks and the training should then be changed. Finally, future research could also concentrate on difference in SEBT scores and enjoyment between male and female participants.

5.6 CONCLUSION

The results of this study reveal that there were no significant differences between SEBT pre and post tests in the TRAD, WII, and control groups. The results also indicated that there was similar balance improvement among the WII and TRAD group. Therefore both balance training exercises should be used interchangeably for balance training in young physically active adults. If an injured population was utilized more results may have been noted due to the lower baseline balance test scores when compared to the physically active population seen in this study. The current study found that enjoyment scores were higher in the WII group compared to the TRAD group. Therefore, to improve compliance and overall happiness of patients during their rehabilitation using the WII may be beneficial. Ultimately the results of this study revealed that there is a place for the Nintendo Wii Fit in balance training; however, further studies are warranted on the long term effects of balance training.

APPENDICES

APPENDIX A

ENJOYMENT QUESTIONNAIRE

THE USE OF THE NINTENDO WII FIT BALANCE PROGRAM COMPARED TO A TRADITIONAL BALANCE PROGRAM IN PHYSICALLY ACTIVE INDIVIDUALS

Please rate how you currently feel about the physical activity you have been doing according to the following scales by circling the number that best describes your feeling.

I enjoyed it 1 2 3 4 5 6 7 I hated it

I felt bored 1 2 3 4 5 6 7 I felt interested

I disliked it 1 2 3 4 5 6 7 I liked it

I found it pleasurable 1 2 3 4 5 6 7 I found it unpleasurable

It was no fun at all 1 2 3 4 5 6 7 It was a lot of fun

How important is doing well on this task to you?

Very important 1 2 3 4 5 6 7 Not important

How important is it for you to improve your balance?

Very important 1 2 3 4 5 6 7 Not important

APPENDIX B.

ENJOYMENT QUESTIONAIRE FREQUENCIES

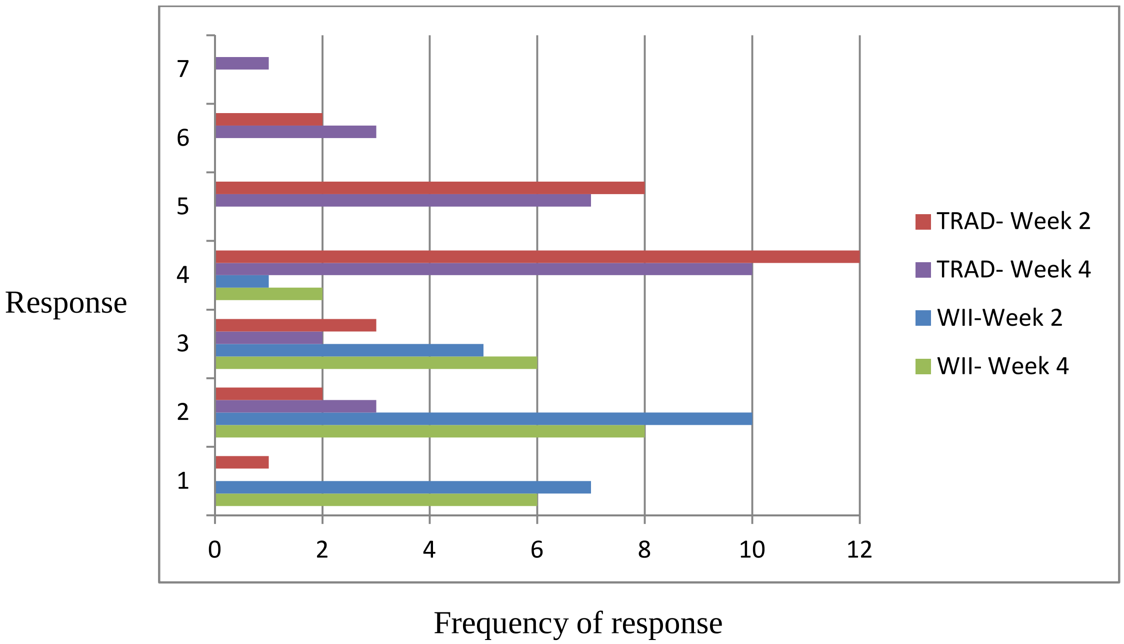

Figure 8 Individual Likert Responses for the Enjoyment Question “I enjoy it” for the Wii and TRAD Groups

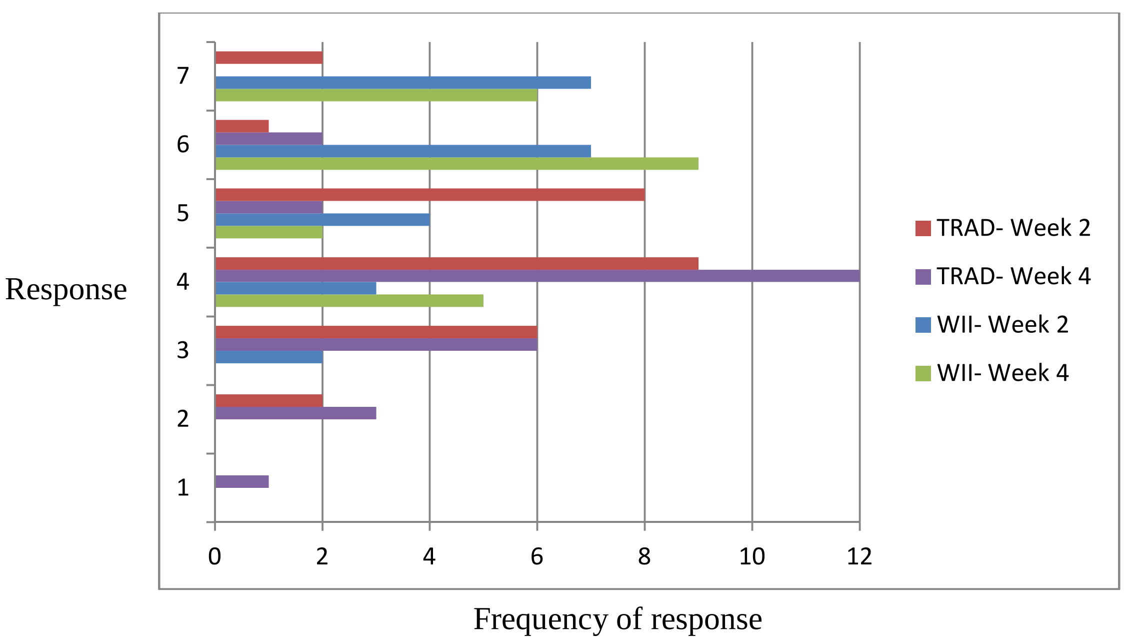

Figure 9 Individual Likert Responses for the “I Feel Bored/Interested” Question for the WII and TRAD Groups.

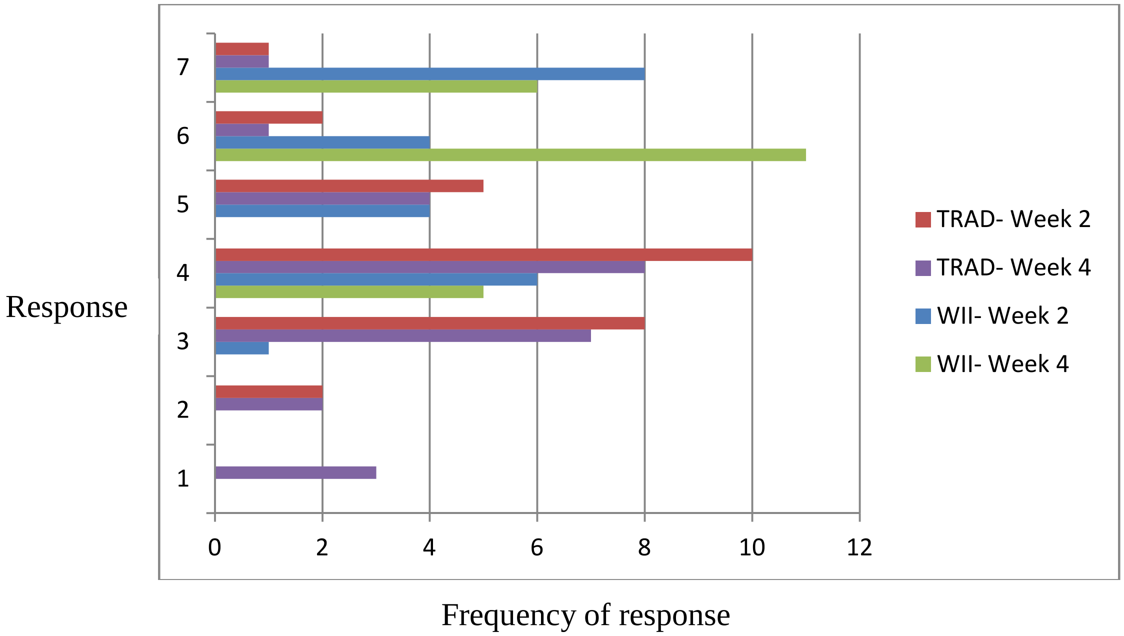

Figure 10 Individual Likert Responses for the “I Dislike/Like it” Question for the WII and TRAD Groups

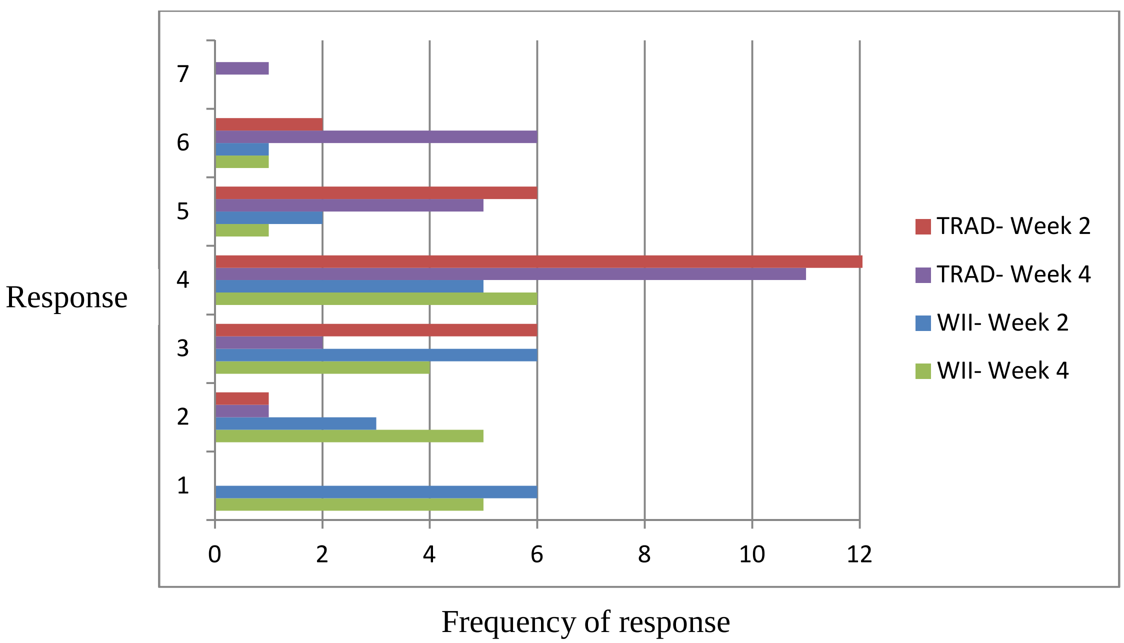

Figure 11 Individual Likert Responses for the “I Find it Pleasurable/Unpleasurable” Question for the WII and TRAD Groups.

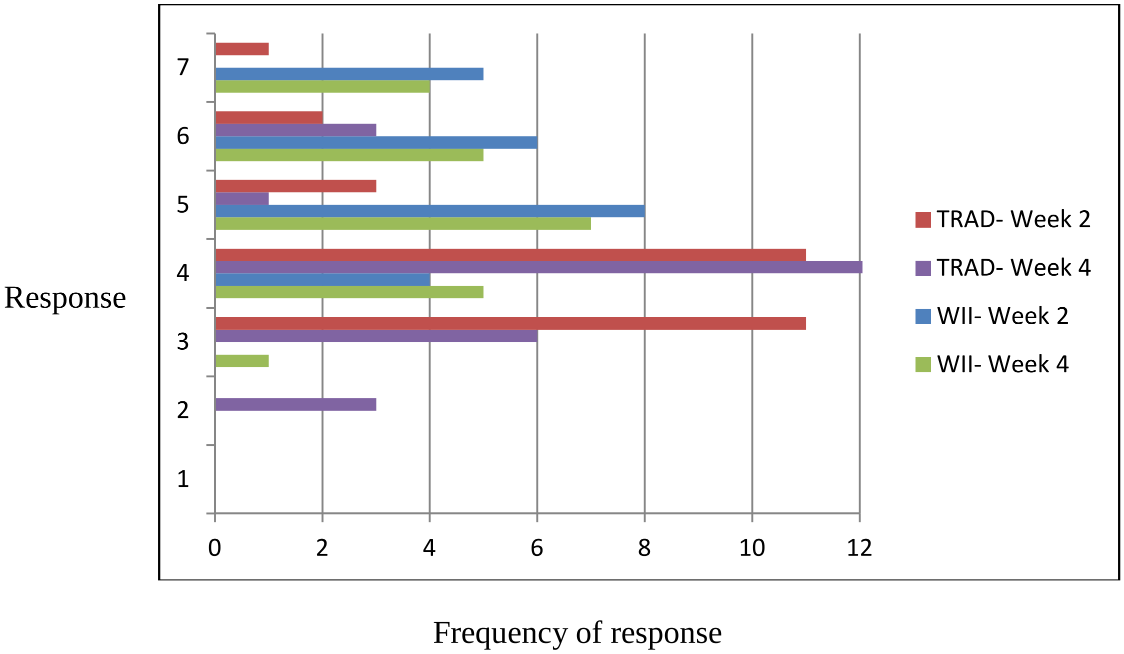

Figure 12 Individual Likert Response to “It is no fun/fun” Question for the WII and TRAD Groups

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