USE OF NINTENDO WII FIT™ TO AUGMENT PEDIATRIC REHABILITATION

A THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

FOR THE DEGREE OF MASTER OF ARTS

IN THE GRADUATE SCHOOL OF THE

TEXAS WOMAN'S UNIVERSITY

SCHOOL OF HEALTH SCIENCES

BY

APRIL McCAIN, B.S.

DENTON, TEXAS

AUGUST 2010

TEXAS WOMAN'S UNIVERSITY

DENTON, TEXAS

June 1, 2010

To the Dean of the Graduate School:

I am submitting herewith a thesis written by April McCain entitled "Use of Nintendo Wii Fit™ to Augment Pediatric Rehabilitation." I have examined this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the Master of Arts with a major in Occupational Therapy.

Mary F. Baxter

Mary F. Baxter, PhD, LOT, Major Professor

We have read this thesis and recommend its acceptance:

Noralyn D. Pickens, PhD, OTR

Catherine Candler

Department Chair or Administrative Equivalent

Accepted:

Jennifer Martin

Dean of the Graduate School

ABSTRACT

APRIL McCAIN

USE OF NINTENDO WII FIT™ TO AUGMENT PEDIATRIC REHABILITATION

AUGUST 2010

Incorporating virtual reality with therapy programs is a unique way to provide therapy in a functional, purposeful, and motivating context that can be individualized. The aim of this pilot study was to determine the effectiveness of augmenting occupational therapy intervention with participation in therapist-guided Wii Fit™ activities in children with motor coordination deficits as measured by the Bruininks-Oseretsky Test of Motor Proficiency – 2nd Ed. (BOT-2). Four children were recruited to the study and randomly divided into an experimental or control group, two in each. Intervention involved 30 minute sessions, twice weekly for ten weeks. Upon comparison of initial and final BOT-2 composite scores, the scores of participants in the experimental group were no higher than the scores of participants in the control group. Even though both therapy regimes produced various skill improvements, it is notable that participants in the experimental group demonstrated high levels of engagement during Wii Fit™ activities.

TABLE OF CONTENTS

LIST OF FIGURES

CHAPTER I

INTRODUCTION

The rehabilitation process can be long and challenging for children with a variety of injuries and developmental disabilities. Sveistrup (2004) points out that "common problems influencing the degree of interaction [with therapy programs] include boredom, fatigue, lack of motivation, and lack of cooperation in attending therapy," (p. 6) which creates a challenge for rehab therapists. Occupational and physical therapists have to provide appealing, meaningful, and motivating therapeutic activities that can be modified to facilitate this process. The use of virtual reality to augment rehabilitation programs is a fairly novel concept and has been documented to produce various benefits in numerous studies using both adult (Eng et al., 2007; Kenyon, Leigh, & Keshner, 2004; Koritnik, Bajd, & Munih 2007; Rand, Kizony, & Weiss, 2008; Viau, Feldman, McFadyn, & Levin, 2004) and pediatric (Bryanton et al., 2006; Deutsch, Borbely, Filler, Huhn, & Guarrera-Bowlby, 2008; Lee, Cherng, & Lin, 2004; Reid & Campbell, 2006; You et al., 2005) populations. Nintendo Wii™, introduced in 2006, is an innovative and child-friendly virtual reality-based game system that is commercially available and has recently been explored for therapeutic uses. Nintendo Wii Fit™, released in 2008, was developed to work directly with the Wii™ console and Wii Balance Board™ to provide fun and exciting games for improving fitness. Incorporation of these virtual reality games, guided by the therapist, has the potential of masking the challenge and therapeutic benefits to the child in rehabilitation, therefore improving compliance and outcomes.

CHAPTER II

REVIEW OF LITERATURE

A child's self-concept develops from successful participation in the typical childhood activities, including sports, leisure activities, writing, and self dressing (Taylor, Fayed, & Mandich, 2007). Children who display characteristics such as poor balance, gross motor coordination, eye-hand coordination, dexterity, motor planning, timing, and core strength represent a common population seen in pediatric rehabilitation therapy clinics. Secondary characteristics often include poor performance in sports, inadequate school work, frustration, poor peer relations, and eventually poor self esteem. Therapists and researchers have noted the impact of coordination difficulties to persist into adolescence and sometimes even into adulthood (Candler & Meeuwsen, 2002; Dunford, Missiuna, Street, & Sibert, 2005; Iversen, Ellertsen, Tytlandsvik, & Nodland, 2005; Miller et al. 2001; Taylor, Fayed, & Mandich, 2007). Tseng, Henderson, Chow, and Yao (2004) state that "the acquisition of motor system skills forms an important learning complex for the child in school and in the environment," (p. 386) which lays the foundation for early development of self esteem and acceptance of a child by his or her peers.

Occupational therapy services for children are aimed at enhancing development of their functional capabilities for achieving an optimal level of independence in home, school, and community environments. A child's occupation is play, self-care, school, and learning about his or her environment. Traditionally, occupational therapists have based interventions on neuromaturational theories which are directed toward improving motor skills, sensory

processing, cognitive functions, and any other deficits which impede participation in childhood occupations (Candler & Meeuwsen, 2002; Mandich, Polatajko, Macnab, & Miller, 2001). This bottom-up approach includes the building of foundational skills through the use of sensory integration, process-oriented, and perceptual-motor programs (Mandich et al., 2001). Research on the effectiveness of a bottom-up approach has demonstrated minimal change in functional outcome (Mandich et al.). In contrast, more recent research provides evidence to support the use of a top-down approach which emphasizes the development of specific skills rather than underlying skill components (Iverson, Ellertsen, Tytlandsvik, & Nodland, 2005; Mandich et al., Missiuna, Rivard, & Bartlett, 2006). It is noted that task specific approaches are not only more goal-directed but are also more motivating for the clients (Iversen et al., 2005). Although this approach appears promising, research on the intervention effects is still limited (Iversen et al.; Mandich et al.; Missiuna et al. 2006). Mandich et al. suggest that "if the goal is to facilitate skill acquisition in children, it may be fruitful to pursue interventions based on functional activities, rather than focusing on underlying components," (p. 64) which will be more meaningful and exciting to the child.

Virtual reality is a technology which allows participants to interact with a computer simulated environment that appears to be and feel similar to real world objects and events. It involves immersion of a person into a computer generated environment. The computer program allows real-time interaction and manipulation of objects in the virtual environment that responds according to the person's motions and produces a feeling of presence in the virtual world (Kenyon et al., 2004; Weiss, Rand, Katz, & Kizony, 2004). Through participation in these three dimensional virtual reality activities, pediatric rehabilitation clients are given the chance to

perform tasks they may not be able to do safely or at all in real world situations (Deutsch et al., 2008). Therapists are able to control exercise duration, repetition, and complexity of tasks to adapt the activity according to the participant's capabilities as well as provide verbal and/or physical assist with motions. Being able to manipulate the virtual task and environment are important advantages since these features are essential to cognitive and motor remediation (Sveistrup, 2004).

The Nintendo Wii™ system has cutting edge graphics and interactivity that provides multisensory feedback, making the games fun to play while enhancing motivation and performance for therapy (Halton, 2008). The game system is based around its wireless controller which has built in speakers and a rumble device that allows one to essentially hear and feel the environment in which he is interacting (Halton, 2008). Through the case report by Deutsch et al. and numerous commentaries, the Wii™ has been found to complement standard rehabilitation programs by engaging clients in a fun and entertaining way. Outcomes discussed in the literature demonstrates the feasibility, usability, and flexibility of supplementing rehabilitation programs with virtual reality activities and shows great promise for a variety of therapeutic goals (Halton, 2008; Meadow, 2008; Merrill, 2008; Tanner, 2008).

The only study found to have investigated the use of the Wii™ to augment pediatric rehabilitation was with an adolescent boy with cerebral palsy. The boy not only demonstrated improvements in postural control, visual perceptual processing, and functional mobility, but was noted to demonstrate faster progression and achieved a higher level of motor skills than he had ever achieved during his previous rehabilitation program alone (Deutsch et al., 2008). Deutsch et al. claim that functional improvements were facilitated by the type of feedback provided by the

Wii™, which includes "auditory, visual, and haptic information along with provision of knowledge of performance and knowledge of results" (p. 1204). It is emphasized that important clinical decisions are made by the therapist throughout training, which supports that it is crucial for children with disabilities to participate in virtual reality activities under the supervision of a skilled therapist. Deutsch et al. suggest performing another study with a larger sample, using more variety of games, and using multiple players at one time.

The Wii Fit™ is a fairly new product that is reported to improve balance, strength, flexibility, fitness, engagement, and general well-being (Brown, Sugarman, & Burstin, 2009; Brumels, Blasius, Cortright, Oumedian, & Soldberg, 2008; Nitz, Kuys, Isles, & Fu, 2009). It is "built around Nintendo's [Wii] Balance Board™, a rectangular, pressure-sensitive platform about the size of a bathroom scale, which communicates with the Wii™ console wirelessly" (Merrill, 2008, p. 1). The board contains multiple pressure sensors that measure weight distribution, center of pressure, and sway which are displayed through a character on the television screen. Two research groups specifically investigated the properties of the Wii Balance Board™. Clark, Bryant, Pua, McCrory, Benell, et al. (2010) determined that the Wii Balance Board™ has "excellent test-retest reliability for center of pressure path length during standing balance and possesses concurrent validity with a laboratory grade force platform," (p. 308) which confirms the accurate representation of the Wii Fit™ character displayed on the television. Shih, C.-H., Shih, C.-T., and Chu (2010) found the board effective when used with an adapted computer program for providing balance feedback to children with multiple disabilities, allowing them to self-correct abnormal standing posture.

Wii Fit™ provides a functional task through various activities that can address attention, visual and cognitive skills, problem solving, balance, coordination, upper and lower body strength, endurance, and balance issues that are associated with many illnesses and injuries. As activity performance improves, the computer makes the games more challenging, in the same way that occupational therapists implement the "just right challenge" (Herz, 2009). Shigeru Miyamota, creator of the game, stated that "what it's actually aiming to do is make you aware of your body," (Vadhavkar, 2008, p.13).

Since the release of the Wii Fit™ in 2008, there has been a gradual increase in research published on the product as a therapeutic tool, however articles and publications continue to be limited. Therapeutic effects of the Wii and Wii Fit™ need to be empirically investigated in order to provide evidence-based practice. Two studies involving healthy adults (Brumels, Blasius, Cortright, Oumedian, & Soldberg, 2008; Nitz, Kuys, Fu, I., Fu, S., 2009) and one case report involving an elderly post-stroke patient (Brown, Sugarman, & Burstin, 2009) was found to utilize the Wii Fit™ for addressing motor coordination. The studies demonstrated the Wii Fit™ to be effective for helping clients to reduce postural sway, improve overall balance and strength, improve stance symmetry, and improve motivation. No research literature has been found discussing the use of Wii Fit™ activities to augment a pediatric rehabilitation program.

Encouraging participation in the therapeutic tasks involved in occupational and physical therapy interventions can be challenging in the pediatric population, hence the need for motivating activities to promote the effectiveness of therapy sessions. Researchers have explored the use of virtual reality for a diverse set of rehabilitation goals including improving postural control, visual perceptual processing, and functional mobility (Deutsch et al., 2008),

improving upper extremity skills (Chen et al., 2007; Reid, 2002; Reid & Campbell, 2006;), improving spatial functioning (Akhutina et al., 2003), improving attention (Cho et al., 2002), and improving motivation and enjoyment (Harris & Reid, 2005; Reid, 2002; Stansfield, Dennis, & Suma, 2005). Reid and Campbell also showed that allowing children with physical impairments to participate in virtual reality activities, from which they would typically be excluded in the real world, increases their self-esteem and self-image. The reported findings support the use of virtual reality to augment pediatric rehabilitation therapy in addition to the need for additional research.

Virtual reality play has been shown to be enjoyable and a good motivator when incorporated with a child's therapy intervention (Harris & Reid, 2005; Reid, 2002; Stansfield, Dennis, & Suma, 2005). Harris and Reid explain that "since participation in therapy is highly dependent on motivation and play is the major occupational behavior of children, it is important to explore the characteristics in therapeutic play environments that are motivating and that engage children" (p. 21). Variability, challenge, and competition in the virtual reality environments are found to be the elements most desired by participants. Harris and Reid conclude that "an accessible environment that is motivating will empower children with disabilities to take an active role in their rehabilitation," (p. 28) therefore maximizing the effectiveness of the interventions. Virtual reality activities incorporated with a cognitive training program have also been shown to enhance the ability to respond and pay attention in teenagers with claims of the motivating virtual reality games being the key factor (Cho et al., 2002). One's devotion to his or her rehabilitation is important for facilitating engagement in occupations that allow experiences of satisfaction, which encourages one to strive to maximize functional

capacities (Forsyth & Kielhofner, 2003). These studies validate the impact of the client valuing and taking an active part in the intervention, in facilitating the mastery of desired goals (Haglund & Kjellberg, 1999).

Rehabilitation interventions often involve activities and exercises that are repetitive for developing and refining skills needed for functional performance. The variety of virtual reality environments motivates participants to repetitively produce desired therapeutic movements. The amount of repetition tolerated, while interacting with a virtual reality environment, is much higher than performing repetitions of a rote activity (Chen et al., 2007). Children with cerebral palsy are a common population receiving rehabilitation services and interventions typically involve use of repetitive activities and exercises to improve functional motor skills. Participation in virtual reality activities, with this population, has been shown to facilitate improvement in the quality of upper extremity skills as demonstrated by faster, smoother, and straighter movements (Chen et al., 2007; Reid, 2002). As children's motor skills improve, they have been noted to demonstrate increased feelings of success and report more social acceptance as they are able to do more things like their peers (Reid & Campbell, 2006). In addition to more efficient upper extremity skills and improved self-esteem, participation in virtual reality activities has been shown to improve spatial functioning in children with cerebral palsy (Akhutina et al., 2003). Akhutina et al. stated that "children with disabilities and developmental delays frequently encounter particular difficulty with spatial concepts and spatial learning, which has considerable impact on both life skills and academic achievement..." (p. 1361) and can then contribute to poor performance in multiple environments as well as poor acceptance by peers. Research

supports that rehabilitation therapies should take advantage of technological advances having developed such engaging media which can be used for therapeutic purposes.

The Bruininks-Oseretsky Test of Motor Proficiency (BOTMP), published in 1978, has been reported to be one of the most commonly used standardized assessments for evaluating motor skill deficits in children and adolescents with various disabilities (Cushing, Chia, James, Papsin, & Gordon, 2008; Wuang & Su, 2009).The BOTMP in addition to its second edition (BOT-2), published in 2005, are "often used to provide support for diagnoses that involve motor performance deficits" (Bruininks & Bruininks, 2005, p. 64). It is a comprehensive assessment that uses engaging, goal-directed activities to measure a wide array of motor skills which is utilized to determine therapeutic effectiveness of therapy interventions (Wuang, Lin, & Su, 2009). The BOT-2 has been studied as a valid and reliable measure of varying deficits in a number of studies. For example, it was not only found effective in determining the incidence of balance dysfunction in children with cochlear implants (Cushing, Chia, et al., 2008) but was also deemed the balance test of choice for evaluating children with profound sensorineural hearing loss (Cushing, Papsin, Rutka, James, & Gordon, 2008). The BOT-2 was also found to have excellent test-retest reliability and internal consistency in addition to acceptable responsiveness when used for children with intellectual disability (Wuang & Su, 2009).

Research Objectives

Specific Aim

The specific aim of this project was to determine the effectiveness of augmenting a child's occupational therapy plan of care with participation in therapist-guided Nintendo Wii Fit™ activities in children with motor coordination deficits as measured by the BOT-2.

Research Question

In children with identified motor coordination deficits, is participation in therapist-guided Nintendo Wii Fit™ activities, in conjunction with conventional activity-based occupational therapy, more effective than participation in occupational therapy alone for improving motor coordination skills as measured by the BOT-2?

Hypothesis

Children demonstrating motor coordination deficits who participate in Wii Fit™ activities in conjunction with occupational therapy will achieve greater score improvements on the BOT-2, and thus better motor skills, than those receiving activity-based occupational therapy alone.

CHAPTER III

METHODOLOGY

Design

This pilot study used a pretest-posttest control group design to determine the effectiveness of occupational therapy incorporating Nintendo Wii Fit™ activities in children with motor coordination deficits as measured by the Bruininks-Oseretsky Test of Motor Proficiency-2nd Ed. (BOT-2).

Participants

Four children were recruited from current patients at Our Children's House at Baylor in Allen, TX. Children were eligible for participation if they were 5-18 years of age, were receiving occupational therapy two times per week, had sufficient cognitive skills for following directions and understanding the games, had normal or corrected vision, and achieved a Total Motor Composite score at least one standard deviation below the mean on the BOT-2. Children were excluded if they had spasticity in any extremity, if they had a musculoskeletal disorder, if they were receiving physical therapy services, if they had access to the Wii Fit™ at home, or if they were currently using it as part of their occupational therapy plan of care. Qualifying children for this study included two 5 year old boys, a 7 year old girl, and a 7 year old boy. Data from a fifth child was collected, however was not used as he concurrently received physical therapy which was considered a confounding factor for this project.

Instrument

The BOT-2 is norm-referenced and is designed to assess both fine and gross motor skills

of individuals 4 through 21 years of age. The BOT-2 is divided into four motor area composites, each of which includes two subtests. The motor area composites are categorized according to the muscle groups and limbs involved in the movements (Wuang & Su, 2009) and include: fine manual control, manual coordination, body coordination, and strength and agility. The fine manual control composite is separated into fine motor precision and fine motor integration subtests which measure control and coordination of the distal musculature of the hands and fingers, especially for grasping, drawing, and cutting. The manual coordination composite is split into manual dexterity and upper limb coordination subtests which evaluate motor skills involving control and coordination of the arms and hands, especially for object manipulation, with emphasis on speed, dexterity, and coordination. The body coordination composite is divided into bilateral coordination and balance subtests which test control and coordination of the large muscles used in maintaining posture and balance. The strength and agility composite is separated into running speed and agility and strength subtests which assess control and coordination of the large musculature involved in locomotion. The four composite scores are then combined to yield a total motor composite score (Wuang & Su, 2009). Scaled scores are obtained for each subtest and standard scores are derived for each motor area composite as well as an overall total motor composite. Reliability data for the total motor composite includes: inter-rater reliability >.98, test-retest reliability ≥ .80, and internal consistency ≥ .95 (Bruininks & Bruininks, 2005). Additional strengths of the test include both face validity and construct validity (Deitz, Kartin, & Kopp, 2007).

Apparatus

The Wii Fit™ offers 40 games divided into four categories including yoga, balance, aerobics, and strength. Each category only provides four to five choices at first but increasingly more difficult levels are made available as the participant's practice time and skills improve. The game's main accessory, the Wii Balance Board™, measures the participant's weight distribution and sway which is then displayed through a character on television for a visual representation of their motions. This game has the ability to track individual progress as well as provide personal performance feedback during and after many training activities. The game records performance data for each participant which can be compared from one session to the next. The gaming system allows for remediation, adaptation, modification, restoration, and gradation of activities and skills so that therapists can individualize the activity and maximize benefits for each client (Herz, 2009).

Procedure

Approval from the Baylor Research Institute and Texas Woman's University Institutional Review Boards, informed parental consent, and child assent were obtained prior to commencement of the study. The participants underwent testing of motor coordination skills using the complete battery of the BOT-2. If the child's scores were below one standard deviation from the mean, he or she then qualified for participation in the study. The BOT-2 was administered before and after completion of the 10 week intervention period by a physical therapist blinded to group assignments (experimental group or control group). The same therapist administered the initial and final assessments to maximize reliability of test results. Test booklets were marked for group designation and drawn randomly prior to administration

to any participants. All participants maintained their current occupational therapy schedule at two times per week throughout the study period. Participants in the experimental group received one session per week of occupational therapy incorporating the Wii Fit™ and one session of occupational therapy not using the Wii Fit™. During the experimental session, participants were allowed to select the Wii Fit™ games but had to complete activities in each category of exercise in order to address all areas of motor difficulty. They were provided with additional verbal and manual cues as needed to correctly perform the motor actions required by the games. Participants in the control group received two sessions per week of occupational therapy not using the Wii Fit™ but still with a focus on motor coordination skills. One weekly session was provided by the participant's regular therapist and the other weekly session was provided by the principal investigator in order to provide all participants with similar treatment tasks regardless of group designation. Both groups received a total of 60-70 minutes of occupational therapy per week as 30 minutes is the duration of a standard session at this facility. A log of sessions was kept for each participant. All assessment and training was conducted individually. Manual or verbal guidance was provided as necessary to help children understand the activity requirements. Participants were closely supervised and allowed to rest as needed to ensure safety and minimize fatigue.

Data Analysis

This pilot study tested two independent samples: the experimental group using the Wii Fit™ intervention and the control group. The dependent variable was the BOT-2 total motor composite test score. Due to a small sample size, descriptive statistics and graphical techniques were used to summarize and describe the data.

CHAPTER IV

RESULTS

Characteristics of Participants

Participant 1, a Caucasian boy in the control group, was 5 years 1 month at the time of initial testing and had multiple diagnoses of conduct disorder, sensory integration disorder, and auditory processing difficulties. His mother presented concerns with overall motor coordination which led to his participation in this study. His cognition was within the normal range, as confirmed from the medical records and his primary occupational therapist. He was motivated by competition, demonstrated poor frustration tolerance for activities he had difficulty performing, and required frequent redirection at times due to decreased attention span. His initial and final Bruininks-Oseretsky Test of Motor Proficiency-2nd Edition (BOT-2) composite scores are displayed in Figure 1. The use of 90% confidence intervals supports all score increases to reflect skill gains, with the exception of the strength and agility motor composite. According to the 90% confidence intervals, he also demonstrated real skill improvements on the upper-limb coordination subset, however it is noteworthy that the upper limit of the pre-test and the lower limit of the post-test are the same number. To address his areas of weakness, as identified by the BOT-2, occupational therapy interventions focused on upper-limb coordination activities involving visual tracking with coordinated arm and hand movement as well as static and dynamic balance activities.

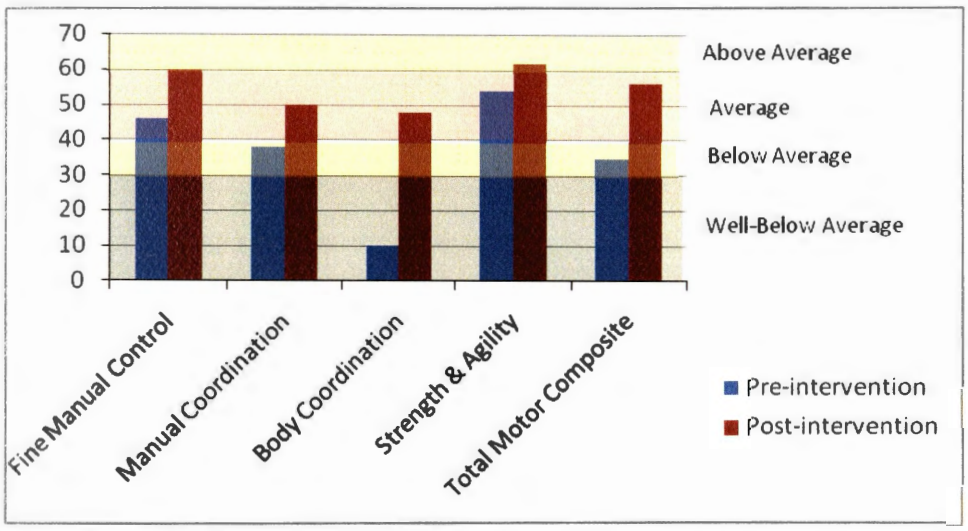

Figure 1. Participant 1 pre- and post- intervention BOT-2 motor composite test scores.

Participant 2, a Caucasian boy in the control group, was 5 years 2 months at the time of initial testing and had a diagnosis of developmental delay. His mother presented concerns with overall motor coordination which led to his participation in this study. In retrospect, his cognition was hard to determine due to difficulties with receptive language. He was able to follow simple one step directions and some related two-step directions. He was cooperative with all occupational therapy activities however maintained a flat affect and did not display any feelings of excitement most of the time. His initial and final BOT-2 composite scores are displayed in Figure 2. The use of 90% confidence intervals does not support any of his score increases to reflect valid skill improvements. To address his areas of weakness, as identified by the BOT-2, occupational therapy interventions focused on upper-limb coordination activities involving visual tracking with coordinated arm and hand movement, bilateral coordination activities that required body control with sequential and simultaneous coordination of the upper and lower limbs, and static and dynamic balance activities.

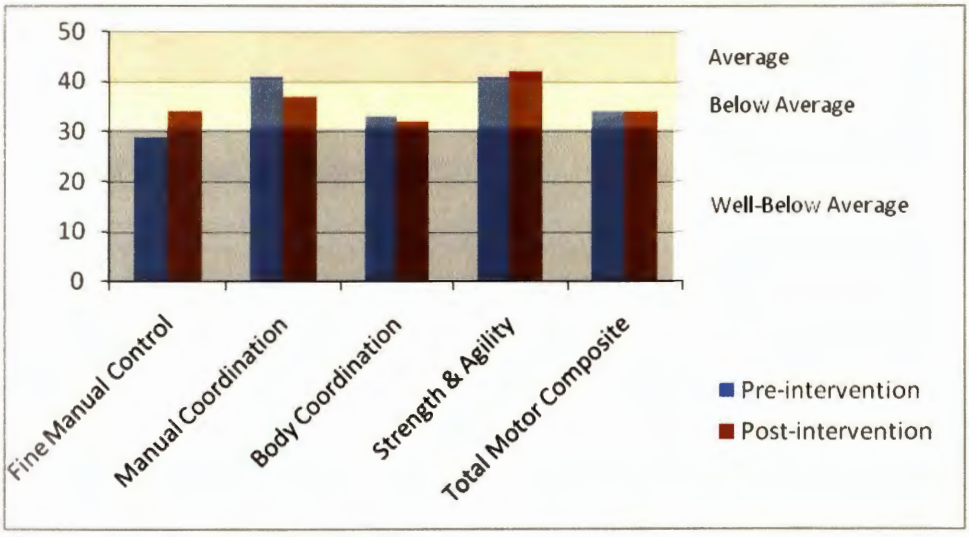

Figure 2. Participant 2 pre- and post- intervention BOT-2 motor composite test scores.

Participant 3, a Caucasian girl in the experimental group, was 7 years 10 months at the time of initial testing and had a diagnosis of lack of coordination. Her mother presented concerns with overall coordination which led to her participation in this study. Her cognition was within the normal range, as confirmed from the medical records and her primary occupational therapist. She was easily motivated and was cooperative with occupational therapy activities with and without the use of Wii Fit™ activities. She was more eager to participate in activities involving the Wii Fit™ than those that did not include the Wii Fit™. Her initial and final BOT-2 composite scores are displayed in Figure 3. According to 90% confidence intervals, the small score increases shown may not accurately represent skill improvements, but did support real progress in balance skills as noted by a score increase on the individual balance subtest. Also according to the 90% confidence intervals, she demonstrated a true skill decline in overall manual coordination. To address her areas of weakness, as identified by the BOT-2, occupational therapy interventions focused on bilateral coordination activities that required

body control with sequential and simultaneous coordination of the upper and lower limbs, static and dynamic balance activities, strength activities involving the trunk, upper body, and lower body, and activities to improve agility.

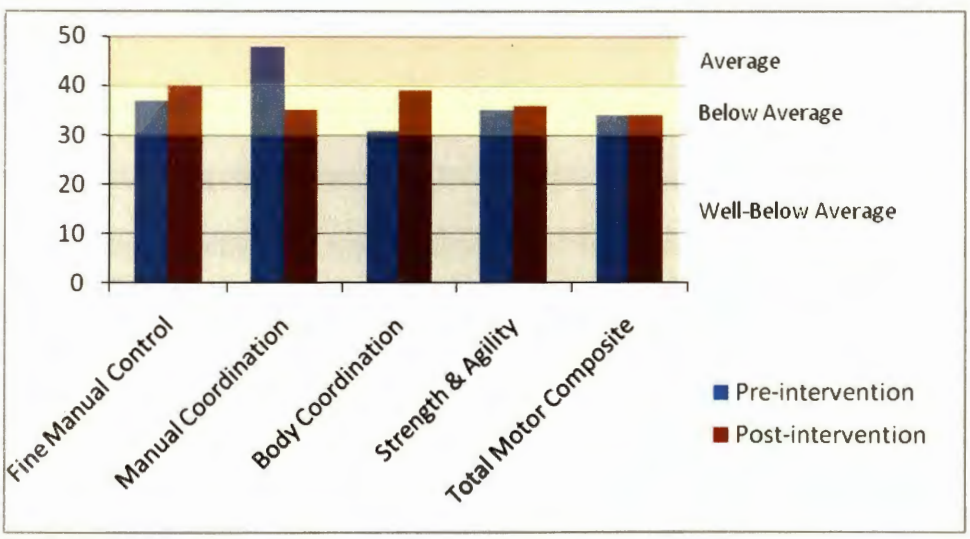

Figure 3. Participant 3 pre- and post-intervention BOT-2 motor composite test scores.

Participant 4, a Hispanic boy in the experimental group, was 7 years 10 months at the time of initial testing and had a diagnosis of feeding difficulties. His mother presented concerns with overall motor coordination which led to his participation in this study. His cognition was within the normal range, as confirmed from the medical records and his primary occupational therapist. He also participated well with occupational therapy activities with and without use of the Wii Fit™. Although he participated equally as well with all interventions, he demonstrated a higher level of engagement when participating in activities involving use of the Wii Fit™ than during tasks without the Wii Fit™, as reported by his primary therapist. His initial and final BOT-2 composite scores are displayed in Figure 4. The use of 90% confidence intervals supports the score increases in the manual coordination and total motor composites to confidently reflect

skill improvements. Of note is that the upper limit of the pre-test and the lower limit of the post-test are the same number on the manual coordination motor composite score. Also, using the 90% confidence intervals, he demonstrated improved ball skills as evidenced by a score increase in the upper-limb coordination individual subtest. To address his areas of weakness, as identified by the BOT-2, occupational therapy interventions focused on upper-limb coordination activities involving visual tracking with coordinated arm and hand movement, bilateral coordination activities that required body control with sequential and simultaneous coordination of the upper and lower limbs, and static and dynamic balance activities.

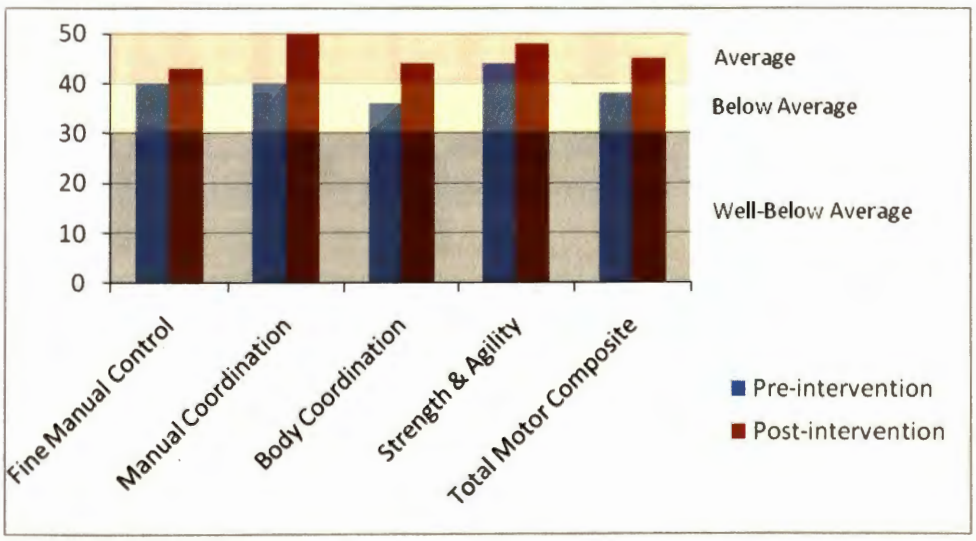

Figure 4. Participant 4 pre- and post- intervention BOT-2 motor composite test scores.

Summary of Findings

Upon comparison of initial and final scale and standard scores using the BOT-2, there was no difference between the scores of the participants in the experimental group and the scores of the participants in the control group. The difference in pre- and post-intervention BOT-2 subtest scale scores for all participants is compared in Figure 5. The difference in pre- and

post-intervention BOT-2 motor area composite standard scores for all participants is compared in Figure 6. Regarding motor area composite scores, all participants demonstrated score improvements in fine manual control as well as strength and agility. Two participants demonstrated score improvements with overall manual coordination and two demonstrated decline. Regarding overall body coordination, three participants demonstrated score improvements and one demonstrated decline. Although quite a few score increases are noted, several are not supported as actual skill gains using 90% confidence intervals.

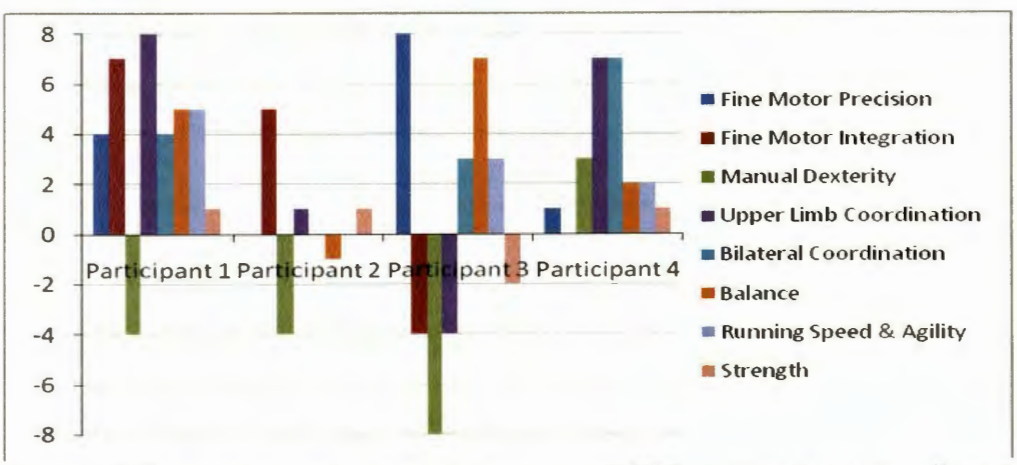

Figure 5. Difference in pre- and post- intervention BOT-2 subtest scores for all participants.

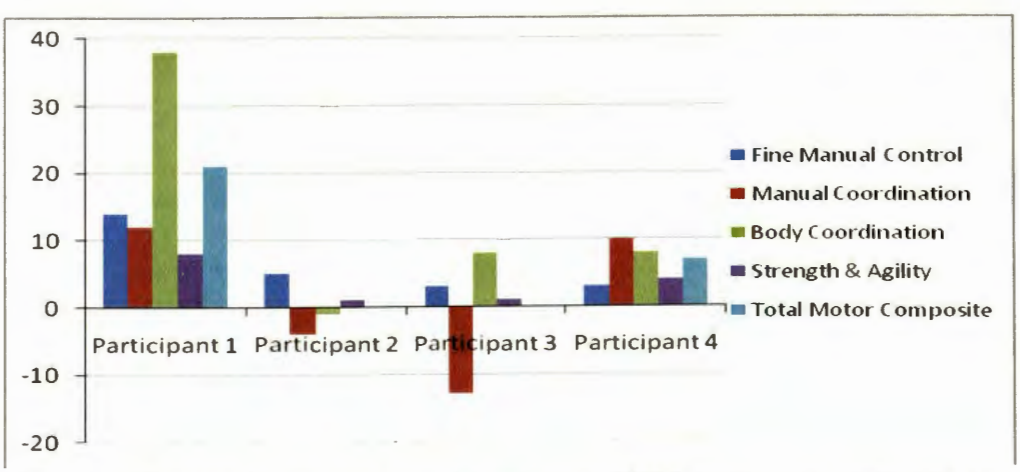

Figure 6. Difference in pre- and post- intervention BOT-2 motor area composite scores for all participants.

CHAPTER V

DISCUSSION

The hypothesis that children with motor coordination deficits who have Wii Fit™ activities incorporated into occupational therapy interventions will achieve greater score improvements on the BOT-2 than those receiving activity-based occupational therapy alone is not supported by data from this study. In fact, the child with the greatest score improvements was in the control group. The two children in the experimental group also had score increases but not as much as the other child. Although there is no indication that one intervention was more beneficial than the other, it is notable that both participants in the experimental group demonstrated high levels of engagement during Wii Fit™ activities. Informal comments made by the participants suggest that incorporation of these activities was a pleasurable experience and was motivating for them, which supports continued use of this top-down approach for improving motor skills.

The Bruininks-Oseretsky Test of Motor Proficiency-2nd Edition (BOT-2) motor area composite of body coordination, made up of the bilateral coordination and balance subtests, was the primary area targeted and anticipated to change after 10 weeks of intervention. Even though three of four participants demonstrated score increases in all of those areas, only two of the nine scores (one composite and two subtests each for three participants) were supported as actual skill advancement using the 90% confidence interval. Wuang, Lin, and Su (2009) performed a Rasch analysis on the measurement properties of the BOT-2 among children with intellectual disabilities which revealed that 18 of the 53 test items did not accurately represent

the child's ability when compiled into a composite score. Most of the identified misfit items were in the body coordination motor composite. The Rasch analysis also discovered that 14 items were not ordered in a progressive level of difficulty, "denoting that the response scale is not efficient to differentiate performance of participants with different levels of motor ability" (Wuang et al., 2009, p. 1140). As the item response categories were shown to not accurately represent the distinct levels of ability in children with intellectual disabilities, the same may also be true for children with motor coordination deficits. It is possible that the response categories are not sensitive enough to detect small skill improvements. Using the BOT-2, each participant received a total of 13 scores including all subtests and composites. When combining the scores of all four participants, 36 of 52 scores increased; however using 90% confidence intervals, only 10 of those score increases are supported to reflect actual skill improvements. Another notable point is that a test of 53 items may be too lengthy for use by children who have limited attention spans. So a question that arises is whether or not the BOT-2 was the best outcome measure to capture the true picture of participant skill levels for this study.

Consistent with previous studies involving the use of virtual reality-based games, participation in Wii Fit™ activities was enjoyable and a good motivator for the participants while working to improve their motor skills. Prior studies also pointed out the multisensory feature of virtual reality-based games, which this study's Wii Fit™ participants benefitted from for increasing awareness of their body movements to make postural adjustments needed for game mastery. Additionally, researchers and therapists discussed another benefit of incorporating virtual reality-based games, such as Wii Fit™, into therapy interventions to include the therapist's ability to control exercise duration, repetitions, and complexity of tasks. This is important for

providing the appropriate level of challenge for the individual client. Using therapist-guided Wii Fit™ activities as a therapeutic tool during rehabilitation therapy sessions works through the childhood occupation of play, which helps to disguise the challenging nature of the task and facilitates the child's inner drive to achieve mastery.

Clinical Implications

The results of this study suggest that incorporating Wii Fit™ activities into occupational therapy interventions provides another therapeutic and motivating option for therapists to utilize for maximizing functional outcomes. In order to facilitate motor skill improvements, a great deal of verbal, visual, and manual guidance was needed by these Wii Fit™ participants while engaged in the games, which demonstrates the therapeutic potential of the activity. Both Wii Fit™ participants achieved score increases in the motor area composites of body coordination, strength and agility, and fine manual control. All of these scores, though not supported by 90% confidence intervals, imply improved bilateral coordination, balance, and strength, which contribute to improvements in fine motor precision. These are the gains that lead to functional improvements desired by the parents of these children.

Enjoyment and motivation are important factors for engaging a child in activities that may be difficult due to underlying deficits. He or she will likely make more gains and quicker when fully engaged in the activities in which he or she is participating as opposed to when performing less meaningful tasks. Because of the motivation factor, therapists could also incorporate Wii Fit™ activities into a home exercise program using specific protocols, which could then facilitate compliance with performing home programs. Because of the adaptability, real-time virtual feedback, and motivational qualities of the Wii Fit™, it is a great adjunct to

occupational therapy interventions and should continue to be researched to provide additional evidence based practice.

Limitations and Future Research

This study presented several limitations. First, making firm assumptions on the effectiveness of incorporating Wii Fit™ activities during occupational therapy sessions is difficult to do with such a small sample size. Further research should include a much larger sample size. Second, selection of potential participants began with suggestion by staff occupational therapists followed by chart review by the principal investigator and then administration of the BOT-2. There were no specific measures to verify the participant's receptive language and cognitive skills other than the ability to follow directions for completing the test procedures. Participant 2 was able to complete testing however had much difficulty responding to task feedback provided by the occupational therapist during therapy sessions, which then made it difficult for him to improve his motor coordination skills. There were also no specific questions asked about participation in extra-curricular activities which could give participants an advantage over those who do not participate. Further research might include more thorough screening of participants for appropriateness to the study and possibly more controls. Third, the timing of this study fell during the autumn holidays which disrupted the therapy schedule and prevented sessions from being completed over 10 consecutive weeks. Future research might be conducted during a time that can minimize possible breaks from therapy. Fourth, three different occupational therapists provided intervention to the participants which may have caused too much variability in therapy activities even though the primary focus was on motor coordination skills. Further research might consider all interventions being provided by one therapist to

ensure equality of sessions. And finally, further research could consider utilizing other standardized assessments to assess motor skills, in addition to the BOT-2, to determine which tests are sensitive enough to detect, with confidence, small changes in performance.

Conclusion

The aim of this pilot study was to determine the effectiveness of augmenting occupational therapy intervention with participation in therapist-guided Wii Fit™ activities in children with motor coordination deficits as measured by the BOT-2. Both participants in the experimental group achieved score increases in various areas which demonstrates that the intervention was effective for the skills targeted. Participant 1, in the control group, showed improvements in the same areas which demonstrates that his interventions were just as effective. As one could anticipate, sessions including Wii Fit™ activities were a great deal of fun for the participants. This study demonstrates the use of a child's occupation of play to provide a task-specific approach for addressing motor skill deficits. As no other research studies were found to utilize the Wii Fit™ as a therapeutic tool during occupational or physical therapy, for children having motor coordination deficits, the results of this pilot study provide support for conducting another larger study to be able to make more conclusive assumptions. It would also be interesting to explore other possible therapeutic effects of participation in therapist-guided Wii Fit™ activities. Use of this popular virtual reality-based game to supplement rehabilitation programs shows great potential for addressing various therapeutic goals with diverse populations.

REFERENCES

Akhutina, T., Foreman, N., Krichevets, A., Matikka, L., Narhi, V., Pylaeva, N., et al. (2003). Improving spatial functioning in children with cerebral palsy using computerized and traditional game tasks. *Disability & Rehabilitation, 25*(24), 1361-1371.

American Occupational Therapy Association. (2008). Occupational therapy practice framework: Domain and process, 2nd Ed. *American Journal of Occupational Therapy, 62*(6), 625-683.

Brown, R., Sugarman, H., & Burstin, A. (2009). Use of Nintendo Wii Fit™ for the treatment of balance problems in an elderly patient with stroke: A case report. *International Journal of Rehabilitation Research, 32(Suppl. 1)*, 109-110.

Bruininks, R., & Bruininks, B. (2005), *Bruininks-Oseretsky Test of Motor Proficiency (2nd Ed.*). Minneapolis, MN: NCS Pearson, Inc.

Brumels, K., Blasius, T., Cortright, T., Oumedian, D., & Solberg, B. (2008). Comparison of efficacy between traditional and video game based balance programs. *Clinical Kinesiology, 62(4),* 26-31.

Bryanton, C., Bosse, J., Brien, M., McLean, J., McCormick, A., & Sveistrup, H. (2006). Feasibility, motivation, and selective motor control: Virtual reality compared to conventional home exercise in children with cerebral palsy. *CyberPsychology & Behavior, 9*(2), 123-128.

Chen, Y.-P., Kang, L.-J., Chuang, T.-Y., Doon, J.-L., Lee, S.-J., Tsai, M.-W., et al. (2007). Use of virtual reality to improve upper-extremity control in children with cerebral palsy: A single-subject design. *Physical Therapy, 87*(11), 1441-1457.

Cho, B.-H., Ku, J., Jang, D., Kim, S., Lee, Y., Kim, I., et al. (2002). The effect of virtual reality cognitive training for attention enhancement. *CyberPsychology & Behavior, 5*(2), 129-137.

Clark, P., & Allen, A. (1985). The role of occupational therapy in pediatrics. In P. Clark & A. Allen, *Occupational Therapy for Children*, (pp. 2-9). St. Louis, MO: The C.V. Mosby Company.

Clark, R., Bryant, A., Pua, Y., McCrory, P., Bennell, K., & Hunt, M. (2010). Validity and reliability of the Nintendo Wii Balance Board for assessment of standing balance. *Gait & Posture, 31(3),* 307-310.

Cushing, S., Chia, R., James, A., Papsin, B., & Gordon, K. (2008). A test of static and dynamic balance function in children with cochlear implants. *Archives of Otolaryngology- Head & Neck Surgery, 134*(1), 34-38.

Cushing, S., Papsin, B., Rutka, J., James, A., & Gordon, K. (2008). Evidence of vestibular and balance dysfunction in children with profound sensorineural hearing loss using cochlear implants. *The Laryngoscope, 118*(10), 1814-1823.

Dawson, G., & Watling, R. (2000). Interventions to facilitate auditory, visual, and motor integration in autism: A review of the evidence. *Journal of Autism and Developmental Disorders, 30*(5), 415-421.

Deitz, J., Kartin, D., & Kopp, K. (2007). Review of the Bruininks-Oseretsky Test of Motor Proficiency, Second Edition (BOT-2). *Physical & Occupational Therapy in Pediatrics, 27*(4), 87-102.

Deutsch, J., Borbely, M., Filler, J., Huhn, K., & Guarrera-Bowlby, P. (2008). Use of a low-cost, commercially available gaming console (Wii) for rehabilitation of an adolescent with cerebral palsy. *Physical Therapy, 88*(10), 1196-1207.

Eng, K., Siekierka, E., Pyk, P., Chevrier, E., Hauser, Y., Cameirao, M., et al. (2007). Interactive visuo-motor therapy system for stroke rehabilitation. *Medical & Biological Engineering and Computing*, *45*(9), 901-907.

Forsyth, K., & Kielhofner, G. (2003). Model of Human Occupation. In P. Kramer, J. Hinojosa, & C. Royeen (Eds.), *Perspectives in Human Occupation: Participation in life,* (pp. 45-86). Philadelphia: Lippincott Williams & Wilkins.

Haglund, L, & Kjellberg, A. (1999). A critical analysis of the Model of Human Occupation. *Canadian Journal of Occupational Therapy, 66*(2), 102-108.

Halton, J. (2008). Virtual rehabilitation with video games: A new frontier for occupational therapy. *Occupational Therapy Now, 10*(1), 12-14.

Harris, K., & Reid, D. (2005). The influence of virtual reality play on children's motivation. *Canadian Journal of Occupational Therapy, 72*(1), 21-29.

Herz, N. (2009). The Wii and occupational therapy. *OT Practice, 14*(7), 19-25.

Iverson, S., Ellertsen, B., Tytlandsvik, A., Nodland, M. (2005). Intervention for 6-year-old children with motor coordination difficulties: Parental perspectives at follow-up in middle childhood. *Advances in Physiotherapy, 7*(2), 67-76.

Kenyon, R., Leigh, J., & Keshner, E. (2004). Considerations for the future development of virtual technology as a rehabilitation tool. *Journal of NeuroEngineering & Rehabilitation, 1*, 1-10. doi: 10.1186/1743-0003-1-13.

Kielhofner, G. (1997). The Model of Human Occupation. In L.B. Caldwell, M. Fithian, & J.H. Martin (Eds.), *Conceptual Foundations of Occupational Therapy,* (2nd ed., pp. 187-217). Philadelphia: F.A. Davis Company.

Koritnik, T., Bajd, T., & Munih, M. (2008). Virtual environment for lower-extremities training. *Gait & Posture, 27*(2), 323-330.

Lee, H-Y., Cherng, R-J., & Lin, C-H. (2004). Development of a virtual reality environment for somatosensory and perceptual stimulation in the balance assessment of children. *Computers in Biology & Medicine, 34*(8), 719-733.

Mandich, A., Polatajko, H., Macnab, J., Miller, L. (2001). Treatment of children with developmental coordination disorder: What is the evidence? *Physical & Occupational Therapy in Pediatrics, 20(2/3),* 51-68.

Meadow, J., (2008, March 29). Wii-habilitation: The techno way at Craig Hospital. *CBS4 News.* Retrieved June 24, 2008 from http://cbs4denver.com/local/craig.hospital.wii.2.662236.html.

Merrill, M. (2008). Ohio hospital uses Wii-habilitation. *Healthcare IT news.* Retrieved June 24, 2008, from http://www.healthcareitnews.com/news/ohio-hospital-uses-wii-habilitation.

Missiuna, C., Rivard, L., Bartlett, D. (2006). Exploring assessment tools and the target of intervention for children with developmental coordination disorder. *Physical & Occupational Therapy in Pediatrics, 26*(1/2), 71-89.

Nitz, J., Kuys, S., Isles, R., & Fu, S. (2009, November 12). Is the Wii Fit a new-generation tool for improving balance, health and well-being? A pilot study. *Climacteric: The Journal of the*

International Menopause Society. Retrieved March 19, 2010, from Pub Med database. (PMID: 19905991).

Rand, D., Kizony, R., & Weiss, P. (2008, December). The Sony Playstation II EyeToy: Low-cost virtual reality for use in rehabilitation. *Journal of Neurologic Physical Therapy, 32*(4), 155-163.

Reid, D. (2002). The use of virtual reality to improve upper-extremity efficiency skills in children with cerebral palsy: A pilot study. *Technology & Disability, 14*(2), 53-61.

Reid, D., & Campbell, K. (2006). The use of virtual reality with children with cerebral palsy: A pilot randomized trial. *Therapeutic Recreation Journal, 40(*4), 255-268.

Shi, C.-H., Shi, C.-T., & Chu, C.-L. (2010). Assisting people with multiple disabilities actively correct abnormal standing posture with a Nintendo Wii™ Balance Board through controlling environmental stimulation. *Research in Developmental Disabilities, 31(4),* 936-942.

Stansfield, S., Dennis, C., & Suma, E. (2005). Emotional and performance attributes of a VR game: A study of children. *Studies in Health Technology & Informatics, 111,* 515-518.

Sveistrup, H. (2004). Motor rehabilitation using virtual reality. *Journal of NeuroEngineering & Rehabilitation, 1,* 1-8. doi: 10.1186/1743-0003-1-10.

Tanner, L. (2008, February 8). Break a leg? Try 'Wiihabilitation': System is used for patients recovering from strokes, surgery. T*he Associated Press.* Retrieved June 24, 2008, from http://www.msnbc.msn.com/id/23070190/from/ET/.

Taylor, S., Fayed, N., Mandich, A. (2007). CO-OP intervention for young children with developmental coordination disorder. *The Occupational Therapy Journal of Research: Occupation, Participation, and Health, 27(4)*, 124-130.

Tseng, M., Henderson, A., Chow, S., & Yao, G. (2004). Relationship between motor proficiency, attention, impulse, and activity in children with ADHD. *Developmental Medicine & Child Neurology, 46*(6), 381-388.

Vadhavkar, N. (2008). Health and the video game revolution. *The Triple Helix,* 11-13.

Viau, A., Feldman, A., McFadyn, B., & Levin, M. (2004). Reaching in reality and virtual reality: A comparison of movement kinematics in healthy subjects and in adults with hemiparesis. *Journal of NeuroEngineering & Rehabilitation, 1*, 1-7. doi: 10.1186/1743-0003-1-11.

Weiss, P., Rand, D., Katz, N., & Kizony, R. (2004, December). Video capture virtual reality as a flexible and effective rehabilitation tool. *Journal of NeuroEngineering & Rehabilitation, 1*, 1-12. doi: 10.1186/1743-0003-1-12.

Wuang, Y-P., Lin, Y-H., & Su, C-Y. (2009). Rasch analysis of the Bruininks-Oseretsky Test of Motor Proficiency- Second Edition in intellectual disabilities. *Research in Developmental Disabilities, 30(6),* 1132-1144.

Wuang, Y-P., & Su, C-Y. (2009). Reliability and responsiveness of the Bruininks-Oseretsky Test of Motor Proficiency- Second Edition in children with intellectual disability. *Research in Developmental Disabilities, 30(5),* 847-855.

You, S., Jang, S., Kim, Y-H., Kwon, Y-H. Barrow, I., & Hallett, M. (2005). Cortical reorganization induced by virtual reality therapy in a child with hemiparetic cerebral palsy. *Developmental Medicine & Child Neurology, 47*(9), 628-635.