NINTENDO WII FIT™ INTERVENTION FOR BALANCE IMPROVEMENT IN A
CHILD WITH DEVELOPMENTAL COORDINATION DISORDER

An Independent Research Study

Presented to

The Faculty of the College of Health Professions and Social Work
Florida Gulf Coast University

In Partial Fulfillment
of the Requirement for the Degree of
Doctorate of Physical Therapy

By
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WII BALANCE IN A CHILD WITH DCD

APPROVAL SHEET

This Independent Research Study is submitted in partial fulfillment of the requirements for the degree of

Doctorate of Physical Therapy

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The final copy of this Independent Research Study has been examined by the signatories, and we find that both the content and the form meet acceptable presentation standards of scholarly work in the above mentioned discipline.
Acknowledgments

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Table of Contents

Abstract.................................................................................................................. 2
Introduction............................................................................................................. 4
Literature Review.................................................................................................. 5
Purpose/Research Question.................................................................................... 9
  Rationale.............................................................................................................. 9
Methods
  Research Design.................................................................................................. 10
  Participant......................................................................................................... 11
  Instrumentation................................................................................................. 12
  Intervention...................................................................................................... 13
  Data Collection................................................................................................. 13
    Procedure...................................................................................................... 14
    Legal and Ethical Concerns.......................................................................... 15
  Data Analysis.................................................................................................... 16
Results.................................................................................................................... 16
  Table 1: Pre- and Posttest PBS Scores............................................................... 17
Discussion.............................................................................................................. 18
Conclusion............................................................................................................. 21
References............................................................................................................ 22
Appendix A: Pediatric Balance Scale................................................................. 25
Appendix B: The Wii Balance Board System.................................................... 33
Appendix C: Wii Balance Board Handout......................................................... 34
Abstract

Objective: This research study aimed to determine if the Nintendo Wii Fit™ video gaming program and its balance games could improve balance in child, age eight, with Developmental Coordination Disorder (DCD) or hypotonia when used as a primary intervention tool. Recent studies have been completed recently as to the effectiveness of the Nintendo Wii Fit™ system as an intervention tool, concluding with positive results. However, there are limited studies focusing on the pediatric population and even less ones concentrating on children with disorders that directly affect their balance capabilities, such as DCD. Method: This single-subject case study involved the participation of a child that has been diagnosed with DCD or related movement deficits to perform selected Nintendo Wii Fit™ balance exercises in a controlled clinical environment three times a week over the course of six weeks. The study consisted of one participant, aged eight, who was diagnosed with hypotonia and was not currently receiving physical therapy. The participant completed six different balance exercises for a total of 18 minutes during each visit. Before starting the intervention, the participant was shown proper use the Nintendo Wii Fit™ gaming system and given a trial run, to assist with alleviating any learning curves. At all times during the study, the participant was in a safe, controlled environment completing tasks that required no more challenge to a child’s balance than is experienced during normal daily activities. A pre- and post-intervention assessment utilizing the Pediatric Balance Scale (PBS) measured the participant’s balance improvement. Results: At the conclusion of the study, the child was shown to have improved his PBS score by 4 points, advancing from the medium fall risk category to the low fall risk category. Conclusion: While more extensive studies need to
be completed, the results found support the Nintendo Wii Fit™ system as a valuable intervention tool for pediatric populations with balance deficits.
Introduction

Nearly 10 percent of today’s childhood population is diagnosed with Developmental Coordination Disorder (DCD) (Loh, Piek, & Barrett, 2011). DCD is a chronic neurological disorder that occurs early in childhood which affects motor planning and coordination as a result of inaccurate neurotransmissions between the brain and the body (Zwicker, Missiuna, Harris, & Boyd, 2012). These children present with inadequate motor coordination and development than can be seen by deficits in balance, gait, and coordination (Fong, Tsang, & Ng, 2012). These complications, with both gross and fine motor skills, can significantly interfere with a child’s daily living activities and academic achievement (Zwicker et al., 2012).

One of the more commonly seen deficits with this population is in balance, both static and dynamic. Static and dynamic upright balance begins developing in children as early as two years of age and may play a significant role in the development of other motor coordination skills, such as gait patterns and coordination (Geuze, 2003). The improvement of balance is a fundamental step in the improvement of these motor skills. For children with poor motor planning, improving their balance strategies have been shown to be a successful technique for helping improve their overall motor coordination (Rahman, 2010).

In recent years, research has been completed on the effectiveness of the video technology in improving balance deficits in children, resulting in positive outcomes. A commonly utilized form of technology is the Nintendo Wii Fit™ system, which gives clinicians a valid and easy way of testing one’s balance and provides virtual interactive activities to aid in the improvement of balance (Clark, Bryant, Pua, McCrory, Bennell, &
Hunt, 2010). Based on the positive current research in this field, this research study aimed to utilize the Nintendo Wii Fit™ system and its balance programming in hopes of improving balance, and thus overall motor coordination, in children with DCD.

**Literature Review**

Developmental Coordination Disorder is a condition affecting 10 percent of our childhood population (Loh, Piek, & Barrett, 2011) in which children suffer from poor motor coordination. Poor motor coordination includes, but is not limited, to clumsiness, abnormal gait, poor balance, and proprioception deficits. This motor incoordination interferes with activities of daily living and includes marked delays in achieving motor milestones with balance, handwriting, and coordination difficulties (Fong et al., 2012). Children with DCD are characterized as having poor motor control that appears early in childhood, that may present as developmental delays (late crawling, walking), unstable sitting, dropping things, and poor performance in sports. DCD is often separated into two subcategories: gross-motor and fine-motor movement impairment (Piek & Dyck, 2004).

Children with DCD are known to have much less consistent and uniform strategies for regulating muscle activity and bilateral motor coordination deficits may interfere with engaging and organizing proper motor control strategies. This lack of motor control can often present itself through lack of balance. Balance is the ability of a body to maintain weight-bearing posture while in a stationary position. This comprises an integral component of most movement activities. Children with deficits in balance control lack the framework necessary for the development of normal functional activities (Tsai, Wu, & Huang, 2008). Postural control is typically recognized to be a pre-requisite for
motor skill development, meaning that deficits in balance control can result in delayed motor development (Geuze, 2003). Of the ten percent of children with DCD, it has been reported that 73 to 87 percent have balance issues (Fong, Lee, & Pang, 2011).

Optimal reception, processing, and integration of sensory information (i.e. somatosensory, visual, vestibular) are required to maintain balance. While needed for successful maintenance of postural stability and coordinated movements, visual-spatial processing, visual perception, and visual-kinesthetic integration are typically impaired in children with DCD. Children with DCD have been found to have difficulty with processing information, and were less able to use visual information when attempting to maintain balance (Fong et al., 2011). The fundamental process of coordinating accurate movements has been suggested to lie in the proprioceptive feedback mechanism, which serves to correct external and internal induced errors in force of movement, position, and velocity. These mechanisms are the main source of sensory information for maintaining balance and may lead to the nervous system placing more importance on proprioceptive information for balance (over visual and vestibular input) (Tsai et al., 2008). The vestibular system, by measuring any acceleration of the head in relation to gravity during stance, is also an important and reliable sensor for postural control and critical in balance control (Fong et al., 2012). However, other studies have shown that integration of sensory modalities (rather than the dominance of any particular one) is important when working on balance with this population (Bair, Barela, Whitall, Jeka, & Clark, 2010).

In addition to the sensorimotor processing issues, children with DCD also exhibit problems with muscle activation. Non-optimal cerebellar function contributes to the balance issues children with DCD have by affecting the development of autonomous
control. This lack of development can also contribute to an increased level of co-activation of muscles (as found in children with DCD), that results in muscle stiffness in the legs and can reduce speed of correction of loss of balance (Geuze, 2003). When correcting for loss of balance, this population also uses more hip strategies than ankle strategies. The excessive use of hip strategy and over-reliance on it might not be effective when they are trying to balance on unstable surfaces. This would lead an overuse of those muscles, a decrease in efficiency of energy usage (increase in energy consumption), and would increase their risk of falling (Fong et al., 2012).

Physical therapy interventions for balance improvements in children with poor postural stability have been demonstrated to be successful and have led to improvements with overall motor coordination. In particular, utilization of the Nintendo Wii Fit™ system has demonstrated to be an effective intervention for improving balance in adults and/or children. A study by Rhaman (2010) supported the effectiveness of the Nintendo Wii Fit™ and its programs as an intervention, specifically for improvement in balance in children. This study focused specifically on the effects of a Nintendo Wii Fit™ intervention in the improvement of balance within the pediatric population with Down syndrome. At the end of a six-week study, the experimental group showed significant improvement in postural stability when compared to the control group. It was concluded that virtual reality-based therapy (in the form of the Nintendo Wii Fit™) is an effective intervention for this population (Rahman, 2010). In a more recent study by Jelsma et al. (2014), findings were positive for the use of the Nintendo Wii Fit™ system as a successful balance intervention for children diagnosed with DCD. This study, which lasted six-weeks, resulted in improvements in the participants with balance problems that
was significantly larger after intervention than after a period of non-intervention. Results also supported that children with DCD and balance problems are less proficient in playing games in which dynamic balance control is needed, showing the need for interventions in this area. Throughout the course of the study, most children also maintained their motivation to participate over the full 6 weeks (Jelsma, D., Geuze, R., Mombarq, R., Smits-Engelsman, B., 2014).

A study by Mombarg et al. (2013) focused on improvement of balance in children with poor motor performance and found an experimental group that exhibited significant improvement in both static and dynamic balance after a six-week intervention with the Nintendo Wii Fit™ system. In this study, the control group showed no improvement while over half of the experimental group moved from a clinical score considered “at risk” on the balance factor to a score no longer at risk. This increase in balance allows these children to have a better opportunity to learn other balance-related skills that are developed in daily classes and regular sporting environments (Mombarg, Jelsma, & Hartman, 2013).

In addition to improvements in balance, physical therapy was also shown to be effective for treating motor issues, task-oriented and cognitive-based tasks, and learning important daily life skills that would increase the quality of life for children with DCD (Fliers et al., 2010). Research provides data to support the use of physical therapy interventions to improve these conditions. Along with improving the motor deficiencies of the DCD, the development of these motor skills provides a sense of self-efficacy that helps improve the child’s confidence (Kopp et al., 2010). The social-emotional benefits this population receives from movement training cannot be undervalued. Failing to
provide children with DCD with therapy intervention is a missed opportunity to provide them with advantages and ways to cope with the challenges of their daily life (Fliers et al., 2010).

**Purpose/Research Question**

The purpose of this study was to determine if balance in a child with DCD, age eight, can be improved during a six-week physical therapy treatment period that employs the Nintendo Wii Fit™ system and activity programs. The research question is: “Is there a difference in balance as measured by the Pediatric Balance Scale in a child, aged eight years, with DCD, following a six-week Nintendo Wii Fit™ balance program?”

**Rationale**

From observations among physical therapists, it was noted that children tend not to complete their home exercise program (HEP) as prescribed (Jin, Sklar, Oh, & Chuen, 2008). The ones who completed the HEP seemed unenthused and disengaged. From these observations, different ways to engage children were speculated upon and the Nintendo Wii Fit™ was identified. Using the Nintendo Wii Fit™ system is very popular among children and seems to be engaging. Within the Nintendo Wii Fit™ system, there are also numerous activity programs one can choose to interact with, allowing patients to participate in programs that interest them. This helps individualize the HEP for that patient, which often results in increasing adherence and a better rehabilitation prognosis (Hammond, Jones, Hill, Green, & Male, 2013).

It is shown that in order to learn, one must have sensory input, feedback, and the need to learn that skill (Fitzgerald, Gruener, & Mtui, 2012). Balance interventions can increase coordination in children with DCD, and from this, increase their overall motor
functioning. Most children in the age group of 6 to 10 also have the desire to keep up with their peers. Since the need to learn that skill is present, the sensory input and feedback are the tools that are necessary to develop this desired skill. One research study found that using the Nintendo Wii Fit™ program for children with DCD had a positive impact on their motor skill development and social and emotional behavior. Hill compared two groups of children with DCD. One group participated in the Nintendo Wii Fit™ program three times per week for ten minutes and the other group participated in the “Jump Ahead” program. The group that participated in the Nintendo Wii Fit™ program performed at a higher level on developmental tests and achieved scores three times higher than the control group on their motor performance assessment (Hammond et al., 2013).

The Nintendo Wii Fit™ appears to be a useful intervention tool to gather further data since it has been associated with beneficial results for children with DCD. The system is relatively inexpensive when compared to most other medical/therapy equipment and is known for its engaging games that improve children’s balance while providing useful feedback (Hammond et al., 2013; Rahman, 2010; Mombarg et al., 2013).

Methods

Research Design

This study was a quantitative research study using a comparative research format, using a one-subject pretest-posttest experimental design. It consisted of one participant who participated in a six-week intervention program and then be reassessed using the same balance measure (Pediatric Balance Scale). Based on the rate of child development, a six-week study was utilized. The six-week time span allowed enough time for potential
improvements in balance to occur, based on the Nintendo Wii Fit™ intervention, while limiting the effects of normal development progression that could have skewed posttest scores.

**Participant**

The study participant was recruited through local physicians’ offices and word of mouth. After IRB approval was given (Protocol ID #s2014-41), local pediatricians were contacted to assist in the identification of potential subjects. HIPPA regulations were followed to protect patient confidentiality during the recruitment process. The child recruited was an eight year-old male, not currently receiving physical therapy, and diagnosed with hypotonia as an infant. He fit the following inclusion and exclusion criteria.

Inclusion criteria included:

1. A child between the ages of six and ten years.
2. A child with DSM-IV diagnosis of DCD or mild to moderate motor delays.
   a. A child who has been diagnosed with movement deficits, without a formal DCD diagnosis, will also be included. The child will present with hypotonicity, decreased muscle strength, and delayed motor planning (common signs of DCD).
3. A child scoring between 21 and 40 on the Pediatric Balance Scale (denoting a medium fall risk).
4. A child with common learning disabilities, such as attention deficit disorder and dyslexia, will be included.

Exclusion criteria included:
1. A child outside of the age range of six to ten years.

2. A child who has a primary diagnosis other than DCD or delayed motor development.
   a. This includes, but is not limited to, a child with cerebral palsy, Down syndrome or other identified genetic factors, hypertonicity, or major neurological issues.

3. A child scoring a 20 or below on the Pediatric Balance Scale pretest (denoting a high fall risk) will not be eligible to participate due to safety concerns.

4. A child currently attending physical therapy and/or who will be starting physical therapy or other activities that could aid in improvement of their balance capabilities during the duration of their participation in the study.

Instrumentation

While the Nintendo Wii Fit™ has its own balance activity scoring system, it found through studies to have poor intersession and intrasession reliability and validity (Wikstrom, 2012). Based on supporting evidence-based research, the Pediatric Balance Scale (PBS) was used for the pretests and posttests. The PBS is a modified version of Berg’s Balance Scale, developed for the pediatric population. It was developed as a balance measure for school-age children (ages five to fifteen) with mild to moderate motor impairments and focuses on functional balance skills. It begins with more static balance positions, then progresses to more dynamic maneuvers that challenge the child’s balance. Interrater and test-retest reliability are high for this scale at 0.98 and 0.99, respectively, which will be essential for this study since there were two researchers performing the pretests and posttests (Franjoine et al., 2003). This test consists of 14
items that relate to everyday activities. Each item is given a score from 0 to 4, with 0 being lowest level of function and 4 being highest level of function. The highest total score achievable is 56. Interpretation of the scores is as follows: 41 to 56 denotes a low fall risk, 21 to 40 a medium fall risk, and 0 to 20 a high fall risk. The PBS takes fifteen to twenty minutes to administer (Franjoine, et al, 2003). See Appendix A for a complete copy of the Pediatric Balance Scale.

**Intervention**

The Nintendo Wii Fit™ program was used for 18 minutes, three times per week as the intervention for this study, utilizing the “Balance Games” option. This system allows the participant to experience experimental and active balance practice and improvement techniques in a safe and controlled environment. The Nintendo Wii Fit™ program utilizes a balance board, which is platform the player stands on during activities. This board is capable of measuring people’s weight along with detecting their center of balance, helping make each activity specific to the participant. The center of balance detection feature is one of the highlights of the system and what helps make it an effective balance intervention. The “Balance Games” that were utilized are as follows: soccer heading, ski slalom, table tilt, balance bubble, penguin slide, and lotus focus. These games include lateral and anterior/posterior weight shifting and static balance. Each game was played for 3 minutes, adding up to 18 minutes of actual game time for each session. See Appendix B for the Nintendo Wii Fit™ balance board system manual.

**Data Collection**

Pretest and posttest scores from the PBS were recorded before and after the intervention and quantitative analysis were performed.
Procedure

The procedure was performed as follows:

1. The participant participated in the Nintendo Wii Fit™ intervention program, recruited from local physicians’ offices.

2. Participant sessions were held at the participant’s home, under the direct supervision of the researchers with University faculty available if needed.

3. The participant completed the PBS as a pretest before any data were collected.

4. The first time the participant used the Nintendo Wii Fit™ system, the researcher demonstrated the basic movements that might be seen during interventions to help alleviate possible learning curves.

5. The following instructions for Nintendo Wii Fit™ balance board placement were performed before each use of balance board (taken from Nintendo Wii Fit™ Balance Board Operations Manual):
   a. “The Nintendo Wii Fit™ Balance Board should be located directly in front of your TV with the Nintendo Wii Fit™ Remote between 3 and 10 feet from the Sensor Bar (power button faces away from the TV).
   b. Make sure you have adequate space between you and any other objects or people during gameplay (Nintendo recommends at least 3 feet)
   c. Place the board on a stable, flat, horizontal surface (avoid slippery surfaces).
   d. The balance sensors must contact the floor directly for proper operation, if carpet or other material contacts the bottom of the board, use the included foot extensions” (Wii Balance Board Operations Manual).
6. Before the first Nintendo Wii Fit™ intervention session, the participant performed a balance test in the Nintendo Wii Fit™ system to determine his appropriate difficulty level.

7. The participant performed the Nintendo Wii Fit™ games including soccer heading, ski slalom, table tilt, balance bubble, penguin slide, and lotus focus (in the “Balance Games” category) for 18 minutes (3 minutes per game), three times per week.
   a. With each session, the amount of time was recorded by the researchers in his individual log in order to make sure he completed the required time.

8. The participant continued the program for six weeks. The program adjusted to the player’s skills. It progressed the difficulty, as player got better.

9. After the six weeks was completed, the participant again took the PBS to determine if any balance improvements have been achieved.

See Appendix C for a handout that can be given for participant to review in regards to balance board use.

**Legal and Ethical Concerns**

Before data collection begun, the project was reviewed and approved by the Institutional Review Board. Parent/guardian consent and child assent was obtained from the child participant and his legal guardian. Since working with the pediatric population, special considerations were made to protect the child’s rights and welfare at all points during the research. This included, but was not limited to, providing constant supervision, providing a safe and secure environment, ensuring the research being conducted will not involve anything greater than minimal risk for the participant, and that the risk is justified
by expected benefits from the intervention. Extra precaution was taken in regards to the child’s safety during balance exercises. Exercises were held on a balance board with a wide base of support and that lies 2.5 inches off the ground. Interventions required no more challenge to a child’s balance than is experienced during normal daily activities (walking, playing sports, etc.).

Data Analysis

Analysis was completed using comparison of pre- and posttest results from the PBS scale, descriptive statistics including subjective balance and motor control improvements.

Results

The participant was an eight year-old male, who was diagnosed with motor delays and hypotonia as an infant and continued to demonstrate balance and coordination difficulties. Prior to the first intervention session, the participant scored a 40 on the PBS, placing him in the Medium Fall Risk category (21-40 points). After six-weeks of intervention, the participant scored 44, increasing in score into the Low Fall Risk category (41-56 points) (Table 1). According to Chen et al. (2013), the minimal clinically important difference (MCID) for the PBS is 3.66 to 5.83. The MCID was determined using an anchor-based and distribution-based approach. With the anchor-based approach, the MCID was determined using a comparison to the WeeFIM-MO, the Childhood Health Assessment Questionnaire, the Pediatric Quality of Life Inventory, and the Pediatric Evaluation of Disability Inventory and participants found to be in the improvement ranges for those were selected for enrollment in the MCID group. The distribution-based MCID was estimated using the Cohen effect size benchmark (Chen et al., 2013). Our
participant had an increase of 4 points, demonstrating clinical importance for increase in balance capabilities.

Table 1: Pre- and Posttest PBS Scores

<table>
<thead>
<tr>
<th>Participant</th>
<th>Pre-Test</th>
<th>Post-Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>40</td>
<td>44</td>
</tr>
</tbody>
</table>

Along with the pre- and posttest data utilizing the PBS, observations were also made that showed the participant’s progression. During the first two weeks of sessions he displayed difficulty understanding the concept of using weight shifting versus whole body movements. He was unable to perform slight weight shifts when the game required. It was also noted that his center of balance shifted posterior and he had a lack of control of his Mii (game character) during the balances games. He did have loss of balance, no falls observed, with delayed righting reactions in the first two weeks. During the third and fourth week he began displaying less gross body movements and used more fine motor weight shifts in order to succeed in the game. He also began scoring more points and exhibited more confidence, resulting in his increased enjoyment while playing the balance games. Loss of balance episodes also decreased throughout the six weeks. In the last two weeks he continued to beat his current high scores and was able to perfect his fine motor weight shifting in the advanced levels of the games. No loss of balance was noted in the last week. Throughout the intervention, the patient displayed increasing confidence and motivation to complete the balance games. As his confidence increased, his enjoyment in completion of the intervention did as well, with him expressing excitement for each session. At the end of the intervention, both the participant and his parents expressed the desire to continue on with use of the Nintendo Wii Fit™, for both the continuation of balance improvements and for the entertainment if provided to the
Discussion

Developmental Coordination Disorder is a condition in which children suffer from poor motor coordination, affecting 10 percent of our childhood population (Loh, Piek, & Barrett, 2011). Poor motor coordination includes, but is not limited, to clumsiness, abnormal gait, poor balance, and proprioception deficits. This motor incoordination interferes with activities of daily living and includes marked delays in achieving motor milestones with balance, handwriting, and coordination difficulties (Fong et al., 2012). Children with DCD are characterized as having poor motor control that appears early in childhood, that may present as developmental delays (late crawling, walking), unstable sitting, decreased fine motor skills, and poor performance in sports (Piek & Dyck, 2004). This lack of motor control can often present itself through lack of balance. Children with deficits in balance control lack the framework necessary for the development of normal functional activities (Tsai, Wu, & Huang, 2008).

The research question for this study was: “Is there a difference in balance as measured by the Pediatric Balance Scale in a child, aged eight years, with DCD, following a six-week Nintendo Wii Fit™ balance program?” The results from the study give affirmative support to the research question and contribute to the understanding of effective balance interventions for this population. Throughout the course of this study, these aspects were addressed and improved upon by utilization of the Nintendo Wii Fit™ and its balance programing. In the beginning of the study, the participant struggled with the concept of small weight shifts versus large gross movements for balance control, using more hip strategies rather than ankle for balance control. As time progressed, the
participant was able to fine tune these movements and employ effective balance strategies that were more efficient and more appropriate for children of this age. Throughout this study the participant’s proprioceptive awareness improved significantly as well. It’s been shown that children with DCD are known to have much less consistent and uniform strategies for regulating muscle activity and bilateral motor coordination deficits may interfere with engaging and organizing proper motor control strategies. This lack of motor control can often present itself through lack of balance (Tsai, Wu, & Huang, 2008). Along with lack of motor control, these children also use hip strategies more than ankle strategies, as was observed with the participant at the start of the study. The excessive use of hip strategy and over-reliance on it might not be effective when they are trying to balance on unstable surfaces. This would lead an overuse of those muscles, a decrease in efficiency of energy usage (increase in energy consumption), and would increase their risk of falling (Fong et al., 2012). With the assistance of the Nintendo Wii Fit™ system, the participant was able to actively practice proper organization of the motor control strategies needed for effective balance skills, including the incorporation of more efficient ankle balance strategies, thus improving the participant’s energy usage. All of this was completed utilizing an intervention that encourages such strategies in order for one to become successful at the game completion and in such a way that does not feel like “work” for the pediatric patient.

With the implementation of proper weight shifting for balance control, the participant was also able to improve his scoring and success in the game, which lead to more confidence and motivation to complete the study. While the trend in increasing high scores was not formally recorded, it was observed throughout the study and showed to be
an effective motivator for the participant to continue in the research study. This type of effect from the increasing high scores demonstrated a positive form of feedback, which could be further investigated in future research. From observations among physical therapists, it was noted that there was a trend that children tend not to complete their home exercise program (HEP) as prescribed (Jin, Sklar, Oh, & Chuen, 2008). From these observations, different ways to engage children were speculated upon and the Nintendo Wii Fit™ was identified. Using the Nintendo Wii Fit™ system individualizes the HEP for that patient, which often results in increasing adherence and a better rehabilitation prognosis (Hammond, Jones, Hill, Green, & Male, 2013). Results from this case study support this notion, with the participant not only completing the exercises regularly, but also expressing excitement to do so.

Balance interventions can increase coordination in children with DCD, and from this, increase their overall motor functioning. Most children in the age group of 6 to 10 also have the desire to keep up with their peers. To do this, age-appropriate motor functioning is needed and can be improved upon by improving a child’s balance. By the end of this case study, it was observed that the participant had increased his balance and balance strategies and was able to join in activities on the same level as his twin brother, which he was not previously able to or had desire to accomplish. While this study did not directly assess the participant’s balance confidence, through subjective and observational methods, it was seen how the participant’s confidence in his balance capabilities flourished throughout the six weeks. This was portrayed throughout the study in the participant’s increasing motivation to complete the game and its higher levels, as well as actively participate in advanced-level activities with his siblings.
Conclusion

Results from this case study support the use of the Nintendo Wii Fit™ and its balance programs as an effective intervention tool for pediatric populations with balance deficits. In this single-subject case study we examined the effects of the Nintendo Wii Fit and its balance programs as an intervention for children diagnosed with Developmental Coordination Disorder and related movement deficits. Results from case study, based on pre- and posttest scores from the PBS and the child’s enjoyment and motivation to complete the study, support the use of the Nintendo Wii Fit as an effective intervention for balance improvement in this population. However, further research on the topic is needed, which would include a larger sample size and comparison against typically developing children.
References


Appendix A: Pediatric Balance Scale

The Pediatric Balance Scale that the subjects will take before and after the six-week research study.

**PEDiatric Balance Scale**

<table>
<thead>
<tr>
<th>Name:</th>
<th>Date:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location:</td>
<td>Examiner:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Score</th>
<th>Seconds</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Sitting to standing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Standing to sitting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Transfers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Standing unsupported</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Sitting unsupported</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Standing with eyes closed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Standing with feet together</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Standing with one foot in front</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Standing on one foot</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Turning 360 degrees</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Turning to look behind</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Retrieving object from floor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. Placing alternate foot on stool</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. Reaching forward with outstretched arm</td>
<td></td>
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</tr>
</tbody>
</table>

**Total Test Score**

**General Instructions**

1. Demonstrate each task and give instructions as written. A child may receive a practice trial on each item. If the child is unable to complete the task based on their ability to understand the directions, a second practice trial may be given. Verbal and visual directions may be clarified through the use of physical prompts.

2. Each item should be scored utilizing the 0 to 4 scale. Multiple trials are allowed on many of the items. The child's performance should be scored based upon the lowest criteria, which describes the child's best performance. If on the first trial a child receives the maximal score of 4, additional trials need not be administered. Several items require the child to maintain a given position for a specific time. Progressively, more points are deducted if the time or distance requirements are not met; if the subject's performance warrants supervision; or if the subject touches an external support or receives assistance from the examiner. Subjects should understand that they must maintain their balance while attempting the tasks. The choice, of which leg stand on or how far to reach, is left to the subject. Poor judgement will adversely influence the performance and the scoring. In addition to scoring items 4, 5, 6, 7, 8, 9, 10, and 13, the examiner may choose to record the exact time in seconds.
Appendix A: Pediatric Balance Scale Continued

B

**Equipment**

The Pediatric Balance Scale was designed to require minimal use of specialized equipment. The following is a complete list of items required for administration of this tool:

- adjustable height bench
- chair with back support and arm rests
- stopwatch or watch with a second hand
- masking tape - 1 inch wide
- a step stool 6 inches in height
- chalkboard eraser
- ruler or yardstick
- a small level

The following items are optional and may be helpful during test administration:

- 2 child-size footprints
- blindfold
- a brightly colored object of at least two inches in size
- flash cards
- 2 inches of adhesive-backed hook Velcro
- Two 1 foot strips of loop Velcro

******************************************************************************

1. **Sitting To Standing**

*Special instruction:* Items #1 and #2 may be tested simultaneously if, in the determination of the examiner, it will facilitate the best performance of the child.

**INSTRUCTIONS:** Child is asked to "Hold arms up and stand up." The child is allowed to select the position of his/her arms.

**EQUIPMENT:** A bench of appropriate height to allow the child's feet to rest supported on the floor with the hips and knees maintained in 90 degrees of flexion.

**Best Of Three Trials**

( ) 4  able to stand without using hands and stabilize independently
( ) 3  able to stand independently using hands
( ) 2  able to stand using hands after several tries
( ) 1  needs minimal assist to stand or to stabilize
( ) 0  needs moderate or maximal assist to stand

Figure. No caption available.
Appendix A: Pediatric Balance Scale Continued

c

2. Standing To Sitting

*Special instruction: Items #1 and #2 may be tested simultaneously if, in the determination of
the examiner, it will facilitate the best performance of the child.

**INSTRUCTIONS:** Child is asked to sit down slowly, without use of hands. The child
is allowed to select the position of his/her arms.

**EQUIPMENT:** A bench of appropriate height to allow the child’s feet to rest supported on
the floor with the hips and knees maintained in 90 degrees of flexion.

**Best Of Three Trials**

- ( ) 4  sits safely with minimal use of hands
- ( ) 3  controls descent by using hands
- ( ) 2  uses back of legs against chair to control descent
- ( ) 1  sits independently, but has uncontrolled descent
- ( ) 0  needs assistance to sit

3. Transfers

**INSTRUCTIONS:** Arrange chair(s) for a stand pivot transfer, touching at a forty-five degree
angle. Ask the child to transfer one way toward a seat with armrests and one way toward a
seat without armrests.

**Equipment:** Two chairs, or one chair and one bench. One seating surface must have
armrests. One chair/bench should be of standard adult size and the other should be of an
appropriate height to allow the child to conformably sit with feet supported on the floor and ninety
degrees of hip and knee flexion.

**Best Of Three Trials**

- ( ) 4  able to transfer safely with minor use of hands
- ( ) 3  able to transfer safely; definite need of hands
- ( ) 2  able to transfer with verbal cueing and/or supervision (spotting)
- ( ) 1  needs one person to assist
- ( ) 0  needs two people to assist or supervise (close guard) to be safe

Figure. No caption available.
Appendix A: Pediatric Balance Scale Continued

4. Standing Unsupported

INSTRUCTIONS: The child is asked to stand for 30 SECONDS without holding on or moving his/her feet. A taped line or footprints may be placed on the floor to help the child maintain a stationary foot position. The child may be engaged in non-stressful conversation to maintain attention span for thirty seconds. Weight shifting and equilibrium responses in feet are acceptable; movement of the foot in space (off the support surface) indicates end of the timed trial.

EQUIPMENT: a stop watch or watch with a second hand
a twelve inch long masking tape line or two footprints placed shoulder width apart

( ) 4 able to stand safely 30 SECONDS
( ) 3 able to stand 30 SECONDS with supervision (spotting)
( ) 2 able to stand 15 SECONDS unsupported
( ) 1 needs several tries to stand 10 SECONDS unsupported
( ) 0 unable to stand 10 SECONDS unassisted

Time in seconds

Special Instructions: If a subject is able to stand 30 SECONDS unsupported, score full points for sitting unsupported. Proceed to item #6

5. Sitting With Back Unsupported And Feet Supported On The Floor

INSTRUCTIONS: Please sit with arms folded on your chest for 30 SECONDS. Child may be engaged in non-stressful conversation to maintain attention span for thirty seconds. Time should be stopped if protective reactions are observed in trunk or upper extremities.

EQUIPMENT: a stop watch or watch with a second hand
a bench of appropriate height to allow the feet to rest supported on the floor with the hips and knees maintained in ninety degrees of flexion.

( ) 4 able to sit safely and securely 30 SECONDS
( ) 3 able to sit 30 SECONDS under supervision (spotting) or may require definite use of upper extremities to maintain sitting position
( ) 2 able to sit 15 SECONDS
( ) 1 able to sit 10 SECONDS
( ) 0 unable to sit 10 SECONDS without support

Time in seconds

Figure. No caption available.
Appendix A: Pediatric Balance Scale Continued

6.  Standing Unsupported With Eyes Closed

**INSTRUCTIONS:** The child is asked to stand still with feet shoulder width apart and close his/her eyes for ten seconds. **Direction:** "When I say close your eyes, I want you to stand still, close your eyes, and keep them closed until I say open." If necessary, a blindfold may be used. Weight shifting and equilibrium responses in the feet are acceptable; movement of the foot in space (off the support surface) indicates end of timed trial. A taped line or footprints may be placed on the floor to help the child maintain a stationary foot position.

**EQUIPMENT:**
- a stop watch or watch with a second hand
- a twelve-inch long masking tape line or two footprints placed shoulder width apart
- blindfold

**Best Of 3 Trials**

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>able to stand 10 seconds safely</td>
</tr>
<tr>
<td>3</td>
<td>able to stand 10 seconds with supervision</td>
</tr>
<tr>
<td>2</td>
<td>able to stand 3 seconds</td>
</tr>
<tr>
<td>1</td>
<td>unable to keep eyes closed 3 seconds but stays</td>
</tr>
<tr>
<td>0</td>
<td>needs help to keep from falling</td>
</tr>
</tbody>
</table>

______ Time in seconds

7.  Standing Unsupported With Feet Together

**INSTRUCTIONS:** The child is asked to place his/her feet together and stand still without holding on. The child may be engaged in non-stressful conversation to maintain attention span for thirty seconds. Weight shifting and equilibrium responses in feet are acceptable; movement of the foot in space (off the support surface) indicates end of timed trial. A taped line or footprints may be placed on the floor to help the child maintain stationary foot position.

**EQUIPMENT:**
- a stop watch or watch with a second hand
- a twelve inch long masking tape line or two footprints placed together

**Best Of 3 Trials**

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>able to place feet together independently and stand 30 seconds safely</td>
</tr>
<tr>
<td>3</td>
<td>able to place feet together independently and stand for 30 seconds with</td>
</tr>
<tr>
<td></td>
<td>supervision (spotting)</td>
</tr>
<tr>
<td>2</td>
<td>able to place feet together independently but unable to hold for 30 seconds</td>
</tr>
<tr>
<td>1</td>
<td>needs help to attain position but able to stand 30 seconds with feet</td>
</tr>
<tr>
<td></td>
<td>together</td>
</tr>
<tr>
<td>0</td>
<td>needs help to attain position and/or unable to hold for 30 seconds</td>
</tr>
</tbody>
</table>

______ Time in seconds

Figure. No caption available.
Appendix A: Pediatric Balance Scale Continued

8. Standing Unsupported One Foot in Front

**INSTRUCTIONS:** The child is asked to stand with one foot in front of the other, heel to toe. If the child cannot place feet in a tandem position (directly in front), they should be asked to step forward far enough to allow the heel of one foot to be placed ahead of the toes of the stationary foot. A taped line and/or footprints may be placed on the floor to help the child maintain a stationary foot position. In addition to a visual demonstration, a single physical prompt (assistance with placement) may be given. The child may be engaged in non-stressful conversation to maintain his/her attention span for 30 seconds. Weight shifting and/or equilibrium reactions in the feet are acceptable. Timed trials should be stopped if either foot moves in space (leaves the support surface) and/or upper extremities support is utilized.

**EQUIPMENT:** a stop watch or watch with a second hand
a twelve inch long masking tape line or two footprints placed heel to toe

**Best Of Three Trials**

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4</td>
<td>able to place feet tandem independently and hold 30 seconds</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>able to place foot ahead of other independently and hold 30 seconds. <strong>Note:</strong> The length of the step must exceed the length of the stationary foot and the width of the stance should approximate the subject's normal stride width.</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>able to take small step independently and hold 30 seconds, or required assistance to place foot in front, but can stand for 30 seconds.</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>needs help to step, but can hold 15 seconds</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>loses balance while stepping or standing</td>
</tr>
</tbody>
</table>

_____ Time in seconds

9. Standing On One Leg

**INSTRUCTIONS:** The child is asked to stand on one leg for as long as he/she is able to without holding on. If necessary the child can be instructed to maintain his/her arms (hands) on his/her hips (waist). A taped line or footprints may be placed on the floor to help the child maintain a stationary foot position. Weight shifting and/or equilibrium reactions in the feet are acceptable. Timed trials should be stopped if the weight-bearing foot moves in space (leaves the support surface), the up limb touches the opposite leg or the support surface and/or upper extremities are utilized for support.

**EQUIPMENT:** a stop watch or watch with a second hand
a twelve inch long masking tape line or two footprints placed heel to toe

**3 Trials Average Score**

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4</td>
<td>able to lift leg independently and hold 10 seconds</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>able to lift leg independently and hold 5 to 9 seconds</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>able to lift leg independently and hold 3 to 4 seconds</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>tries to lift leg; unable to hold 3 seconds but remains standing</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>unable to try or needs assist to prevent fall</td>
</tr>
</tbody>
</table>

Figure. No caption available.
Appendix A: Pediatric Balance Scale Continued

10. **Turn 360 Degrees**

**INSTRUCTIONS:** The child is asked to turn completely around in a full circle, STOP, and then turn a full circle in the other direction.

**EQUIPMENT:** A stop watch or watch with a second hand

( ) 4 able to turn 360 degrees safely in 4 seconds or less each way (total of less than eight seconds)

( ) 3 able to turn 360 degrees safely in one direction only in 4 seconds or less completes turn in other direction requires more than four seconds

( ) 2 able to turn 360 degrees safely but slowly

( ) 1 needs close supervision (spotting) or constant verbal cueing

( ) 0 needs assistance while turning

_____ Time in seconds

11. **Turning To Look Behind Left & Right Shoulders While Standing Still**

**INSTRUCTIONS:** The child is asked to stand with his/her feet still, fixed in one place. "Follow this object as I move it. Keep watching it as I move it, but don't move your feet."

**EQUIPMENT:** a brightly colored object of at least two inches in size, or flash cards

a twelve inch long masking tape line or two footprints placed shoulder width apart

( ) 4 looks behind/over each shoulder; weight shifts include trunk rotation

( ) 3 looks behind/over one shoulder with trunk rotation; weight shift in the opposite direction is to the level of the shoulder; no trunk rotation

( ) 2 turns head to look to level of shoulder; no trunk rotation

( ) 1 needs supervision (spotting) when turning; the chin moves greater than half the distance to the shoulder

( ) 0 needs assist to keep from losing balance or falling; movement of the chin is less than half the distance to the shoulder

12. **Pick Up Object From The Floor From A Standing Position**

**INSTRUCTIONS:** The child is asked to pick up a chalkboard eraser placed approximately the length of his/her foot in front of his/her dominant foot. In children, where dominance is not clear, ask the child which hand they want to use and place the object in front of that foot.

**EQUIPMENT:** a chalkboard eraser

a taped line or footprints

( ) 4 able to pick up an eraser safely and easily

( ) 3 able to pick up eraser but needs supervision (spotting)

( ) 2 unable to pick up eraser but reaches 1 to 2 inches from eraser and keeps balance independently

( ) 1 unable to pick up eraser; needs supervision (spotting) while attempting

( ) 0 unable to try, needs assist to keep from losing balance or falling

Figure. No caption available.
Appendix A: Pediatric Balance Scale Continued

13. Placing Alternate Foot On Step Stool While Standing Unsupported

INSTRUCTIONS: The child is asked to place each foot alternately on the step stool and to continue until each foot has touched the step/stool four times.

EQUIPMENT: a step/stool of four inches in height
a stop watch or watch with a second hand.

( ) 4 stands independently and safely and completes 8 steps in 20 seconds
( ) 3 able to stand independently and complete 8 steps >20 seconds
( ) 2 able to complete 4 steps without assistance, but requires close supervision (spotting)
( ) 1 able to complete 2 steps; needs minimal assistance
( ) 0 needs assistance to maintain balance or keep from falling, unable to try

_____ Time in seconds

14. Reaching Forward With Outstretched Arm While Standing

General Instruction And Set Up: A yardstick affixed to a wall via Velcro strips will be used as the measuring tool. A taped line and/or footprints are used to maintain a stationary foot position. The child will be asked to reach as far forward without falling, and without stepping over the line. The MCP joint of the child's fisted hand will be used as the anatomical reference point for measurements. Assistance may be given to initially position the child's arm at 90 degrees. Support may not be provided during the reaching process. If 90 degrees of shoulder flexion cannot be obtained, then this item should be omitted.

INSTRUCTIONS: The child is asked to lift his/her arm up like this. "Stretch out your fingers, make a fist, and reach forward as far as you can without moving your feet."

3 Trials Average Results

EQUIPMENT: a yardstick or ruler
a taped line or footprints
a level

( ) 4 can reach forward confidently >10 inches
( ) 3 can reach forward >5 inches, safely
( ) 2 can reach forward >2 inches, safely
( ) 1 reaches forward but needs supervision (spotting)
( ) 0 loses balance while trying, requires external support

_____ Total Test Score

Maximum Score = 56
Appendix B: The Wii Balance Board System

(Taken from Wii Balance Board Operations Manual)

“Each subject will go through the Body Test prior to using the system as a therapy tool. The body test includes balance, body mass index (BMI), body control, Wii Fit age, and tracks progress. The balance aspect will test the participant’s center of balance and posture. The Wii system will ask the subjects height and record their weight. It will even ask the participant to provide an estimate of the weight of their clothes in order to achieve the most accurate measurement. Since BMI is normally taken for adults to assess their fitness, the level the accuracy of taking a child’s BMI can be skewed. It could be skewed because of the variability of growth rates in children. Next the system will test your body control. It will randomly select two balance tests. Based on the results from those balance tests, it will compute your “Wii Fit Age”. Before using the system, each subject will make a “Mii”. A Mii is a personalized character each subject will use each time they log into the Wii system. This will keep track of each subject’s progress.”
Appendix C: Wii Balance Board Handout

Balancing on one leg

Leaning your body

Rotating your hips

Moving your body to a rhythm