

The Impact of a Six Week Exergaming Curriculum on Balance with Grade Three School Children using the Wii FIT+™

Dwayne Patrick Sheehan¹ & Larry Katz²

¹Department of Physical Education and Recreation Studies, Mount Royal University, Calgary, Alberta

²Faculty of Kinesiology, University of Calgary, Calgary, Alberta

Abstract

The development of fundamental movement skills (FMS) is at the heart of promoting physical literacy in children. The competence to perform basic motor tasks coupled with the confidence to try new activities will encourage children to embrace a positive attitude about being active for life. Balance is one FMS that can be specifically targeted for improvement and assessment. This paper explores the school-based application of exergaming technology as it relates to balance. Third grade students in this study improved their postural stability significantly over a 6-week period compared to a control group. The improvements in postural stability were also evident in a parallel intervention of children receiving more traditional training in agility, balance and coordination (gymnastics and dance). Gender did not have an effect on the changes in postural stability for either group; however, postural stability in the girls was better than the boys in all tests. Based on the results of this study, it is apparent that for the purpose of improving balance in elementary school children, the use of exergaming is emerging as a practical option available to physical educators. Specifically, the Wii Fit+™ has promising potential as an inexpensive and enjoyable tool for the development of balance.

KEYWORDS: EXERGAMING, ELEMENTARY SCHOOL, CHILDREN, BALANCE, FUNDAMENTAL MOVEMENT SKILLS

Introduction

A well designed elementary school physical education (PE) program plays a vital role in the promotion of basic motor skills learned at home or in preschool. With a foundation of well taught fundamental movement skills (FMS), a child can acquire the competence and confidence necessary to pursue more complicated athletic and fitness pursuits (Atwater, Crowe, Deitz, & Richardson, 1990). Much like with other school skills, there is a learning curve with physical activity known as physical literacy (PL). According to Physical Health and Education Canada (2012), PL is defined as moving with confidence and competence in a wide array of physical activities in various environments that benefit the holistic health and development of the person. The quest for PL requires an early emphasis on learning proper movement skills along with the integration of cognitive, social, and emotional development

(Whitehead, 2005, 2010).

The inclusion of balance instruction in an elementary school PE program lays the groundwork for a child to learn agility, coordination, and an abundance of FMS (Clark, 2007). Teachers use a variety of methods to achieve the outcomes of agility, balance, and coordination. A typical introduction to postural stability in the early grades begins with simplistic static balance (maintaining the centre of body mass over the base of support while standing still) activities with a varying base of support (one leg, two legs). Other activities that require competency in dynamic balance (maintaining the centre of body mass over the base of support while moving) include curricular choices such as gymnastics and dancing.

The introduction of activity-promoting video games (exergames) may be another innovative choice for PE teachers to consider when designing a FMS experience for their students. Exergames have been studied primarily to determine the levels of PA and energy expenditure compared to sedentary behaviors like watching television (Foley & Maddison, 2010; Lanningham-Foster, et al., 2006; Tan, Aziz, Chua, & Teh, 2002; Unnithan, Houser, & Fernhall, 2006). Schools are beginning to consider using exergaming in PE as more evidence accumulates about its use as a calorie burning tool in the fight against childhood obesity (Ni Mhurchu, et al., 2008; Straker & Abbott, 2007). Using exergames as a strategy to develop balance in a school setting underpins the research questions for this paper.

The momentum of the exergaming industry is already starting to influence how Canadian recreation facilities deliver a meaningful PA experience for their members (Staiano & Calvert, 2011). As this technology gains acceptance as an alternative to spin bikes and treadmills in fitness facilities, physical educators may begin wondering about its applications in a school environment. However, not all exergames are designed to meet the same PA outcome. The acquisition of FMS may be possible with the correct selection of an appropriate exergame that emphasizes foundational skills like agility, balance, and coordination.

There is a void in the literature with respect to the application of exergaming and motor development in children. This study investigates the impact of an exergaming curriculum experience on the postural stability of third grade elementary school children.

Physical Literacy in School

The fight against the increasing prevalence of inactive children is a shared responsibility by society in which schools play an important role. Establishing a habit of making healthy choices and pursuing daily PA throughout a lifetime would certainly help in this struggle for children. Mastery of FMS has been shown to be an important factor in preventing unhealthy weight gain among children and youth (Okely, Booth, & Chey, 2004). However, the development of those basic skills is dependent on the ability of physical educators to balance a couple of major considerations. Aside from environmental limitations, the two biggest constraints to motor learning are the difficulty of the task and the skill level of the learner (Hay & Cote, 1998; Okely & Booth, 2004; Okely, et al., 2004).

Developmentally appropriate PE would suggest that a child-centered approach to early childhood movement experiences will provide the best opportunity to explore individual movement potential (Sanders & Stork, 2001). Penney and Chandler (2000) point out that even though motor development is the primary contribution of PE, knowledge, skills, and understanding of body awareness, enjoyment, and expression are all related to the holistic development of children. Therefore, the multi-disciplinary nature of physical development requires consideration of the social and psychological elements when planning and teaching

children's physical activities (Penney & Chandler, 2000).

PL should be promoted and explicitly supported for every child. Although all children have the capacity to achieve their own personalized level of PL, not all of them will master the FMS in the same order or at the same age (Malina, Bouchard, & Bar-Or, 2004; Whitehead, 2007a, 2007b). Children learn FMS in a progressive sequence of identifiable milestones that move toward the acquisition of mature movement capacities (Maude, 2001). All individuals have their own distinctive timetable since the pace and level of physical maturation are individually determined (Brady, 2004). The variety and quality of early skill learning experiences and the freedom allowed to each child to experiment and explore may influence that individual child's chance for acquiring skills earlier or later in comparison to other children. Predictable stages of development are common, but there are also periods of ideal readiness when children are physically, emotionally, and cognitively prepared to learn motor skills (Bayli, et al., 2008; Higgs, et al., 2008).

To increase the likelihood of developmental success, children should experience as many different physical activities as they can (McPherson & Brown, 1988). Early specialization in sports may actually limit a child's ability to learn a wide variety of skills that are important for an active lifestyle into adulthood (Rowland, 1998; Tzetzis, Kakamoukas, Goudas, & Tsorbatzoudis, 2005; Wall & Côté, 2007). The message for professionals that teach or coach elementary-age children is clear: teach an assortment of basic skills in multiple environments to maximize the potential of each child. The greatest emphasis should be on movement skill acquisition during the preschool and early elementary grades (Colvin, Egner-Markos, & Walker, 2000). Emphasis should always be placed on learning basic skills in a non-competitive environment and by having children cultivate relationships in a variety of settings (Brady, 2004; Gould, 1996).

Balance and Postural Stability

Evidence shows that many students dread a traditional PE program because they lack the movement foundation (Morey & Karp, 1998; Wrotniak, Epstein, Dorn, Jones, & Kondilis, 2006). Missing out on the vital building blocks for participation could stifle the opportunity for young people to develop confidence and competence during crucial physical skill development stages. Examples of these FMS are running, hopping, catching, and throwing. These skills are often preceded by the acquisition of agility, balance, coordination, and laterality. Children who have not developed these abilities face difficulties later in situations that require a more difficult skill set (Canadian Sport for Life, 2009). Being unable to participate fully in daily school activities can then lead to feelings of exclusion, low self-esteem, and poor academic performance (Tremblay, Inman, & Willms, 2000). This negative cycle can be improved through creative quality physical education programs with an emphasis on FMS (Canadian Paediatric Society, 2002).

Even during quiet standing, body sway occurs and has been the target of interest in several studies throughout the 20th century (Baker, Newstead, Mossberg, & Nicodemus, 1998; Goodenough, 1935; Peeters, Breslau, Mol, & Caberg, 1984; Seils, 1951). As children develop balance, body sway diminishes and by the time they reach the ages of nine to twelve it is comparable to an adult (Riach & Hayes, 1987; Taguchi & Tada, 1988). A highly referenced study (N = 21, age range = 1.25-10 years) using the Sensory Organization Test (SOT) reported that children between the ages of 7 to 10 exhibited adult-like postural stability (Shumway-Cook & Woollacott, 1985). In addition to the small sample size, this study had an excessive age range of participants, which limits its usefulness. Another study by Forssberg and Nashner

(1982) made a similar claim regarding the postural response of children greater than 7.5 years old. However, it, too had a small sample size ($N = 18$). Conversely, other larger studies reported that the levels of postural sway continued to develop past the age of 10 and possibly until 15 (Hirabayashi & Iwasaki, 1995; Peterka & Black, 1990; Rine, Rubish, & Feeney, 1998; Rival, Ceyte, & Olivier, 2005). A more recent study concluded that adult-like sensory information in children is not demonstrated until age 12 (Peterson, Christou, & Rosengren, 2006). The use of the SOT with a larger sample size ($N = 154$) and smaller age range (6-12 years) in the Peterson et al. (2006) study suggests children continue to develop balance up to and beyond puberty. A Stanford University study of 92 children discovered that all balance parameters from a piezoelectric force plate improved with age until the age of 16 (Wolff, et al., 1998). The conflicting results are influenced by factors such as sample size and advances in technology.

Mickle, Munro and Steele (2011) found that girls have lower postural sway (displacement of the body at waist-level) in a study of dynamic and static postural balance in 8 and 10 year old children. Holm and Vøllestad (2008) also found girls generally performed better at balance tasks than boys between the ages of 7 and 12 years of age. A possible explanation of this gender difference suggests that neurological, visual, vestibular and proprioceptive systems, which are all used for balance, mature earlier in girls than boys (Mickle, et al., 2011).

Balance intervention programs are often simple exercises an individual can do to increase balance, reduce postural sway, and prevent injury. Emery, Cassidy, Klassen, Roychuck, and Rowe (2005) introduced a 6-week home-based balance intervention program for high school students between the ages of 14 and 19 that used a wobble board with increasing interval levels. The average balance scores for static and dynamic increase by 18 seconds and 3 seconds respectively from the baseline measurements. Kidgell, Horvath, Jackson, and Seymour (2007) compared the effectiveness using a dura disc and a mini trampoline as balance intervention methods for adults who have suffer from functional ankle instability. After a 6-week intervention program, all participants had improved balance and postural stability scores. (1996).

Exergaming

Today's youth have become so familiar with technology that any hope of increasing PA must consider this powerful behavioral influence. For example, cellular phone applications (apps) that track activity levels and promote healthy choices are popular with adults and are now being adapted for children. Schools have also embraced the advantages of technology to assist in the instruction of core knowledge such as literacy and numeracy. Contemporary physical educators must, too, consider how the use of technology can promote PA and the benefits of health related fitness.

Constructivist theory suggests that the learner is constantly engaging with incoming new information by connecting it with past experiences that help construct a meaningful understanding to the individual learner (Zhu et al., 2011). Constructivist understanding of information is created by the individual interpretation, relation and integration (Manely & Whitaker, 2011). The greater sense of autonomy and control that results from this method of processing new information leads to an enhanced persistence to learn, enhanced performance, and a more intrinsically satisfying learning experience (Manely & Whitaker, 2011). Given the massive cultural shift in the engagement of children in video gaming, a constructivist's approach could apply that context in the learning environment since it is a relatable medium to convey new information that connects with a child's previous experiences.

Exergaming activities are videogames that require participants to engage in physical movement in order to play the games (Hansen & Sanders, 2008). This unique concept attempts to link exercise and fun by providing stimulating opportunities for video game players to become more physically active. Traditional videogames have long been viewed as a rival to advocates of increased PA in children. However, there is a realization that these opposing views can, in fact, work together as one small part of a solution to the crisis of inactivity. The trend toward this type of videogame has provided an active alternative to traditional sedentary video gaming, making it an appealing supplement for promoting a healthy, active lifestyle (Graf, Pratt, Hester, & Short, 2009). However, caution must be exercised when using technology in any curriculum area. Exergaming must compliment the prescribed PE program and not simply be an opportunity for free play. Additionally, depending on the type of equipment, exergaming in schools can be an expensive endeavor that must be accompanied by a plan to maintain and upgrade equipment.

With sedentary screen time at an all-time high, some research has shown that exergaming is motivating children to be more active in an environment comfortable to them; one based in technology (Lieberman, 1997, 2001, 2006; Prensky, 2001, 2003). Exergaming has been shown to provide the stimulus for engagement to those students who have started to lose interest in more traditional forms of PA (Widman, McDonald, & Abresch, 2006). The graduated levels of contemporary exergaming allow children to progress at a pace that is individualized to their physiological and psychological readiness. The excitement of advancing to a higher and more difficult level can be a powerful motivational tool and the virtual world of exergaming can provide users with a safe, yet exciting, version of reality. Beck and Wade (2004) stated that the attraction to the gaming world was due to the simplicity of the games, the customized reward system, and the highly stimulating entertainment experience that allowed players to escape from boredom.

Researchers have taken advantage of this new active video game technology as a potential tool for balance intervention programs. In a comparison study of traditional balance intervention program using dura disc exercises to an active video game based intervention program that used DDR® and Wii Fit™, researchers found that both methods had significant improvement in balance with the exergaming intervention group outperforming the traditional intervention group (Brumels, Blaisus, Cortright, Oumedian, and Solber, 2008). Vernadakis, Gioftsidous, Ioannis and Giannousi (2012) found that, although an exergaming intervention is effective for improving balance, they did not find a significant difference in results between traditional and exergaming balance methods. Despite the evidence for the effectiveness of exergaming in balance intervention programs, very little research is available on the effectiveness of exergaming training programs for children developing FMS.

A number of studies have suggested that improvements in adult and adolescent postural stability can be shown using a minimum 6-week intervention period. (Emery et al., 2005; Kidgell, et al., 2007; Mansfield, Peters, Liu, & Maki, 2010; Sefton, Yarar, Hicks-Little, Berry, & Cordova, 2011). However, to date there do not appear to be balance studies with six or more weeks of intervention related to elementary school children. This is important because results from studies with shorter time lengths were generally inconclusive (Zech, et al., 2010) although a study by Kliem and Wiemeyer (2010) showed balance effects after only three weeks of intervention.

The current study was designed to investigate the effect of a PE exergaming curriculum on the postural stability of grade 3 (9 and 10 year old) students in a school setting.

The following questions were addressed:

1. Does a 6-week Wii Fit+™ PE exergaming experience and a custom designed agility, balance, and coordination (ABC) PE experience (three times per week) improve postural stability (compared to a control group) as measured by the HUR BT4™ balance platform?
2. What is the relationship between a 6-week Wii Fit+™ and an ABC unit?
3. What is the gender influence on the postural stability of children in this study?

Methods

Participants

The research was conducted during the winter of 2010 and included 67 third grade students (38 females, 29 males, age range of 83-111 months). Parental consent was required for student participation in the study and students could withdraw from the study at any point. The University of Calgary research ethics board approved this study. Two students did not provide permission to partake in the data collection but participated in the activity as part of their PE experience. No injuries, chronic balance disorders, or long-term lower body impairments were identified by the parents of the children involved in the primary study.

Facility and Exergaming Equipment

A 750ft² elementary school stage was converted to a Wii Fit+™ teaching station in a local public school in Calgary, Alberta, Canada. This living lab is currently functioning as the Canadian Exergaming Research Center (CERC; www.ucalgary.ca/exergaming). A privacy curtain was installed to eliminate the visual distractions between the exergaming center and the gymnasium.



Figure 1. Canadian Exergaming Research Centre (CERC).

The Wii Fit+™ Plus (Nintendo, Japan) software was used exclusively with all Wii™ console activities. This exergaming platform offered a variety of activities related to strength, flexibility, balance, and dance (each of which has an element of agility and coordination). Personalized feedback based on basic anthropometric measures is one of the unique customization features of this product. There were twelve Wii Fit+™ stations available in the CERC.

Research Design

A multi-factor, multi-variable repeated measures design with convenience sampling was chosen for this school-based research. The non-equivalent pre-post control group study resulted in minimal impact on student learning and the least amount of disruption for the school. Students participated in this research study as part of their regularly scheduled PE classes which consisted of 34 minutes of activity, three days per week (Monday, Wednesday, and Friday).

Research Groupings

The groups consisted of the pre-existing third grade classes but were randomly assigned to the exergaming intervention, the agility, balance, and coordination (ABC) intervention, or the control group. The ABC group was included in the design to allow for a comparison of the exergaming results to a 6-week unit with similar goals. Both were compared against the control group.

Control Group

Students from the designated grouping referred to as class 3CON. Activities included paddle sports, low organized games, badminton, and fitness Friday circuits. The classes were led by one of the school's PE specialists who used the same teaching techniques and strategies utilized during the school year. The activities selected were part of the preplanned PE year plan.

Wii Fit+™ Group

Students from the designated grouping referred to as class 3Wii. Children participated in a structured exergaming experience using only the Wii Fit+™ Plus. The classes were led by one of the school's PE specialists using curriculum designed by the Principal Investigator (PI) and the lead PE teacher. Daily Wii Fit+™ task sheets were created and all game scores and Wii Fit+™ results were self-recorded by the student. The students were expected to follow the prescribed order of activities listed on the daily task sheet (Appendix A). The activities were chosen from the Wii Fit+™ categories found in Appendix B. If the students completed the prescribed activities they used the remaining class time to return to their favorite Wii Fit+™ activity.

Agility, Balance, and Coordination (ABC) Group

Students from the designated grouping referred to as class 3ABC. Children were instructed by one of the school's PE specialists using a variety of custom designed lessons focusing on agility, balance, and coordination. Dance, gymnastics, and obstacle course activities were included in this unit. A variety of innovative equipment was introduced including duck walkers, jump bands, balance pads, reaction balls, agility ladders, BOSU™ balls, and yoga mats.

Testing Procedures

The pretesting of postural stability with the students was completed in week one of the study. Anthropometric measures and the assessment of postural stability were completed by the PI. Balance testing was done on the HUR BT4™ platform, a sophisticated portable assessment device designed for advanced testing of postural stability (balance). Postural stability is measured using trace length which is how far the participant shifts from the center of pressure

over a 20-second period while performing balance tasks. The sum of the successive straight length segments separated in time by one-fifth of a second provides a measure of postural stability in millimeters (mm). The sampling frequency was set to 50 Hz, which was recommended by the manufacturer to balance consistent data acquisition and manageable data size. The HUR BT4™ platform has a sensitivity of 2mV/V +/- 0.25% and an acceptable combined error maximum of 0.03% (HUR Labs, 2009).

All balance testing was done in the elementary school gymnasium with varying levels of noise and distraction. Students with long hair were asked to ensure their eyes were visible during testing. Students performed all balance testing and exergaming activity with socks on. A new rectangular high density (50 kg/m³) closed-cell Airex Balance Pad (47 cm x 39 cm x 6 cm, 0.7 kg) was used for all tests requiring a foam surface. The balance pad was rotated 180° after each test to ensure even wear. Subjects were given a 10 to 15 second opportunity to get used to the foam pad prior to the first trial of balance testing with the foam. Gymnastics mats were placed around the subject for safety and to decrease the impression that a subject was elevated when testing on a foam pad.

A complete description of the balance trials can be found in Sheehan, Lafave and Katz (2011). Briefly, the non-dominant foot was used to balance on during any single leg trial (subjects were asked which leg they would use to kick a soccer ball in order to establish their non-dominant foot). Subjects were asked to maintain the contra lateral limb in 20° to 30° of hip flexion and 40° to 50° of knee flexion during the single-leg balance tests. During the tandem stance, students were asked to stand heel to toe with their feet as close as possible without touching with the non-dominant foot behind the dominant foot. Hands had to be kept on the hips for all tests.

The study took place over the course of eight weeks, where pretesting occurred in week one, the intervention took place in weeks 2 through 7 and posttesting occurred during week eight. There were a total of 18 PE classes involved in this research over the 6-week period.

Data Analysis

Data were analyzed using SPSS for Windows version 17.0 (SPSS Inc., 2009). A two-way analysis of variance with one repeated measure was conducted to explore the interaction effect for Time by Group and Time by Gender. Simple effect testing was conducted to determine the specific relationship between groups and time. A Pairwise comparison was used to evaluate the mean composite score between each sub-group after the balance pretesting. This investigation was done to determine the uniformity between research groupings at the start of the intervention. An additional Pairwise comparison of the pre and posttest mean composite scores determined the significance of change in postural stability for each group. The observed power of Group x Time was .81 and the partial Eta Squared was 0.139. Using η_p^2 as the measure of association, the interaction between Group and Time accounted for 14% of the total variability in the performance score. According to the convention set by Cohen (1988), this constitutes a large effect.

Exclusion Criteria

This study used the exclusion criteria established by Emery and colleagues (2005). Since the physical activity in this study was part of the required school day, these conditions did not exclude a student from participating, but rather only from the data collection.

Results

Descriptive results from postural stability pre and post testing of are presented in Table 1.

Table 1. Means and Standard Deviation for HUR BT4™ Composite Trace Length Scores (mm).

Group	n	PRETEST		POSTTEST		OVERALL
		<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	Range
Control	M = 8 F = 13	7473	3486	7940	4411	3751-19394
Wii Fit™	M = 12 F = 10	8405	3295	6253*	2451	3717-18904
ABC	M = 9 F = 13	7179	2220	5546*	1137	3917-14132
Total	M = 29 F = 36 Total 65	7689	3042	6559	3080	3717-19394

Note. *A decrease in trace length represents an improvement in postural stability

A 3x2 ANOVA (Table 2) indicated that there was a statistically significant interaction effect when using the HUR BT4™ trace length (mm) as a measure of postural stability ($F(2,62) = 14.32, p < .001$).

Table 2. HUR BT4™ 3 X 2 ANOVA (Time x Group).

Source	df	Mean Square	<i>F</i>	Sig.
Time	1	39,710,000	27.720	.000***
Group	2	20,810,000	1.255	.292
Time * Group	2	20,520,000	14.324	.000***
Error (time)	62	1,432,640		
Residual error	62	16,580,000		

Note. *** $p < .001$

Simple effect testing was conducted to determine the specific relationship between groups and time. A Pairwise comparison was used to evaluate the mean composite score between each sub-group after the balance pretesting. This analysis was done to determine the uniformity between research groupings at the start of the intervention. The evaluation of the pretest means

indicated that there was no significant difference in the starting point of the three groups (Table 3).

Table 3. HUR BT4™ Pairwise Comparison of Pretest Means by Group.

(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.
Control	ABC	294.424	928.785	1.000
Wii Fit™	Control	931.477	928.785	.959
Wii Fit™	ABC	1225.901	917.922	.560

An additional Pairwise comparison of the pre and posttest mean composite scores (Table 4) indicated that there was no significant change in the postural stability of the control group over time ($n = 21$, $p = .211$). The mean composite score for the Wii Fit+™ group was significantly different over time ($n = 22$, $p < .001$). The mean composite score for the ABC group was also significantly different over time ($n = 22$, $p < .001$).

Table 4. HUR BT4™ Scheffe Pairwise Comparison of Pre and Posttest Means by Time.

Group	Pretest	Posttest	Mean Difference	Std. Error	Sig.
Control	1	2	-467.140	369.380	.211
Wii Fit™	1	2	2151.540	360.888	.000***
ABC	1	2	1632.637	360.888	.000***

Note. *** $p < .001$

Percentage of Balance Improvement (by Group)

The students who participated in the exergaming study using the Wii Fit+™ improved their postural stability by 26% (Figure 1). The ABC group had a 23% improvement in postural stability. The improvements experienced by the Wii Fit+™ group were not significantly different from those experienced by the ABC group. The control group had no statistically significant difference in postural stability.

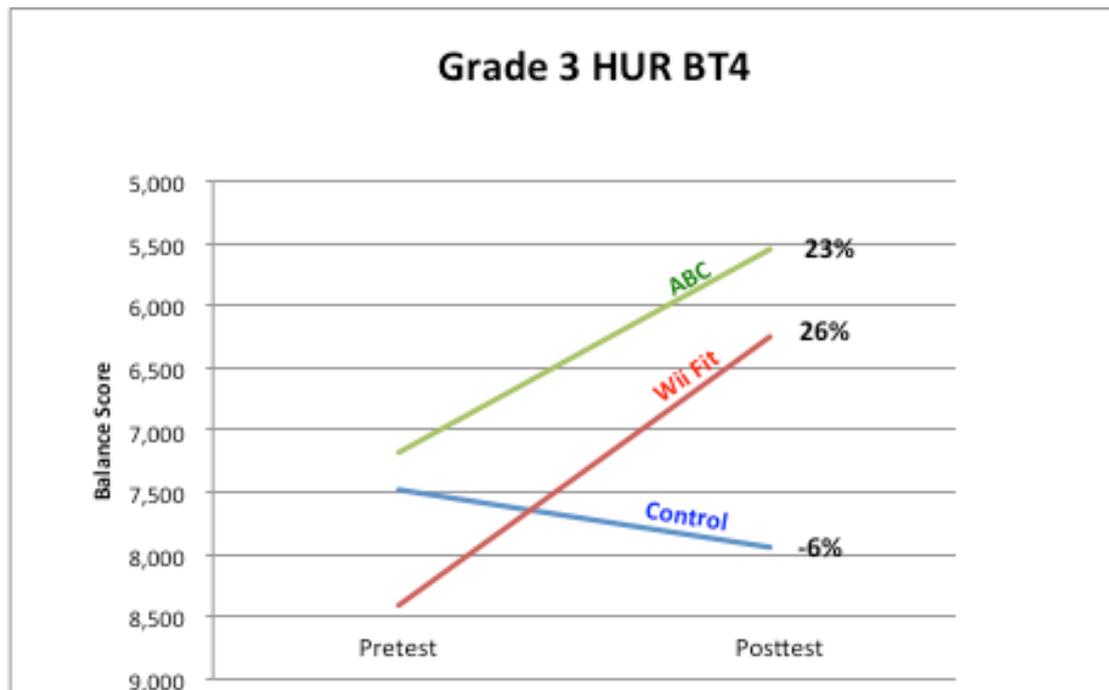


Figure 2. Percentage of balance improvement (by group) using the HUR BT4 balance platform.

Comparing the Percentage of Balance Improvement (by Gender)

The pre and posttest composite mean score of each gender was compared (Table 5). A two-way between-groups analysis of variance was conducted to explore the impact of gender by time, as measured by the HUR BT4™ balance platform (Table 6). There was no statistically significant interaction effect for gender by time ($F(1,63) = .469, p = .496$). However, the girls had significantly better postural stability than the boys ($F(1,63) = 8.252, p < .01$).

Table 5. Mean and Standard Deviation by Gender with HUR BT4™.

Gender	Time	Mean	Standard Deviation
Male	Pretest	8712	2835.85
	Posttest	7780	3795.32
Female	Pretest	6914	2999.75
	Posttest	5635	2005.78

Table 6. HUR BT4™ 2 X 2 ANOVA (Time x Gender).

Source	df	Mean Square	F	Sig.
Time	1	38,980,000	19.052	.000***
Gender	1	123,900,000	8.252	.006**
Time * Gender	1	959,396	.469	.496
Error(time)	63	2,046,132		
Residual error	63	15,010,000		

Note. ** $p < .01$; *** $p < .001$

Discussion

The Canadian Exergaming Research Centre (CERC) was established to investigate the potential of using exergaming technology to develop fundamental movement skills (FMS) in children. Agility, balance, and coordination are at the core of FMS and are the groundwork that other more complex motor skills rely on (Bell, Gibbons, & Temple, 2008; Berry, et al., 2002; Fisher, et al., 2005; Malina, 2008; Okely & Booth, 2004; Okely, et al., 2004). Improving balance can translate to greater confidence and an increased likelihood of participation in physical activity (Claxton, Troy, & Dupree, 2006). The use of exergaming in schools is a novel approach to embedding the training of FMS in the PE curriculum.

To understand the use of exergaming for balance improvement in elementary-aged children to the fullest, three groups of grade three children were studied: an exergaming group (using the Wii Fit™), an enhanced agility training group (ABC) and a standard PE curriculum group which provided a control. The control group posttest assessment of postural stability using the HUR BT4™ platform was similar to their pretest scores. The Pairwise comparison indicated that the change in the control group over time was not significant. The intervention groups of Wii Fit+™ and ABC improved their balance substantially (26% and 23% respectively). As a result of there being no change in the postural stability of the control group, a significant interaction effect occurred among the groups over time. The graph in Figure 1 demonstrates the substantial impact of both training interventions, especially considering there was no statistically significant difference in the starting point of all three groups.

The Wii Fit+™ and ABC data indicates that the use of the Wii Fit+™ three days per week (for 6-weeks) in PE class was relatively equivalent to the traditional ABC training offered for the same amount of time. Both classes were taught by the same physical education specialist. Students in the CERC were participating in a structured class with a combination of designated tasks and free time that had outcomes similar to that of the ABC group. The Wii Fit+™ appears to be an effective tool for helping to improve balance in third grade children. Comparing the intervention results to the control group demonstrates the importance of focusing on the introductory skills of agility, balance, and coordination regardless of whether exergaming equipment is available. The superior balance performance demonstrated by the girls in this study was consistent with the findings of similar research with children.

Congruent with the findings of Brumels et al. (2008) and Vandernakis et al. (2012),

exergaming is an effective tool in PE for balance training. Brumels (2008) stated that participants found the exergaming intervention more engaging, and therefore yielded a higher compliance rate to the program. From a constructivist perspective, this is consistent for children, as this digital generation is already familiar with the technology used in the study. The use of exergames for improving balance builds on existing schemas children already hold about video games. By incorporating them into the class room, it can demonstrate to students that videos games can be both fun to engage in and beneficial to their health.

Based on the results of this study, it is apparent that for the purpose of improving balance in elementary school children, the use of exergaming is emerging as a practical option available to physical educators. Specifically, the Wii Fit+™ has promising potential as a relatively inexpensive and enjoyable tool for the development of postural stability.

Limitations

There were a number of limitations that may limit widespread generalization of the research conclusions. The most obvious constraint is the challenge of conducting scientific research in a functioning school environment. As such, the testing environment cannot be considered clinical as conditions changed on a regular basis (i.e. noise levels). Cost to purchase and maintain equipment may be a limiting factor in widespread uptake of exergaming in schools. Moreover, there is limited technical support available in Canada. However, the students themselves are often helpful and trouble shooting and resolving matters related to the set up and playing of games.

Conclusions and Future Considerations

The development of FMS is at the heart of promoting PL in children (Fisher et al., 2005). It is the competence to perform basic motor tasks coupled with the confidence to try new activities that will encourage children to embrace a positive attitude about being active for life. Balance is one such FMS that can be objectively evaluated and specifically targeted for improvement. Pedagogikinesics is the art and science of teaching FMS, and is becoming a key consideration in the evolution of PE curriculum for both practitioners and researchers (Sherman, 1987). Innovative methods that embed the development of FMS into activities that children enjoy are being introduced in schools (i.e., Bosu™ balls, yoga mats, duckwalkers).

The exergaming movement is another such practice that is being studied as an alternative method of increasing PA levels without regard for the potential as a tool to develop FMS (Lanningham-Foster et al., 2006; Mellecker & McManus, 2008; Unnithan et al., 2006). The evidence provided in this paper suggests that balance is one FMS that can be improved by the strategic and intentional use of exergames. Additionally, the potential for a beneficial change in postural stability and other basic motor abilities may affect children's perceptions of PA by involving them in activities that they enjoy (Sheehan & Katz, 2010).

Subsequent studies should expand the investigation about the potential use of exergaming to develop other FMS such as laterality, coordination, and agility. Simple methods of assessing those skills in PE classes using exergaming technology may also be a topic for future consideration.

Parents, teachers, and recreational leaders can confidently know that based on the discoveries of this study there is a measurable benefit to balance development when using the Wii Fit+™ exergame. Future studies may want to consider studying balance in children by isolating other

exergaming equipment and determining the long-term effects of the intervention. Building on that knowledge, subsequent studies may also want to consider the effect of home-based exergaming use on the acquisition of FMS.

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