ASSOCIATION OF EXERGAMING WITH PHYSICAL LITERACY IN CANADIAN CHILDREN

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PHYSICAL LITERACY IN RELATION TO EXERGAMING IN CANADIAN CHILDREN

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Dedication

"I took a walk in the woods and came out taller than the trees" – Henry David Thoreau

I dedicate this piece of work to my loving family, who never wavered in their support and guidance. My mother, Janice, who always lent an ear and instilled in me the mantra "one step in front of the other and repeat as necessary" and to my father, Michael, who's words of wisdom will remain with me throughout my life. My brothers, Andrew and Chris, who were always there with a glass of whiskey or zombie killing session to relieve the stress.

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Abstract

Prolonged sedentary time in children and youth is associated with decreased physical fitness, motor competence and overall health. Active video games (e.g. exergames) have been suggested as a more active alternative to sedentary screen time. While there is research examining the effect of video game use on specific physiological outcomes, there is limited evidence exploring how they affect the development of physical literacy. This study examined physical literacy using Canadian Assessment of Physical Literacy (CAPL) self-report questionnaires from 317 eight to thirteen year old Lethbridge area children. Independent sample t-tests were used to determine differences between genders as well as exergame users and non-users. Multiple linear regression analyses were conducted to determine if a relationship was present between exergaming time and the overall physical literacy score as well as the individual domains (physical competence, knowledge and understanding, motivation and confidence, and daily behavior). A discriminate function analysis was used to determine if CAPL interpretation group membership could be predicted by weekly exergame use. Sedentary screen-based activities were inversely related to the overall physical literacy score ($P>.001$), whereas exergaming time was not significantly associated with overall physical literacy. Self-reported exergaming time was negatively associated with knowledge and understanding and positively related to motivation and confidence. Our results suggest that increased screen time, regardless of exergame use, is detrimental to overall physical literacy. However, exergaming has the potential to increase children's motivation and confidence.

Keywords: Active Video Gaming; Exergaming; Fitness; Motor Competence; Physical Literacy; Physical Activity; Screen time; Children

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ABC: Agility Balance Coordination
CAPL: Canadian Assessment of Physical Literacy
CSEP: Canadian Society for Exercise Physiology
CVD: Cardiovascular Disease
EX: Exergames
FMS: Fundamental Movement Skills
MVPA: Moderate-Vigorous Physical Activity
MET: Metabolic Equivalent PLAY: Physical Literacy Assessment for Youth
SVG: Sedentary Video Games
TV: Television
VO_{2max}: Maximal oxygen uptake

Chapter 1: Exergaming and Physical Literacy: A Review of the Literature

Introduction

The physiological and psychological benefits of physical activity for children are well known (Janssen, & LeBlanc, 2010), and yet 26% of Canadian children aged five to thirteen are still not obtaining the amount of physical activity that is recommended by the Canadian guidelines for physical activity (Botey, Bayrampour, Carson, Vinturache, & Tough, 2016). In fact, as a group, Canadian children received a grade of D- on both physical activity and sedentary behaviour on the 2015 annual Active Healthy Kids Canada Report card on physical activity (Active Healthy Kids Canada, 2015). Physical inactivity is rising at an alarming rate, which is affecting the short and long term health of children, putting them at a much higher risk for developing conditions such as cardiovascular disease, diabetes, and chronic respiratory diseases (Candeias, Armstrong, & Xuereb, 2010). This situation threatens to put a significant strain on health care and government systems (Specchia et al., 2015). Thus, governments and researchers must attempt to find and promote new ways of dealing with this mounting problem.

The documented increase in physical inactivity among children makes it clear that new recommendations (Hamilton, Healy, Dunstan, Zderic, & Owen, 2008) and methods to improve physical literacy in Canada are needed (Giblin, Collins, & Button, 2014). Physical literacy describes the physical, psychological, and behavioural factors that influence an individual's likelihood of being physically active for life (Whitehead, 2010). Tremblay and Lloyd (2010) state new schools of thought and objective assessment tools are needed to potentially increase children's physical activity participation. Several school systems have begun to use physical literacy measures in their physical education curriculums in order to promote physically active lifestyles (Sheehan & Katz, 2011; Trout & Christie, 2007). Others are examining possible alternatives, including the use of exergaming (video games incorporating motion) as a way to improve physical literacy (George et al., 2016; Sheehan & Katz, 2010).

Given the importance of this problem, and the potential impact of exergaming on children's health and well-being, there is an urgent need for rigorous empirical research examining the impact of exergames on physical literacy. This paper provides a foundation for such research by documenting our current understanding of how sedentary screen time and exergaming may influence children's physical literacy. I will then carefully define the concept of physical literacy, discussing current methods and protocols used for its measurement, and highlight its association with motor skill competencies. I will conclude by summarizing what we know about exergaming and its relationship to children's physical literacy as well as identifying future research directions of inquiry.

Sedentary Behaviour and Childhood Inactivity

Physical inactivity in Canadian children has increased substantially in the last several decades (Colley et al., 2011). The new Canadian Sedentary Behaviour Guidelines recognize two distinct types of sedentary behaviours: screen-based sedentary behaviours (TV, computer games, YouTube, etc.) and non-screen sedentary behaviours (Reading, writing, painting, etc.; Tremblay et al., 2011). Average sedentary behaviour and physical inactivity are inextricably linked, however, they are distinctly different. Sedentary behaviour can be described as being in a seated or reclined posture using 1 to 1.5 METs (Metabolic Equivalents; Sedentary Behaviour Research Network, 2012) while physical inactivity is understood as not obtaining government recommendations for physical activity, or not being physically active (Tremblay et al., 2011). Canadian children spend an average of 8.6 hours per day (62% of their waking hours) engaging in various screen- and non-screen based sedentary pursuits (Colley et al., 2011). The most commonly reported cause of increased of childhood inactivity is increased time spent involved in screen-based behaviours.

The significant increases in physical inactivity reported worldwide have now been estimated to be the fourth leading cause of death in adults (Kohl et al., 2012). One potential negative health impact of excessive sedentary behaviour is the increase in childhood obesity (Birmingham, Muller, Palepu, Spinelli, and Anis, 1999; Wang & Lobstein, 2006). Child and adolescent obesity rates in Canada have consistently increased over the past four decades and are currently reported at thirteen percent (Carroll, Navaneelan, Bryan, & Ogden, 2015). This increase is significant, as children who are overweight tend to have a harder time maintaining a healthy weight during adulthood (Daniels, 2006). Accordingly, the rate of adult obesity has increased correspondingly, with research predicting further increases (Twells, Gregory, Reddigan, & Midodzi, 2014).

The effects of screen and sedentary time on adiposity, obesity, morbidity, and mortality in adults are well known (Clark et al., 2011; Schmidt et al., 2012; Stamatakis, Hamer, & Dunstan, 2011). Stamatakis et al. (2011) posited that increased screen-based sedentary time could play a role in cardiovascular disease (CVD) and decreased future quality of life. It is possible that screen-time also increases the risk of obesity by promoting poor food choices as a result of excessive exposure to fast-food advertisements (Schmidt et al., 2012). This unhealthy food in combination with screen-based sedentary time can cause a plethora of negative outcomes in children and continue into adulthood including, but not limited to, diseases such as obesity (Boone et al., 2007; Vandewater, Shim, & Caplovitz, 2004; Laurson, et al., 2008; Tremblay, & Willms, 2003), metabolic syndrome (Mark & Janssen, 2008), and cardiovascular diseases (Chaput et al., 2013; Ekelund, et al., 2012).

Three mechanisms for the association between leisure screen time and obesity have been proposed: 1) reduced energy expenditure as a result of screen time displacing physical activity (Durant, Baranowski, Johnson, & Thompson, 1994; Robinson & Killen, 1995); 2) increased energy intake resulting from eating while watching television (TV) or an alteration in diet as a result of the food advertisements (Taras, Sallis, Patterson, Nader, & Nelson, 1989; Story & Faulkner, 1990); and 3) decreased resting metabolic rate while watching television (Mark & Janssen, 2008).

Screen Time

Screen-based activities have become more popular in recent years due to an inundation of electronic entertainment devices, whether they are TV, computer, phone, or tablet (Melkevik, Torsheim, Iannotti, & Wold, 2010). Children in Canada reportedly spend an average of 49 minutes a day playing video games and up to two hours a day participating in other screen activities such as television viewing or computer use (Daley, 2009; Hansen & Sanders, 2010). For children today, technology is an integral part of their lives and, as such, screen use dominates children's spare time (Sheehan & Katz, 2010; Gentile, 2009; Leblanc et al., 2015).

One factor that has been proposed to be driving this issue is the increased use of screen-based media in both school and home settings. Children today are frequently exposed to screens whether it is at home or school (Leatherdale, Faulkner, & Arbour-

Nicitopoulos, 2010), and this inundation causes shifts in perceptions and acceptance of being sedentary as a part of life and can negatively influence children's physical activity levels (Boone, Gordon-Larsen, Adair, & Popkin, 2007; Busch, Manders, & De Leeuw, 2013; Sandercock, Ogunleye & Voss, 2012). Canadian children have been reported to not meet government physical activity or screen time recommendations (Hinkley, Salmon, Okely, Crawford, & Hesketh, 2012), which in turn has been circumstantially correlated with increased likelihood of childhood obesity (Barnett et al., 2010) as noted above.

Video games are a prevalent screen-based behaviour in North American children (Zackariasson, & Wilson, 2012). The use of video games in North America has doubled in the last 10 years (Zackariasson, & Wilson, 2012), and the increase is due in large part to children being exposed to them at a younger age (Zimmerman, Christakis & Meltzoff, 2007), as well as, the greater breadth of distribution (Gentile, 2009). There is extensive research exploring the effects of excessive screen time on health and physical activity, the results are mixed. Hinkley et al. (2012) suggest that physical activity, as well as motor competence, are negatively influenced by sedentary screen time. Meier, Hager, Vincent, Tucker, and Vincent (2007) demonstrated that a decrease in screen time resulted in increased physical activity in children aged five to twelve. The observed increase in physical activity was demonstrated by an increase in step count, which has been suggested to influence weight status and obesity risk (Meier et al., 2007). In addition, increased body mass index (BMI) and physical inactivity are strongly correlated and thought to be a result of sedentary screen time (Garrett, Brasure, Schmitz, Schultz, & Huber, 2004). While multiple studies have found a negative correlation between screen time and physical activity (Snoek van Strein, Janssens & Engels, 2006; Parsons at al., 1991; Laurson, Eisenmann, Welk, Wickel, Gentile, & Walsh, 2008), others found no relationship (Hager, 2006). Hager (2006) suggests that these contradictory findings could be a result of not controlling for seasonal effects and higher socioeconomic status leading to increased opportunity for physical activity in some of the samples. The results appear to be mixed as to the impact of sedentary screen time on physical activity in children. Nevertheless, a consensus seems to be growing that screen time has a negative effect on health status and motor development in children (Pearson, Braithwaite, Biddle, Sluijs, & Atkin, 2014). The potential adverse effects of excess sedentary screen time have resulted in active screen time alternatives being developed and researched.

Exergaming

In response to criticisms about the impact of screen time and video gaming on physical inactivity, health, and obesity, game developers have started to capitalize on the opportunity to transform these inherently sedentary behaviours into opportunities for physical activity. A new class of video game designed to encourage physical activity are called exergames (Sween et al., 2014). Exergaming describes motion or activity-based video games that attempt to increase the energy expenditure of computer/video gaming. Instead of using traditional simple finger or hand movements, exergames use the player's full body movements to play virtual sports, participate in group fitness exercises, or other interactive physical activities, as an active alternative to traditional sedentary video gaming (Mears & Hansen, 2009; Sheehan & Katz, 2010). Exergames typically involve dance or sports movement (swinging a tennis racquet, bowling, boxing, etc.) activities and require the player to move in order to interact and play.

Before exergaming, exercise and video gaming were distinctly and fundamentally separate activities. This dichotomy was true until the release of the Sony Eye Toy in 2003 and the Wii in 2006, which allowed players to "act" or "perform" motions that controlled the game. Another popular and well-documented type of exergame is "Dance Dance Revolution" (DDR) which makes users step to a certain pattern or speed (Yang, 2010; Maloney et al., 2008). Dance based exergames have been shown to increase moderate to vigorous physical activity (MVPA) as well as increase energy expenditure by two to three times resting values (Bailey, & McInnis, 2011; Graf, Pratt, Hester, & Short, 2009; Lieberman, 2006). Siegel, Haddock, Dubois and Wilkin (2009) found that DDR increased motivation and desire to be physically active in activities other than exergames. This finding may be one of the most significant findings as it discusses the post exergame bout behaviour, which seems to elicit positive feelings in regards to physical activity. Since the invention and dispersion of these consoles, development and sales of movement-based video games have increased exponentially (Gentile et al., 2009; Gentile et al., 2011).

There are three main potential benefits of exergames: increased energy expenditure (Graves, Ridgers, Williams, Stratton, & Atkinson, 2010; White, Schofield, & Kilding, 2011), development of fundamental motor skills (George et al., 2016; Sheehan & Katz, 2010; Vernadakis, Papastergiou, Zetou, & Antoniou, 2015) and increased motivation to participate in physical activities (Gao, Podlog & Huang, 2013; Siegel et al., 2009; Sun, 2012). One of the benefits of exergaming is an increase in energy expenditure during participation compared to that of traditional, sedentary video gaming. Exergaming can provide a way for children to increase energy expenditure and levels of physical activity so that they can meet the reported guidelines of 60 minutes of moderate to vigorous intensity physical activity a day for at least three days a week (Botey et al., 2016). Compared to video games where the player is typically seated and using a controller, exergaming can be a healthier choice since it increases energy expenditure during use (Graves, Ridgers & Stratton, 2008; Prot, McDonald, Anderson & Gentile, 2012; Sween et al., 2014). Children who play exergames experience increased heart rates, total body movements, and energy expenditure (Graves et al., 2010). In fact, the intensity experienced while playing Wii Boxing and DDR are reported to be similar to the current physical activity for intensity and duration recommendations for children (Bailey & McInnis, 2011).

Exergaming can elicit light to moderate intensity activity through the alteration of a typically sedentary activity (Graves et al., 2010). For example, it was estimated that if the most frequent users of sedentary video games in the United States replaced sedentary gaming with exergaming using the Wii Fit, this would result in an increase in total energy expenditure of 4.5% a week. If this increase was sustained, this could contribute to weight management (Graves et al., 2010). For children who normally spend a great deal of time participating in sedentary video games, new generation exergames can prove to be a means of providing entertainment and increased energy expenditure (Graf et al., 2009; Siegel et al., 2009).

In terms of increased energy expenditure over sitting, Lanningham-Foster et al. (2006) found a significant increase in energy expenditure between seated and standing video games, which suggests that any movement while standing is better than sitting. Other studies have reported increases in VO2 max, and physical activity levels and decreases in resting heart rate due to regular use of exergames (Lambogila et al., 2013). Other researchers assert that, although these games are better than sitting, they are still not an adequate replacement for moderate to vigorous physical activity (Daley, 2009). Another proposed benefit of exergaming is that it helps develop Fundamental Movement Skills (FMS) in children.

Exergaming has been identified to potentially develop physical literacy and to combat childhood physical inactivity (Sheehan & Katz, 2010). Sheehan and Katz (2011) suggest that exergames could potentially improve FMS, physical fitness and interest in physical activity to improve physical literacy. A correlation has been found between exergaming ability and some FMS like catching, throwing, or kicking to hit a target, and balance (George et al., 2016; Reynolds, Thornton, Lay, Braham & Rosenberg 2014; Sheehan & Katz, 2010). These are important findings as exergames are becoming more socially acceptable for use in school physical education programs, which are designed to include FMS acquisition. Staiano and Calvert (2011) reported that increasing the utilization of exergames in classrooms has a mental, as well as physical benefits, such as increased concentration and productivity. Recent studies have examined the practicality of tools like the virtual gym (an instructional tool for teaching FMS through virtual game interaction) in the school setting and found that exergames have the potential to improve motor skill competence and the understanding of movement principles (Fiorentino & Gibbone, 2005; Staiano & Calvert, 2011). However, further research is required to compare these tools to traditional PE learning outcomes and their impact on physical literacy. Research needs to focus on the costs and benefits of exergaming, as well as the reduction of video games as they are becoming more ingrained in society and are more socially acceptable (Pasco, Bossard, Buche, & Kermarrec, 2010).

Lastly, exergames have been examined for their effects on intrinsic motivation and interest to be involved in physical activity. Activities that are exceedingly intrinsically motivating attract attention and illicit positive feelings about the activity which may lead to activity continuation (Hidi & Harackiewicz, 2000). Sun's (2012) study aimed to assess the differences between 4 weeks of both exergaming and fitness curriculums on motivation and situational interest. Sun (2012) reported that situational interest was significantly higher in an exergame experimental group than the traditional gym class curriculum following the 4 week study duration. Furthermore, observations on the effects of exergames suggest these active videogames increase moderate to vigorous physical activity (MVPA; Gao et al., 2013) and individuals' motivation to be physically active outside of screen-based behaviours (Siegel, Haddock, Dubois, & Wilkin, 2009; Dos Santos, Bredehoft, Gonzalez, & Montgomery, 2016). Dos Santos et al. (2016) also found that children who underwent a 7-week exergaming intervention were more likely to be involved in a new sport during a 1 and 2 year follow-up period. The preliminary research regarding exergames seems encouraging, and exergaming does seem to have advantages over sedentary video games. However, the impact of exergaming on FMS and physical literacy needs further research before a consensus can be reached; especially about their use as PE substitutes.

Physical Literacy

The concept of physical literacy emerged in the late 80's (Whitehead, 1990) in an effort to understand the decline in children's physical activity in a more comprehensive manner. Physical activity and physical literacy are fundamentally linked as those who enjoy and participate in physical activity are more likely to have the skills, fitness, motivation, and knowledge to continue this positive lifestyle throughout their life. Canadian provincial governments have begun to acknowledge the potential of developing physical literacy programs to possibly prevent obesity by improving school curriculums and promoting sport participation (McKean, 2013). Through these programs children are afforded the opportunity to develop the skills and knowledge that will allow them to become, and remain, active for life. Although improving physical literacy has been endorsed as having the potential to positivity impact the obesity crisis, limited research has been done to determine the multitude of factors that influence a child's physical literacy development.

Physical literacy encompasses both the physical and mental factors that influence the likelihood of an individual to be physically active throughout their life (Whitehead, 2014). Physical Health and Education (PHE) Canada describe physical literacy as "moving with competence and confidence in a wide variety of physical activities in multiple environments that benefit the healthy development of the whole person" (PHE Canada, n.d.). While this definition accurately identifies the physical and physiological components of physical literacy, it does not provide concrete measurable facets which makes research using this definition difficult. Whitehead discusses this shortcoming and proposes a more holistic definition of physical literacy "the motivation, confidence, physical competence, knowledge and understanding, to value and take responsibility for engagement in physical activities for life." (Whitehead, 2010, p. 5). This definition arguably provides more measurable outcomes and highlights that physical literacy is a life-long journey not something that you can obtain. Using this working definition, Tremblay and Lloyd (2010) suggest that the first step in understanding the link between childhood inactivity and physical literacy should involve the development of a rigorous method of assessment.

Assessing Physical Literacy

Given the increasing concern pertaining to children's physical activity levels, and overall physical condition, there has been a demand for a universal standard physical literacy assessment tool from educators and government (Tremblay & Lloyd, 2010). An assessment tool that can provide policy makers with objective and holistic evidence upon which to make policy decisions about what needs to be done to increase physical literacy in Canada is the goal of many agencies (Tremblay & Lloyd, 2010). In an attempt to measure and encourage physical literacy levels in Canadian children, several tools have been developed: the Physical Literacy Assessment in Youth (PLAY) program released in 2013, the Passport for Life program, and the Canadian Assessment of Physical Literacy (CAPL) program which was developed by The Healthy Active Living and Obesity Research Group (HALO) in 2008.

Physical Literacy Assessment for Youth (PLAY)

The (PLAY) tools were designed by Dr. Dean Kriellaars to improve Canada's physical literacy levels (Physical Literacy Assessment for Youth, n.d.). Directed toward individuals aged seven and up, the PLAY tools determine gaps in physical literacy development, and provide solutions to help improve these areas (Physical Literacy Assessment for Youth, n.d.). The PLAY tools aim to assess motivation, participation, and physical coordination in a sports setting. They are designed to assess children's physical literacy through parents, coaches, and teachers reporting on physical activity and sedentary behaviours. These tools assess individual aspects, or specific contexts, of physical literacy, and provide guidance on how to develop a program to encourage physical literacy. A limitation of these tools on a wider scale is their inability to account for the psychological and daily behaviour factors related to physical literacy. For example, the PLAY parent forms, questionnaires designed for parents asking questions about their children's physical literacy, employ a scale that suggests children to be on a continuum ranging from "not physically literate" to "perfect physical literacy". This scale implies that the development of physical literacy is restricted, which contradicts the belief of other researchers that physical literacy is a lifelong journey without finite limits (Whitehead, 2010). Given these limitations, it is perhaps not surprising that the validity and reliability of these protocols have not been assessed in academic research (Longmuir et. al., 2015).

Canadian Assessment of Physical Literacy

Responding to the lack of an valid and reliable instrument to assess physical literacy, the Canadian Assessment of Physical Literacy (CAPL; Longmuir et al., 2015) was developed as a measurement protocol that can be used to assess the domains of physical literacy originally discussed by Whitehead (2010): motivation and confidence; physical competence; knowledge and understanding; and daily behaviour. Figure 1 demonstrates a model of the four domains of the CAPL. These four domains provide a holistic view of an individual's current physical literacy and may provide an indication of the likelihood of continued participation in physical activity throughout the lifespan (Francis et al., 2016). These domains can also be used to determine specific areas that could be improved upon, while also giving an aggregate score to provide an easily understood assessment of the physical literacy of an individual.

This tool was designed to reliably assess a broad spectrum of skills and abilities that contribute to, and characterize, the physical literacy level of a participating child

(Longmuir et al., 2015). The CAPL assesses physical literacy in four domains by examining daily behaviours, physical fitness, motivation and confidence, knowledge and understanding, and motor skill proficiency (Tremblay & Lloyd, 2010). Each of the physical literacy domains are measured using specifically designed instruments and protocols to create a holistic understanding of each student's level of physical literacy. Motor competence is assessed using an obstacle course that includes dynamic motor skills such as, hopping, skipping, kicking, catching, sliding and throwing. Daily behaviour is objectively measured using both pedometers, to determine the number of steps taken, and a self-reported account of pedometer wear time over a seven day period. Physical fitness is assessed with measures of aerobic fitness, muscular strength and endurance, flexibility, and anthropometric measures. Motivation and confidence, as well as knowledge and understanding, are assessed using the Physical Education Knowledge Questionnaire, which measures children's knowledge regarding health, physical fitness, motor skills, physical activity preferences, as well as attitudes and beliefs regarding health and fitness-related variables (Tremblay & Lloyd, 2010). This tool provides holistic evidence of physical fitness, physical activity and the respondent's likelihood of continuing with physical activity using reliable and validated research instruments.

Passport for Life

The Passport for life program was designed to increase knowledge, awareness, and understanding of physical literacy in Canada (PHE Canada, n.d.). This program includes assessment in the following areas: fitness and movement skills and active participation in sport. The program provides tools that help parents and educators to interpret results, as well as resources that a) are specific to improving physical literacy levels in children and b) help to enhance knowledge and competence of physical education teachers. The passport for life program is a relatively new physical literacy tool which puts much emphasis on developing physical education teacher's competence and programs for developing physical literacy. To date, no published research has attempted to validate these tools or use these measures in research.

These three physical literacy assessment and development tools all place significant importance on the acquisition and practice of specific FMS as they are thought to be fundamental in order to afford individuals the opportunity to be physically active for life. The Physical and Health Education Canada website states that: "To become completely physically literate, children need to master the fundamental movement skills" Motor competence and FMS are viewed as integral to the development of a child's physical literacy (Whitehead, 2010).

Motor Competence

Motor competence has been demonstrated to be positively associated with physical activity participation, cardiorespiratory fitness, and muscular strength and endurance (Robinson et al., 2015). Furthermore, perceived competence and health status are also positively influenced by motor competence (Hands, Larkin, Parker, Straker, & Perry, 2009). In contrast, low motor competence is associated with lower cardiorespiratory fitness and physical activity levels in children and adolescents (Hardy, Reinten-Reynolds, Espinel, Zask, & Okely, 2012). Lack of motor competence is hypothesized to lead to a negative spiral of disengagement in physical activity as children lack the competence and confidence to move and thus, will not enjoy participation in activities where they understand they will not be successful. Thus, motor competence development is paramount in early childhood to increase physical literacy and has the potential to promote physical activity throughout the life course (Goodway, Famelia, & Bakhtiar, 2014).

Over the past few decades FMS, and consequently motor competence, have been steadily declining in western countries (Roth et al., 2010) and have been posited as one of the causes of childhood inactivity (Hardy et al., 2012; Kantomaa et al., 2011; Okely, Booth, & Chey, 2004; Tester et al., 2014). These findings are of major concern as high motor competence has been linked with positive outcomes in both physical activity and weight status in children (Lubans et al., 2010; Spessato, Gabbard & Valentini, 2013). Furthermore, motor competence predicts levels of physical activity and fitness later in life (Barnett, Van Beurden, Morgan, Brooks, & Beard 2009; Jaakkola, Yli-Piipari, Huotari, Watt, & Liukkonen, 2016; Lloyd, Saunders, Bremer, & Tremblay, 2014; Loprinzi, Davis, & Fu, 2015). Given these findings, it is important to examine and monitor motor competence during childhood in order to provide appropriate strategies to support children's motor development.

Children who lack FMS are more likely to experience frustration and difficulty learning more advanced skills, thereby reducing their enjoyment of sport and physical activity (Stodden et. al., 2008). Consequently, a lack of enjoyment in physical education classes has been shown to have a negative effect on perceived competence and physical activity behaviours (Carroll & Loumidis, 2001). Côtè, Lidor, and Hackfort (2009) suggest that children who do not develop the skills necessary to be physically active are more likely not to participate or withdraw from organized sport earlier. Therefore, children who possess the FMS are more likely to play and enjoy sports, while those who lack the motor competence are often left out of physical activity and sports opportunities. This activity disengagement creates a vicious circle as those children that lack FMS do not participate, which results in decreased practice and play time to learn these FMS (Whitehead, 2010).

The development of movement competence emerges from the learning and practice of FMS (PHE Canada, n.d.). FMS are thought to be the building blocks of movement and thus one of the fundamentals of physical literacy (PHE Canada, n.d). The development of FMS, such as running, hopping, kicking, and throwing, can lead to enhanced feelings of confidence and competence and often precede more sport specific skills such as agility, balance, and laterality (Sheehan & Katz, 2010). The aforementioned research suggests that the health and physical activity benefits associated with the development of FMS warrant the inclusion of the fundamental movement skills in physical education classes and curriculum (McKean, 2013).

Mastery of FMS can have a direct and lasting effect on the health and fitness of children. Studies have shown that children with greater FMS competence tend to be more physically active, typically demonstrate higher aerobic fitness (Okely et al., 2001) and self-esteem (Ulrich, 1987), and are less likely to be overweight (Okely et al. 2004). Despite heightened awareness of the overall importance of these FMS and efforts to improve them, sedentary behaviours, obesity and screen time are still on the rise in Canada (Colley et al., 2011; Melkevik et al., 2010).

Clearly, if exergaming is to be seen as a solution for the problems of inactivity, evidence of the impact of exergaming on PL and the development of FMS is required.

Conclusions

Physical inactivity is an increasingly prevalent problem among Canadian children that has significant current and future negative health implications. While sedentary screen time has many negative health outcomes associated with it, activity and motion-based video games have the potential to be an effective alternative to sedentary leisure time. This is not to say that exergaming can, nor should it, be a complete substitute for MVPA, however, the assumption is that it is better than being sedentary while participating in screen-based entertainment and may have the potential to provide some MVPA for largely inactive children. Tests of this assumption are required before mass adoption of the virtual gym or exergames in homes or school curriculums.

Research is beginning to explore the potential for exergames to aid in this problem by being used to develop FMS and physical literacy in children. Exergames have been shown to increase energy expenditure similar to that of traditional physical activity, increase children's motivation to be physically active, and increase FMS skill acquisition which may lead to more physically literate children. While positive effects have been found on all of these outcomes, the level of activity is often compared to that of sedentary video games and not physically literate, active children. In addition, most of these studies were conducted within a lab or controlled setting which may not get at whether exergames are effective within the home environment. In addition, many studies only measure physical activity which does not get at the individual motivation or confidence factors necessary to understand physical literacy behaviours and attitudes. The impact of exergaming on physical literacy is not clear. Comparing the research to date has been limited by the lack of standard measures for assessing physical literacy. Ignoring the important influencing factors that make up physical literacy may explain why the results of the current research are inconsistent.

Several new approaches to measure and develop physical literacy have emerged over the last ten years (PLAY, CAPL, PASSPORT). However, only the CAPL focuses on providing a rigorous, valid, and reliable way to measure physical literacy. The CAPL literacy protocol provides researchers with a standard tool to assess physical literacy, and this tool will allow for a more holistic understanding of the underlying factors that affect the development of physical literacy. Expanding the outcome measures of research from simple measures of physical activity to more broad-based measures such as the CAPL allow us to develop a more sophisticated understanding of the interaction of physical and psychological elements of physical activity with exergaming.

This research agenda would aid policy makers, game designers, and researchers. Policy makers in school boards, community governments and education ministries trying to address the growing obesity and sedentary behaviour problems are turning to game designers for a more child-friendly approach to helping children develop the FMS and physical literacy required to live healthy lives. Providing objective measures of the results that can be expected from exergaming will help them to develop such programs. Game designers are attempting to develop alternative markets for their games as contributing to health and physical literacy. Providing them with clear direction on what aspects of physical literacy their games currently improve provides them with marketing information and direction for improving future generations of these games. Finally, providing evidence of the impact of using common, reliable measures of physical literacy and its relationship to exergaming will provide a foundation from which other researchers can develop further more sophisticated ways to contribute to theory and practice of physical literacy development.

Hypothesis and Purpose

While interest in the potential effects of exergames on physical activity and physical literacy is ongoing, empirical evidence to illustrate these effects are limited. Motor competence is an integral and central component of physical literacy and as such is an area for which the effects of active video games could potentially influence. Studies examining these effects largely focus on stationary or relatively simple movement patterns which are fundamental to physical activity engagement, however, examining more complex movements may provide a better indication of the effects of exergames.

The purpose of this thesis was to examine the effect of exergames on physical literacy and more specifically on the motor competence, knowledge and understanding, and motivation and confidence domains. Based on this review of the literature, small to modest increases in both motor competence and physical literacy score were anticipated with greater reported exergame use. In addition, we expected that sedentary screen time (both TV and Videogame) would have moderate to large negative effects on physical literacy development in children.

Chapter two presents the relationships between exergaming and physical literacy as well as predictions of physical literacy score based on exergame use. Finally, to conclude, a general discussion will summarize the implications of the study on educational policy, exergaming design and physical literacy research.

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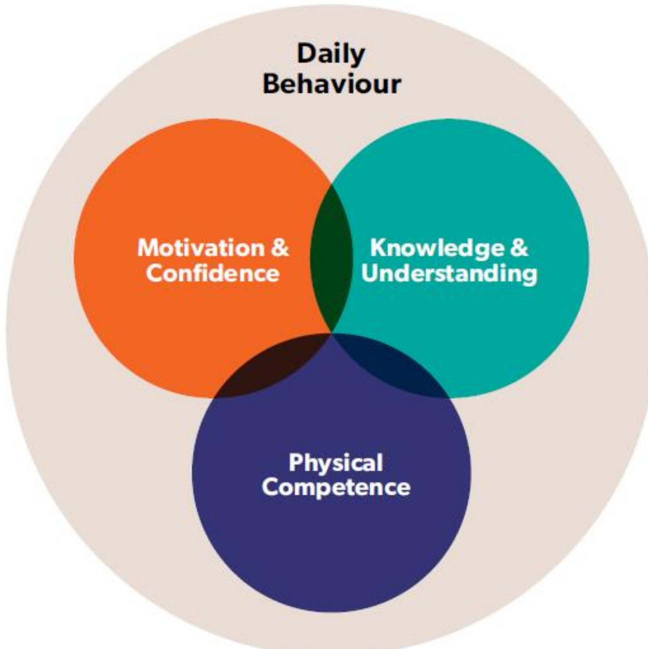

Figure 1.1 A model of the four domains of the CAPL

Chapter 2: Comparing the Effects of Sedentary Behaviours and Exergames on Physical Literacy in 8-12-year-old Children in Lethbridge and Surrounding Area

Introduction

Canadian children spend an average of nearly eight hours per day engaging in sedentary behaviours (Colley, Garriguet, Janssen, Craig, Clarke, & Tremblay, 2011), and 26% percent of children exceed the nationally recommended maximum of screen time two hours per day (Botey, Bayrampour, Carson, Vinturache, & Tough, 2016). This reported increase in leisure sedentary and screen time has been linked to increases in body mass, and subsequent obesity in Canadian children (Colley et. al, 2011; Tremblay & Willms, 2003). The decline of childhood physical activity and the increase in obesity are often attributed to an increase in leisure sedentary screen time (Barnett et al., 2010; Hands, Chivers, Parker, Beilin, Kendall, & Larkin, 2011; Tremblay & Willms, 2003). To help understand the increase in childhood inactivity and screen time the concept of physical literacy has gained momentum in the last decade. Physical literacy is an important factor in childhood development and encompasses the physical, psychological, and behavioural factors that influence the likelihood of an individual being physically active throughout a lifespan (Whitehead, 2010). Physical literacy includes four main domains: knowledge and understanding, motivation and confidence, daily physical behaviour, and physical competence (Longmuir et al., 2015). Developing physical literacy early in a child's life is critical for enabling lifelong participation in various physical activities. Current research in this area suggests that there is an inverse relationship between sedentary screen time and physical activity; which may in turn influence physical literacy (Gebremariam et al., 2013).

Video game use is a significant contributor to the increase in sedentary screen time and has been increasing significantly over the last 15 years largely due to two significant changes to the market; younger children are being exposed to video games earlier (Zimmerman, Christakis, & Meltzoff, 2007), and a greater breadth of distribution of games (Gentile, 2009). In recognition of the childhood inactivity epidemic, new video games have been developed that incorporate movement and physical activity into their gameplay. These active video games or “Exergames” allow people to physically interact with the game through large gross movement and small hand-eye coordination skills. While there is much research examining the effect of sedentary behavior (e.g., video game use and TV time) on specific physiological and psychological outcomes, there is very little literature on how dynamic screen time or exergaming may affect the development of physical literacy or motor competence.

There are three main proposed benefits of exergames. First, it is argued that they have the potential to increase energy expenditure higher than that of traditional videogames (Bailey, & McInnis, 2011; Graf, Pratt, Hester, & Short, 2009). Second, along with the physiological and metabolic effects examined above, researchers have suggested exergames can potentially increase fundamental movement skill (FMS) acquisition. Recently, Sheehan & Katz (2010) examined the effects of 8 weeks of an exergaming protocol on balance performance and found a significant improvement on quiet standing performance in exergaming conditions when compared to traditional gym class curriculum. Exergaming has also been shown to increase manual dexterity and throwing and catching skills (George, Rohr, & Byrne, 2016). The final proposed potential benefit of exergames is the gateway theory (Gao, Zhang, & Stodden, 2013; Roemmich, Lambiase, McCarthy, Feda, & Kozlowski, 2012). This theory is based on observations that exergames increase moderate to vigorous physical activity (MVPA; Gao et al., 2013) and individuals' motivation to be physically active outside of screen-based behaviours (Dos Santos, Bredehoft, Gonzalez, & Montgomery, 2016; Siegel, Haddock, Dubois, & Wilkin, 2009).

Exergaming has potential as a solution to the challenge of excessive sedentary behaviour and its possible impact on physical literacy in children. Thus, the primary purpose of this study was to determine if there is a relationship between exergame use and physical competence, knowledge of physical activity, and motivation and confidence.

Methods

Participants

The present analyses were conducted using data from 317 children (n= 136 males and n= 181 females) between the ages of eight to thirteen (11.14 ± .84 yrs). Twenty-five classes from eight schools within three Lethbridge area school divisions participated in this study. Of the 317 children, 182 (57.4%) reported using an exergaming system (Wii, Kinect, DDR, etc.) within the last month; 49.5% of exergame users were boys.

Materials and Measures

Physical literacy. A cross-sectional design was used to examine the influence of exergame use and sedentary screen behaviours on the different domains of physical literacy. Physical literacy was assessed using the Canadian Assessment of Physical Literacy (CAPL; Longmuir et al., 2015). The CAPL protocol assesses the four domains of physical literacy: motivation and confidence, knowledge and understanding, daily behaviour, and physical competence. The physical competence domain incorporates aspects of physical fitness and fundamental motor skills performance, which aims to assess children's ability to be physically active (Healthy Active Living and Obesity Research Group, 2013). This domain was assessed by the Canadian Agility and Movement Skills Assessment (CAMSA), Progressive Aerobic Cardiovascular Endurance Run (PACER), plank, grip strength, sit and reach, height, weight, and waist circumference. The daily behaviour domain incorporates aspects of objective and subjective measures of physical activity and sedentary behaviour (Healthy Active Living and Obesity Research Group, 2013). The daily behaviour domain was obtained both by objective pedometer step count and self-reported physical activity and sedentary behaviour. The daily behaviour domain was removed from the analysis due to self-reported screen time behaviours being nested within the domain. Lastly, the Knowledge of Physical Activity Questionnaire (KAPQ) and Children's Self-Perception of Adequacy in and Predilection for Physical Activity (CSAPPA) were able to assess both the motivation and confidence and the knowledge and understanding domains. The KAPQ and CSAPPA can be found in Appendix A. The knowledge and understanding domain evaluates a child's understanding of physical fitness, sedentary behaviour, and safety during physical activity (Healthy Active Living and Obesity Research Group, 2013). The motivation and confidence domain assesses a child's confidence in their ability to be physically active, and their motivation to participate in physical activity (Healthy Active Living and Obesity Research Group, 2013). A brief description of the CAPL protocols and measures can be found in Table 2.1, and detailed procedures for each assessment are outlined in the CAPL Manual for Test Administration available at www.capl-ecsfp.ca (Healthy Active Living and Obesity Research Group, 2013). An aggregate score was produced for each domain as well as a total CAPL score (overall physical literacy score) which is calculated by adding the four domains scores together. The score for each domain as well as the total CAPL score is rated in one of four categories: beginning, progressing, achieving, and excelling. All assessments were conducted by experienced research staff who were trained prior to data collection with practice children. During CAMSA training all staff were trained using the same cue words in order attempt to improve consistency and reliability, also research assistants marked the same children in order to improve inter-rater reliability. Research assistants underwent approximately twenty hours of training prior to data collection and both watched videos explaining CAPL protocols from the CAPL website (https://www.capl-ecsfp.ca/) as well as in person training. Figure 2.1 describes the CAPL scoring breakdown and Table 2.2 identifies the CAPL classification groups.

Sedentary screen time. Participants self-reported weekday and weekend sedentary behaviours, which were divided into TV, videogame, and non-screen based activities. For each of these behaviours participants were required to provide an answer on a 7-point Likert-type scale that ranged from "I did not engage in the behaviour" to "5+ hours per day". An adjusted mean score was calculated by summing the products of weekday sedentary screen time multiplied by five and weekend time multiplied by two, followed by dividing by seven to get an estimate of hours per day. The mean score allowed us to examine day screen time use and compare these values with previous literature within this area.

Exergaming. Exergaming was assessed by asking participants if they had used an exergaming system within the last 30 days. To determine leisure time exergaming use, participants were asked to self-report the number of hours per day they spent using an exergaming system both on week and weekend days. The answers were provided on a 7-point Likert-type scale that ranged from "I did not play" to "5+ hours per day." An adjusted mean score was calculated by summing the products of weekday exergaming time multiplied by five and weekend time multiplied by two, followed by dividing by seven to get an estimate of hours per day.

Procedures

Participants were convenience sampled from schools and summer camps in Lethbridge and surrounding areas. All procedures were approved by the University of Lethbridge's Human Subject Research Committee, and both parental written consent and children's verbal assent were obtained prior to participation. Parents were also required to fill out a medical clearance form that stated that their child was healthy enough to take part in the study. Participants were free to decline any assessment with no negative consequence.

Analysis

Data were analyzed using the Statistical Package for Social Sciences (SPSS) software v23.0 for Windows (SPSS, Chicago, IL). Shapiro-Wilk and descriptive statistics were utilized to determine data normality. A log transformation was used to correct a negative skew in exergame use. Independent sample t-tests were conducted to determine whether differences were present between the screen time behaviours of boys and girls as well as users and non-users of exergames. Multiple linear regressions were then conducted to determine the relationship between exergaming time and physical literacy scores. Sedentary screen time including TV time and computer video games was also included in the regression models to examine the effects of both active and sedentary screen-based activities. All models were adjusted for age and gender. A discriminant function analysis was used to determine if weekly exergame time can predict CAPL interpretation group classification. All descriptive results are presented as mean ± standard deviation and statistical significance was set at $p < 0.05$.

Results

The descriptive characteristics of the study sample (n=317) comparing the age, sedentary behaviours, physical activity and exergame use of both boys (42.9%) and girls are provided in Table 2.3. There were no significant differences in age, physical activity, TV time, and non-screen sedentary time between boys and girls. Boys reported significantly higher total exergame (EX) and sedentary video game (SVG) time than girls, with significant differences present on weekdays ($p < .05$) and weekend days ($p < .05$) (Table 2.3). Although boys reported greater total screen time, there were no significant differences in total physical literacy score for gender. However, girls had significantly higher knowledge and understanding domain scores ($p < .05$) and boys had higher pedometer scores ($p < .05$) (Table 2.4). Along with the comparisons of gender, descriptive statistics for differing CAPL domain scores based on exergame use can be found in Table 2.5. There were no significant differences in CAPL domains between children who played exergames and those who didn't.

Correlations

Daily TV time ($r = .249$, $p < .01$), Video game time ($r = .239$, $p < .001$) as well as non-screen sedentary time ($r = .251$, $p < .01$) were weakly related to exergame time. Correlations between independent variables can be seen in Table 2.6.

Physical Competence Score

Linear regression was used to develop a model for predicting children's physical competence scores from time spent in four activities: exergaming, non-screen sedentary activities (eg. reading), computer/ video games and watching TV. The regression coefficients are reported in Table 2.7. Sedentary computer and video game time was negatively associated with physical competence ($p<.001$) while exergame time, TV time, and non-screen sedentary time were not significantly associated with physical competence. The five predictor model was able to account for 8.0% of the variance in physical competence score, $F(1, 316) = 5.582$, $p < .001$, $R^2 = .080$, 95% CI [4.214, 15.860].

Knowledge and Understanding Score

Results of the linear regression for the knowledge and understanding domain are reported in Table 2.8. Exergame time was negatively associated with knowledge and understanding ($p<.05$) while non-screen sedentary time was positively related ($p<.001$). All other variables except for age were non-significant. The five predictor model was able to account for 8.9% of the variance in knowledge and understanding score, $F(1, 316) = 6.048$, $p < .001$, $R^2 = .089$, 95% CI [3.464, 10.468].

Motivation and Confidence Score

Results of the linear regression for the motivation and confidence domain are reported in Table 2.9. Exergame time was positively associated with motivation and confidence score ($p<.01$) while non-screen sedentary time, TV time, and sedentary computer/video game time were negatively related to motivation and confidence. The five predictor model was able to account for 24.8% of the variance in motivation and confidence score, $F(1, 316) = 17.050$, $p < .001$, $R^2 = .248$, 95% CI [6.754, 14.204].

Overall Physical Literacy Score

Results of the linear regression for the overall physical literacy score are reported in Table 2.10. TV and sedentary computer/video game time were significant negative predictors of physical literacy score. Exergame time and non-screen sedentary time were not significantly associated with physical literacy. The five predictor model was able to account for 35.7% of the variance in CAPL score, $F(1, 316) = 30.201$, $p < .001$, $R^2 = .357$, 95% CI [32.620, 58.817].

Discriminant Function Analysis

The results from the discriminant function analysis revealed that CAPL interpretation group membership could be significantly discriminated based on children's weekly exergame use time. Participants were categorized in CAPL interpretations based on their overall scores (Beginning; n=9, Progressing; n=169, Achieving; n=94, Excelling; n=35). The overall Chi-square test was significant (Wilks $\lambda = .949$, Chi-square = 9.419, df = 3, Canonical correlation = .227, p <. 05); the function extracted accounted for 5.1% of the variance in CAPL interpretation. 34.1% of the cases were correctly classified into the correct CAPL interpretation groups based on children's weekly exergame use. The results of this analysis suggest that physical literacy score can be predicted, in small part, by weekly exergame use.

Discussion

The primary objective of this study was to determine if active video games, also known as exergames, are associated with physical literacy in children. We found that while self-reported exergame time had no association with physical competence, it was positively associated with the Motivation and Confidence domain of physical literacy.

However, exergame time was negatively associated with the Knowledge and Understanding domain of physical literacy. Sedentary screen time behaviours such as TV and video game/computer use were negatively related to both physical competence and motivation and confidence. These findings suggest that different types of screen time may have different effects on physical literacy.

Exergame use has been demonstrated in previous research to potentially increase caloric expenditure (Bailey, & McInnis, 2011; Graf, Pratt, Hester, & Short, 2009) and improve fundamental movement skills (FMS) (George et al., 2016; Sheehan and Katz, 2010) both of which may influence physical literacy development. The majority of previous research was conducted on relatively small samples in a laboratory or controlled settings, which did not take into account other sedentary screen time. Therefore, many of these studies may not accurately represent children's behavior within the home environment. This study extends these findings by examining a large group of children as well as analyzing both exergame use and other sedentary forms of screen time. Contrary to previous research examining exergame use, the results of this study found no relationship on overall physical literacy in children. However, exergame time was significantly related to the knowledge and understanding as well as motivation and confidence domains. These results potentially could be due to exergame use alone however, a possible alternative theory could be that children who had higher exergame time also participated in more traditional sedentary screen-based activities (TV, video games, online media, etc.). Children who used exergaming systems also played more sedentary video games (Table 2.5), thus this result could confound the negative results in overall physical literacy score we observed. This is not a possible theory when looking at the motivation and confidence domain score as sedentary screen time and exergames had different associations. Due to this finding future research should further examine if exergame time has a moderating effect on physical literacy.

Physical Competence as well as FMS acquisition and execution are strong predictors of children's ability to be physically active and literate throughout their life course. Contrary to the majority of previous research on the effect of exergames on fitness and FMS (George et al., 2016; Sheehan & Katz, 2011), this study found no relationship between exergames and physical competence. This finding has also been observed by Barnett, Ridgers, Reynolds, Hanna, and Salmon (2015) who examined the effects of exergames on object control skills over a 6 week period. They concluded exergames may be useful to introduce children to sports and activities, however, they are unlikely to be able to develop FMS. The secondary finding from this study, that sedentary computer/video game time is negatively associated with physical competence, is consistent with previous research and not necessarily a surprising result as the more time spent sedentary displaces potential time to develop physical competence.

Knowledge and understanding of physical activity is a strong determinate of children's physical activity levels later in life (DiLorenzo, Stucky-Ropp, Vander Wal, & Gotham, 1998). To our knowledge, this is one of the first studies to examine the effect of exergames on children's knowledge and understanding of physical activity and fitness. Our findings indicate that exergames are negatively related to knowledge and understanding which suggests that exergames do not teach children about the physical activities they are participating in. This may result in children, who primarily use exergames for their daily physical activity, to undervalue traditional physical activity later in life as they do not have the same baseline knowledge of the benefits as their traditionally active counterparts. The opposite could also be true, in that exergames may attract children who have lower knowledge and understanding of physical activity and believe that exergames provide adequate physical activity. These explanations may explain why we found the results that we did with regards to the negative relationship found between exergame use and knowledge and understanding.

The motivation to be physically active and the confidence in one's physical abilities are important factors to an individual's likelihood to be physically active throughout their life. We found that sedentary screen time such as TV and video games and non-screen sedentary time were both negatively associated with motivation and confidence. In contrast, exergame time was positively associated with motivation and confidence. This is consistent with previous research that found exergame use increased both motivation and self-confidence, which can lead to increased physical activity and sport engagement (Dos Santos, Bredehoft, Gonzalez, & Montgomery, 2016). Although exergames have been shown to be more entertaining and motivating to children than traditional physical activity, these increases appear to be based largely on extrinsic motivators that are more transient than intrinsic motivation (Sun, 2015). Thus, prolonged exergame-based physical activity programs are more likely to be ended prematurely due to the lack of intrinsic motivation. Interestingly, our results suggest that children who engage in more exergaming time are more confident but less knowledgeable than those who play less. However, there were no observed differences in overall physical competence or physical literacy scores.

Sedentary screen time has been shown to have a significant negative effect on children's physical fitness and motor competence (Leblanc et al., 2015). The secondary focus of this study was to determine the influence of sedentary screen activities on physical literacy in order to compare the effects of both sedentary and active screen based activities. Results of this study were consistent with previous research, demonstrating that screen time had significant negative relationships with the physical competence, and motivation and confidence domains leading to a lower overall physical literacy score. Our analysis showed that the amount of time spent in front of a screen, whether active or sedentary, had detrimental effects on specific physical literacy domains. However, motivation and confidence was positively associated with exergaming time. This finding may be due to the fact that exergames, like all video games, provide some extrinsic motivation or tokens for completing tasks which potentially could lead to a false sense of confidence in one's abilities participating in traditional physical activity. As stated earlier, a weak relationship between exergame use and other sedentary behaviours could play a role in this result.

Lastly, our gender analysis revealed that boys reported using more of both exergaming and traditional video game time, with no difference between genders in regards to TV or non-screen sedentary activities. This result is consistent with previous research identifying the differences between genders use of sedentary screen-based media (Taverno et al., 2013). Lam, Sit, and McManus (2011) alternatively, identify that both boys and girls use exergames for similar amounts of time, with only activity intensity being higher in boys. Due to the unclear and inconsistent results, further analysis of exergame use varying by gender is warranted.

The discriminate function analysis results suggest that exergaming time can correctly predict physical literacy interpretation 34% of the time. While this is a relatively low correct classification, the overall model was significant and it is an interesting finding as it indicates that exergame time can predict physical literacy interpretation groups. The low correct classification percentage could, in part, be due to the uneven loadings of the CAPL interpretations. For example, 169 children were classified as progressing, however, only 9 participants were within the beginning group. Future studies are required to determine the efficacy of using this analysis for exergaming and physical literacy research.

As with all cross-sectional studies, a fundamental limitation is that causal relationships cannot be determined. For example, our finding that exergames had a negative relationship with knowledge and understanding may be due to exergames causing decreased knowledge of physical activity in children or it could be the case that children with less knowledge are drawn to exergames as they see the as a replacement of physical activity. Another limitation of this study is that the participants may not all have differentiated their exergaming time from the total sedentary video game time, such that the total video game time may have included exergame time as well. Additionally, the sample was comprised of eight to twelve-year-old children who were healthy enough to perform the protocol. Therefore, the findings of this study may not generalize to other populations outside of the studies age range or children with significant mental or physical delays. Furthermore, there are limitations associated with the self-reported measures of screen time and exergame time, as not all children may have reported accurate numbers. Also, the exergaming questions used in the study have not been tested for reliability and validity. Lastly, selection bias may have influenced the study as active parents may value physical activity research more than their inactive counterparts and thus consent for their children to participate. Previous research has demonstrated a relationship between active children and active parents (Moore et al., 1991).

If we accept that video games and sedentary screen activities will continue to be a regular part of children's leisure pursuits, then active forms of gaming should be promoted as they potentially have less detrimental effects on physical literacy than sedentary screen activities. Future research must continue to compare the effects and implications of exergame and sedentary screen activities on physical literacy in order to discover novel tools and techniques that could potentially mitigate childhood inactivity.

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Table 2. 1 Brief Description of CAPL Protocols

Domain	Measure	Instrument	Description
Physical Competence	FMS execution	CAMSA	Accurately and quickly complete FMS such as kicking, throwing, skipping, etc
	Cardiovascular fitness	15 meter PACER	Run until volitional fatigue or inability to maintain the pace
	Trunk Flexibility	Flexometer	Straight leg trunk forward flexion
	Upper body Strength	Hand grip Dynamometer	Alternating hand grip maximal contractions
	Trunk muscular endurance	Plank	Hold plank position until fatigue or inability to maintain form
	Weight	Seca digital scale	Measure taken in bare feet and facing away from scale
	Height	Seca stadiometer	Measure taken in bare feet and taken at deep inhale
	Waist Circumference	Anthropometric measuring tape	Measure taken at top of the iliac crest during normal exhale
Motivation/ Confidence	self-report	KPAQ and CSAPPA	Identifies benefits/barriers and motivation to be physical active
Knowledge/ Understanding	self-report	KAPQ	Assesses awareness of guidelines, safety and opinions of health
Daily Behavior	self-report and measured steps	Pedometers and KPAQ	Determines adherence to physical activity and SBG

Note. Instruments and procedures can be found at https://www.capl-ecsfp.ca/capl-manual/CAPL: Canadian Assessment of Physical Literacy, CAMSA: Canadian Agility and Movement Skills Assessment, FMS: Fundamental Movement Skills, PACER: *Progressive Aerobic Cardiovascular Endurance Run, KPAQ: Knowledge of Physical Activity Questionnaire, CSAPPA:* Children's Self-Perception of Adequacy in and Predilection for Physical Activity

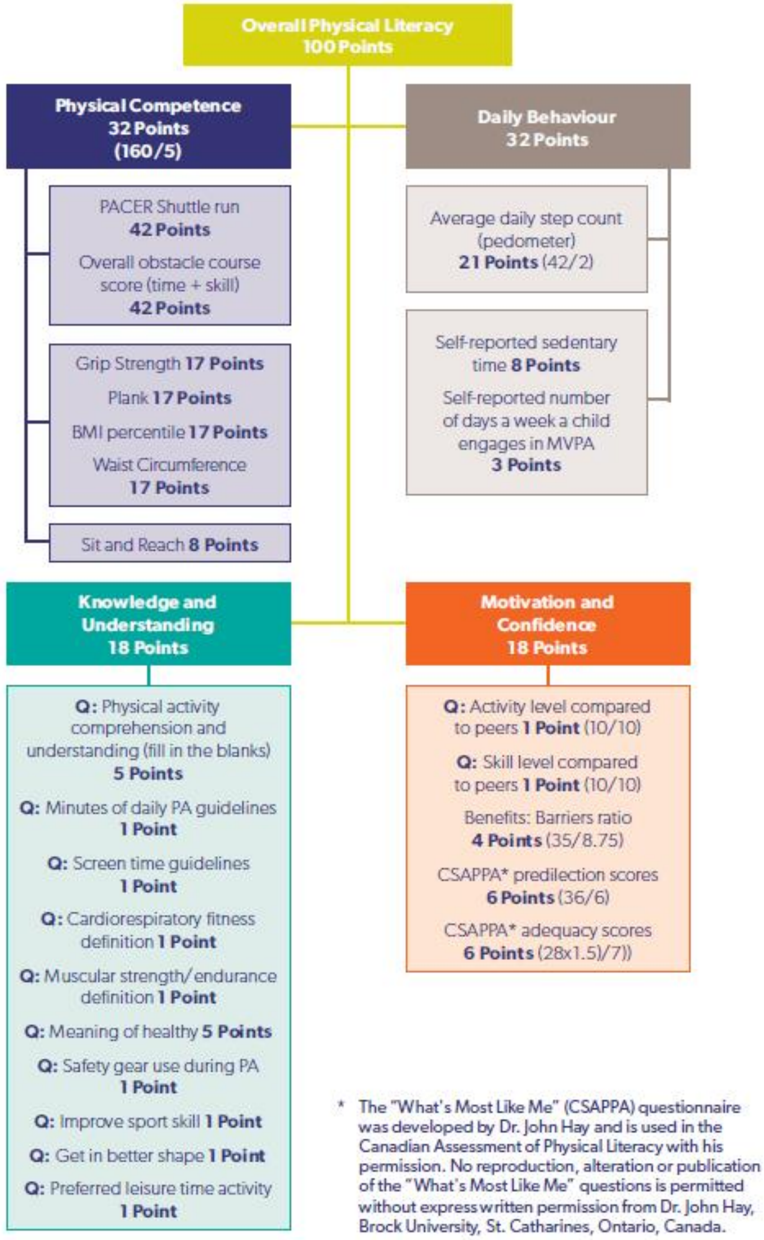

Figure 2.1 CAPL scoring breakdown

Table 2. 2 CAPL Score Interpretations

Interpretation	CAPL Score Range
Beginning	< 43.8
Progressing	43.8 to 63.8
Achieving	63.8 to 74.0
Excelling	> 74.0

Table 2. 3 Self-reported Sedentary Time and Physical Activity Time in 317 8-12 Year Old Boys and Girls (Mean ± SD)

Measure	Boys (42.9%)	Girls
Age (years)	11.10 ± .87	11.17 ± .81
Physical Activity (days/week)	4.70 ± 2.02	4.62 ± 1.80
Non-screen Sedentary Time (hrs/day)	1.78 ± 1.44	1.86 ± 1.25
Non-screen Sedentary time Weekday (hrs/day)	1.77 ± 1.49	1.81 ± 1.38
Non-screen Sedentary Weekend day (hrs/day)	1.81 ± 1.59	2.00 ± 1.42
TV Time (hrs/day)	1.31 ± 1.11	1.14 ± 1.04
TV Weekday (hrs/day)	1.11 ± 1.15	.95 ± 1.04
TV Weekend day (hrs/day)	1.75 ± 1.54	1.64 ± 1.30
Computer/Video Game Time (hrs/day) *	1.27 ± 1.14	.88 ± 1.08
Computer/Video Game Weekday (hrs/day) *	1.09 ± 1.12	.76 ± 1.04
Computer/Video Game Weekend day (hrs/day) *	1.71 ± 1.51	1.16 ± 1.38
Exergame time (hrs/day) *	.88 ± 1.04	.61 ± .80
Exergame Weekday (hrs/day) *	.82 ± 1.08	.57 ± .85
Exergame Weekend day (hrs/day) *	1.03 ± 1.23	.70 ± .95
Total Sedentary Time (hrs/day)	3.07 ± 1.94	3.01 ± 1.81

*Note. Independent Sample t-tests were run to determine differences between boys and girls. *denotes significant differences between groups (p<.05).*

Table 2. 3 CAPL Domain Scores in 317 8-12 Year Old Boys and Girls (Mean ± SD)

Measure	Boys (42.9%)	Girls
Pedometer Score (/21) *	10.00 ± 5.39	8.55 ± 4.51
Physical Competence Score (/32)	19.35 ± 4.58	19.80 ± 3.63
Motivation and Confidence Score (/18)	12.43 ± 3.03	12.01 ± 2.71
Knowledge and Understanding Score (/18) *	12.72 ± 2.60	13.36 ± 2.31
Physical Literacy Score (/100)	61.34 ± 12.45	61.41 ± 9.70

*Note. Independent Sample t-tests were run to determine differences between boys and girls. *denotes significant differences between groups (p<.05).*

Table 2. 4 Physical Literacy Scores According to Whether or Not Children Used Exergaming System in the Last 30 Days

	Have you used an Exergaming System in the last 30 days?	
Domain	Yes (n=182)	No (n=135)
Physical Competence Score	19.39 ± 4.19	19.90 ± 3.90
Pedometer Steps Score	9.17 ± 4.83	9.19 ± 5.14
Motivation and Confidence Score	12.15 ± 2.92	12.25 ± 2.76
Knowledge and Understanding Score	13.07 ± 2.50	13.11 ± 2.41
CAPL Score	60.74 ± 11.50	62.24 ± 10.14
Videogame Time (hrs/day)*	1.19 ± 1.13	.85 ± 1.08
TV Time (hrs/day)	1.28 ± 1.06	1.11 ± 1.09
Exergame time (hrs/day)	.99 ± .97	-

*Note. Independent Sample t-tests were run to determine differences between physical literacy domain scores and different screen activities based upon whether or not participants had used an exergaming system within the last 30 days. *denotes significant differences between groups (p<.05).*

Table 2. 5 Pearson Correlations Between Linear Regression Independent Variables

Measure	Age	Non-screen	TV	Exergame	Videogame
Age (yrs)	1	.144*	.142	.024	.104*
Non-screen ST (hrs/day)		1	.192**	.251**	.083
TV (hrs/day)			1	.249**	.282**
Exergame (hrs/day)				1	.239**
Videogame (hrs/day)					1

*Note. *p<.05, **p<.001*

Table 2. 6 Summary of Linear Regression Analysis for the Physical Competence Score (n=317)

Measure	B	SE(B)	β	t(316)	Sig (p)
Gender	-.024	.454	.-.003	-.053	.958
Age	.993	.268	.204	3.702	.000
Exergame (hrs/day)	-.009	.259	-.002	-.036	.971
Non-screen Sedentary (hrs/day)	-.170	.174	-.056	.-.980	.328
Computer/Video Game (hrs/day)	-.838	.210	-.231	-3.983	.000
TV (hrs/day)	-.236	.220	-.062	-1.073	.284

Note. R^2 = .080.

Table 2. 7 Summary of Linear Regression Analysis for the Knowledge and Understanding Score (n=317)

Measure	B	SE(B)	β	t(316)	Sig (p)
Gender	-.425	.273	-.086	-1.553	.122
Age	.548	.161	.187	3.397	.001
Exergame (hrs/day)	.-.386	.156	-.144	-2.472	.014
Non-screen Sedentary (hrs/day)	.363	.105	.197	3.474	.001
Computer/Video Game (hrs/day)	-.052	.127	-.024	-.412	.680
TV (hrs/day)	-.110	.133	-.048	-.831	.406

Note. R^2 = .089.

Table 2. 8 Summary of Linear Regression Analysis for the Motivation and Confidence Score (n=317)

Measure	B	SE(B)	β	t(316)	Sig (p)
Gender	.766	.291	.133	2.634	.009
Age	.291	.171	.086	1.699	.090
Exergame (hrs/day)	.486	.166	.156	2.924	.004
Non-screen Sedentary (hrs/day)	-.254	.111	-.119	-2.286	.023
Computer/Video Game (hrs/day)	-1.014	.135	-.398	-7.527	.000
TV (hrs/day)	-.572	.141	-.216	-4.059	.000

Note. R^2 = .234.

Table 2. 9 Summary of Linear Regression Analysis for Overall Physical Literacy Score (CAPL score) Using Both Children Who Answered Yes and No to Playing Exergames in the Last 30 Days Sample (n=317)

Measure	B	SE(B)	β	t(316)	Sig (p)
Gender	2.260	1.023	.102	2.210	.028
Age	2.095	.603	.160	3.472	.001
Exergame (hrs/day)	.079	.584	.007	.136	.892
Non-screen Sedentary (hrs/day)	-.114	.391	-.014	-.290	.772
Computer/Video Game (hrs/day)	-4.404	.474	-.451	-9.301	.000
TV (hrs/day)	-3.227	.496	-.317	-6.508	.000

Note. R^2 = .357.

Chapter 3: Conclusions: Exergaming, Physical Literacy, and Future Directions

Physical inactivity and sedentary time in children are serious social issues in most developed countries (LeBlanc, Katzmarzyk et al., 2015). Many negative health outcomes have been found to be related to sedentary time in children independent of MVPA (moderate to vigorous physical activity) (Cliff et al., 2013; Janssen et al., 2015; Mitchell, Pate, Beets, & Nader, 2013). Two proposed causes of increased sedentary time in children have been increased leisure time TV and videogame use (LeBlanc, Broyles et al., 2015). As presented in Chapter 1, much research has been directed at finding causes, assessment tools, and possible active alternatives to these inherently sedentary behaviours.

Exergames are videogames that use gross or fine body movements to interface and interact with the game (Hansen & Sanders, 2008). Recently, exergames have been identified as one potential solution to excessive sedentary time while playing videogames. Exergames have been shown to improve cardiovascular function (Mills et al., 2013), situational motivation and interest (Gao, Podlog, & Huang, 2013; Sun, 2012), fundamental movement skills (FMS; Reynolds, Thornton, Lay, Braham & Rosenberg 2014; Sheehan & Katz, 2010), as well as many others. While these characteristics have shown improvement, limited research (Sheehan & Katz, 2013; George et al., 2016) has been done to examine the effect of exergames on physical literacy. The overall goal of this thesis was to determine if exergames are associated with children's physical literacy scores, and if so the nature of the association. A secondary focus of this research was to determine the effect of sedentary screen-time on physical literacy.

Physical literacy can be described as the motivation and confidence, knowledge and understanding, physical competence, and daily behaviour needed in order to be physically active for life (Whitehead, 2010). All four of these domains have been determined to influence an individual to be physically active throughout the life course (Whitehead, 2010). Physical literacy is a holistic term that incorporates both the physical and psychological factors that potentially affect an individual's likelihood to live a physically active lifestyle. Research suggests that physical literacy has the potential to be part of the solution to the childhood inactivity epidemic (Giblin, Collins, & Button, 2014). This thesis aims to determine whether exergames are associated with children's physical literacy. Empirical evidence of this connection is limited.

Exergames

Children typically spend a large portion of their day engaged in sedentary activities (LeBlanc, Broyles et al., 2015), regardless of physical activity involvement. Unsurprisingly, this study found that children who participated in large amounts of sedentary time (both screen and non-screen sedentary time) had lower physical literacy than their counterparts who engaged in less sedentary time. Therefore, our results support the prevailing theory that large amounts of TV and videogames, sedentary or exergames alike, are potentially detrimental to the physical and psychological development of young children.

This study showed no association between exergame time and total physical literacy score which is contrary to much of the recent exergaming literature. This finding raises important questions about their use in physical education and as a substitute for other physical activity that will be discussed later. At the same time, although our study demonstrated that children with higher exergame time had higher motivation and confidence scores, and lower knowledge and understanding scores, which may suggest that exergaming improves confidence at the expense of knowledge and understanding of physical activity. While there is no previous research directly examining the specific outcomes from this study, we can examine individual components of physical literacy to compare our results with previous research as well as to look at specific gaps in knowledge pertaining to exergame use in different contexts.

Exergames have been promoted primarily for their potential to increase physical fitness, FMS, and physical activity participation. While there is a relatively large body of evidence to support this hypothesis, recent research has not observed the same effects. Barnett, Ridgers, Reynolds, Hanna, and Salmon (2015) observed that children demonstrated no significant changes in object manipulation skills over a 6 week exergame intervention study. The authors note that their exergaming dose was less than previous studies and go on to say that if structured exergaming curriculum and lessons, as well as a longer intervention were used, increases in object manipulation could be observed. Sheehan and Katz (2013) examined the effect of 6 weeks of exergaming on balance and compared it to traditional PE programming and an agility balance and coordination (ABC) class. They observed improvements in balance in the exergaming condition as well as similar improvements in the ABC curriculum condition. Students in all conditions participated in a structured class with similar outcomes. This study demonstrates how exergames can be potentially used in the school setting, however, similar improvements were observed in the specialized lesson plan (ABC) leading to inconclusive inferences. The results of our research are consistent with the findings of Barnett et al. (2015) and again suggest that exergaming time is not related to motor competence unless very structured participation is adhered to. While the results of our study could be explained due to the non-experimental nature of our study, and the fact that participants may play exergames with varying levels of intensity, and proper form adherence, two sets of similar findings of lack of correlation suggests a need for further study. In particular, longitudinal, structured experimental studies that examine the effect of exergames on physical competence are still warranted. Furthermore, qualitative investigations may be able to study children's choice and adherence to proper exergaming form. If however, exergames do not influence physical competence on their own, then examining their potential to motivate children to be physically active outside of the home is pertinent.

Increasing children's motivation to be physically active is a goal of many studies and programs (Baranowski et al., 2012). Exergames have been shown to increase motivation and situational interest in children (Penko & Barkley, 2010; Sun, 2012). Our findings are consistent with these earlier studies and suggest that exergames can be a useful tool to introduce and motivate children to participate in sport and physical activity. Interestingly, our results also indicate that children who use exergames are more confident in their abilities even though there were no observed differences between exergame users and non-users in their physical competence scores. This result demonstrates how exergames influence children's perceptions of their own abilities through high levels of positive reinforcement. Previous research has similarly examined the persuasive effect of exergaming systems due to positive reinforcement and generating feelings of achievement (Staiano, Abraham, & Calvert, 2012). This may influence children's motivation and likelihood to be physically active outside of the virtual world.

Children gaining the knowledge and understanding to value physical activity throughout their life is of the utmost importance. Sallis, Prochaska, and Taylor (2000) observed that understanding of physical activities was related to physical activity participation and continuation in childhood. Exergames may be a potential medium to increase children's knowledge of sports and physical activity (Papastergiou, 2009). The results of our study were contrary to this finding however, as we observed children who used exergames for more time had lower knowledge and understanding scores. This is another interesting finding as it reveals a potential gap in exergame development and suggests that exergames should include better instructional components.

Exergame intervention studies conducted in a laboratory setting have found increases in energy expenditure (Bailey & McInnis, 2011; Graf, Pratt, Hester, & Short, 2009), MET's, VO2 max, physical activity, and enjoyment as compared to sedentary behaviours. Although these findings are promising, caution needs to be taken when promoting their use, as field studies have found non-significant to small effects on the aforementioned outcomes (Bethea, Berry, Maloney, & Sikich, 2012; Duncan, Staples, 2010). While results from field based studies are mixed, further examination is warranted and should focus on the home environment, as well as exergame selection and proper use. Promotion of exergames must also be acutely directed towards replacing sedentary behaviours, but not physical activities and sports, as our findings as well as previous literature suggest that exergames cannot be thought of as an adequate substitute for traditional physical activity.

Exergames in Physical Education

Exergames have the potential to be used in a physical educational setting as a novel way for teachers to get their students physically active (Yang, Smith, & Graham, 2008). Previeous research suggests that exergames have the potential to increase PE class participation, exergy expenditure (Bailey & McInnis, 2011; Graf et al., 2009) and academic results (Sheff, 1994). Garde et al. (2016), examined the effect of mobile exergames within the school environment by using a 6 week random cross-over design study. They observed a ten percent increase in steps per day and a sixteen percent increase in total active minutes within the schools environment. The results of their study suggest that exergames have the potential to increase physical activity within the school setting outside of gym or recess time. Sheehan and Katz (2013) also studied the effects of exergames within the school setting with their study examining the effect of 6 weeks of an exergaming intervention as compared to traditional gym class and ABC lesson planning on quiet standing performance. They observed that both exergaming and ABC classes improved their balance performance similarly and concluded that with proper programming and instruction exergames could potentially be used to supplement gym classes within an educational setting. Although positive results have been found, studies have also discovered limitations and negative findings regarding exergaming use within the school setting. McDougall and Duncan (2008) studied the effect of implementing an exergaming intervention aimed at substituting traditional recess activities with exergaming time. Children who were in the exergaming group were less physically active and took fewer steps per day than those who participated in traditional recess activities. They concluded that exergaming time is not an adequate substitute for unstructured free play time for children. This further affirms that exergaming cannot and should not be used to replace traditional physical activity. Results of our study indicate that this approach to PE needs to be carefully presented as a way to introduce and motivate children to be physically active outside of screen-based entertainment. Future research in a controlled setting is necessary before wholesale adoption of this approach to PE provision becomes more prevalent.

Implications

The main findings from this thesis extend and support the emerging theory that exergames should replace sedentary screen time, not traditional physical activity. Our study found that exergames do not have an influence on overall physical literacy, however, motivation and confidence score were higher in children who used exergames more frequently. This finding supports the use of exergames as an introductory and motivating medium for children, with the main goal of sport or traditional physical activity application. Another important finding from this study, that sedentary time is negatively associated with physical literacy, suggests that observing and limiting children's sedentary time could potentially improve physical literacy in Canadian children.

Finally, children who used exergames for large amounts of time had lower knowledge and understanding scores. This finding brings to light a potential limitation of current exergaming systems as either attracting children with lower knowledge of physical activity or causing children to develop less understanding of physical activity due to playing exergames. Future exergames should include further educational components, especially in popular games, in order to improve children's knowledge of physical activity. Future systems should also diversify the movement patterns and activities in order to potentially improve physical competence levels of children and keep them interested.

Strengths and Limitations

A major strength of this study was the large sample size. Another strength was controlling for age and gender within the linear regression models. By doing this, we were able to observe the isolated effects of sedentary and active screen time on physical literacy. All research is limited by the very nature of the exercise. As such, this study has some limitations with respect to the sample, the use of self-report and retrospective measures, and the cross sectional nature of the research that must be taken into consideration in generalizing the findings. First, despite the large sample size, this study may be difficult to generalize because of the nature of the sample. The study was conducted in one geographic area at one point in time with one age group and so the results may not be generalizable to other ages or locations. Until further studies in different locales produce different results, these studies are the best we have on this topic. Furthermore, the sample used in the study was reasonably affluent, as families were able to afford exergaming systems. Lower socioeconomic status has been consistently shown to result in less physical activity and higher sedentary time in children and adults (Tandon et al., 2012). Second, this study depends on self-report and retrospective measures which may lead to reporting bias or inaccuracies. For instance, there is no way to know the intensity with which the exergames were used by participants or which exergaming systems or games were being used. Also, adherence to proper exergaming form, standing rather than sitting, was not recorded or examined which could have resulted in some of our findings. If proper form is not used, then this negates the potential positive benefits of active videos games and turns them into sedentary activities. Third, the assessment of video game time could be a potential limitation as the exergaming questionnaire, as it was written, may have not been adequately distinguished from sedentary video gaming questions. This potentially could have caused participants to report their exergame time within their videogame time, thus inflating their sedentary videogame time. Lastly, the cross sectional nature of the study means that many variables are out of the control of the researcher in this study. This makes it impossible to determine causality. Future investigations should take these limitations in to account to better understand the influence of exergaming on physical literacy in children.

Future Directions

After discussion of the potential benefits and risks of exergame use, future investigations should examine which specific exergames and systems have the potential for promoting physical fitness and literacy in children without replacing traditional physical activity. Studies also need to look at how exergames are used within the home environment to determine what games are being played most and also how exergaming systems could evolve to further promote physical activity. As stated earlier, exergame use in the school environment warrants further examination of the influences of exergames on PE curriculums. Furthermore, if introduced to the curriculum, exergames that target different FMS and fitness components will need to be evaluated to determine if curriculum goals are being met. A future study that compares real-life movements with their virtual complements seems logical as then game developers can further liken the simulated movements in future exergames.

As new exergames are introduced, ongoing investigations will need to compare new games to the older versions rather than sedentary time to get a better understanding of the effects of exergames. Recently, Naintic Inc. released their smartphone app "Pokemon GO" which integrates the virtual and real worlds as players are encouraged to explore the physical world in order to progress in the game. This game is unlike other exergames as it forces players to walk, run, or bike outside which potentially could improve aerobic fitness levels more than games similar too Wii Fit. This new form of exergame is very popular and easily accessible to a large proportion of the public as it is conveniently on a smart phone. Additionally, children are very motivated to use these games as they connect popular culture to games in order to promote physical activity. Garde et al. (2016) study examined the effect of mobile exergames on activity in a school setting, and concluded that Pokémon GO has the potential to influence physical activity in children and merits investigation. While their study observed increases in steps per day and activity, one current limitation of these type of games is the lack of FMS, strength, and low exercise intensity. As these new real-virtual world integrated games potentially grow in number and evolve, investigators should examine the efficacy of using these games to improve children's fitness and physical literacy through increased active components of the games. Although exergames continue to progress and become more life-like, they should fundamentally never be equated to or replace traditional physical activity and sport. Exergames are a useful tool to introduce children to sports, new activities, and also to motivate children to be physically active in the real world.

Conclusion

The results of this thesis demonstrate that exergame use is positively related to motivation and negatively related to knowledge of physical activity, however, no relationship with overall physical literacy is observed. The influence of sedentary screen time on physical literacy was largely negative and demonstrated that active videogames may be useful as an alternative to its sedentary counterpart. This is only true however, if exergame time replaces sedentary screen time rather than traditional physical activity. These findings have implications for parents, educators, game designers, and researchers. Fundamentally, these findings suggest that further experimental research is required before a consensus will be achieved regarding the efficacy of exergaming systems for the development of physical literacy.

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Appendices

Appendix A: Informed Consent and Medical Screening Form

CAPL Project Information Letter

Dear Parent/Guardian:

Your child's recreation provider, health unit and/or school has been chosen to participate in a research study conducted by the Children's Hospital of Eastern Ontario (CHEO) Research Institute. We are inviting 3000 children 8-12 years of age from each of the 3 implementation sites to participate in our study. The Research Ethics Board of the CHEO's Research Institute and the University of Lethbridge has approved this research project.

We hope that you will support our research study by allowing your child to participate. The study will be done during your child's scheduled physical activity. All children in your child's program are invited to participate, and the children will participate in groups. Your child will also wear a small monitor for 1 week so we can count how many steps your child takes each day.

If you are willing to have your child participate in our study, please:

1. **Complete the attached Parent/Guardian Consent Form**
2. **Complete the attached Physical Activity for Kids Screening Questions**
3. **Return both the Parent/Guardian Consent Form and the Physical Activity for Kids Screening Questions to your child's program (via your child)**

Over the past 3 years we have developed the Canadian Assessment of Physical Literacy (CAPL for short). The purpose of the CAPL was to create a new way to learn whether children have the skills, knowledge and abilities to pursue an active, healthy lifestyle. With the CAPL test now finalized, we are recruiting children 8 to 12 years of age from 3 provinces (a total of 9000 children) to participate in CAPL. This large scale multi-province testing will allow for greater knowledge to be gained about the current levels of physical literacy in Canada. All of the research testing will be at a time chosen by your child's leader/teacher.

We encourage you to read the study consent form included with this letter. **It is your choice whether or not your child participates in this study.** Whether or not your child is involved will have no impact on your child's outcomes in their programs, and your child can withdraw at any time without consequence. If you agree to have your child participate in the study please sign one of the enclosed consent forms and return it to your child's recreation leader and/or school teacher.

If you have any questions or concerns about this study please do not hesitate to contact the research coordinator for the project Mr. Charles Boyer (613-737-7600 ext 4408), Dr. Jennifer Copeland (403-317-2804), or Dr. Luc Martin (403-332-4435). Thank you for your time in considering our request for your child's study participation.

Sincerely,

Dr. Jennifer Copeland & Dr. Luc Martin

CAPL-RBC Parent/Guardian Informed Consent Form
(Document to be signed)

What is the title of this research study?
The Canadian Assessment of Physical Literacy (CAPL)

Who is doing this research?
In Lethbridge (from the University of Lethbridge):

Dr. Jennifer Copeland
Tel: (403) 317-2804, email: Jennifer.copeland@uleth.ca
Dr. Luc Martin
Tel: (403) 332-4435, email: luc.martin@uleth.ca

In Ottawa (from the original site and primary investigators):

Dr. Mark Tremblay, Principal Investigator
Healthy Active Living and Obesity Research Group, CHEO- Research Institute
tel: 613-737-7600 x 4114, email: mtremblay@cheo.on.ca
Dr. Pat Longmuir, Co-Investigator
Healthy Active Living and Obesity Research Group, CHEO- Research Institute
tel: 613-737-7600 x 3908, email: plongmuir@cheo.on.ca
Mr. Charles Boyer, Research Coordinator
Healthy Active Living and Obesity Research Group, CHEO- Research Institute
tel: 613-737-7600 x 4408, email: cboyer@cheo.on.ca

The Children's Hospital of Eastern Ontario (CHEO) and the University of Lethbridge have approved of this research study.

Why are we doing this study?
We are doing this study because teachers, coaches and other physical activity leaders have told us they need a new way of measuring how well children are doing in physical and health education. The test we have created is called the Canadian Assessment of Physical Literacy. "Physical Literacy" means everything that children need to have or learn so that they can lead a healthy, active and enjoyable life. There are many ways to measure how well children are learning in many school subjects, like math and language. However, at the moment there is no measure of physical literacy, which is why we are creating a new one. Having an accurate and reliable way to measure physical literacy will help us to identify children who are not learning everything they need to know for a healthy, active lifestyle. It will also help us to better evaluate programmes designed to encourage physical activity and healthy living so that children will not be at risk for the health problems that result from being overweight.

What will your child do during the study?

The Canadian Assessment of Physical Literacy includes many activities that are similar to what your child would typically do during physical education class. **Your child will be asked to "do the best that you can" and "try your hardest" for each activity**. As a result, your child may exercise very strenuously during the study although your child will be allowed to stop any activity at any time.

Before your child tries any of the study activities, we will ask your child whether they want to participate. Your child can say either "Yes" or "No", and their choice will be respected even if you want your child to participate. If your child agrees to participate, we will record your child's gender, age and grade. Your child will then be asked to complete each of the following tasks:

- Obstacle Course – Includes jumping, running, hopping, catching, throwing and kicking balls while running
- Grip Strength – Squeezing a handle as hard as possible
- Plank – A core strength exercise commonly used in yoga-like activities and sport training: holding a Push Up position while resting only on the toes and forearms
- Sit and Reach - Reach toward the toes while sitting with their legs straight, to measure flexibility.
- PACER (Beep Test) - Run laps back and forth across the gym, starting at a slow speed and gradually getting faster. They will continue running until they are too tired or do not wish to continue running at the faster speed.
- Body measurements - Have their height, weight, and size of their waist measured while they are dressed in their gym clothes. Waist size will be measured while wearing their gym clothes. The measurements will be done in a private area away from others.
- Questionnaire - Answer questions about physical activity by writing their answers on a questionnaire or using a computer to answer the questions. The questions will tell us what children know about physical activity, physical fitness and the skills they need to be active. The questions will also ask about your child's interest in physical activity.
- Pedometers - a small square device, worn clipped to a belt or pant waistband, to measure the number of steps your child takes daily every day for 8 days. The pedometer should be worn at all times during waking hours except when the child is swimming or bathing. It does not measure the type of activities or where the child is, it only measures how much movement the child makes. Your child will also be asked to write down the times that the pedometer is not worn, as well as the activities that were done when your child was wearing the pedometer. It is very important that the pedometer is returned to us at the end of the study. However, if it is misplaced and absolutely cannot be found you will not have to purchase a replacement.

Children who participate in this research will perform study activities over two days. All of the research activities for both test days will take place at the organization where your child is registered and your child's instructor/leader/teacher will be present at all times. Most activities will take place in the gymnasium.

If you choose not to allow your child to participate in this study, your child will be supervised by their instructor and engaged in appropriate program-focused activities while the other children in the program are completing the study.

Who can participate in this research?

We are asking 3000 children 8 to 12 years of age over two years. Your child's instructor/leader/teacher and your child's Recreation Provider and/or School are interested in having children in their programmes participate in this research. **Physical activity and fitness testing are safe for most children**, and the activities done in this study are similar to what your child normally does during physical education. Providing us with more information about your child's health and your family's history will help us to make the research study fun and safe for your child. **Please also complete the "Physical Activity for Kids" screening form enclosed, and return it with the consent form to your child's program leader.** If you have questions about the information we are asking you to provide on the screening form, please contact: Dr.'s Copeland or Martin by telephone or by sending an email (contact information above).

Could something bad happen to my child during this study?

We do not expect bad things to happen to children who participate in this study. All the activities for the study are similar to what your child does in their regular physical education programmes. There are no needles or invasive procedures. As with any type of physical activity, there is a small risk of falling or getting hurt. However, all the research equipment is similar to what your child uses in physical education and safety is our first priority. All study personnel are trained in First Aid and CPR, and in the event of an injury, standard organizational policies will be followed. The pedometers are very durable, however if one happens to break the smaller broken off pieces may present a choking hazard to children under the age of 3. For this reason, please keep the pedometer out of reach of children under the age of 3.

In the unlikely event that your child is injured as a direct result of participating in this research, the normal legal rules about compensation for the injury will apply. By signing this consent form you are in no way waiving your legal rights or releasing the investigator and the sponsor from their legal and professional responsibilities.

Will my child or family get something for being in this study?

You and your child will not be paid or given a reward for being in this study. We cannot promise that you will get any benefit from your child's study participation. The information that we gather during this study will help us to assess physical literacy of Canadian children 8 to 12 years of age. Knowing more about the current levels of physical literacy in Canadian children will help to inform future studies. Your child's participation in this study is completely voluntary. You or your child are free to withdraw from this study at anytime, even after the research testing has been completed. Neither participation nor withdrawal from the study will affect your child's outcomes in their programmes.

Who will know that my child is in this research study?

The information we collect about your child will not identify your child. We will use a coded identification number instead of your child's name so that only the researchers will know who the information is about. The data collected in this study will be locked in a safe place. All information from your child will be numbered and will not contain your child's name. A list of names and matching code numbers will be stored separately in a locked office at the University of Lethbridge. At the end of the study, that information will be transferred to the Children's Hospital of Eastern Ontario (CHEO). It is intended that only the staff involved in this research study will have access to the research information collected during this study. However, there are specific situations where other people may be given access to the research information. A member of the Research Ethics Board at the Children's Hospital of Eastern Ontario (CHEO) may be given access to the research records for auditing purposes. There are also limits to the confidentiality of research information in situations of suspected child abuse, concerns of harm to self or others, or any request for information by court order.

The coded information collected during this research study will be stored for 7 years after all of the results of this research have been published. After that time, all records will be destroyed in the way required by Canadian research data regulations. Overall study results may be published for scientific purposes, but the identity of the research participants will remain confidential. No information that could identify your child or your child's organization will be published.

Who should I contact if I have questions about the research study?

If you have questions about this study please contact Dr.'s Copeland or Martin who can be reached at the information provided above. Alternatively, if you have any questions regarding your rights as a participant in this research, please contact the Office of Research Services, University of Lethbridge at (403) 329-2747 or Email at research.services@uleth.ca. Finally, you may also contact Mr. Charles Boyer. Mr. Boyer by telephone at (613) 737-7600 ext. 4408 or by email (cboyer@cheo.on.ca). Mr. Boyer is the project coordinator and is located in Ottawa, Ontario, Canada.

This study has been reviewed and approved by the University of Lethbridge Human Subject Research Committee as well as the CHEO Research Ethics Board. The CHEO Research Ethics Board is a committee of the hospital that includes individuals from different professional backgrounds. The Board reviews all research done by scientists at the hospital that involves people. Its goal is to ensure the protection of the rights and welfare of people participating in research. The Board's work is not intended to replace a parent or child's judgment about what decisions and choices are best for them. You may contact the Chair of the Research Ethics Board, for information regarding participant's rights in research studies at (613) 737-7600 ext. 3272, although this person cannot provide any health-related information about the study. The Board could review your study records in fulfilling its roles and responsibilities.

<u>PLEASE SIGN HERE</u> – CAPL Parent/Guardian Informed Consent

I, ____ (Your Name),
the parent/guardian of ____________________________________(Your Child's Name)

__ **Give** consent to my child's participation in the above study.

__ **Do not give** consent to my child's participation in the above study.

I have read and understood the attached study information or had the attached information verbally explained to me. I understand that my child will be asked to exercise strenuously, and to do the best that they can for each type of exercise. I have been fully informed of the details of the study and have had the opportunity to discuss my concerns. I understand that I am free to withdraw my child at any time or not answer questions that make us uncomfortable, and that my child's performance outcomes will not be affected if I do. I have received a copy of the study information and consent form.

___________________________ ___________________________

Parent/Guardian **Email Address** Name of Parent/Guardian

__________________________ __________________

Signature of Parent/Guardian Date

After your child completes the study, you will receive a letter containing a login and password. The information will enable you to confidentially obtain your child's research study results.

More information can be found at: http://www.cheori.org/halo/

CAPL-RBC Physical Activity for Kids Screening Questions
(To be completed by parent/guardian)

Parent/Guardian's Name: ________________________________

Child's Name: ________________________________

Physical activity and fitness testing are safe for most children. However, sometimes children need to be careful when they do specific types of activity.

Help us to supervise your child's activity appropriately by answering the following question(s).

1. Has a doctor ever told you that there are some types of exercises or physical activity that your child should not do? (Please circle)

Yes No

2. **If you answered yes**, please describe the types of exercises or physical activity that your child cannot do at this time:

____

____

____

____

Appendix B: CAPL questionnaire

Physical Activity Questionnaire
(Canadian Assessment of Physical Literacy)

What school grade are you in:
1 2 3 4 5 6 7 8 **(please circle one)**

Are you a: boy girl **(please circle one)**

What month is your birthday: **(please circle one)**
Jan Feb Mar Apr May Jun Jul Aug Sept Oct Nov Dec

How old are you:
5 6 7 8 9 10 11 12 13 14 15
(please circle one)

In this project, when we talk about physical activity, we mean when you are moving around, playing or exercising. Physical activity is any activity that makes your heart beat faster or makes you get out of breath some of the time.

Why are we asking you these questions? We want to know what kids like you think about physical activity, sports and exercise.

Please remember:

- ☺ **There are no right or wrong answers. We only want to know what you think.**
- ☺ **If you do not know an answer, please write your best guess.**
- ☺ **There is no time limit, so please take all the time you need.**

1. **How many minutes each day should you and other children do physical activities that make your heart beat faster and make you breathe faster, like walking fast or running? Count the time you should be active at school and also the time you should be active at home or in your neighbourhood.**
   a) 10 minutes
   b) 20 minutes
   c) 30 minutes
   d) 60 minutes or 1 hour

2. **Kids say there are many different reasons that they like to be active or play sports. Being active is anything that you do when you are moving, exercising or not sitting still. Below are some reasons that other kids have told us why they like to be active. For each reason, tell us what you think. If you think it is a good reason then you would "Agree a little" or "Agree a lot". If you do not think it's a good reason, then you would "Disagree a little" or "Disagree a lot". If you are not sure or you don't think the reason is good or bad then you are "in between".**

A reason that I might be active is because when I am active. . .	Disagree a lot	Disagree a little	In between	Agree a little	Agree a lot
…I look better	1	2	3	4	5
… I have more energy	1	2	3	4	5
…I feel happier	1	2	3	4	5
…I have fun	1	2	3	4	5
… I make more friends	1	2	3	4	5
…I get stronger	1	2	3	4	5
… I like myself more	1	2	3	4	5
…I get in better shape	1	2	3	4	5
…I feel healthier	1	2	3	4	5

3. **Kids say there are also reasons that make it hard for them to be active. For each reason, tell us what you think. If you think it is a good reason then you would "Agree a little" or "Agree a lot". If you do not think it's a good reason, then you would "Disagree a little" or "Disagree a lot". If you are not sure or you don't think the reason is good or bad then you are "in between".**

I might <u>not</u> be active if. .	Disagree a lot	Disagree a little	In between	Agree a little	Agree a lot
…I didn't have enough time to be active	1	2	3	4	5
…I have too many chores to do	1	2	3	4	5
…I didn't have a good place to be active	1	2	3	4	5
…If the weather was too bad	1	2	3	4	5
…I didn't have the right clothes/shoes	1	2	3	4	5
…I didn't know how to do the activity	1	2	3	4	5
…I didn't have the right equipment	1	2	3	4	5
…I had too much homework	1	2	3	4	5
…I didn't have anyone to be active with	1	2	3	4	5
…I didn't like to be active	1	2	3	4	5

4. Compared to other kids your age, how active are you? (circle one number)

A lot less active				Same				A lot more active	
1	2	3	4	5	6	7	8	9	10

5. Compared to other kids your age, how good are you at sports or skills? (circle one number)

Others are better			Same				I'm a lot better		
1	2	3	4	5	6	7	8	9	10

6. Sometimes children watch television, play video games or play on the computer or on a smart phone. What is the most time that children should look at a screen each day? Do not count the time that you have to look at a screen to do your homework.

a) 30 minutes
b) 60 minutes or 1 hour
c) 2 hours
d) 4 hours

7. There are many different kinds of fitness. One type is called endurance fitness or aerobic fitness or cardiorespiratory fitness. Cardiorespiratory fitness means… (circle the right answer)

a) How well the muscles can push, pull or stretch.
b) How well the heart can pump blood and the lungs can provide oxygen.
c) Having a healthy weight for our height.
d) Our ability to do sports that we like.

8. Muscular strength or muscular endurance means… (circle the right answer)

a) How well the muscles can push, pull or stretch.
b) How well the heart can pump blood and the lungs can provide oxygen.
c) Having a healthy weight for our height.
d) Our ability to do sports that we like.

9. Draw a line to all the words you think describe what "Healthy" means.

Being skinny

Eating well

looking good

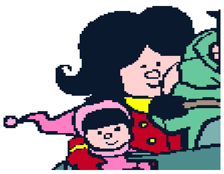
feeling good

10. This story about Sally is missing some words. Fill in the missing words below. Each word can only be used to fill one blank space in the story.

Fun **Endurance** **Good**
Pulse **Strength**

Sally tries to be active every day. Running every day is good for her heart and lungs. Sally thinks that physical activity is ______________ and is also _____________ for her. At her sport team's practice she does more running to improve her __________________. The team also does exercises like push-ups and sit-ups that increase her __________________. After exercising, she checks her heart rate which is also called a _______________.

11. **Circle each activity that you do. If you <u>always</u> or <u>almost always</u> wear safety gear (like helmet or shin pads) when you do the activity, add a check mark inside the circle.**










12. If you wanted to GET BETTER AT A SPORT SKILL like kicking and catching a ball, what would be the best thing to do?

(circle one answer)

a) Read a book about kicking and catching a ball

b) Wait until you get older

c) Try exercising or being active a lot more

d) Watch a video, take a lesson or have a coach teach you how to kick and catch

13. If you wanted to IMPROVE YOUR FITNESS, what would be the best thing to do?

(circle one answer)

a) Read a book about improving your fitness

b) Wait until you get older

c) Try exercising or being active a lot more

d) Watch a video, take a lesson or have a coach teach you how to improve your fitness

14. If you were allowed to pick what you do after school, which activity would you pick? (circle only one activity)

Play video/computer games

Read

Do homework

Play outside with my friends

Go to my sports team's practice

Walk my dog

Chat with friends online

Watch television

When answering the following questions (questions 15-21), please tell us about what you did <u>LAST WEEK</u>

15. On a <u>school day</u>, how many hours did you watch TV?

☐ I did not watch TV on <u>school days</u>
☐ Less than 1 hour ☐ 1 hour ☐ 2 hours ☐ 3 hours ☐ 4 hours ☐ 5 or more hours

16. On a <u>school day</u>, how many hours did you play video or computer games or use a computer for something that was <u>not</u> school work?

☐ I did not play video/computer games or use a computer other than for school work on <u>school days</u>
☐ Less than 1 hour ☐ 1 hour ☐ 2 hours ☐ 3 hours ☐ 4 hours ☐ 5 or more hours

17. On a weekend day, how many hours did you watch TV?

☐ I did not watch TV on weekend days

☐ Less than 1 hour ☐ 1 hour ☐ 2 hours ☐ 3 hours ☐ 4 hours ☐ 5 or more hours

18. On a weekend day, how many hours did you play video or computer games or use a computer for something that was not school work?

☐ I did not play video/computer games or use a computer other than for school work on weekend days

☐ Less than 1 hour ☐ 1 hour ☐ 2 hours ☐ 3 hours ☐ 4 hours ☐ 5 or more hours

19. During the past week (7 days), on how many days were you physically active for a total of at least 60 minutes per day? (all the time you spent in activities that increased your heart rate and made you breathe hard)

a) 0 days
b) 1 day
c) 2 days
d) 3 days
e) 4 days
f) 5 days
g) 6 days
h) 7 days

20. On a school day how many hours did you spend sitting down doing non-screen based activities (e.g. reading a book, doing homework, sitting and talking to friends, drawing, etc.). Do not count the time that you sit at school.

☐ I did not spend time sitting down in non-screen based activities (e.g. reading a book, doing homework, sitting and talking to friends, drawing, etc.) on school days

☐ Less than 1 hour ☐ 1 hour ☐ 2 hours ☐ 3 hours ☐ 4 hours ☐ 5 or more hours

21. On a weekend day how many hours did you spend sitting down doing non-screen based activities (e.g. reading a book, doing homework, sitting and talking to friends, drawing, etc.). Do not count the time that you sit at school.

☐ I did not spend time sitting down in non-screen based activities (e.g. reading a book, doing homework, sitting and talking to friends, drawing, etc.) on a weekend day

☐ Less than 1 hour ☐ 1 hour ☐ 2 hours ☐ 3 hours ☐ 4 hours ☐ 5 or more hours

☺ Thank you for your help! ☺

What's Most Like Me

For the rest of the questions you have to read 2 sentences and then circle the sentence you think is **MORE LIKE YOU**.

Try the following **SAMPLE QUESTION**:

Some kids have one nose on their face!	**BUT**	**Other kids have three noses on their face!**

That shouldn't be too hard for you to decide! Once you have circled the sentence that is more like you, then you have to decide if it is **REALLY TRUE** for you or **SORT OF TRUE** for you.

Here is another sample question for you to try. Remember, first circle the sentence that is more like you and then put a check in the correct box if it is really true or only sort of true for you. THERE ARE NO RIGHT OR WRONG ANSWERS, JUST WHAT IS **MOST LIKE YOU**.

SAMPLE QUESTION #2:

Some kids like to play with computers		**BUT**	**Other kids don't like playing with computers**	
□ **REALLY TRUE for me**	□ **SORT OF TRUE for me**		□ **REALLY TRUE for me**	□ **SORT OF TRUE for me**

Now you are ready to start filling in this form**.** Take your time and do the whole form carefully. If you have any questions, just ask! If you think you are ready you can start now.

BE SURE TO FILL IN BOTH SIDES OF EACH PAGE!

What's Most Like Me

Some kids can't wait to play active games after school		**BUT**	**Other kids would rather do something else after school**	
□ REALLY TRUE for me	**□ SORT OF TRUE for me**		**□ REALLY TRUE for me**	**□ SORT OF TRUE for me**

Some kids don't like playing active games		**BUT**	**Other kids really like playing active games**	
□ REALLY TRUE for me	**□ SORT OF TRUE for me**		**□ REALLY TRUE for me**	**□ SORT OF TRUE for me**

Some kids don't have much fun playing sports		**BUT**	**Other kids have a good time playing sports**	
□ REALLY TRUE for me	**□ SORT OF TRUE for me**		**□ REALLY TRUE for me**	**□ SORT OF TRUE for me**

Some kids are good at active games		**BUT**	**Other kids find active games hard to play**	
□ REALLY TRUE for me	**□ SORT OF TRUE for me**		**□ REALLY TRUE for me**	**□ SORT OF TRUE for me**

Some kids don't like playing sports		**BUT**	**Other kids really enjoy playing sports**	
□ REALLY TRUE for me	**□ SORT OF TRUE for me**		**□ REALLY TRUE for me**	**□ SORT OF TRUE for me**

Some kids always hurt themselves when they play sports		**BUT**	**Other kids never hurt themselves playing sports**	
□ REALLY TRUE for me	**□ SORT OF TRUE for me**		**□ REALLY TRUE for me**	**□ SORT OF TRUE for me**

Some kids like to play active games outside		**BUT**	**Other kids would rather read or play video games**	
□ REALLY TRUE for me	**□ SORT OF TRUE for me**		**□ REALLY TRUE for me**	**□ SORT OF TRUE for me**

Some kids are among the last to be chosen for active games.		**BUT**	**Other kids are usually picked to play first.**	
□ REALLY TRUE for me	**□ SORT OF TRUE for me**		**□ REALLY TRUE for me**	**□ SORT OF TRUE for me**

Some kids do well in most sports		**BUT**	**Other kids feel they aren't good at sports**	
□ REALLY TRUE for me	**□ SORT OF TRUE for me**		**□ REALLY TRUE for me**	**□ SORT OF TRUE for me**

Some kids learn to play active games easily	**BUT**	**Other kids find it hard learning to play active games**
□ REALLY TRUE for me | **□ SORT OF TRUE for me**		**□ REALLY TRUE for me** | **□ SORT OF TRUE for me**

Some kids learn to play active games easily		**BUT**	**Other kids find it hard learning to play active games**	
□ REALLY TRUE for me	**□ SORT OF TRUE for me**		**□ REALLY TRUE for me**	**□ SORT OF TRUE for me**

Some kids think they are the best at sports		**BUT**	**Other kids think they aren't good at sports**	
□ REALLY TRUE for me	**□ SORT OF TRUE for me**		**□ REALLY TRUE for me**	**□ SORT OF TRUE for me**

Some kids find games in physical education hard to play		**BUT**	**Other kids are good at games in physical education**	
□ REALLY TRUE for me	**□ SORT OF TRUE for me**		**□ REALLY TRUE for me**	**□ SORT OF TRUE for me**

Some kids like to watch games being played outside		**BUT**	**Other kids would rather play active games outside**	
□ REALLY TRUE for me	**□ SORT OF TRUE for me**		**□ REALLY TRUE for me**	**□ SORT OF TRUE for me**

Some kids like to take it easy during recess		**BUT**	**Other kids would rather play active games at recess**	
□ REALLY TRUE for me	**□ SORT OF TRUE for me**		**□ REALLY TRUE for me**	**□ SORT OF TRUE for me**

Some kids aren't good enough for sports teams		**BUT**	**Other kids do well on sports teams**	
□ REALLY TRUE for me	**□ SORT OF TRUE for me**		**□ REALLY TRUE for me**	**□ SORT OF TRUE for me**

Some kids like to read or play quiet games		**BUT**	**Other kids like to play active games**	
□ REALLY TRUE for me	**□ SORT OF TRUE for me**		**□ REALLY TRUE for me**	**□ SORT OF TRUE for me**

Some kids like to play active games outside on weekends		**BUT**	**Other kids like to relax and watch TV on weekends**	
□ REALLY TRUE for me	**□ SORT OF TRUE for me**		**□ REALLY TRUE for me**	**□ SORT OF TRUE for me**

Appendix C: Exergaming Questionnaire

<u>Exergaming Questions</u>

1. Have you used an Exergaming system (WII, Kinect, DDR, Move, etc…) in the last 30 day period?

☐ Yes ☐ No

2. On a weekday how many hours did you spend doing active video games (Exergames)

☐ I did not spend time playing exergames (Wii, Kinect, etc.) on <u>a week day</u>

☐ Less than 1 hour ☐ 1 hour ☐ 2 hours ☐ 3 hours ☐ 4 hours ☐ 5 or more hours

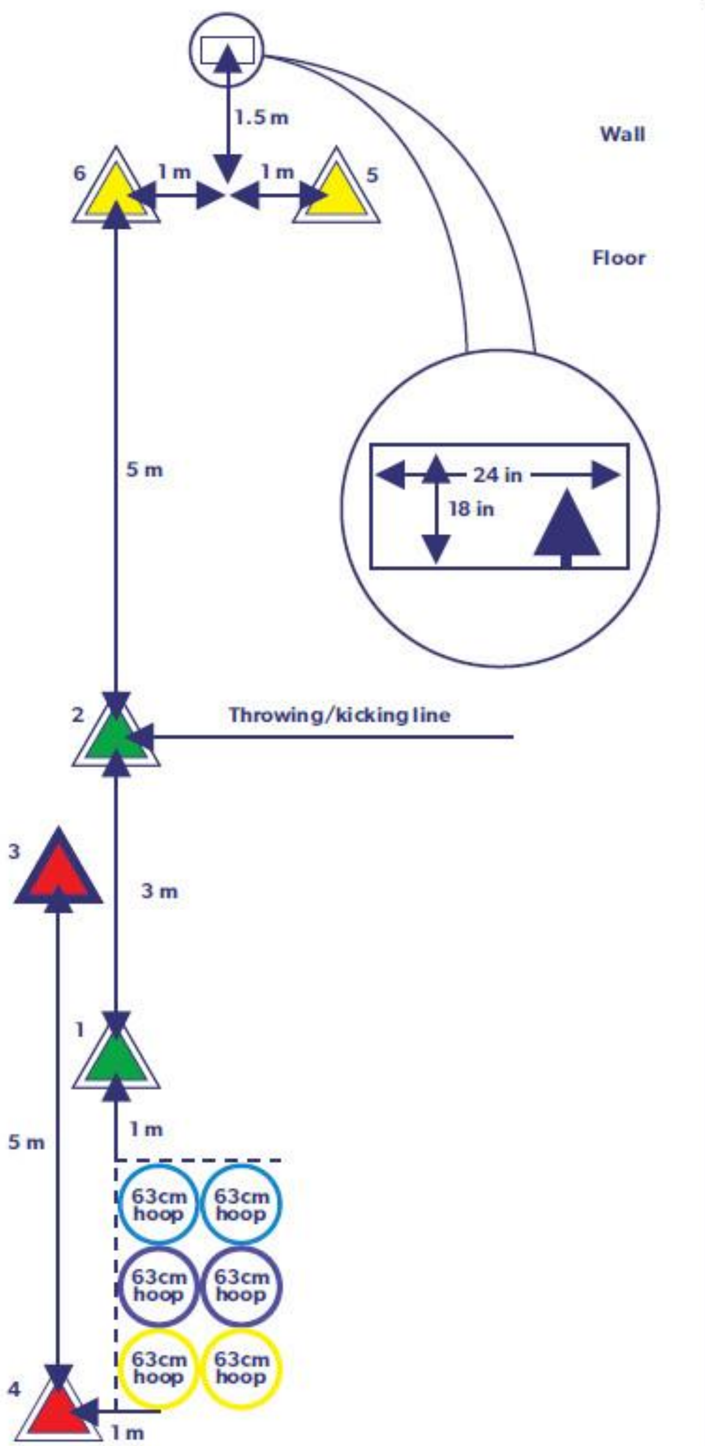
3. On a weekend day how many hours did you spend doing active video games (Exergames)

☐ I did not spend time playing exergames (Wii, Kinect, etc.) on <u>a weekend day</u>

☐ Less than 1 hour ☐ 1 hour ☐ 2 hours ☐ 3 hours ☐ 4 hours ☐ 5 or more hours

☺ Thank you for your help! ☺

Appendix D: CAMSA Obstacle Course Layout



Appendix E: CAPL Scoring Breakdown