

An examination of the relationships between fundamental motor skills, perceived physical competence, and physical activity levels during the primary years

by

Jeff R. Crane

MSc, Texas Woman's University, 2009

BEd, Acadia University, 2008

BKIN, Acadia University, 2005

A Dissertation Submitted in Partial Fulfillment  
of the Requirements for the Degree of

Doctor of Philosophy

in the School of Exercise Science, Physical & Health Education

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University of Victoria

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## **Supervisory Committee**

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**Supervisor**

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## Abstract

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Canadian children have policy and infrastructure rich environments, but their physical activity levels are among the lowest in the world. The disconnection between opportunities to be active and actual physical activity suggests that factors other than policies and resources need to be investigated in the Canadian context. Finding ways to increase physical activity levels is critical in order for children to obtain adequate levels throughout childhood. Fundamental motor skill proficiency and positive perceptions of physical competence have been previously identified as factors that may contribute to physical activity engagement across childhood. This dissertation examined the developmental trajectories of fundamental motor skill proficiency (FMS), perceptions of physical competence (PPC), physical activity (MVPA), and sedentary behaviour (SB) from kindergarten to grade 2, in both cross-sectional and longitudinal samples of children. Three interrelated studies were conducted to address the overall purpose.

The aim of study 1 was to examine the change in the relationship between fundamental motor skill proficiency and perceptions of physical competence from early to the beginning of middle childhood. The Test of Gross Motor Development–2 (TGMD-2) and The Pictorial Scale of Perceived Competence and Social Acceptance for Young Children were used to measure FMS and PPC from kindergarten to grade 2 (n=250). Motor skills improved from kindergarten to grade 2, while PPC was high in both kindergarten and grade 2. Mixed design analyses of variance revealed overall significant effects for object control skills and PPC from kindergarten to grade 2. Furthermore, boys

had higher object control skills and girls had higher locomotor skills and perceived physical competence.

The aim of study 2 was to examine the levels of physical activity and sedentary behaviours sequentially from kindergarten to grade 2. A sample of 176 cross-sectional and 21 longitudinal participants wore Actigraph GT1M accelerometers for  $\geq 10$ hrs per day for 7 days to measure physical activity and sedentary behaviour. Physical activity levels were lower in grade 2, while sedentary behaviour was higher. Pearson product-moment correlations revealed sedentary behaviour tracked more consistently over time than MVPA or total physical activity.

The aim of study 3 was to examine whether perceptions of physical competence mediated the relationship between motor competence as the predictor variable and both physical activity and sedentary behaviour as dependent variables among children in grade 2 or 3. The TGMD-2 measured FMS and Actigraph GT1M accelerometers measured physical activity and sedentary behaviour for 129 grade 2–3 children. The Pictorial Scale of Perceived Competence and Social Acceptance for Young Children and The Self-Perception Profile for Children were used to assess PPC. Overall, PPC did not mediate the relationship between object control skills and MVPA or SB. Also, the path between object control skills and MVPA was significant for boys as were the paths between MVPA and SB for boys and girls.

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## **Dedication**

To Mom, you're the strongest person I know. Words can't describe how grateful I am for your constant love, support, energy, time and the sacrifices you've so selflessly made over the years. Thank you for always believing in me, supporting me, encouraging me, and trusting me. None of this would have been possible without you so I dedicate this to you. I love you.

## Chapter 1 – Introduction

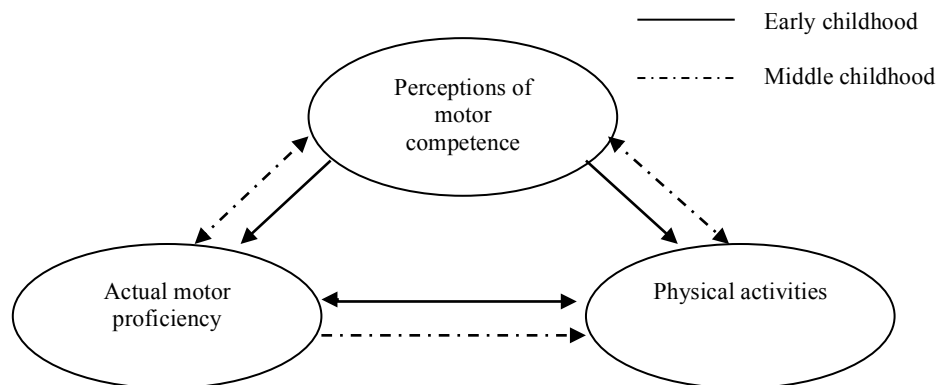
A decade of report cards from Active Healthy Kids Canada paints a concerning picture for overall physical activity levels and engagement in sedentary behaviours (Active Healthy Kids Canada, 2015). Since 2005, the overall physical activity levels of Canadian children have been awarded two D's, two D minuses, and six F's; while sedentary behaviour has been awarded one C minus, two D minuses, and seven F's. To put this into perspective, compared to 15 countries that span 3 continents, Canadian children's physical activity levels ranked 12<sup>th</sup> out of those 15 countries; and sedentary behaviour ranked 10<sup>th</sup>. The 2014 Report Card also showed that the proportion of children and youth meeting the Canadian physical activity guideline of 60 minutes of daily moderate- to vigorous-intensity physical activity (MVPA) was lower among older children and youth (Active Healthy Kids Canada, 2014). Eleven percent of preschool aged children (3 – 4 years) met the daily MVPA guideline, compared with 7% of school-aged children (5 – 11 years) and 4% of youth (12 – 17 years) (Active Healthy Kids Canada, 2014). These compelling accelerometry data were derived from nationally representative samples of children and youth (Colley et al., 2011; Colley et al., 2013). However these data were also cross-sectional, which inhibits some level of interpretation since it is not clear whether this is a cohort effect (Atingdui, 2011) of having been born in a particular period, or whether physical activity levels decrease as a child transitions from one stage of childhood to another.

The transition from early to middle childhood is of particular interest as it is a period when children's motor and perceptual systems develop rapidly (Canadian Paediatric Society, 2005; Gabbard, 2012), their cognitive skills (e.g. memory, attention span, and decision making) become more mature (Canadian Paediatric Society, 2005; Harter, 2012), and their at-school and after-school lives become more structured and demanding (Sigmund, Sigmundova, & Ansari, 2009; Taylor, Williams, Farmer, & Taylor, 2013). It is likely that these personal and environmental changes interact to affect children's physical activity levels and patterns (Stodden et al., 2008).

The developmental systems perspective posits that developmental outcomes arise from recurring interactions between the individual and his or her environment as well as

the integration of individual's attributes, such as their biology, physiology, motivation, and cognition (Gabbard, 2012; Lerner, Agans, DeSouza, & Gasca, 2013). Lerner and colleagues also argued that to optimize developmental trajectories such as engaging in healthy behaviours (e.g. physical activity); researchers need to identify the attributes of individuals who display those behaviours and ascertain when in the lifespan these processes are at play. The aim of this dissertation was to identify change in engagement in physical activity and specific motor and cognitive attributes from early to middle childhood; and most importantly, reveal how physical activity, motor skill proficiency, and perceptions of physical competence interact at the beginning of middle childhood.

This work is informed by Stodden and colleagues' (2008) seminal paper on children's physical development that identified mechanisms that may influence children's physical activity participation trajectories (see Figure 1). The early childhood path between actual motor proficiency and physical activities was published erroneously in 2008 as a uni-directional path. Dr. Stodden provided the correct model with the bi-directional path between actual motor proficiency and physical activities in early childhood to our research team in 2013 (D. Stodden, personal communication, May, 2013). To avoid confusion throughout the rest of this dissertation, I will refer to the Stodden et al. (2008) paper as if it contained the bi-directional path, as this is what was described in the manuscript. As illustrated by this model, fundamental motor skill proficiency influences engagement in physical activity directly (mechanism 1) and indirectly via children's perceptions of their physical competence (mechanism 2).



*Figure 1.* Extract of a model developed by Stodden and colleagues (2008) illustrating developmental mechanisms influencing physical activity trajectories of children.

The first mechanism proposed by Stodden and colleagues (2008) is that fundamental motor skill proficiency directly influences physical activity levels; however these authors also suggest that the direction of this influence changes between early and middle childhood. They hypothesized that in early childhood the relationship is reciprocal (Stodden et al., 2008). With regular bouts of physical activity stimulating neuromotor activity and therefore the development of fundamental motor skills; while at the same time, motor skill competence is enabling participation in activities, games, and/or sports that are physical in nature (Stodden et al., 2008). By middle childhood, Stodden et al. suggest that relationship between motor skill proficiency and physical activity participation will be stronger than in early childhood, but unidirectional. Where children with higher levels of motor competence will be more physically active in various forms of organized and unorganized physical activities and sport because they have the necessary skills to participate with. Conversely, children who demonstrate lower levels of gross motor proficiency will have lower engagement in physical activity (Stodden et al., 2008).

The model (Figure 1) also illustrates a second mechanism that is thought to influence participation in physical activities, and this mechanism is also believed to change from early to middle childhood. Mechanism 2 involves children's perceptions of their physical competence. As Figure 1 illustrates, perceived physical competence is thought to influence both motor skill development and participation in physical activity in

early childhood. Young children tend to have unrealistically high perceptions of their physical competence (Horn, 2004) because they are unable to differentiate between competence and effort or compare their own performances to those of their peers. As a result, young children often rely on the feedback from significant others, which is generally very positive (Harter, 2012). Consequently, children's beliefs about their physical competence are often inflated or exaggerated. These inaccurate beliefs help children continue to be physically active and persist with activities that nurture motor skill proficiency (Stodden et al., 2008). Therefore, in early childhood, the inaccurate perceptions of physical competence may help in the development of proficient motor skills, and these motor skills support physical activity engagement (Cliff, Okely, Smith, & McKeen, 2009; Crane, Naylor, Cook, & Temple, 2015; Williams et al., 2008).

As children transition from early to middle childhood, their perceptions of competence should become reciprocally related to their motor skill proficiency (see Figure 1) as they begin to more accurately assess their own physical competence (Stodden et al., 2008). This increased accuracy is related to the development of higher cognitive functions (Shonkoff & Phillips, 2000) such as working memory and cognitive control processes (Paz-Alonso, Sunge, & Ghetti, 2014). These enhanced cognitive abilities allow children to be more aware of their own competence and performances, compare their performances to their peers' performances, and analyze the reasons for their successes and failures (Harter, 2012; McKiddle & Maynard, 1997). These more accurate perceptions mean that children with less proficient skills are more likely to have less favourable perceptions of their physical competence (Stodden et al., 2008).

Systematic reviews of the literature have demonstrated that positive perceptions of physical competence are associated with greater physical activity among adolescents (Biddle, Whitehead, O'Donovan, & Nevill, 2005; Sallis, Prochaska, & Taylor, 2000) and lower levels of perceived competence are associated with dropout from organized sport among children and youth (Crane & Temple, 2015). When a child is not succeeding in an activity, they may perceive their competence less favourably and discount the importance of, or withdraw from, physical activities in order to protect their self-esteem (Horn, 2004). As Stodden and colleagues (2008, pp. 296-297) theorise for middle and late

childhood “...low levels of motor competence will be significantly related to lower perceived motor skill competence and, subsequently, lower levels of physical activity”.

Although not represented in the Stodden et al. (2008) model, gender differences have been identified in physical activity, sedentary behaviour, motor skill proficiency, and perceptions of physical competence, as well as in the interactions between some of these factors. Overall, boys are more active than girls (Chung, Skinner, Steiner, & Perrin, 2012; Colley et al., 2011; Troiano et al., 2008), but there doesn't appear to be a gender-based difference in sedentary behaviour during early childhood (Cliff et al., 2009) or middle and late childhood (Colley et al., 2011). The findings for motor skills are mixed. The literature consistently shows that boys have significantly better object control skills than girls (Barnett, Morgan, van Beurden, & Beard, 2008; LeGear et al., 2012; Robinson, 2010). However, for locomotor skills, some studies found girls performed better than boys (Barnett et al., 2008; LeGear et al., 2012; van Beurden, Zask, Barnett, & Dietrich, 2002), while other studies have shown no differences between boys and girls (Hume et al., 2008). Finally, few studies have examined childhood perceived competence levels and gender (Goodway & Rudisill, 1997; LeGear et al., 2012; Robinson, 2010). LeGear and colleagues found 5-year old girls' perceived physical competence was higher in comparison to boys, while Robinson (2010) found that 4-year old boys had higher perceived physical competence than girls. Finally, Goodway et al. (1997) found no gender-based differences in perceptions of physical competence among 3 and 4-year olds.

My dissertation examined the developmental trajectories of fundamental motor skill proficiency, perceptions of physical competence, and participation in physical activity and sedentary behaviour from kindergarten to grade 2 in longitudinal and cross-sectional samples of children. Further, I tested whether, as expected for middle childhood, perceptions of physical competence mediated the relationship between motor skill proficiency and participation in physical activity. This test of mediation will build on my previously published work testing a mediation model with kindergarten children (Crane et al., 2015). The results of that study partially supported the early childhood component of a conceptual model presented by Stodden et al (2008). Consistent with the model, my colleagues and I found there was a reciprocal relationship between motor skill proficiency and participation in physical activity, but this relationship was only

significant for object control skills. Contrary to the early childhood component of the Stodden et al. (2008) model, we did not find a significant relationship between perceptions of physical competence and participation in physical activity, but there was a significant (albeit modest) relationship between object control skills and perceptions of competence, which was not modelled by Stodden et al. The third paper in this dissertation allowed me to test the extent to which the relationships between motor skill proficiency, perceptions of physical competence, and participation in physical activities had changed from early childhood to the beginning of middle childhood.

### **1.1) Research Questions**

This dissertation consists of three related studies that focus on childhood engagement in physical activities and the relationships with fundamental motor skills and perceptions of physical competence. The overarching question for each study was:

1. Did the relationship between fundamental motor skill proficiency and perceived physical competence strengthen as children transition from early to middle childhood?
2. To what extent did physical activity levels and sedentary behaviour levels track from kindergarten to grade 2?
3. Did perceived physical competence mediate the relationship between fundamental motor skill proficiency and physical activity levels in middle childhood?

## Chapter 2 – Literature Review

An international comparison of the physical activity levels of children and the physical activity policies, practices, and infrastructure of the countries in which those children reside, revealed that Canadian children have policy and infrastructure rich environments, but their physical activity levels are among the lowest in the world (Tremblay et al., 2014). The disconnection between opportunities to be active and actual physical activity suggests that factors other than policies and resources need to be investigated in the Canadian context. Finding ways to increase physical activity levels is critical in order for children to obtain adequate levels throughout childhood. Fundamental motor skill proficiency and positive perceptions of physical competence have been previously identified as factors that may contribute to physical activity engagement across childhood and into adulthood (Barnett et al., 2008; Barnett, van Beurden, Morgan, Brooks, & Beard, 2009; Crane et al., 2015; Okely, Booth, & Patterson, 2001; Robinson, 2010).

Prominent motor development researchers and theorists identified two mechanisms involving these factors that may influence physical activity levels in childhood: 1) the direct (both reciprocal and unidirectional) relationships between fundamental motor skill proficiency and physical activity levels, and 2) the indirect influence of perceived physical competence on the relationship between fundamental motor skills and physical activity in middle childhood (Stodden et al., 2008). For the first mechanism, Stodden and colleagues suggested that in early childhood the relationship between gross motor skills and physical activity is bi-directional, arguing that engagement in physical activity promotes neuromotor development, which in turn leads to the development of fundamental motor skills. Also, that motor skills are the tools that allow children to participate in physical activities. However, in middle and late childhood, motor skill proficiency is thought to impact physical activity levels in a unidirectional manner. Stodden and colleagues (2008) theorized that in middle and late childhood, similar to early childhood, children who demonstrate higher proficiency levels of motor competence are more likely to continue to participate in various activities because they have the requisite requirements to participate with, whereas a child with

lower proficiency levels of motor competence is less likely to pursue those types of activities.

The second mechanism focused on how children feel about their competence. Perceptions of physical competence are thought to indirectly influence the relationship between motor competence and physical activity, a process known as mediation (Stodden et al., 2008). The mediating effects of children's perceptions of physical competence have been demonstrated to some extent among adolescents. Barnett and colleagues (2008) found that perceived physical competence mediated the relationship between childhood object control proficiency and adolescent physical activity levels. However, these authors did not examine the relationship between perceptions of competence and motor skill proficiency in childhood, and little attention has been given to these relationships during middle childhood. As developmental psychologists have suggested that children are able to make more accurate self-appraisals during middle childhood (Fingerman, Berg, Smith, & Antonucci, 2011; Harter, 2012; Horn, 2004; Shaffer & Kipp, 2014), the question of when children's perceptions of their abilities begin to influence their physical activity levels and mediate the relationship between motor skill proficiency and physical activity is intriguing.

Before middle childhood, perceived physical competence is thought to positively drive the development of motor proficiency and participation in physical (Stodden et al., 2008). Young children tend to have very positive outlooks on their own abilities because they are unable to differentiate between competence and effort, or compare their own performances to those of their peers, and because young children tend to accept the positive feedback usually given by significant persons at face value (Harter, 2012; Horn, 2004). As a result, children's beliefs about their physical competence are often inflated or exaggerated in early childhood. These inaccurate beliefs help children continue to be physically active and develop motor competence because these positive perceptions increase the children's motivation to persist and continue to practice and participate (Stodden et al., 2008). These inaccurate perceptions also mean that perceptions should not mediate the relationship between motor skill proficiency and participation in physical activity in early childhood (Stodden et al., 2008). Empirical evidence from one study of 5-year old children supports this assertion (Crane et al., 2015). Crane and colleagues

found that children's participation in physical activity was related to motor skill proficiency, but the children's perceptions of their physical competence did not mediate the relationship between locomotor and object control skills and accelerometer measured physical activity.

From middle childhood however, the relationship between perceived competence and motor proficiency and perceived competence and physical activity are thought to be reciprocal as children begin to more accurately assess their own physical competence (Stodden et al., 2008). Children in middle childhood have a greater ability to process information compared to early childhood as well as a greater cognitive capacity. At this stage of development, children are becoming more aware of their own performances as well as their successes and failures. They are more accurate in comparing themselves to their peers and they are exposed to more comparative circumstances and norms (Harter, 2012). The consistent positive relationship between higher levels of perceived physical competence and participation in physical activity among older children and youth (Barnett et al., 2008; Crocker, Eklund, & Kowalski, 2000; Crocker, Sabiston, Kowalski, McDonough, & Kowalski, 2006) and evidence that lower perceptions of competence are associated with drop-out from sport (Crane et al., 2015), suggests that children with lower levels of perceived physical competence are at a higher risk of becoming disengaged from physical activity as they downplay the importance of participation to protect their self-esteem (Harter, 2012). Thus, as Stodden and colleagues describe, low perceptions of physical competence may create a spiral of disengagement from participation in physical activity; whereas children with more positive perceptions are more likely to continue to engage in various forms of activity and master motor skills, which in turn results in positive perceptions, and so on, in a positive spiral of engagement (Stodden et al., 2008).

This literature review provides a rationale for examining the relationships between children's fundamental movement skills, perceived physical competence, and physical activity and sedentary behaviour both cross-sectionally and longitudinally as they transition from early to middle childhood. The review has been divided into the following sections 1) Developmental patterns of fundamental motor skills, 2) Developmental patterns of perceived physical competence, 3) Developmental physical

activity patterns of Canadian children, and 4) The relationships between fundamental motor skills, perceived physical competence, and physical activity.

### **2.1) Developmental patterns of fundamental motor skills**

Motor development is the study of change in human motor behaviour over the lifespan, the processes that underlie these changes, and the factors that affect them (Payne & Issacs, 2012). Early developmental theorists believed a person's biological makeup was the force behind development and that one's environment was just a secondary factor (Gesell, 1925). Years later, theorists such as Bruner (1973) and Thelen (1995), demonstrated that the biological makeup of a child is one factor contributing to development and that other factors such as the environment also play a key role. A contemporary view of development is the developmental systems perspective (Gabbard, 2012; Lerner et al., 2013). This perspective posits that human development is cumulative, and developmental outcomes arise from recurring interactions between the individual and his or her environment and from the integration of individual's attributes, such as their biology, physiology, motivation, and cognition.

#### **2.1.1) Models of motor development**

Models help us understand complex concepts. In the motor development field, models have been created to describe expected movements, changes in movements throughout the lifespan, and to explain why movement develops the way it does (Payne & Issacs, 2012). Two prominent models that have been used to help explain motor development are Gallahue's 'Triangulated Hourglass' and Clark and Metcalfe's 'Mountain of Motor Development' (Clark & Metcalfe, 2002; Gallahue & Ozmun, 2002). These models were created to describe and explain the developmental stages of change in motor behaviour that occur throughout the lifespan. Each model identifies constraints consistent with the developmental systems perspective that play a role in a person's ability to progress through the various stages of either model. Constraints are the limitations or restrictions that may be related to the individual's biological makeup and/or the conditions of the learning environment (Gallahue & Ozmun, 2002). Gallahue's triangulated hourglass model contains constraining factors of the task, environment, and the individual that impact motor development (Gallahue & Ozmun, 2002). Similarly,

Clark and Metcalfe (2002) note that how far an individual climbs on their ‘mountain of motor development’ is dependent on his or her biological makeup as well as environmental constraints. In other words, the level an individual reaches on ‘the mountain’ is determined by the interaction between the biology of the individual (e.g. genetics) and the conditions of the environment (Gallahue & Ozmun, 2002).

Both Gallahue and Ozmun (2002) and Clark and Metcalfe (2002) include a ‘reflexive period/phase’ at the base or starting point of their respective developmental models. Infant reflexes include both primitive (e.g. rooting and sucking reflexes) as well as postural (e.g. head and body righting and pull-up reflexes). These involuntary reflexes are important as they serve to both protect and help in the survival of the infant. For example, the sucking reflex can be seen when anything touches the newborns lips and also the pull-up reflex is the involuntary attempt of an infant to remain upright (Gabbard, 2012). With the development and maturity of the infant’s nervous system, infants begin to demonstrate more control of their movements. As more voluntary movements are established, the infant typically develops basic control of their posture as well as locomotion (Gabbard, 2012). These rudimentary, or basic abilities, labelled the ‘preadapted period’ by Clark and Metcalfe, provide the foundation for the development of fundamental movement skills. For example, from birth until about the first year, infants progress through stages of locomotion from crawling to creeping and once children have mastered these movements and developed the necessary strength as well as coordination and control of their movements, most infants begin to walk (Gabbard, 2012). Clark and Metcalfe consider the onset of walking and self-feeding as the passage out of the preadapted period.

Next, both models identify a fundamental motor phase/stage that focus on the importance of the development and mastery of locomotor (e.g. running), object manipulation (e.g. throwing), and non-locomotor (e.g. bending) skills (Clark & Metcalfe, 2002; Gallahue & Ozmun, 2002). The significance of developing proficiency in the fundamental motor phase/stage is based on the premise that fundamental motor skills are the basis for more complex skills and lead to engagement in physical activities (Clark & Metcalfe, 2002; Gallahue & Ozmun, 2002) that are further refined in the context-specific (Clark & Metcalfe, 2002) or the specialized period (Gallahue & Ozmun, 2002) of

development. This stage of development focuses the transition from fundamental motor skill development (e.g. running or throwing) towards more complex movements in context (e.g. throwing a ball to first base in softball) and recreational activities or sports such as soccer, baseball, or playing Frisbee (Clark & Metcalfe, 2002; Gallahue & Ozmun, 2002). Children in this phase are learning to adaptively apply their skills in different environments (Clark & Metcalfe, 2002), and in keeping with the developmental systems perspective, the recurring interactions between the environment and the individual shapes development.

The final period of development in both models is referred to as either the 'skillful period' (Clark & Metcalfe, 2002) or 'lifelong utilization period' (Gallahue & Ozmun, 2002) of development. The authors of both models refer to this period as being the pinnacle of motor development; and therefore both contain similarities and differences worth noting. In both models, the authors highlight the importance of demonstrating proficient levels in a variety of skills that can then be applied to more complex organized and unorganized types of sports and activities. In the 'peak' of motor development the authors of both models illustrate that motor proficiency levels vary, are individualistic, and range from activities/sport for daily living to highly competitive pursuits. Gallahue and Ozmun (2002) indicate that by early adolescence, many individuals may reach the lifelong utilization period of development. Furthermore, the skills used in the lifelong utilization period (i.e. activities of daily living, recreational activities, or competitive activities) are specific to the individual and the result of factors that include physical capabilities, skill level, motivation to participate, having opportunities to participate, and access to facilities/equipment. Therefore, two individuals may be climbing towards different peaks during their ascent. For example, an individual who has a goal to reach the Olympics or is training to perform as a professional in a specific sport or activity will be climbing to a different peak, which will require different skills and levels of expertise in comparison to a person who has a goal to participate in a variety of recreational activities for lifelong physical activity participation. While both individuals may have developed similar skills to perform the same activities, each individual may have a different level of expertise. Although the authors of both models use their own unique

methods to explain motor development, both models emphasize that both biology and the environment interact to affect motor development.

As this dissertation focuses on children in kindergarten and grade 2/3, the transition from kindergarten to grade 2, it is most likely that children in kindergarten will be in the fundamental patterns period, building proficiency in fundamental motor skills; whereas a majority of the children in grade 2/3 will be transitioning from the fundamental patterns period to the context-specific period.

### **2.1.2) Factors affecting motor skill development**

Like human development in general, the development of motor skill proficiency is influenced by a child's physical growth and maturation, their genetic potential, and the environmental and sociological affordances in the physical and sociocultural environment (Malina, 2004). Children who are exposed to, and presented with, various opportunities to explore their own movement capabilities are more likely to develop proficient levels of motor skills earlier compared to children who are not offered those same opportunities (Temple, Crane, Brown, Williams, & Bell, 2014; Thelen, 1995). This notion is supported by Temple et al. who found that among kindergarten children, participation in organized sports and object control skills were significantly related. Furthermore, sociocultural agents such as one's family, peers, school (teachers and other significant people), and community play an important role in a person's development. For example, play and activity affordances provided to children are often based on stereotypical gender roles for both boys and girls (Eccles, 1991). As a result, children will more frequently participate in types of play or activities that fit the gender-roles, which in turn impact the development of specific motor patterns (Gabbard, 2012). This is supported by empirical evidence, which shows that girls perform better in locomotor based activities (e.g. hopping, skipping, leaping) in comparison with boys (Hardy, King, Farrell, Macniven, & Howlett, 2010; LeGear et al., 2012; Vameghi, Shams, & Dehkordi, 2013; van Beurden et al., 2002), while boys perform better at object manipulation activities (throwing, kicking, catching) (Barnett et al., 2008; Cliff et al., 2009; Okely, Booth, & Chey, 2004).

### **2.1.3) Fundamental motor skills**

Whether referred to as the ‘fundamental patterns period’ (Clark & Metcalfe, 2002) or the ‘fundamental movement phase’ (Gallahue & Ozmun, 2002) the key feature of this period/phase is the development of fundamental motor skills (FMS). FMS are common movement patterns (e.g. run, walk, and throw) (Gabbard, 2011) that are believed to be the building blocks for the development of higher context-specific skills (Clark & Metcalfe, 2002; Malina, 2004). As motor development is cumulative, both locomotor and object manipulative skills are the building blocks for future more complex movements throughout childhood, adolescence, and into adulthood (Clark & Metcalfe, 2002).

During the fundamental movement period in development, children need opportunities to participate in a wide variety of activities to help develop a diverse motor repertoire. These skills contribute to learning and transferring, adapting and or modifying these basic motor skills, which can then be applied to different and specific movement concepts (Clark & Metcalfe, 2002). Three domains of motor behaviour emerge during the fundamental patterns period that involve patterns of locomotion and two patterns of interactive coordination (i.e. object projection and object interception) (Clark & Metcalfe, 2002). After children have gained sufficient experience with the basic locomotive patterns of walking, as well overall improvements in their balance, coordination and leg strength, most children will begin to run and explore other forms of locomotion such as hopping, galloping, and sliding. These new and more complex alternative methods of locomotion build from walking and result in a greater motor repertoire (Clark & Metcalfe, 2002). The two patterns of interactive coordination described by Clark and Metcalfe are object projection and object interception. Object projection is the ability to control and manipulate an object and then project it into the environment (Clark & Metcalfe, 2002). Throwing a ball is an example of object projection and requires coordination of the entire body, while simultaneously generating and applying an amount of force to the projected object. By comparison, object interception is the ability to stop, capture or intercept an object as it passes throughout the environment. There are two types of object interception that should be noted, object deflection and object reception (Clark & Metcalfe, 2002). Kicking a ball is a form of object deflection, where the

individual rather than controlling the ball or object, sends it away back into the environment. Catching a ball on the other hand is an example of object reception, where the individual attempts to control the object as it moves through the environment (Clark & Metcalfe, 2002).

Gallahue and Ozmun (2002) posit that during the fundamental movement phase of development children are expanding and exploring their bodies in regards to movement capabilities that involve stability (e.g. balancing on one foot), locomotor (e.g. running), and manipulation (e.g. throwing). In addition to developing these types of movements, children at this time are also learning to apply these skills to a variety of situations. Gallahue and Ozmun identify three stages that take place during the fundamental movement phase that are: the initial stage, emerging elementary stage, and proficient stage. The initial stage is marked by the early attempts of children to execute fundamental motor skills and are often seen as incomplete or awkward that includes an exaggerated use of the body and poor coordination and rhythm (Gallahue & Ozmun, 2002). In the emerging elementary stage, children begin to establish the proper sequence of the movement and with more attempts and practice, greater overall control and coordination of the skill is seen (Gallahue & Ozmun, 2002). The proficient stage is identified by mature, coordinated, rhythmic, and controlled movements. With many opportunities to practice and refine their fundamental motor skills, children will then have the ability to increase the complexity of their movements (e.g. using both locomotor and manipulative skills simultaneously) as well as improve the rate, force, and accuracy of their movements (Gallahue & Ozmun, 2002). The next section describes the major locomotor, non-locomotor, and object manipulation motor skills, and briefly how these skills are developed.

#### **2.1.4) Locomotor skill development**

Towards the end of the rudimentary stage of development, basic motor behaviours such as standing and creeping are beginning to be replaced by more advance and coordinated forms of locomotion skills such as walking, running, hopping, and jumping (Haywood & Getchell, 2010). Walking in its earliest form starts at about nine months of age and typically rapidly develops over the next three to six years (Payne & Issacs, 2012). Walking is a prerequisite to other bipedal movements such as running, jumping,

and hopping (Haywood & Getchell, 2010). Running initially develops between the ages of 1.5 – 2.5 years of age, with a large percentage of children acquiring a mature motor pattern (e.g. running) towards the later part of childhood (Haywood & Getchell, 2010; Payne & Issacs, 2012). At about the same time (late childhood), children begin to develop mature patterns of jumping. The earliest stages of jumping are characterized by an inappropriate preparatory and landing phase (Payne & Issacs, 2012). Typically, as the child develops better coordination and overall muscular strength, more mature jumping patterns are seen from about age 6, and peaking by 10 years of age (Payne & Issacs, 2012). Hopping is similar to jumping with the exception that it occurs on one foot only (Ulrich, 2000). This movement, in comparison to jumping, is more difficult given the muscular strength and the degree of balance and coordination required to consistently propel the body upward repeatedly. For this reason children are typically incapable of hopping until about the age of 3 – 5 years and development usually begins on the dominant foot before unilateral control is developed (Haywood & Getchell, 2010). Other locomotor skills such as galloping, sliding, leaping, and skipping are combinations of the previously described skills (Gallahue & Ozmun, 2002; Ulrich, 2000). The leap involves the transfer of weight from one foot to the other coupled with a period where both feet are off of the ground, similar to the run (Gallahue & Ozmun, 2002). Galloping and sliding, much like hopping, are learned and mature on the dominant leg first, and usually begin to develop between the ages of 2 – 4 years (Haywood & Getchell, 2010). Skipping develops from approximately 4 years of age and is one of the more difficult motor skills to learn. The late development is related to the difficult combination of a forward step and hop on one foot, while alternating the lead foot (Haywood & Getchell, 2010; Payne & Issacs, 2012).

#### **2.1.5) Non-locomotor development**

Non-locomotor skills are movements of the body that typically do not result in the body traveling from one place to another (Haywood & Getchell, 2010). Non-locomotor skills include both simple and complex movements such as bending, twisting, clapping, and pedalling a bicycle (Haywood & Getchell, 2010). The importance of the development of these skills is not to be underestimated. As noted in Clark and Metcalfe's *Mountain of Motor Development*, the fundamental motor period is characterized by the establishment

of a sufficient variety of movements to ensure both the quantity and quality of movement skills across the lifespan (Clark & Metcalfe, 2002). Without the development of basic non-locomotor skills such as bending or static balance, more specified or difficult skills such as dribbling a soccer ball while running down the field would not be possible. Stretching is a non-locomotor skill that is useful in both preparation and completion of physical activity or repetitive movements. Furthermore, stretching is also important in the prevention of injuries, as well as increasing blood flow and circulation and improving overall flexibility (Payne & Issacs, 2012; Sigelman & Rider, 2010).

### **2.1.6) Object manipulation development**

Manipulative skills or object control skills develop in conjunction with eye-hand, and eye-foot coordination and involve the use of both gross motor skills and fine motor manipulation (Payne & Issacs, 2012). Object control skills include throwing, catching, kicking, striking, dribbling, and rolling a ball and begin to develop in early infancy. The development of object manipulative skills is the result of both maturational changes (e.g. development of the corpus callosum and therefore improved communication between the hemispheres of the brain) and environmental influences such as opportunities to practice receiving and projecting objects and the encouragement to do so (Clark & Metcalfe, 2002). As children continue to practice and develop their manipulative skills, children will also be increasing their fine motor control, which will contribute to more skilful movements over time (Gallahue & Ozmun, 2002). Fine motor manipulation utilizes the smaller muscle groups such as in the hand or wrist. As children become proficient in both gross and fine motor movements, the basic skills can then be applied to more complex skills or activities and refined (Gallahue & Ozmun, 2002; Payne & Issacs, 2012). Furthermore, this continued development combined with maturational growth will lead to greater force production for gross motor movements and greater accuracy and control of the fine motor movements (Gallahue & Ozmun, 2002). Throwing is perhaps the most difficult object manipulation skill because of motor patterns associated with the different types of throwing (e.g. underhand or overhand) and the coordinated movements of body parts required to summate forces and execute the skill (Payne & Issacs, 2012). For example, while the throwing action is the result of gross motor movements, the trajectory, and control of the throw is a result of fine motor control (i.e. the fingers). Clark and

Metcalfe identify throwing to be part of what they called ‘object projection’, which is the ability to control and object before projecting it into the environment. Immature patterns of throwing are observed as early as 1.5 years and do not begin to resemble more mature throwing patterns until sometime between 5 – 8 years of age when children gain more control over their fine motor movements (i.e. wrists, hands, and fingers) (Haywood & Getchell, 2010). A mature pattern is identified by a downward backswing followed by torso rotation as well as the opposite leg coming forward and the hand crossing the midline of the body upon release of the ball (Haywood & Getchell, 2010; Payne & Issacs, 2012; Ulrich, 2000). These more refined aspects of the movement demonstrate fine motor control. Similarly, catching occurs from about the age of 1.5 years and develops rapidly from about 5 years of age. Perhaps the most difficult aspect of catching is the ability to anticipate the objects’ trajectory, while maintaining control over the object as it enters the hands (Haywood & Getchell, 2010). Clark and Metcalfe identified catching as an object reception skill and noted that in addition to coordinating the movements to intercept a moving object within the environment, the skill requires additional cognitive and perceptual abilities such as tracking a moving object and using kinaesthetic awareness to anticipate where the object is going. Immature patterns of kicking begin as early as 1.5 years of age and are developed to a more refined or mature pattern by age of 6 to 8 years (Payne & Issacs, 2012). Kicking an object is also known as object deflection where an individual rather than controlling the object deflects it back into the environment. The ability to strike usually begins around the age of 2 years with more advanced and mature patterns occurring around age 7 – 9 years (Payne & Issacs, 2012). Dribbling (e.g. basketball) in its most mature form involves the use of the hand (i.e. the fingers) to push the ball downward, while using the palm of the same hand to cushion or cradle the ball as it returns back to the hand. A low centre of gravity and bend in the knees usually accompanies this movement and is often seen around the age of 8 years. Immature patterns of the movement involve a lack of control as well as the slapping of the ball (lack of fine motor control), which may lead to an uncontrolled flight pattern (Payne & Issacs, 2012). Once children become proficient in these basic fundamental patterns of movement, continued maturational growth as well one’s environment (e.g. continued practice and development of these skills) will result in more refined types of movement

as well as the ability to apply these skills to more complex types of movements and activities.

### **2.1.6) Fundamental motor skills and gender**

Gender differences in childhood fundamental motor skill proficiency are typically the result of environmental influences. However, the findings for different types of motor skills are mixed. The weight of evidence shows boys have significantly better object control skills in comparison to girls (Barnett et al., 2008; LeGear et al., 2012; Robinson, 2010). For locomotor skills, some studies found girls performed better (Barnett et al., 2008; LeGear et al., 2012; van Beurden et al., 2002), while other studies have reported no differences between boys and girls (Hume et al., 2008). These findings highlight the importance of continuing to examine motor skill proficiency levels and differences between boys and girls because motor skill proficiency is a predictor of (Barnett et al., 2008; Crane et al., 2015) and positively related to (Cliff et al., 2009; Fisher et al., 2005b; Williams et al., 2008; Wrotniak, Epstein, Dorn, Jones, & Kondilis, 2006) MVPA levels.

### **2.2) Developmental patterns of perceived physical competence**

Perceived competence are the individual beliefs, thoughts, attitudes, and feelings about one's own self or abilities (Horn, 2004). Harter (2012) describes perceived competence as being a continuous versus a discrete process, where it is more common to see sub-stages or mini-steps occurring during transitional periods of development rather than definitive changes. Harter also suggests that cognitive maturity plays an integral role in the development of perceived competence, namely, how much an individual can evaluate one's self across various domains of perceived competence (i.e. differentiation) and the ability to make higher-order generalizations about the self (i.e. integration). Cognitive capabilities as well as level of maturity allow for an individual to more accurately view the self (Harter, 2012). Older children are more capable of distinguishing between the real self and the ideal self than younger children because of their relative cognitive maturity. Thus, older children are able to compare their own performance to those of their peers, which can create discrepancies between the real and ideal self, which can impact overall self-esteem (Harter, 2012). Moreover, these greater cognitive

capabilities identified in older children allow children to begin constructing a concept of one's self and their overall global self-esteem.

Perceived physical competence is associated with fundamental motor skill proficiency in children (Crane et al., 2015; LeGear et al., 2012; Robinson, 2010) and adolescents (Barnett et al., 2008), and is a correlate of participation in physical activity (Biddle et al., 2005; Sallis et al., 2000). To date, the majority of studies examining perceived physical competence have been conducted with older children or adolescents (Barnett et al., 2008; Crocker et al., 2000; Wrotniak et al., 2006). The following paragraphs outline the development of the self in early and middle childhood as well as how perceptions of competence develop.

The rapid change in motor development across early and middle childhood is paralleled by development of cognitive processes. During very early childhood (2 – 4 years old), children's thought processes tend to be egocentric and narcissistic (Harter, 2012; Shaffer & Kipp, 2014). Ego-centrism means that children think one-dimensionally and are able to only see their own perspective, and they cannot appreciate the perspective of others. Thus, children believe that their view is the same view for everyone. For example, a child is asked on the telephone what they are going to wear to day care and the child responds with 'this' assuming that the person sees the same thing as the child highlights the self-centred train of thought (Shaffer & Kipp, 2014). Furthermore, young children have a difficult time problem solving or understanding change, they tend to accept things at face value, and they rely on the feedback from significant others to form their perceptions of perceived competence (Harter, 2012). Parents and caregivers play a significant role in development in these early stages and may directly influence their child through the nature of parent-child interactions, parenting practice such as mentoring and discipline, and indirectly through behaviour modeling (Fingerman et al., 2011; Kipp & Weiss, 2013).

Inaccurate or inflated perceptions of physical competence during early childhood are common because children: do not or are unable to use peer comparisons as a source of information to judge personal competence, rely on the feedback of significant others (e.g. parents or guardians) that are generally very positive, and because they are not cognitively capable of distinguishing between the "real" self and one's "ideal" self (e.g.

“If I ran fast, I’m therefore the fastest”) (Horn, 2004; Kipp & Weiss, 2013). These positive levels of perceived physical competence have been documented in four of five studies in early childhood, they used the same survey to measure perceived physical competence (Crane et al., 2015; Goodway & Rudisill, 1997; LeGear et al., 2012; Spessato, Gabbard, Robinson, & Valentini, 2012). The raw scores for perceived physical competence reported in each of the studies ranged from 3.0 – 3.4 out of a possible 4.0, which are consistent with children (3.0 – 3.4) from the original validation study for the survey (Harter & Pike, 1984).

As children begin to transition from early to middle childhood (~ 5 – 7 years of age) a child’s social environment, particularly the people within that environment, plays a significant role in the development of the self (Fingerman et al., 2011; Harter, 2012; Horn, 2004; Shaffer & Kipp, 2014). Children become aware of the perspective of these people through these interactions. Children are still very egocentric in their way of thinking during early childhood, which contributes to the inability to criticize the self (Fingerman et al., 2011). As a consequence, beliefs about physical competence tend to be unrealistically high in early childhood.

Perceived competence develops rapidly in middle childhood (Horn, 2004). Often referred to as the concrete-operational stage of development, children’s cognitive abilities mature quickly and the complexity of their mental operations expand (Shaffer & Kipp, 2014). Children begin to reorganize their thoughts and produce their own logical conclusions (Shaffer & Kipp, 2014); and their perceptions of their personal abilities become more accurate and consequently lower than in early childhood (Harter, 2012; Horn, 2004). The children’s greater awareness of their personal performances and increased ability to compare their performance to those of their peers (Harter, 2012; Horn, 2004) heightens children’s sensitivity to their experiences. This sharpened sensitivity can positively or negatively impact the individual’s perceptions of their competence (Horn, 2004; Jacobs, Lanza, Osgood, Eccles, & Wigfield, 2002; Rodrigues, Saraiva, & Gabbard, 2005). Furthermore, from middle childhood (~ 7 years), children tend to experience more normative comparisons such as the results of tests, game outcomes (e.g. winning or losing and goals scored), and receive feedback from a wider range of individuals than early childhood (e.g. peers and coaches), and this feedback may

not be as positive as when they were younger. These experiences facilitate the development of self-perceptions across different sub-domains such as perceived physical, social, and academic competence (Horn, 2004).

To date, two studies reported on the perceived physical competence of children in middle childhood (Piek, Baynam, & Barrett, 2006; Wrotniak et al., 2006). Although, both studies found significant relationships with fundamental motor skills, neither study reported whether perceptions of physical competence were either high or low. Therefore, whether perceived physical competence is actually higher or lower than in early childhood is unknown.

### **2.2.1) Perceived physical competence and gender**

There does not appear to be a clear or consistent picture of whether perceptions of physical competence are different for boys and girls. In early childhood, Robinson (2010) found that 4 year old boys had higher perceived physical competence than girls, while Goodway and Rudisill (1997) found no differences, and LeGear et al. (2012) found that the girls' perceptions of their physical competence were significantly higher than the boys'. In middle childhood there is little definitive evidence about boys and girls perceived physical competence levels. Spessato et al. (2012) found a modest significant relationship between perceptions and motor skill proficiency among 6 year old children, and a similar strength relationship that was not significant among the 7 year old children. However, these authors did not stratify their sample by gender. Therefore, it is not possible to say whether the nature of the relationships between perceived and actual motor skills differed for the boys and the girls as they reached 7 years of age.

In adolescence, Barnett and colleagues (2008) found that boys had higher perceptions of sports competence than girls; and these perceptions predicted participation in physical activity. Barnett et al. also found that the youth's perceptions were influenced by their motor skill proficiency assessed during childhood. How perceptions of physical competence differ for boys and girls is unclear, and to date no study has examined whether there are gender-based differences as children transition from early to middle childhood.

### **2.3) Current Canadian physical activity guidelines**

Based on a systematic appraisal of the volume, intensity, and type of physical activity needed for positive health benefits (Janssen & LeBlanc, 2010), the Canadian physical activity guidelines recommend that children between the ages of 5 – 11 years accumulate a minimum of 60 minutes of daily moderate to vigorous physical activity (Tremblay et al., 2011). The guidelines also indicate that children should participate in vigorous activity and engage in activities aimed at strengthening skeletal structure and muscular strength three times per week. These Canadian guidelines are consistent with those developed by other countries, including: the United States (US Department of Health and Human Services, 2008), Australia (Australian Government Department of Health, 2012) and the United Kingdom (Department of Health, 2011); and with the World Health Organization's Global Strategy on Diet, Physical Activity and Health (World Health Organization, 2011). Therefore it is of concern that only 7% of Canadian children (5 – 11 years of age) meet the recommendation of 60 minutes of moderate to vigorous physical activity daily (Active Healthy Kids Canada, 2014). The proportion of Canadian children accruing 60 minutes of moderate to vigorous physical activity climbs to 40% when three days per week is a criterion, and to 75% when the criterion is 30 minutes of moderate to vigorous physical activity at least three days per week (Active Healthy Kids Canada, 2014). However, these lower criteria for physical activity are well below the minimum recommended for good health.

The positive health benefits of participating in physical activity (Janssen & LeBlanc, 2010) are juxtaposed against the negative outcomes of sedentary behaviours (Tremblay, Colley, Saunders, Healy, & Owen, 2010). As Tremblay and colleagues mention "Emerging evidence identifies sedentary time as a ubiquitous attribute of contemporary lifestyles, which appears to have a unique relationship with health risk that is independent of MVPA" (p.735). Again, it is concerning that 31% of 5 – 11-year old children do not meet the Canadian sedentary behaviour guideline of no more than two hours of screen time per day. Further, it is estimated that Canadian children aged 5 – 11 years spend 7.6 hours per day engaged in sedentary behaviours (Colley et al., 2011). Overall, the majority of 5 – 11-year old Canadian children spend large portions of the day

engaged in sedentary activities and half an hour engaging in moderate-vigorous physical activity.

#### **2.4) Data collection using accelerometry**

The advent of new approaches to more accurately assess young children's physical activity levels and sedentary behaviour, particularly the use of motion sensors, has led to a burgeoning of literature on this age group (Hinkley, Salmon, Okely, Crawford, & Hesketh, 2012; Hnatiuk, Salmon, Hinkley, Okely, & Trost, 2014; Jones, Hinkley, Okely, & Salmon, 2013). As Temple, Naylor, Rhodes, and Wharf Higgins (2009) note, "With these new approaches, long-held assumptions that young children are typically active are being challenged; accelerometer studies reveal that pre-schoolers' levels of sedentary behaviour are high, and levels of moderate-vigorous physical activity are low" (p. 794).

##### **2.4.1) Methodological inconsistencies**

The burgeoning literature based on the new approaches to collecting physical activity and sedentary behaviour data are fraught with inconsistencies in measurement tools and data collection protocols that make comparisons between populations somewhat difficult. Hnatiuk and colleagues' (2014) systematic review of studies conducted with North American, Australian, and European preschool children revealed that six different types of accelerometers were used to collect physical activity data and five different sets of cut-points were used to differentiate between sedentary, light-intensity, and moderate to vigorous intensity physical activity levels when analyzing and interpreting the data. Perhaps the most noted among the inconsistencies identified by Hnatiuk and colleagues as well as by other researchers (Trost, Loprinzi, Moore, & Pfeiffer, 2011) is the variability in cut-points using the same accelerometer.

How moderate-to-vigorous physical activity (MVPA) is classified is a major issue. Using a threshold count that is too low may overestimate the amount of time spent in MVPA, because these low cut points may misclassify light intensity activity as being moderate and lead to an overestimation of time spent in MVPA (Hnatiuk et al., 2014; Pate et al., 2006b; Trost et al., 2011). The cut off for MVPA typically used with adults is 3 metabolic equivalents (METs), however several studies with children have shown that

brisk walking, which is a form of moderate intensity activity, requires an energy expenditure of 4 METs (Mattocks et al., 2007; Riddoch et al., 2007; Trost et al., 2011). Therefore, measuring MVPA at 4 METs among children is a more conservative approach and yields more accurate results (Mattocks et al., 2007; Pate et al., 2006b). Secondary methodological issues identified in the accelerometry literature are epoch length and wear-time. An epoch is a filtered digitized acceleration signal over a user-specified time interval, which sums counts of movement, which is typically in counts per minute (1-minute epochs) (Reilly et al., 2004; Ward, Evenson, Vaughn, Rodgers, & Troiano, 2005). However, researchers have concluded that unlike adults, children's physical activity patterns are usually sporadic and intermittent in duration typically lasting several seconds and suggest that using 1-minute epochs may result in an underestimation of participation in MVPA (Trost et al., 2011).

Although the epoch length debate continues, there does seem to be some consensus that when measuring physical activity intensity in children, a shorter epoch length is more appropriate and accurate in capturing moderate and vigorous intensity activities (McClain, Abraham, Timothy, Brussea, & Tudor-Locke, 2008; Nilsson, Ekelund, Yngve, & Sjostrom, 2002; Vale, Silva, Soares-Miranda, & Mota, 2009). This is further supported by the increase in studies using a shorter epoch length for children in recent years, which has been identified by Cain and colleagues (2013) review of methodological considerations when using accelerometers. Between 2005 and 2010, accelerometer based studies using shorter epoch lengths (less than 60-second epochs) increased from zero studies to almost half of all studies (45%).

The length of time that accelerometers should be worn to assess physical activity is another inconsistency of using this technology evident in the literature. Known as "wear-time", this is the minimum number of hours and days that an individual must wear an accelerometer (Trost, McIver, & Pate, 2005). The inconsistencies for wear-time while using accelerometers are: 1) how many days are needed to provide an accurate snapshot of the physical activity levels of children? and 2) how many hours per day are needed to constitute a valid day? Spearman-Brown Prophecy Formulae based on Intraclass Correlation coefficients of .80 were used to predict the number of days of accelerometer wear-time among children. Based on these findings, a child must wear the device for a

minimum of 4 days (including at least one weekend day), but 7 days are recommended (Troost et al., 2005). Although 7 days is preferable, 70% of physical activity studies using accelerometers with children use 3 or 4 days (Cain et al., 2013). Further, although Trost and colleagues (2005) showed that including a weekend day is important for capturing an accurate sample of activity levels for a typical week, Cain et al. found that only 30% of the 270+ studies in their review included a weekend day. The second aspect of wear-time is how many hours per day the device should be worn. Approximately one-third of studies in the Cain et al. review used 10 hours of wear-time per day as the threshold to be considered a valid data collection day (Cain et al., 2013).

As a consequence of the variability in tools and protocols it can be difficult to consolidate the findings of accelerometer studies focusing on children. Hnatiuk and colleagues' (2014) systematic review of young children's physical activity and sedentary behaviour demonstrated that among the 33 accelerometer studies among young children, daily physical activity and sedentary behaviour rates ranged from 4% – 33% for light physical activity, 2% - 41% for MVPA (which equates to 13 minutes – 5 hours per day), and 23% - 95% (equivalent to 3 – 12 hours per day) for sedentary behaviour. However, it is very difficult to tease out differences between populations of children from the variability generated by the different approaches to measurement. The findings from Hnatiuk and colleagues (2014) review highlight the variability and inconsistencies used when measuring physical activity. As suggested by Cain et al. (2013) there is an urgent need for consistent standards among accelerometer use. To date, the general consensus to determine typical patterns of physical activity is that children wear the device for a period of seven days, but minimally three week days and one weekend day, for at least 10-hours per day, and that the cut off for MVPA is 4 METs (Matthews, Hagstromer, Pober, & Bowles, 2012; Trost et al., 2005; Ward et al., 2005).

### **2.5) Physical activity and sedentary behaviour in childhood in Canada**

Although not often examined, two recent studies have assessed young Canadian children's (5-year olds) physical activity levels using accelerometry (Colley et al., 2013; Crane et al., 2015), and Colley and colleagues also examined sedentary behaviour. Colley et al. found that 5-year old Canadian children spend an average of 68 minutes (9% of the day) engaged in MVPA and 343 minutes of their day engaged in total physical activity

(light, moderate, and vigorous). However, only 14% of the sample met the Canadian guideline of 60 minutes of MVPA on at least six days of the week at 3 METs (Colley et al., 2013) compared to the 58% of the participants in the Crane et al. study at the higher cut-point of 4 METs.

Overall, children in the Colley et al (2013) study spent approximately 53% (> 6 hours) of their wake time engaged in sedentary behaviours and roughly 4.5 hours engaged in light physical activity. In comparison, Crane et al. (2015) found that 5-year old children in Victoria, BC participated in 135 minutes of MVPA per day. Overall the children engaged in 357 minutes of physical activity (light, moderate, and vigorous) daily. However, Crane and colleagues did not report the sedentary behaviour of children in their study. Although both Colley et al. and Crane et al. used accelerometers to measure physical activity, each study used different: accelerometer type, epoch length, intensity cut-points, and participant wear-time. Colley and colleagues used Actical accelerometers and a 60-second epoch length for collections whereas Crane et al. used Actigraph accelerometers and a 15-second epoch. Using a 60-second epoch with younger children overestimates the amount of light physical activity accumulated and underestimates the amount of MVPA because the longer epochs fail to capture the sporadic and intermittent movements of young children (Strong et al., 2005; Tucker, 2008; Vale et al., 2009). Colley et al. (2013) used cut-points that were specifically developed for Actical accelerometers based on an activity energy expenditure value of approximately 3 METs for 3–5 year old children. To be included in the Crane et al. study the wear-time criteria was 10-hours per day, which was six hours more per day than Colley et al. (2013). It is likely that the Colley et al. study underestimated the children's physical activity levels because of the relatively long epoch length, but overestimated MVPA because of the 3 MET cut off. Notwithstanding these methodological differences, there was a huge difference between the estimates of MVPA provided by Crane et al. and Colley et al. To date, the Crane et al. study is the only study of young Canadian children that has used the consensus recommendations for collecting accelerometer data with children. However these data were collected in one small community, which limits generalization to other parts of Canada. The high MVPA levels of the children may, in part, reflect the two-level consent process used by Crane et al., where parents/guardians

could opt into the physical activity portion of the study. These children may have been from family circumstances that encouraged and/or supported more physical activity. Therefore, there are many unanswered questions about the physical activity levels and sedentary behaviours of 5-year old children in Canada.

### **2.5.1) Total volume of physical activity vs. moderate-to-vigorous physical activity**

As the majority of national and international physical activity guidelines (Australian Government Department of Health, 2012; CSEP, 2011; Department of Health, 2011; US Department of Health and Human Services, 2008; World Health Organization, 2011) emphasize MVPA as the intensity of physical activity recommended to achieve health benefits, a great deal of the physical activity literature to date has focused on children's MVPA, rather than total physical activity (Hnatiuk et al., 2014; Jones et al., 2013; Tucker, 2008). However, there is evidence that total physical activity is an important contributor to overall health (Bassett, Troiano, McClain, & Wolff, 2014; Colley et al., 2013; Crane et al., 2015; Kim, Tanabe, Yokoyama, Zempo, & Kuno, 2013; Pate, Pfeiffer, Trost, Ziegler, & Dowda, 2004; Ruiz et al., 2006; Tanaka & Tanaka, 2013). To lend support to the importance of total physical activity, researchers have found both light physical activity and MVPA are independently related to lowering the risk for the metabolic syndrome (Kim et al., 2013). Furthermore, Carson et al. (2013) found that in addition to MVPA, light physical activity was associated with lower both diastolic blood pressure and increased HDL-Cholesterol among approximately 1700 adolescents in the United States. The emerging evidence of the importance of physical activity of all intensities on health outcomes suggests that examining light and total physical activity in addition to MVPA is an important line of inquiry.

The majority of studies examining children's physical activity and the relationship of physical activity to other outcome variables focus on MVPA, rather than total physical activity. Although, a few studies with young children have included either light or total physical activity in their analyses and findings (Cliff et al., 2009; Crane et al., 2015; Fisher et al., 2005b; Reilly, 2010), there has been little examination of total physical activity with other outcome variables (Iivonen et al., 2013). Further, the relationships between total physical activity, perceived physical competence, and fundamental motor

skills have not been examined. It is possible that the relationships between physical activity and these factors have been missed as a result of predominance of studies focusing on MVPA.

The available cross-sectional evidence suggests that during early childhood the majority of time during waking hours is spent engaged in sedentary behaviours (Cliff et al., 2009; Colley et al., 2013; Crane et al., 2015; Fisher et al., 2005b; Reilly, 2010). This research has been largely conducted with pre-school aged children (i.e. 3 to 4 year olds) (Cliff et al., 2009; Fisher et al., 2005a; Reilly, 2010; Williams et al., 2008) rather than 5-year olds who may or may not be pre-schoolers. Of the two studies focusing on 5-year old children (Colley et al., 2013; Crane et al., 2015), it is unclear whether the participants in the Colley et al. (2013) were attending school or pre-school, which may be important because of the differences in the contexts. What seems evident is that levels of MVPA and total physical activity are higher among 5-year old children (Colley et al., 2013; Crane et al., 2014) compared to 3 – 4-year old children (Cliff et al., 2009; Fisher et al., 2005a; Reilly, 2010; Williams et al., 2008).

### **2.5.2) The transition from early childhood to middle childhood**

The age of 5-years for children in Canada is an age of transition, where many children are beginning their formal school career. This transition is acknowledged by the Public Health Agency of Canada with different physical activity and sedentary behaviour guidelines for the Early Years (0 – 4 years) and for Children (5 – 11 years) (Public Health Agency of Canada, 2011). The physical activity guidelines change from ‘at least 180 minutes of physical activity at any intensity per day’ for the early years to ‘at least 60 minutes of moderate to vigorous physical activity per day’ for 5 year olds. These age-based guidelines largely reflect the transition from pre-school to school. Sigmund and colleagues (2009) note that as children transition from pre-school to school, their physical activity declines on both weekdays and weekend days. This trend is somewhat supported by Active Healthy Kids Canada, who report that 84% of 3 – 4-year old children achieved the recommended 180 minutes of any type of activity per day (Active Healthy Kids Canada, 2014). However, once these children turn 5-years of age, the guidelines change to at least 60 minutes of MVPA per day, which only 7% of children achieve. This decline might also extend from the beginning of a child’s school career through the elementary

years. Two studies have shown that from 5 – 10 years children's physical activity levels decline both during school and after school (Arundell et al., 2013; Ridgers, Timperio, Crawford, & Salmon, 2012). However, there is no longitudinal evidence of this trend among Canadian children in the primary years.

Similar to what has been demonstrated among young children, the majority of cross-sectional studies examining physical activity and sedentary behaviour in middle childhood (8 – 11-years) conclude that sedentary behaviour levels are much higher than MVPA levels. A majority of these accelerometer studies have been conducted in developed countries; namely in Canada (Chaput et al., 2012; Colley et al., 2011; Herman, Sabiston, Mathieu, Tremblay, & Paradis, 2014; Nettlefold, McKay, Naylor, Bredin, & Warburton, 2012), the United States of America (Dorsey, Herrin, & Krumholz, 2011; Troiano et al., 2008; Wrotniak et al., 2006), and one in the United Kingdom (Harrison et al., 2011). In the United Kingdom, Harrison and colleagues found children spent 466 minutes per day engaged in sedentary activity while engaging in 72 minutes of MVPA daily (Harrison et al., 2011). Using accelerometers to measure both physical and sedentary activity, the authors attributed the high levels of sedentary behaviours to rainfall during data collection, but also pointed to school policy (e.g. children must stay indoors when it rains) and the negative impact of having no organized indoor physical activity opportunities during those times (Harrison et al., 2011).

In the United States, Troiano et al. (2008) measured MVPA with a nationally representative sample using accelerometers for children (6 – 11 years), adolescents (12 – 19 years), and adults (20+ years). Although, sedentary behaviour was not reported, MVPA was lower for successively older groups. Forty-two percent of children were achieving the national guidelines of at least 60 minutes of MVPA per day, whereas only 8% of adolescent participants were meeting that same guideline. Also in the United States, Wrotniak et al. (2006) measured physical activity and sedentary activity among 65 boys and girls (8 – 10 years old) from New York state using accelerometers. These authors found that participants spent approximately 32 minutes, or 4.5% of their day, engaged in MVPA, 22% of their day in light activity, and the majority of their day (73%) engaged in sedentary activities (Wrotniak et al., 2006).

Among Canadians, Colley et al. (2011), reported that children 6 – 10 years of age accrued 58 minutes of MVPA and a further 256 minutes of light activity per day using accelerometers. More concerning was the 516 minutes (over 8 hours) per day spent engaged in sedentary behaviour. Further, these 516 sedentary minutes accounted for 62% of the participants' waking hours. This high level of sedentary behaviour was similar to Nettlefold and colleagues' (2012) study of children in British Columbia. These authors found that children 8 – 11 years old accrued almost 540 sedentary minutes per day (Nettlefold et al., 2012). However, Nettlefold et al. also reported more than double the amount of MVPA (124 minutes) and far less light activity (116 minutes) than those found by Colley et al. Two studies using participants selected from the same cohort found sedentary activity levels of approximately 6 hours (340 minutes) of total waking hours among 8 – 10-year old children in Quebec (Chaput et al., 2012; Herman et al., 2014). Accompanying these high sedentary levels were the 378 minutes per day spent in light types of physical activity and 55 minutes spent engaged in MVPA. The discrepancies in MVPA and light activity for Chaput et al. (2012), Herman et al. (2014), and Colley et al. (2011) compared to those of Nettlefold et al. (2012) is most likely the result of the epoch length used in each study. Although all four studies reported similar wear-time criteria, and used 3 METs as the cut-point for MVPA to measure energy expenditure, Chaput et al., Colley et al., and Herman et al. used a 60-second epoch (Chaput et al., 2012; Colley et al., 2011; Herman et al., 2014), while Nettlefold et al. used 15-second epochs (Nettlefold et al., 2012). As previously stated, a 60-second epoch typically underestimates MVPA and overestimates light physical activity with younger children and it has been recommended that a 15-second epoch should be used in order to better capture the sporadic types of activity and movement in children (Strong et al., 2005; Tucker, 2008; Vale et al., 2009). Therefore, the extreme differences among these Canadian studies may be the result of the epoch length used, however it is not possible to discount the possibility that children in British Columbia are more active than children in other areas of Canada.

### **2.5.3) Longitudinal studies and tracking coefficients**

There are relatively few longitudinal studies examining participation in physical activity and sedentary behaviour during the early childhood period (pre-school and the

beginning of school), during middle childhood, or from early childhood to middle childhood. However, fairly recently Jones and colleagues (2013) published a systematic review of longitudinal physical activity and sedentary behaviour studies that included 11 studies from 4 countries. The authors extracted and classified tracking coefficients from the 11 studies to document how stable physical activity and sedentary behaviour were across early childhood and from early to middle childhood (Jones et al., 2013). In their review they considered early childhood as 0 – 5 years and middle childhood as 6 – 12 years. Jones et al. found that in early childhood and from early to middle childhood, physical activity tracked moderately well (mean;  $r = 0.39$ ), while sedentary behaviour tracking coefficients were moderate to large (mean;  $r = 0.50$ ). It was also notable in the Jones et al. review that only 3 of the 11 studies reported both physical activity and sedentary behaviour tracking coefficients (Janz, Burns, & Levy, 2005; Kelly et al., 2007; Taylor et al., 2009).

Of the possible seven tracking studies focusing on physical activity in either early childhood or from early to middle childhood reporting physical activity, 4% reported large coefficients, 60% reported moderate coefficients, and 34% reported small tracking coefficients (Jones et al., 2013). Of the possible seven studies tracking sedentary behaviours, 33% reported large tracking coefficients, 50% reported moderate coefficients, and 17% reported small tracking coefficients (Jones et al., 2013). Overall, 83% of studies reported moderate to large tracking coefficients for sedentary behaviour compared to the 64% of studies that reported moderate or large tracking coefficients for physical activity (Jones et al., 2013). Based on these longitudinal studies it appears that tracking is stronger for sedentary behaviour compared to physical activity in early childhood as well as throughout middle childhood.

#### **2.5.4) Physical activity and sedentary behaviours and gender**

Researchers have consistently found that boys are more active than girls across childhood and adolescence (Chung et al., 2012; Dumith et al., 2010; Stratton, Ridgers, Fairclough, & Richardson, 2007; Trost et al., 2002; Van der Horst, Paw, Twisk, & van Mechelen, 2007). Trost et al. (2002) measured physical activity levels in a sample of children in grades 1 – 12 using accelerometry. They found that across all grades, boys were more active than girls, and that the major difference between the boys and girls was

not the volume of activity, but rather the intensity of activity. These authors found that the boys engaged in 45% more vigorous physical activity, but the difference in MVPA was approximately 11%. This suggests boys and girls moderate physical activity engagement patterns were similar and that the gender-based differences in physical activity are the result of the lower vigorous activity engagement among girls. Trost and colleagues' findings also highlight the importance of using accelerometry to measure activity as it can provide more detail about the amount and intensity of activity.

Gender-based patterns of sedentary behaviour are less clear than physical activity patterns. Colley et al. (2011) found that in a representative sample of 6 – 10 year old Canadian children, there were no differences in minutes per day of sedentary behaviour between boys and girls. Furthermore, while it has been estimated that approximately a quarter of North American and European children between the ages of 8 – 16 years watch at least 4-hours of television per day (World Health Organization, 2014), there appears to be little difference in sedentary behaviour for boys and girls. Specifically, in North America, 23% of girls and 29% of boys watch a minimum of 4-hours of television per day; whereas for European children, 25% and 31% of girls and boys watch at least 4-hours of television per day (World Health Organization, 2014). Although there is no evidence to suggest there are gender-based differences in sedentary during childhood, evidence does suggest that sedentary behaviour levels of children are high.

The next section of this review will examine the research surrounding the relationship between motor competence and physical activity, the relationship between motor competence and perceived competence, between perceived competence and physical activity, and finally how perceived competence may mediate the relationship between motor competence and physical activity.

## **2.6) The relationship between physical activity and fundamental motor skills**

Stodden and colleagues (2008) suggest that throughout childhood (early, middle, and late) motor skill proficiency directly impacts physical activity engagement patterns and that the direction and strength of the relationship varies with age (early vs. middle and late childhood). In early childhood, Stodden et al. (2008) contend that the relationship between physical activity and motor skill proficiency is reciprocal. This relationship is bi-directional because children's play and physical activities stimulates

neuromotor activity and widens their movement experiences, both of which help develop and strengthen the children's motor skill repertoire. In turn, more proficient motor skills allow children to pursue more active patterns of play (Adolph & Avolio, 2000; Berger & Adolph, 2007). Perhaps surprisingly, there is very little evidence of this bi-directional relationship in early childhood. While examining the relationship between kindergarten children's motor skills and accelerometer measured MVPA, Crane et al. (2015) found that the relationship was bi-directional using regression analyses, however this relationship was only significant for object control skills. Crane and colleagues found these relationships were not evident for locomotor skills in either direction.

More generally, the literature examining relationships between motor skill proficiency and physical activity in early childhood has not examined whether the relationships are bi-directional. Researchers have either used correlation analysis (Fisher et al., 2005b; Williams et al., 2008), which does not afford the opportunity to examine relationship direction, or statistical models attempting to predict physical activity levels from motor skill proficiency (Cliff et al., 2009; Williams et al., 2008). Both Fisher et al. and Williams et al. found that motor skills were modestly, but positively, related to more intense levels of physical activity (MVPA and VPA) among both boys and girls, but movement skills were not related to light-intensity physical activity. Williams and colleagues also demonstrated that children with the highest tertile of motor skill proficiency spent significantly more time in MVPA and VPA than children in the middle and lowest tertiles of motor skill proficiency. Cliff and colleagues also found that higher motor skill scores predicted MPVA and MPA, but this was only significant for boys and for object control skills. After controlling for age, SES, and z-BMI, object-control skills accounted for 13.7% of the shared variance in total physical activity. Cliff et al. also found that object control skills were not related to physical activity levels among preschool aged girls, and the girls' locomotor skill scores were negatively related to participation in MPA.

Variation in the strength and the direction of the relationships between fundamental motor skills and physical activity during early childhood is still somewhat unclear since there are so few studies; however it appears that the relationship is affected by the type of motor skill, the intensity of physical activity examined, the child's sex, and

interactions between these factors. For type of motor skill, Williams et al. (2008) found that children with greater locomotor proficiency spent more time in MVPA whereas Cliff and colleagues (2009) found that object control skills predicted 16.9% and 13.7% of the variance in MVPA.

Only one study examined the impact that age has on the strength of the relationship between motor skills and physical activity in early childhood. Williams et al. (2008) found age-related differences the relationship between physical activity intensity (MVPA and VPA) and fundamental motor skills among 3 – 4-year olds. When stratified by age group, significant relationships were found between motor skills and physical activity for the 4-year old children (MPA,  $r = .33$  and VPA,  $r = .41$ ), but not 3-year old children. Exploring the relationship across age groups cross-sectionally and longitudinally will show the strength of the relationship across time and perhaps points to important periods in children's development.

Finally, one study has examined whether a child's sex affects the relationship between motor skill proficiency and accelerometer measured physical activity (Cliff et al., 2009). These authors found that object control skills predicted MVPA levels, but this was only evident for boys. Cliff and colleagues suggested that the nature activities that Australian boys typically participate in that feature object control skills (e.g. cricket, soccer, and Australian rules football) may strengthen the relationship between physical activity and motor skills. Whereas for girls, the relationships are absent or negative because it is possible that skills they develop (e.g. moving rhythmically to music) were not represented in the motor skills assessment. These findings are supported by Temple, Crane, Brown, Williams, and Bell (2014), who found that boys' locomotor skills predicted participation in questionnaire measured physical activities and their object control skills predicted participation in physical activities and organized sport. However, like Cliff et al., these relationships were not evident for girls. When Temple et al. examined the relationship between the leap (a locomotor skill related to dance and gymnastics) and the girls' participation; they found that the leap was significantly correlated with girls' participation in both physical activities and active physical recreation. These studies highlight the complexities of the interactions between motor skills, physical activity engagement, and gender.

Stodden and colleagues (2008, see Figure 1) suggest that in middle childhood the relationship between motor skill proficiency and physical activity is stronger than in early childhood, but the relationship is unidirectional. Where motor skill proficiency influences physical activity participation, but not the reverse. Children who demonstrate greater motor proficiency levels will engage in more structured and unstructured forms of physical activity and sport because they are able to apply their motor repertoire to a variety of activities. In comparison, children who have not sufficiently developed adequate levels of motor competence will display lower patterns of physical activity engagement (Stodden et al., 2008). However, middle childhood is a relatively unexamined stage of development in terms of the relationship between motor skills and physical activity. Only Wrotniak and colleagues (2006) have examined this relationship. These authors found that fundamental motor skill proficiency shared 9% of the variance with physical activity among 8–10-year old children. Although there is only one study examining the relationship between motor skill proficiency and physical activity in middle childhood, the importance of motor skills at this stage of development is supported by evidence of the direct relationship between object control skills assessed in middle childhood and both adolescent physical activity and fitness levels (Barnett et al., 2008).

In summary, a modicum of cross-sectional research has demonstrated that in early childhood the relationship between fundamental motor skills and accelerometer measured physical activity is positive and weak to moderate in strength. However, as only one study has examined this relationship in middle childhood, the strength and direction of that relationship is largely unknown. The evidence from early childhood suggests that the relationship is stronger for object control skills and more obvious among boys. No studies have examined these relationships longitudinally among children, which may provide evidence about the change in the relationship over time.

### **2.7) The relationship between fundamental motor skills and perceptions of physical competence**

Theory suggests that in early childhood, perceptions of physical competence will be high among young children because of their inability to differentiate between effort and actual competence, they received largely positive feedback from significant others,

and they are not able to compare their own performances with their peers (Harter, 2012). Motor development experts have suggested and modelled that these high perceptions will help children to continue to engage and persist in physical activities because they believe they are good at the activities (Harter, 2012; Horn, 2004; Stodden et al., 2008).

Persistence with physical activities nurtures neuromotor development, which leads to development of motor skills. Therefore, as a result of having these higher perceptions in early childhood (Harter, 2012) perceptions of physical competence should influence fundamental motor skill development.

Five studies have examined the relationship between perceptions of physical competence and motor proficiency in early childhood (3 – 5-year olds) (Crane et al., 2015; Goodway & Rudisill, 1997; LeGear et al., 2012; Robinson, 2010; Spessato et al., 2012) using identical tools. Each of these studies used the Test of Gross Motor Development – 2 (TGMD – 2, Ulrich, 2000) to assess motor proficiency and the Pictorial Scale of Perceived Competence and Acceptance for Young Children (Harter & Pike, 1984) to measure perceptions of physical competence. Positive and significant correlation coefficients ranging from  $r = .37$  to  $r = .43$  were reported in two studies for the relationship between locomotor skills and perceived physical competence (LeGear et al., 2012; Robinson, 2010). Similarly, significant correlations between object control skills and perceived physical competence were found by LeGear et al. ( $r = .14, p < .05$ ) and Robinson ( $r = .44, p < .01$ ). Crane and colleagues (2015) also reported a significant relationship between object controls skills and perceived physical competence, but unlike the previous two studies, the relationship with locomotor skills was not significant. Two other studies examining the relationship between perceptions of physical competence and fundamental motor skills among 4- and 5-year old children did not reveal significant correlations (Goodway & Rudisill, 1997; Spessato et al., 2012). The participants in Goodway and Rudisill's study who were identified as at risk of becoming educationally disadvantaged and/or developmentally delayed demonstrated very low motor skill scores i.e. the mean object control scores for girls and boys were 2.28 and 3.93 (out of 48), respectively; despite average scores for perceived competence (3.29 out of 4.00). The perceptions of competence scores were similar to those established by Harter and Pike (1984) (range from 3.00 – 3.40) in their validation study. Taken together, the fairly

positive perceptions, coupled with low motor skill scores, suggest that in this disadvantaged group, children's perceptions of their abilities were not impacted by their low actual motor skills scores. It is also possible that the children's very low TGMD – 2 scores created a 'floor effect', which is when most participants score near the bottom on the testing instrument (Field, 2013). In other words, there is little variance because the 'floor' or bottom scoring of the test is too high. Furthermore, the majority of inferential statistics rely on the assumption of having a normal distribution of the variables involved and if all scores fall near the bottom it may not be possible to compute a significance test or run the risk of committing a type II error. Spesseto and colleagues (2012) reported no significant correlations between perceived physical competence and motor skills among 4 – 5- and 7-year old children, but a small correlation among 6-year old children. To date, the evidence examining the relationship between fundamental motor skills and perceived physical competence in early childhood is mixed.

In middle childhood, only one study has examined the relationship between perceived physical competence and fundamental motor skills (Wrotniak et al., 2006). But because the tools used to measure perceived competence and motor skills were not specific to the factors being examined (gross motor skills and perceived physical competence) no clear conclusions can be drawn. However, in late childhood (Carroll & Loumidis, 2001; Piek et al., 2006; Raudsepp & Pall, 2006) and in adolescence (Barnett et al., 2008; Crocker et al., 2000) researchers have found significant positive relationships between perceived physical competence and motor skill proficiency.

## **2.8) The relationship between perceptions of physical competence and physical activity**

Theory suggests that having high perceived physical competence in early childhood positively influences physical activity (Stodden et al., 2008). This relationship is hypothesized because young children tend to have inaccurate and unrealistically positive beliefs about their own ability (Harter, 2012; Horn, 2004) which encourages persistent engagement with physical activities. This perseverance plays an important role in the development of motor proficiency, which in turn, enables physical activity (Harter, 2004; Stodden et al., 2008). To date, this relationship between perceptions of competence and physical activity participation has been virtually unexamined among young children.

Crane et al. (2015) explored the relationship as part of a model examining whether perceived physical competence mediated the relationship between fundamental motor skills and MVPA. Although Crane et al. found that kindergarten children had high levels of perceived physical competence as expected in early childhood, perceived physical competence did not mediate this relationship, nor did perceived physical competence predict physical activity levels as hypothesized by Stodden et al. (2008). However, Crane et al. did not examine whether physical activity predicted perceived physical competence. Given that only one study has partially examined this relationship it is difficult to be definitive about the relationship between perceptions of physical competence and participation in physical activity among young children.

The relationship between perceived physical competence and physical activity in middle childhood has not been examined. This is surprising since middle childhood has been identified as a transition period, where it is expected that children will begin to more accurately assess their own performances and the feedback they receive, and compare their performances with the performances of individuals around them (Harter, 2012).

By late childhood, the relationship between perceived physical competence and physical activity is expected to change in comparison to early childhood (Stodden et al., 2008). Developmentally, a reciprocal relationship between the two variables is expected; that is, children with higher levels of physical activity engagement will have higher levels of perceived physical competence and vice versa (Robinson et al., 2015). According to Harter (2004), these higher levels of perceived competence motivate children to continue to be active and that being physically active contributes to a more positive beliefs about one's self if the children's experiences are positive. This is also important because having negative experiences may lead to being less motivated to participate in physical activities and may lower one's overall feelings about the self.

To date, two studies have examined the relationships between perceived physical competence and physical activity levels in late childhood (Carroll & Loumidis, 2001; Crocker et al., 2000). Crocker et al. (2000) found that perceived physical competence explained 27-29% of the variance in physical activity among boys and girls aged 10 – 14 years. Using self-report measures to recall physical activity, Crocker et al. (2000) found that although boys had significantly higher physical activity scores, the strength of the

relationship between physical activity and physical self-perceptions were similar in both boys and girls (Crocker et al., 2000). Similarly, Carroll and Loumidis (2001) who used self-report measures of physical activity, found that children aged 10 – 11 years with higher perceptions of competence accumulated significantly more minutes of, and greater intensity of, physical activity per day compared to those with lower levels of perceived physical competence. The evidence from both Crocker et al. and Carroll and Loumidis indicate that perceived competence is related to physical activity levels by 10-years of age.

In summary, only one study has examined the relationship between children's perceptions of physical competence and accelerometer measured physical activity in early childhood, and that study did not find a significant relationship. There has not been any research examining this relationship in middle childhood, but by late childhood – early adolescence, the relationship is positive and significant. What is unclear is whether perceived physical competence affects physical activity before late childhood, or how this relationship changes in a longitudinal cohort of children as they transition from early childhood to middle childhood. It is also unclear whether the effect of perceptions of physical competence on participation in physical activity is largely direct or an indirect effect of actual motor skill proficiency.

### **2.9) Perceived physical competence as a mediator of the relationship between fundamental motor skills and physical activity**

Mediation occurs when the relationship between a predictor variable and an outcome variable is influenced by an intermediary variable, or mediator (Field, 2013). Currently, the only two studies that have demonstrated that perceived physical competence mediates the relationship between motor skills and physical have been conducted with adolescents (Barnett, Morgan, Van Beurden, Ball, & Lubans, 2011; Barnett et al., 2008). Adolescence is a time when individuals are most sensitive and aware of their own beliefs about the self. Adolescents tend to develop strategies to either enhance or protect the self are often used as a result of the increasing emphasis of comparison among peers and others (Harter, 2012). These strategies can include making excuses (e.g. not feeling well) to cover the lack of success in comparison to his or her peers. Similarly, those individuals who have higher perceptions of their own competence

will attribute their success to their skill level. As a result, individuals who do not excel in one area navigate towards and place a higher level of importance on activities and areas where they feel comfortable and have success (Harter, 2012). This is particularly important in explaining mediation; individuals who believe they are competent within the physical domain will continue to not only build their motor skill repertoire but as a result will also continue to engage in physical activities. Conversely, individuals with lower motor skill proficiency levels by adolescence are aware of their abilities and therefore, may downplay the importance of physical activity and spend less time engaged in these types of activities. These patterns have been documented by Barnett, Cliff, Morgan, and van Beurden (2013), who found that a major reason why adolescents continue to participate in organized sport was because of high skill level. What was expressed throughout the adolescents' interviews was the belief that individuals who were 'good' continued to play and individuals who were 'not good' or did not pick up an activity quickly encountered barriers to participation (Barnett et al., 2013).

To date, three studies (two in adolescence and one in early childhood) have examined whether perceived physical competence mediates the relationship between fundamental motor skills and physical activity (Barnett et al., 2011; Barnett et al., 2008; Crane et al., 2015). Barnett and colleagues (2008) examined whether perceptions of sport competence mediated the relationship between object control skills (predictor) measured in middle childhood and MVPA ( $\geq 3.0$  METS) physical activity levels (outcome) in adolescence. Perceived sport competence explained 18% of the variance in their mediation model, whereas the direct relationship between object control skills and physical activity explained 8%. In a follow up study using the same data set, Barnett and others (2011) tested whether perceptions of sport competence mediated the relationship between adolescent object control skill proficiency and engagement in MVPA (MVPA; Barnett et al., 2011) in both directions, with physical activity as the predictor and the outcome. The authors explored the directional relationship between motor competence and physical activity (MVPA;  $\geq 3.0$  METS), which is important in determining whether or not participation in physical activity enhances motor skill development (Barnett et al., 2011). Barnett et al. found that perceived sports competence partially mediated the

relationship between object control proficiency and MVPA for both directions with motor proficiency as both the predictor and the outcome.

The findings from Barnett and others (2008) provide insight about the role that perceived competence plays in the relationship with motor skills and physical activity among adolescents 14 – 18 years of age. Specifically, they show that perceptions of physical competence mediate the effect of fundamental motor skills on physical activity. This means that motor skill proficiency is both directly affecting physical activity levels, as well as influencing physical activity indirectly via the bearing that motor skill proficiency has on the youth's ability beliefs. These beliefs (or perceptions of physical competence) then effect physical activity participation. It should be noted that the fundamental motor skills in Barnett and colleagues' (2008) mediation model were collected when the participants were 10-year old, but perceptions of physical competence and physical activity data were collected in adolescence. These authors also used a subjective measure (questionnaire) of physical activity, which has previously been shown to limit the accuracy of physical activity reporting (Cain et al., 2013). Notwithstanding these limitations, the Barnett et al. (2008) model revealed that perceived physical competence during adolescence influenced the strength of the relationship between childhood object control skills and adolescent physical activity levels. However, Barnett and colleagues (2008) did not examine the relationship between motor skills and physical activity or mediation during middle childhood. Although the available literature is scant and it has limitations, it does appear that by adolescence, perceptions of sport competence partially mediate the relationship between adolescent object control skill proficiency and participation in physical activity (Barnett et al., 2011) and childhood object control skills and adolescent physical activity (Barnett et al., 2008).

Before adolescence, only Crane and colleagues (2015) have examined whether perceived physical competence mediates the relationship between motor skill proficiency and physical activity. Although the majority of developmental theorists indicate children's perceptions of their physical competence in early childhood are inaccurate (Harter, 2012; Horn, 2004; Stodden et al., 2008), relatively recent evidence indicates there is a significant relationship between motor skill proficiency and perceived physical competence (LeGear et al., 2012; Robinson, 2010; Spessato et al., 2012) and between

motor skill proficiency and physical activity (Cliff et al., 2009; Fisher et al., 2005b; Williams et al., 2008). However, prior to the Crane et al. study, the question of when perceptions of competence begin mediate the relationship between motor skills and physical activity as seen in late childhood and adolescence had been unexamined. Crane et al. measured actual motor competence, perceived physical competence, and physical activity (via accelerometry) among 116 children in their first year of school. Similar to each of Barnett and colleagues' studies (2008; 2011), object control skills, but not locomotor skills, were related to levels of moderate to vigorous physical activity. However, perceived competence did not mediate the relationship between object control skills and MVPA, nor was there a significant relationship between perceived physical competence and MVPA (Crane et al., 2015). Crane et al.'s findings demonstrate that similar to other early childhood studies (LeGear et al., 2012; Robinson, 2010; Spessato et al., 2012), there is a significant relationship between motor skill proficiency and perceived physical competence; but, perceived physical competence was not significantly related to children's physical activity levels.

Although there is little evidence (Barnett et al., 2008; Barnett et al., 2011; Crane et al., 2015), it appears that perceptions of physical competence begin to mediate the relationship between motor skills and physical activity after the end of early childhood but before mid-adolescence. Theorists suggest that as children transition from early to middle, late childhood and continuing into adolescence, individuals are more accurately assessing their own personal performances, internalizing feedback, as well as comparing their own performances with their peers. Furthermore, the importance of social comparison is becoming greater as children age and thereby helping children develop a more accurate perceptions of their own abilities (Harter, 2012; Horn, 2004). In children as early as 10 years, relationships have been reported between perceived physical competence and physical activity levels (Carroll & Loumidis, 2001; Crocker et al., 2000). The next logical step in this line of research will be to examine whether perceived physical competence mediates the relationship between motor skill proficiency and physical activity in middle childhood.

## **2.10) The relationship between physical activity, motor skills, and perceived competence longitudinally**

Tracking is defined as the tendency of individuals to maintain their rank or position within a group over time (Malina, 2001). Tracking variables such as physical activity are useful in identifying trends or patterns of change in physical and sedentary behaviour of individuals or specific age groups. Findings from tracking studies can be important for policy makers, practitioners, and the general public who are interested in understanding how well physical activity tracks over time.

### **2.10.1) Tracking physical activity**

The Jones et al. (2013) systematic review of tracking studies provides evidence about how well physical activity tracks in early childhood (pre-school aged and school aged), in middle childhood, and from early childhood to middle childhood. Jones et al. (2013) reported that in early childhood or from early to middle childhood, Pearson product-moment correlation coefficients reveal that physical activity tracks moderately well (mean;  $r = 0.39$ ), while the sedentary behaviour tracking coefficients were moderate – large (mean;  $r = 0.50$ ). However, among the eleven studies examined in the Jones et al. review, only three of those studies reported both physical activity and sedentary tracking coefficients (Janz et al., 2005; Kelly et al., 2007; Taylor et al., 2009). Participants in two of the 11 studies were under the age of 5 years at the time of follow up (Cheng, Maeda, Yoichi, Yamagata, & Tomiwa, 2010; Jackson et al., 2003). Of the seven studies tracking physical activity in either early childhood or from early to middle childhood, 4% reported large coefficients, 60% reported moderate, and 34% reported small tracking coefficients (Jones et al., 2013). For sedentary behaviour, of the seven studies, 33% reported large tracking coefficients, 50% reported moderate, and 17% reported small tracking coefficients (Jones et al., 2013). Similar to the cross-sectional findings in both early and middle childhood, sedentary behaviour was more prominent than physical activity; approximately 84% of studies reported moderate tracking compared to the 64% that reported moderate tracking for physical activity (Jones et al., 2013). Based on these longitudinal studies it appears that high levels of sedentary behaviour in early childhood remain high through middle childhood, whereas physical activity levels are more variable during childhood.

### **2.10.2) Fundamental motor skills longitudinally**

Currently three studies have measured change in fundamental motor skills during childhood (early to late childhood) (D'Hondt et al., 2013; Temple & Foley, in press; Zask et al., 2012). D'Hondt (2013) and colleagues' longitudinal study of motor coordination measured change in gross motor coordination for children aged 6 – 10 years at baseline (Mean age = 8.2 years) over two years. Using the Körperkoordination Test für Kinder (KTK) (Schilling, 1974) to measure motor competence and over the two year period, D'Hondt et al. (2013) found both normal weight and overweight/obese children improved in overall gross motor coordination but no differences were found between the two groups. Similarly, Temple and Foley found that both boys and girls significantly improved their locomotor and ball skills from grade 3 to grade 4 as measured using the TGMD – 3 (Ulrich, 2013). Contrastingly, an Australian study following up on preschool movement skill intervention by testing motor skills at age 4, 5, and 8 years, found that the children's locomotor skills improved from age 4 – 5 years, but did not significantly increase from 5 – 8 years of age. The children's object controls skills, increased significantly at each time point (Zask et al., 2012). Zask and colleagues' three-year follow up study (Mean age for time one, two, and three were: 4.3, 5.0, and 8.2 years, respectively) used the Test of Gross Motor Development to examine fundamental motor skill proficiency among a group who were part of a movement skill intervention in preschool and a control group. The authors were interested in knowing if motor skill proficiency is sustained over time in young children. Overall, the intervention groups' object control proficiency levels were higher compared to the control groups at time three, however the difference was sex-based. Girls from the intervention group had significantly higher object control skills than the control group but there was no difference for boys. Furthermore, Zask and colleagues suggested that if girls were given the same opportunities as boys, the difference might be reduced. They also note that physical education in Australian schools tends to focus heavily on large-sided team sports (male focused) that typically involve manipulative skills rather than catering to the skills and abilities of girls. These intervention results are similar to the findings of an observational study by Temple and Foley (in press). These authors found that girls' ball

skills significantly improved from grade 3 to grade 4. However, their ball skills were low for their age, and also low in comparison to boys.

Although no studies have tracked fundamental motor skills or perceived physical competence, one study (Spessato et al., 2012) did compare 4 – 7-year old children’s motor skills and perceived physical competence cross-sectionally but did not examine the differences between each age group. There is no clear reason why researchers have not examined these factors longitudinally but may be because the developmental literature suggests that perceived competence is inaccurate until about the age of seven, which from about the age of seven to children begin to develop more accurate beliefs about their personal abilities (Harter, 2012; Horn, 2004). However, there have been cross-sectional studies examining perceived competence in both early childhood (Crane et al., 2015; Goodway & Rudisill, 1997; LeGear et al., 2012; Robinson, 2010; Spessato et al., 2012) and late childhood (Carroll & Loumidis, 2001; Crocker et al., 2000), but given the contrasting findings it is difficult to identify a trend.

### **2.11) Summary**

Despite the methodological inconsistencies in accelerometry measurement, it appears that on average Canadian children are accumulating the recommended 60 minutes of MVPA per day. However, Canadian children are also spending the majority of their time engaged in sedentary behaviour. Evidence of the consistency of these behaviours during childhood is limited, but does show that both sedentary behaviour and physical activity track over time, with sedentary behaviour tracking more consistently than physical activity. The variability in these behaviours over time is worthy of attention since it suggests that activity levels could increase or decrease during childhood. Unfortunately, it seems that on the whole, physical activity decreases with age, while sedentary behaviour increases. The transition from early to middle childhood is of particular interest in the struggle to prevent the decline in physical activity levels, as it is a period when children’s motor and perceptual systems are rapidly developing, their cognitive skills (e.g. memory, attention span, and decision making) are becoming more mature, and their at-school and after-school lives are becoming more structured and demanding. These personal and environmental changes very likely interact to affect children’s physical activity levels and patterns.

Fundamental motor skills are positively and significantly related to physical activity throughout childhood; one study reported a bidirectional relationship between object control proficiency and MVPA (Crane et al., 2015). While, Crane and colleagues reported this reciprocal relationship, they did not find any relationship with locomotor skills. The majority of studies examining the relationship between physical activity and motor skills have focussed on MVPA. There is little evidence examining total physical activity and motor skills or the impact that sedentary behaviours has on motor development or the effect of motor development on sedentary behaviour. Given the positive health outcomes associated with participation in light physical activity further examination of the relationships between light physical activity and motor skills is warranted. Measuring light physical activity along with MVPA is important as it provides a more accurate picture of total physical activity levels as well as being important for well being instead of focussing solely on MVPA. Additionally, assessing sedentary behaviour may provide greater evidence of how children are spending the majority of their day.

Few studies have simultaneously explored the relationships between perceived physical competence and physical activity or between perceived physical competence and fundamental motor skills in childhood. There is evidence of modest relationships between perceived physical competence and fundamental motor skills among children aged 4 – 5 years old. Also perceived physical competence has been shown to mediate the relationship between physical activity and motor skills among adolescents. However, perceived physical competence does not mediate the relationship between motor skills and physical activity among kindergarten children. A significant bi-directional relationship was reported in early childhood (4 – 5 years) between fundamental motor skills and perceived physical competence and as well as between fundamental motor skills and physical activity (MVPA). Although it has previously been determined that adolescents' perceived physical competence influences their physical activity levels, it is unclear at what age this effect begins. Middle childhood marks a critical period of development for an individual; theorists suggest this is when children begin to better accurately assess their own performance resulting in a more realistic perception of their physical competence (Harter, 2012; Horn, 2004). However, more research is needed to

explore the relationship between perceived physical competence, fundamental motor skills, and physical activity levels in middle childhood.

The following series of three studies will examine physical activity and sedentary behaviour levels and their interactions between activity levels and fundamental motor skills and perceived physical competence. The first study will examine the relationship between fundamental motor skills and perceived physical competence from kindergarten to grade 2. As both a longitudinal and cross-sectional study this will be the first to track this relationship from early to the beginning of middle childhood and determine whether the relationship changes. The study will also test whether the cross-sectional data differ from the longitudinal data. The second study will examine the changes in physical activity levels and sedentary behaviours over time. This study will track total physical activity levels, including light and moderate-to-vigorous physical activity, as well as sedentary behaviour from kindergarten to grade 2. The third, and final study in this dissertation will examine whether perceptions of physical competence mediate the relationship between fundamental motor skills and physical activity and sedentary behaviour in grade 2 – 3 children.

## **Chapter 3 – Study 1. The relationship between fundamental motor skills and perceived competence from kindergarten to grade 2**

### **Abstract**

As children transition from early to middle childhood, two processes should serve to strengthen the relationship between motor skill proficiency and perceptions of physical competence. First, it is expected that motor skills will generally improve during childhood, and secondly, perceptions of physical competence generally decrease as children develop cognitively. However, this has not been examined longitudinally. Therefore, this study examined the relationship between fundamental motor skill proficiency and perceptions of physical competence from early childhood to the beginning of middle childhood. Three hypotheses were tested: 1) That motor skill proficiency levels from kindergarten to grade 2 would improve, 2) That perceptions of physical competence levels would decrease from kindergarten to grade 2, and 3) That the relationship between motor competence and perceived physical competence would strengthen from kindergarten to grade 2. Participants were 250 boys and girls (M = 5 years 8 months at baseline). The Test of Gross Motor Development – 2 and The Pictorial Scale of Perceived Competence and Social Acceptance for Young Children were used to measure fundamental motor skills and perceptions of physical competence of children at baseline and follow-up. Descriptive statistics were calculated on motor skills and perceptions of competence in kindergarten and in grade 2 and mixed-design analyses of variance using gender as the between-subject factor and grade level as the within-subjects factor were used to examine change over time. Overall, there was a significant increase in object control skills from kindergarten to grade 2. Furthermore, boys had higher object control skills compared to girls in both grades, whereas girls had higher locomotor skills and higher perceptions of their physical competence. Linear regression analyses showed that locomotor skills and object control skills each explained approximately 8% of the shared variance of perceived competence in kindergarten girls and 7% and 11% of the shared variance for boys. In grade 2, locomotor skills predicted 11% of the variance in perceived physical competence and object control skills predicted 19.3% in the boys only. The findings from this study suggest that the relationship between fundamental

motor skills and perceived physical competence strengthened from kindergarten to grade 2. However, this was only true for boys, whereas the relationship weakened for girls. It seems that forces other than motor skill proficiency influence the girls' perceptions of their abilities in grade 2.

### Introduction

‘Perceptions of competence’ can be thought of as individual beliefs, thoughts, and feelings about personal capabilities in particular areas of achievement (Horn, 2004). Lower perceptions of physical or sport competence are associated with dropout from organized sport among children and youth (Crane et al., 2015), whereas higher perceptions of physical competence are consistently associated with greater participation in physical activity among children and youth (Barnett et al., 2013; Cairney et al., 2012; Sallis et al., 2000; Stuntz & Weiss, 2010).

As children transition from early to middle childhood, two processes should serve to strengthen the relationship between motor skill proficiency and perceptions of physical competence. First, it is expected that motor skills will generally improve during childhood (Livesey, Coleman, & Piek, 2007; Temple & Foley, in press; Ulrich, 2000; van Beurden et al., 2002; Westendorp et al., 2014), and secondly, perceptions of physical competence generally decrease as children develop cognitively (Barnett et al., 2013; Barnett et al., 2008; Harter, 2012; Stodden et al., 2008). On the whole, young children have less developed motor skills than children in middle childhood (Ulrich, 2000), however their beliefs about their physical competence tend to be inflated and inaccurate (Harter, 2012; Horn, 2004). This inaccuracy stems from the difficulty young children have distinguishing between performance and effort as well as their tendency to accept positive praise of their efforts at face value (Harter, 2012; Horn, 2004). Of the five studies examining the relationship between perceptions of physical competence and motor skill proficiency in early childhood, three of those studies found positive significant correlations with locomotor skills ranging from  $r = .37 - .43$  (LeGear et al., 2012; Robinson, 2010), object control skills  $r = .14$ ,  $p < .05$  for LeGear et al. and  $r = .44$   $p < .001$  for Robinson. Furthermore, Crane and colleagues (2015) also found a positive relationship between object control skills and perceived physical competence but the relationship with locomotor skills was not significant. Finally, two studies found that among 4 – 5 year olds, there is no relationship between perceived physical competence and motor skill proficiency (Goodway & Rudisill, 1997; Spessato et al., 2012). While it has been suggested that the extremely low mean object control scores for boys and girls (3.93 and 2.28) created a ‘floor effect’, it is also possible that given inferential statistics

rely on data being normally distributed, it may not have been possible to compute a significance test without running the risk of committing a type II error. For Spessato et al. (2012) they did not find a significant relationship between motor skills and perceived physical competence in 4 – 5 – and 7-year olds, but did find a significant relationship among 6-year old children. These studies highlight the mixed evidence to that has been found to date in examining the relationship between motor skill proficiency and perceived physical competence.

As children transition to middle childhood (~ 7 years of age) the accuracy of their perceptions should start to improve and become less inflated (Harter, 2012). Children's enhanced cognitive abilities allow them to be more aware of their own competence and performances (Kipp & Weiss, 2013), compare their performances to their peers' performances, analyze the reasons for their successes and failures, and internalize feedback they receive (Harter, 2012; Horn & Hasbrook, 1987; McKiddle & Maynard, 1997). While the children's ratings of their ability may actually decrease as their judgements become more realistic in middle childhood, accuracy tends to increase (Ferrer-Caja & Weiss, 2000; Rudisill, Mahar, & Meaney, 1993; Weiss & Amorose, 2005). Increasingly accurate perceptions of competence suggests that as children mature, those with less proficient skills will be more likely to have less favourable perceptions of their physical competence, and the reverse for those with well-developed motor skills (Stodden et al., 2008).

In middle childhood, Wrotniak and colleagues (2006) examined the relationship between perceived physical competence and fundamental motor skills. The findings in their study however, are difficult to interpret as a result of using tools that were not specific to the factors being measured. However, in late childhood (Carroll & Loumidis, 2001; Piek et al., 2006; Raudsepp & Liblik, 2002) and in adolescence (Barnett et al., 2008; Crocker et al., 2000) researchers have found positive relationships between perceived physical competence and motor skill proficiency.

Overall there limited evidence to elucidate the relationship between motor competence and perceived competence in middle childhood. The findings of Spessato and colleagues (2012) suggest there may be positive change in the strength of the relationship as children transition to middle-childhood, but the study was underpowered

in the older age band. Although the results from the Piek et al. (2006) and Wrotniak et al. (2006) studies are confounded somewhat by the tools used to measure motor skills and perceived physical competence, both studies are suggestive of relationships between gross motor skills and perceptions of physical competence, but only among the boys.

Gender-based differences have been identified in fundamental motor skill proficiency, perceived physical competence levels, as well as the relationship between motor skills and perceptions. Evidence consistently shows that boys have significantly better object control skills than girls (Barnett et al., 2008; LeGear et al., 2012; McKenzie, Sallis, & Broyles, 2002; Robinson, 2010; van Beurden et al., 2002; Wrotniak et al., 2006); whereas the evidence is less clear for locomotor skills. Several studies demonstrate that girls have better locomotor skill proficiency (Barnett et al., 2008; LeGear et al., 2012; van Beurden et al., 2002), while other studies found no differences between boys and girls (Hume et al., 2008). Gender-based patterns of perceptions of physical competence in early childhood are diverse (Goodway & Rudisill, 1997; LeGear et al., 2012; Robinson, 2010). While LeGear and colleagues (2012) found 5-year old girls had significantly higher levels of perceived physical competence than boys, Robinson (2010) found that 4-year old boys had higher levels than girls, and Goodway et al. (1997) found no gender-based differences among 3 – 4-year olds. LeGear et al. and Robinson found that the relationship between perceptions of physical competence and locomotor skills was significant for both the boys and the girls. Robinson also found that the relationship between perceptions and object control skills was significant for both sexes, while LeGear et al. found the relationship was only significant for boys. As noted in the previous paragraph, there is little evidence of the relationships between perceptions of physical competence and motor skill proficiency in middle-childhood at all, but the little evidence that does exist alludes to stronger relationships for boys (Piek et al., 2006; Wrotniak et al., 2006).

Perceived physical competence tends to be high among young children and is thought to decrease and become more accurate with age (Horn & Weiss, 1991). However, only Spessato et al. (2012) have examined changes in the accuracy and levels of perceived physical competence from early to middle childhood. Given that higher levels of perceived competence has been identified as a positive correlate of participation in

physical activity (Barnett et al., 2008; Stodden et al., 2008) and lower perceptions of competence are associated with dropout from sport (Crane & Temple, 2015), it is important to understand the developmental trajectory of perceptions of competence and the relationship between perceptions and motor proficiency. This study examined the relationship between fundamental motor skill proficiency and perceptions of physical competence from early to the beginning of middle childhood. Focusing on children's transition from kindergarten to grade 2, three hypotheses were tested: 1) That motor skill proficiency would increase, 2) That perceptions of physical competence would decrease, and 3) That the relationship between motor competence and perceived competence would strengthen.

### **Method**

The University of Victoria Human Research Ethics Board and the school district granted approval for this study (see Appendix A). In this study, a longitudinal design was used to examine change in motor skill proficiency, perceptions of physical competence, and the relationship between these variables as children progressed from kindergarten to grade 2.

#### **3.1) Participants**

Children were eligible to participate in the study if they were attending one of eight consenting (see Appendix B) elementary schools in one school district in the province of British Columbia, Canada. Two cohorts of children were examined in the present study. In kindergarten, participants for cohort one was recruited during the 2010 – 2011 school year (wave 1) and cohort two during the 2011 – 2012 school year (wave 2). These kindergarten cohorts were tracked to grade 2 using data that were collected in 2012 – 2013 and 2013 – 2014 school years.

Children were included in the longitudinal sample if there were complete motor skills and perceptions of competence data in both kindergarten and grade 2. The data were collected between the months of October and May for both the kindergarten and grade 2 cohorts. Data for each child was given an individual identification number.

### 3.2) Measures

Fundamental motor skills (six locomotor skills: run, jump, hop, slide, gallop, and leap; and six object control skills: throw, roll, kick, strike, catch, and dribble) were assessed using the Test of Gross Motor Development-2<sup>nd</sup> Edition [TGMD-2] (Ulrich, 2000). The TGMD-2 (see Appendix B) is a criterion and norm-referenced test that is used to assess the motor skill development of children. Mean test-retest reliability scores for locomotor skills and object control skills have been reported as .88 and .89, respectively for children aged 3 - 5 years and .94 and .96 for children aged 6 - 8 years (Ulrich, 2000). Content validity was established with the help of content experts whom indicated that the gross motor skills included were representative of the categorized gross motor skills domain and that these skills were regularly taught to this age group. Further, the moderate to strong correlation between the TGMD-2 subtests and the Basic Motor Generalizations subtest of the Comprehensive Scales of Student Abilities (Hammill & Hresko, 1994) is evidence of criterion validity of the test. Finally, five constructs thought to influence the TGMD-2: age differentiation, group differentiation, item validity, subtest correlations, and factor analysis were used to determine the construct validity of the test.

For kindergarten children, The Pictorial Scale of Perceived Competence and Social Acceptance for Young Children (Harter & Pike, 1984) was used to assess perceptions of physical competence of children in kindergarten. For children in first and second grade, Harter and Pike developed The Pictorial Scale of Perceived Competence and Social Acceptance for Young Children, which used questions specific to the older age group. The survey has demonstrated acceptable reliability and validity for kindergarten and grade 2 children (Harter & Pike, 1984). Internal consistency reliability for kindergarten children was .86 for total scale and for the physical domain was .55. Further, convergent validity was determined in the physical domain as children could provide concrete reasons for their competency. Each scale consists of 24 items subdivided into four subscales (6 statements each) that are: Cognitive Competence, Physical Competence, Peer Acceptance, and Maternal Acceptance; however only the perception of physical competence sub-scale was used for this study. Items in each subscale were presented in the form of bipolar statements that are accompanied by a picture for each statement; for example, two pictures display a child running, which are

followed by a statement describing the child's ability (e.g. 'this boy can run pretty fast' and 'this girl can't run very fast'). The child selects the picture they believe most closely represents them. Once a picture is chosen, a follow up question is asked to determine the degree of competence within the skill (i.e. 'Are you'; 'really fast' or 'pretty fast'). Each item is scored on a four-point scale, where a 4 indicates the highest degree of perceived competence and 1 the lowest. Both versions of the test contain the same number of questions and the same sub-scales; the only difference between the scales are that from the pre-school and kindergarten version of the survey to the grade one and grade 2 version there are questions that are no longer appropriate for older children and therefore is substituted for a question more suitable. For the physical domain, two questions (bouncing a ball, and jumping rope) were added to the survey while tying one's shoes and hopping on one foot were omitted.

### **3.3) Procedures**

A team of 10 trained research assistants collected these data. Training for the research assistants included a period of familiarization with the tools and also a hands-on guided tutorial on how to administer both the TGMD-2 and the The Pictorial Scale of Perceived Competence and Social Acceptance for Young Children. The TGMD-2 was administered during scheduled physical education classes in accordance with the testing procedure outlined in the Examiner's Manual (Ulrich, 2000). Each class was divided into four small groups prior to entering the gymnasium with each group consisting of 3 – 5 children. Each child performed the skills at their station twice before moving onto the next station. Due to scheduling and time constraints (e.g. physical education lessons ranged in duration from 30 – 60 minutes) data were collected over multiple visits to each school. Consented children were digitally video-recorded performing six locomotor skills (run, jump, hop, slide, gallop, and leap) and six object control skills (throw, roll, kick, strike, catch, and dribble). The Pictorial Scale of Perceived Competence and Social Acceptance for Young Children (Harter & Pike, 1984) were administered by the research assistants individually with each child in a quiet area following a motor skills testing session.

### 3.4) Data Treatment and Analyses

The principal investigator scored the behavioural components of each of the 12 skills dichotomously using digital video. The number of components completed correctly for each subtest (locomotor and object control skills) was summed to provide a raw score (range 0 – 48). The items of both versions of The Pictorial Scale of Perceived Competence and Social Acceptance for Young Children assessing physical competence were scored on a scale of 1-4 for each item. Scores from the physical competence sub-scale questions were summed (six items total) to provide a raw score out of 24 (range 6 – 24). Descriptive statistics were then computed for locomotor skills, object control skills, and perceptions of physical competence in kindergarten and grade 2. Specifically, means and standard deviations, and percent of maximum possible score (Cohen, Cohen, Aiken, & West, 1999) were calculated. POMP is calculated using the following equation:  $[(\text{Observed score} - \text{minimum possible}) / (\text{maximum possible} - \text{minimum possible}) \times 100]$ . To test hypotheses 1 and 2, a mixed design analysis of variance using gender as the between-subject factor and grade level as the within-subjects factor was performed to examine the change in locomotor skills, object control skills, and perceived physical competence over time. Further, paired-sample *t*-tests were conducted to examine change or stability in each of the 12 skills. To test the third hypothesis that the relationship between fundamental motor skills and perceived physical competence would strengthen over time, Pearson product-moment correlation coefficients were computed for the relationship between locomotor skills and perceptions of physical competence and between object control skills and perceptions of physical competence for boys and girls in kindergarten and in grade two. Further, a series of linear regression analyses were conducted to predict perceptions of physical competence (as the outcome variable) from locomotor and object control skills (predictor variables) in kindergarten and grade 2 for boys and girls separately. All statistical analyses were conducted using IBM SPSS (Version 23.0) for Windows (IBM Corp, 2015) and alpha value for rejecting the null hypothesis was set at  $< 0.05$  (Fisher, 1956).

### Results

Of the 780 children who had data collected in kindergarten and grade 2, a longitudinal sample of 250 children with complete motor skills and perceptions of

competence data in both kindergarten and grade 2 were included in this study. The mean age for children in kindergarten and grade 2 was 5.8 years and 7.7 years, respectively. Descriptive statistics grouped by gender for locomotor skills, object control skills, and perceptions of physical competence are reported in Table 1. The raw and POMP motor skill scores indicated that the children's skills in kindergarten were in the middle of the range of possible scores, but had increased to approximately 57% to 67% of the maximum possible by grade 2. Contrastingly, the perceived physical competence scores were high in both grades.

Table 1 *Descriptive raw scores for locomotor skills, object control skills, perceived physical competence, and percent of maximum possible score in kindergarten and grade 2*

Subscale raw scores (range)		Kindergarten			Grade 2		
		Mean	SD	POMP	Mean	SD	POMP
Locomotor skills (0 – 48)	Boys	25.8	7.1	53.9	29.3	5.6	61.0
	Girls	26.9	6.8	56.2	31.9	4.9	66.6
Object control skills (0 – 48)	Boys	23.6	8.0	49.2	31.5	6.3	65.6
	Girls	19.8	6.5	41.3	27.2	5.8	56.8
Perceived physical competence (6 – 24)	Boys	18.2	3.2	76.0	19.5	3.1	81.4
	Girls	19.3	2.7	80.4	20.5	2.5	85.5

*Note.* POMP = Percent of maximum possible score (0 – 100)

The mixed analyses of variance revealed a significant improvement in object control skill raw scores from kindergarten to grade 2, Wilk's Lambda = .873,  $F(1, 248) = 36.129$ ,  $p < .001$ ,  $\eta^2 = .13$  as well as a significant effect for gender  $F(1, 248) = 29.992$ ,  $p < .001$ ,  $\eta^2 = .11$ . Boys had significantly higher object control skills compared to girls in both kindergarten and grade 2 (see Table 1). There was no overall improvement in locomotor scores from kindergarten to grade 2; Wilk's Lambda = .994,  $F(1, 248) = 1.611$ ,  $p = .206$ ,  $\eta^2 = .006$ . However, there was a significant effect for

gender, revealing girls had significantly higher locomotor skills compared to boys in both kindergarten and grade 2  $F(1, 248) = 8.806, p = .003, \eta^2 = .04$ . There was also a significant increase overall in perceived physical competence from kindergarten to grade 2 as evidenced by a Wilk's Lambda of .983,  $F(1, 248) = 4.257, p < .040, \eta^2 = .02$ . In addition, there was a significant effect of gender on perceived physical competence  $F(1, 248) = 11.369, p = .001, \eta^2 = .044$ , revealing that girls had higher perceptions of physical competence than boys in both kindergarten and grade 2.

Change or stability of each of the 12 TGMD – 2 skills is presented in Table 2. Across both the boys and the girls, there was significant improvement in 7 out of the 12 skills (run, hop, leap, slide, strike, dribble, and catch) from kindergarten to grade 2.

Table 2 *Examining the differences of individual skills from the TGMD - 2 using paired-sample t-test*

Skill	Boys ( $n = 124$ )					Girls ( $n = 126$ )					
	Kindergarten	Grade 2			$p$	Kindergarten	Grade 2			$p$	
	M	SD	M	SD		M	SD	M	SD		
Run	5.6	1.8	6.6	1.5	<.001**	Run	5.3	1.9	6.7	1.2	<.001**
Gallop	3.6	2.2	4.1	1.9	.060	Gallop	4.2	2.1	4.9	1.6	.004*
Hop	4.7	1.9	5.5	1.7	<.001**	Hop	5.0	1.9	5.9	1.8	<.001**
Leap	3.2	1.3	3.2	1.1	.912	Leap	2.8	1.9	4.0	1.6	<.001**
Jump	3.5	2.2	3.6	2.2	.629	Jump	3.3	2.1	4.1	2.0	<.001**
Slide	5.0	2.4	6.0	1.3	<.001**	Slide	5.3	2.3	6.1	1.3	<.001**
Strike	6.4	2.0	7.1	1.6	<.001*	Strike	5.2	2.0	5.9	1.7	.006*
Dribble	2.4	2.3	5.5	2.1	<.001**	Dribble	2.2	2.1	4.6	1.9	<.001**
Catch	3.2	1.5	4.0	1.4	<.001**	Catch	3.1	1.5	4.2	1.4	<.001**
Kick	5.1	1.6	6.2	1.1	<.001**	Kick	4.4	1.6	5.6	1.0	<.001**
Throw	3.1	2.4	4.5	2.1	<.001**	Throw	1.8	1.3	1.9	1.3	.895
Roll	3.1	2.0	4.1	1.6	<.001**	Roll	3.7	1.3	3.9	1.1	.238

Gender-based differences were evident with respect to boys' improved catching and rolling of a ball, which the girls did not improve; and girls' improved gallop, leap, and jump; which showed no significant change among the boys.

In kindergarten, significant relationships were found between perceived physical competence and both locomotor skills and object control skills for both girls and boys (see Table 3). In grade 2, significant correlations were found between perceived physical competence and locomotor skills for boys but not for girls; whereas significant correlations were found between perceived physical competence and object control skills for girls and boys.

Table 3 *The relationship between motor skills and perceived physical competence*

TGMD-2 subtest	Perceived physical competence			
	Kindergarten		Grade 2	
	Boys	Girls	Boys	Girls
Object control skills	.326*	.288**	.450**	.193*
Locomotor skills	.271**	.255**	.327**	.064

Note. \* $p < .05$  and \*\* $p < .001$ .

Because there were significant differences between the boys' and girls' motor skills and perceptions of physical competence, separate linear regression analyses were calculated to predict perceptions of physical competence from fundamental motor skills. In kindergarten, and after controlling for age in months, both the regression model for locomotor skills  $F(1, 123) = 5.340, p = .006, R^2 = .081$  and for object control skills  $F(1, 123) = 5.240, p = .006, R^2 = .082$  predicted girls' perceived competence. Similarly, both regression models for kindergarten boys were statistically significant: locomotor skills  $F(1, 123) = 4.365, p = .015, R^2 = .067$ ; and object control skills  $F(1, 123) = 7.294, p < .001, R^2 = .108$ . In grade 2, and after controlling for age in months, neither of the regression models were statistically significant for girls: locomotor skills  $F(2, 121) = .525, p = .593, R^2 = .009$ ; and object control skills  $F(2, 121) = 2.716, p = .070, R^2 = .009$ . For boys in grade 2 however, locomotor skills  $F(2, 121) = 7.104, p = .001, R^2 = .109$  and

object control skills  $F(2, 121) = 13.995, p < .001, R^2 = .193$  significantly predicted perceptions of physical competence.

The current study included only children with complete motor skill and perception of physical competence data in kindergarten and grade 2. To shed some light on the generalizability of the findings of this study, I tested whether the 250 children in the longitudinal sample were representative of children not included in the longitudinal sample in both kindergarten ( $n = 137$ ) and grade 2 ( $n = 143$ ) from the same school. Using independent t-tests, children's locomotor skills, object control skills, and perceptions of physical competence scores were compared. No significant differences were found between the two groups for locomotor raw scores  $t(386) = -.417, p = .677$ , object control raw scores  $t(386) = .405, p = .685$ , or perceptions of physical competence  $t(386) = -.613, p = .541$  in kindergarten. Similarly, no significant differences were found between the two groups for locomotor raw scores  $t(391) = 1.587, p = .113$ , object control raw scores  $t(391) = 1.650, p = .653$ , or perceptions of physical competence  $t(391) = .457, p = .459$  in grade 2. These findings suggest the longitudinal sample is representative of the larger cross-sectional sample.

### **Discussion**

The aim of this study was to examine the relationships between fundamental motor skill proficiency and perceived physical competence from early childhood to the beginning of middle childhood. In addition, the influence of gender on this relationship was examined. Consistent with the principle that motor development is cumulative (Gabbard, 2012; Lerner et al., 2013), the children's locomotor and object control skills significantly improved from kindergarten to grade 2. The POMP scores showed that locomotor skills improved 7% for boys and 10% for girls and object control skills improved by 15% and 14% for boys and girls, respectively. More detailed skill level analyses revealed that girls improved in all 6 locomotor skills and most object control skills, with the roll and throw being the exceptions (Table 2). The boys also significantly improved all 6 object control skills and demonstrated significant improvements in 3 of the 6 locomotor skills. The boys' gallop, leap, and jump did not change (Table 2). These findings are consistent with the research that has previously shown that boys perform better with object control skills (Barnett et al., 2008; LeGear et al., 2012; McKenzie et

al., 2002; Robinson, 2010; van Beurden et al., 2002; Wrotniak et al., 2006); and support studies showing that girls have more mature development of locomotor skills than same age boys (Barnett et al., 2008; LeGear et al., 2012; van Beurden et al., 2002). The locomotor (gallop, leap, and jump) and object control skills (roll and throw) that did not improve in the current study may reflect the types of activities children are engaging in. For example, both the boys and girls significantly improved their kicking and running, two predominant skills associated with soccer. In Canada, soccer is most popular team sport for children and youth (3 – 19 years) (Mendes, 2014). One in four respondents in a nationwide survey reported having at least one child (5 – 14-years old) living in the household playing soccer on a regular basis (Canadian Heritage, 2013) and that more than 750,000 children in Canada are part of an organized soccer program (Mendes, 2014). Therefore, the motor skills that did not improve in this study may reflect a lack of experience and/or practice. The impact that experience and/or practice can have on motor skill proficiency is evident in Williams and colleagues' (1996) study on throwing patterns of boys and girls. These authors found that young boys and girls did not differ in throwing velocity when using their non-dominant hand. But boys threw significantly harder than girls when using their dominant hand, which demonstrated that the large differences in throwing when children use their dominant hand could be attributed to practice (Williams et al., 1996). Opportunities to engage in activities and play often conform to stereotypical gender norms, which often reflect sociocultural influences and beliefs upon how boys and girls should act (Gabbard, 2012). There some evidence to suggest that girls play more of a spectator role in typical invasion type activities (Gutierrez & Garcia-Lopez, 2012) and fewer team sports than boys (Temple et al., 2014), while girls participate in more dance than boys (Temple et al., 2014). These participation patterns likely have an effect on the motor skills that boys and girls develop, and as Stodden et al. suggested, these motor skills are the tools that enable participation.

Perceptions of physical competence raw scores were high as indicated by the POMP scores. Perceived physical competence scores were approximately 78% and 83% of the possible maximum in kindergarten and grade 2, which support previous findings reporting higher levels of perceived physical competence in early childhood (Crane et al., 2015; Goodway & Rudisill, 1997; LeGear et al., 2012; Spessato et al., 2012) and middle

childhood (Spessato et al., 2012). The second hypothesis stated that perceptions of physical competence would decrease from kindergarten to grade 2. Although the change in perceived physical competence was statistically significant from kindergarten to grade 2, the effect size ( $\eta^2 = .02$ ) of change was small (Field, 2013), which equated to an increase in perceived physical competence raw score of approximately one on a scale ranging from 6 – 24. Perhaps more surprising was that perceptions of physical competence increased, which is not consistent with developmental theory (Harter, 2012; Horn, 2004; Stodden et al., 2008).

Theoretically, middle childhood has been identified as a significant time for development of perceived competence in young children. The increase in cognitive function in comparison to early childhood should result in perceived ability becoming more accurate (Harter, 2012; Horn, 2004). It might be expected in middle childhood that children use standards of performance to judge their levels of competence (Koka & Hein, 2003). They may compare their performance with their previous performances, or their peers' performance. These internal comparisons produce positive, negative, or neutral feelings. At the same time that children are engaging in these internal processes, they are receiving feedback from external sources. Positive feedback in response to performances can increase self-perceptions and intrinsic motivation (Deci & Ryan, 1985; Ryan & Deci, 2000). Whereas feelings associated with a lack of competence and the need to perform in public can lead to avoidance of physical education (Gibbons, 2008) and dropout from sport (Boiche & Sarrazin, 2009; Crane & Temple, 2015). In this study, the children's levels of perceived physical competence remained high in grade 2. It appears that perceptions were not more accurate than when the children were in kindergarten. No data were collected on the variables that may influence the children's perceptions of physical competence other than motor skill proficiency. Future research would benefit from including a range of internal and external variables such as pressures from coaches, peers, and family members (Crane & Temple, 2015) that may influence perceptions of physical competence.

In this study, the small increase in perceived physical competence raw scores from kindergarten to grade 2 suggests that perceptions of physical competence are not yet becoming more accurate. This is important given that developmental psychologists

(Harter, 2012; Horn, 2004) consider 7-years of age to be the beginning of this transitional period. Along with Spessato and colleagues (2012), this is one of the first studies to examine children's perceptions of physical competence during this transition period. Spessato et al. found a modest significant relationship between perceptions and motor skill proficiency among 6 year old children, and a similar strength relationship that was not significant among the 7 year old children. However, these authors did not stratify their sample by gender, so it is not possible to say whether the nature of the relationships between perceived and actual motor skills differed for the boys and the girls as they reached 7 years of age. The findings of this study show that the relationships between fundamental motor skills and perceived physical competence were significant for both boys and girls in kindergarten and became stronger for the boys in grade 2. For the girls however, the relationship between perceptions of physical competence and both types of skills was weaker in grade 2.

Although the girls' perceptions of physical competence increased from kindergarten to grade 2, the relationship with motor competence decreased. This suggests that factors other than the motor skills measured by the TGMD – 2 are influencing the formation of girls' perceptions of physical competence. It is possible that the TGMD – 2 is not capturing a specific range of motor skills that influence girls' perceptions of competence. Previous studies have suggested that slightly older girls may discount their abilities and therefore have lower perceptions of physical competence (Gibbons, 2008; Sollerhed, Apitzsch, Rastam, & Eijlertsson, 2007). However, this is not the case in this study, where girls' perceptions of physical competence stayed high in grade 2 and were significantly higher than the boys. Previous evidence in grade 2 from the same 8 schools as the present study show that girls participate in significantly more swimming, gymnastics, and formal and informal dance than boys (Mirjafari, 2015). The skills used for these types of activities are not well captured in the TGMD – 2 and therefore, the potential to see the relationship to see motor skill proficiency and perceived physical competence is likely to be diminished.

This is the first study to provide evidence about the relationship between fundamental motor skills and perceived physical competence longitudinally as children transition from early to the beginning of middle childhood. Theory suggests that middle

childhood might be the start of lower and more accurate perceptions of physical competence. However, the findings of this study suggest that at beginning of middle childhood, this change is not yet apparent and there are gender-related differences surrounding the relationship between fundamental motor skills and perceived physical competence.

### **3.5) Limitations**

A limitation of longitudinal research and the current study is the loss of participants due to attrition (e.g. choosing to withdrawal from the study) or other factors (e.g. switching schools) that results in incomplete data. In the current study, approximately 500 participants had incomplete data, most of who were not consented in year one of the study but were recruited for year two. However, no significant differences were found between the cross-sectional and longitudinal samples for either locomotor or object control raw scores, which suggests that the longitudinal cohorts are representative of the larger sample of kindergarten and grade 2 children. Furthermore, the survey used to assess perceived physical competence was limited by a lack of questions pertaining to specific object control skills (no questions in kindergarten and 1 question in grade 2). As a result, stronger relationships may have been established if the tool used in this study more closely reflective the motor skills of the children.

### **Conclusion**

From a developmental perspective, exploring the relationship between perceived and actual motor skill proficiency during the transition to middle childhood is important in understanding how perceptions are formed and at what age they begin to become more accurate. While motor skill proficiency is improving, having positive perceptions of one's self will continue to foster further development motor skills, which have also been previously found to be related to physical activity levels during childhood (Cliff et al., 2009; Crane et al., 2015; Robinson, 2010) and adolescence (Barnett et al., 2008).

The findings from this study suggest that the change in the relationship between fundamental motor skill proficiency and perceived physical competence is very different for boys and girls over time. It appears that girls perform better at locomotor tasks, while boys perform better with object control skills. Both boys and girls perceived their abilities

favourably in kindergarten and maintain those high levels in grade 2. In kindergarten, a small but significant increase was found for boys and girls, but by grade 2, the relationship had diverged. A significant relationship was found for boys, whereas, there was no relationships between the perceived physical competence and motor skills in grades 2 for girls. This suggests that there are factors other than motor skills measured in this study that are influencing their perceptions. This leaves unanswered questions about the development of perceptions of physical competence for girls in comparison to boys.

Part of the impetus for this study was to test aspects of Stodden and colleagues' (2008) developmental model published in *Quest*. Stodden et al. hypothesized that in both early and middle childhood perceptions of competence would predict motor skill proficiency, but for slightly different reasons. In early childhood positive perceptions may help in the development of motor skills because the children don't really differentiate between the effort they put into their activity and the outcomes (i.e. success or failure). While in middle-childhood improvements in motor skill proficiency coupled with positive perceptions of their ability should encourage children to continue to practice and refine their skills, which in turn lead to more positive perceptions. However, Stodden et al. (2008) did not include gender in their model. In the present study, the girls' motor skills and perceptions of physical competence improved from kindergarten to grade 2, but the strength and significance of the relationships decreased. Whereas the boys' motor skill proficiency increased, as did the strength of the relationships between motor skills and perceptions. This was despite the maintenance of high perceptions of physical competence at grade 2. These findings suggest that: 1) gender should be included in a developmental model such as the one conceived by Stodden et al. (2008) since the relationship between motor skills and perceived physical competence among the grade 2 children was vastly different for boys and girls. 2) motor skill proficiency should be conceptualized as a more differentiated construct that is currently evaluated in the Stodden et al. (2008) model. Not only were the relationships between motor skills and perceptions of physical competence different for boys and girls, but there were gender-based differences in object control skills, locomotor skills proficiency; as well as the strength of the relationships between perceptions of physical competence and each of the TGMD – 2 subtests.

It is clear that the motor skills assessed in this study were not associated with the girls' perceptions of physical competence in grade 2. Efforts need to be made to better understand what factors influence girls' perceived physical competence and what that means for the girls' cognitive, social, and physical development.

## **Chapter 4 – Study 2. Tracking the physical activity and sedentary behaviour of children from kindergarten to grade 2**

### **Abstract**

The issue of consistent engagement in MVPA has gained considerable attention in the physical activity and public health literature because of the health benefits associated with regular participation. Regular physical activity has musculoskeletal and cardiovascular health benefits and assists with the maintenance of healthy body weight among children. However, nationally representative data reveal that approximately 7% of Canadian 5 – 11-year old children meet daily MVPA guidelines. The purpose of this study was to examine the levels of physical activity and sedentary behaviours from kindergarten to grade 2. Specifically, it was hypothesized that: 1) children's MVPA and total physical activity levels would decline from kindergarten to grade 2, 2) sedentary behaviour would increase from kindergarten to grade 2, 3) the cross-sectional sample would accumulate less physical activity and more sedentary minutes compared to the longitudinal sample, and 4) sedentary behaviour would track more consistently than MVPA or total physical activity. Participants were 96 kindergarten children recruited in the 2010-11 and 2011-12 school years and 94 grade 2 children recruited in the 2012-13 and 2013-14 school years. A sub-cohort of 21 children were tracked longitudinally from kindergarten to grade 2. Actigraph GT1M accelerometers were worn for 7 days to measure physical activity and sedentary behaviour. Cross-sectional participants accumulated on average between 65 – 210 minutes of MVPA per day, 240 – 476 minutes of total activity, and 264 – 476 minutes of sedentary behaviour in kindergarten. In grade 2, minutes of MVPA ranged between 37 – 166 minutes, 193 – 463 minutes for total activity, and 322 – 642 minutes of sedentary behaviour per day. For the longitudinal sample, repeated measures analyses of variance revealed a significant increase in sedentary behaviour by 68 minutes and a significant decrease in MVPA by 40 minutes and total activity by 72 minutes from kindergarten to grade 2. Furthermore, intra-class correlation coefficients revealed that sedentary behaviour tracked more consistently than MVPA or total physical activity. The findings of the current study show that sedentary behaviour tracked consistently from early to middle childhood while physical

activity displayed low levels of tracking. Continuing to track these behaviours with objective tools and identifying the root causes of the decline is important. Moreover, there is a critical need to invest in strategies to maintain higher levels of physical activity across the primary years and reduce sedentary time since these behaviours are associated with positive and negative health outcomes, respectively.

## Introduction

The Canadian physical activity guidelines recommend that children 5-11-years of age accumulate a minimum of 60 minutes of moderate-to-vigorous physical activity (MVPA) per day to achieve health benefits (Active Healthy Kids Canada, 2014). In addition, it is recommended that children engage in both vigorous activities and activities to strengthen muscles and bones a minimum of three days per week. Nationally representative data reveal that approximately 7% of Canadian 5 – 11-year old children meet daily MVPA guidelines (Colley et al., 2011; Colley et al., 2013). Further, when fewer days per week were examined, 40% of Canadian children achieved the recommended daily 60 minutes of MVPA at least three days per week, but almost 80% achieves this level on at least one day per week (Tremblay et al., 2011). These data illustrate that in a single day, 60 minutes of MVPA is achievable for most Canadian children; however consistency continues to be problematic.

The issue of consistent engagement in MVPA has gained considerable attention in the physical activity and public health literature because of the health benefits associated with regular participation (Biddle, Gorely, & Stensel, 2004; Dencker et al., 2006; DuRant, 1996; Ekelund et al., 2006; Sallis, 2000; Tremblay et al., 2011; Trost, Kerr, Ward, & Pate, 2001). Regular physical activity has musculoskeletal and cardiovascular health benefits and assists with the maintenance of healthy body weight among children (Ekelund et al., 2006; Janssen & LeBlanc, 2010; Sallis et al., 2000; Strong et al., 2005; Tremblay et al., 2010; Tremblay et al., 2011). Additionally, regular physical activity decreases the likelihood of becoming overweight or obese by as much as 70% (Tremblay & Willms, 2003). Furthermore, consistent participation (9 – 30 minutes per day) in MVPA (e.g. brisk walking) has been linked to reductions in blood pressure among children and youth (Janssen & LeBlanc, 2010). Mark and Janssen (2008) also measured the dose-response relationship between MVPA and blood pressure and hypertension among 12 – 19-year olds and found that as physical activity increased, the odds of hypertension decreased. Specifically, engaging in at least 60 minutes of MVPA per day reduced the likelihood of hypertension by approximately one-third compared to those with no MVPA (Mark & Janssen, 2008).

In contrast to the health benefits afforded by regular participation in MVPA, being sedentary has adverse health outcomes. Tremblay and Willm's (2003) examination of physical inactivity patterns among a nationally representative sample of Canadian children (7 – 11 years of age) found that engagement in sedentary activities (e.g. television watching) significantly increased the likelihood of becoming overweight or obese by as much as 61%. Furthermore, for children, these sedentary activities (e.g. video game use, television time) were positively correlated with being at risk of the metabolic syndrome and hypertension (Mark & Janssen, 2008; Pardee, Norman, Lustig, Preud'homme, & Schwimmer, 2007; Tremblay et al., 2010). Pardee and colleagues (2007) study of hypertension levels among 4 to 17-year old obese children found that watching television for more than two hours per day increased a child's likelihood of hypertension by 2.0-3.3 times, compared to children and youth who watched 0 – 2 hours of television per day.

Although a majority (69%) of Canadian 5 – 11-year old children meet the guidelines for sedentary behaviour (i.e. engaging in no more than two hours of daily screen time), Colley et al. (2011) found that on average children spent 8.5-hours per day engaged in sedentary behaviours, which include screen time and sitting in class. Similar evidence among Canadian 5-year old children reveal these children spend approximately 6.5-hours per day in sedentary pursuits (Colley et al., 2013). Collectively, these studies suggest that many Canadian children are spending large amounts of time in sedentary behaviour and are at risk of not only becoming overweight or obese, but are also increasing the risk of other potential health issues such as the metabolic syndrome and hypertension (Mark & Janssen, 2008; Pardee et al., 2007; Tremblay et al., 2010).

To date, evidence of age-related trends in physical activity participation during childhood has consisted of both cross-sectional and longitudinal studies. Cross-sectional studies have shown that the physical activity levels of younger children (3-5-years of age) are higher than children in middle/late childhood and adolescence, and levels of sedentary behaviour are lower (Belanger, Gray-Donald, O'Loughlin, Paradis, & Hanley, 2009a; Belanger et al., 2009b; Caspersen, Pereira, & Curran, 2000; Nader, Bradley, Houts, McRitchie, & O'Brien, 2008; Sallis, 2000). Similarly, longitudinal studies (Herman, Craig, Gauvin, & Katzmarzyk, 2009; Janz et al., 2005; Kelly et al., 2007;

Kristensen et al., 2008) as well as a systematic review (Jones et al., 2013) examining physical activity and sedentary behaviour over time, highlight a decline in physical activity and increase in sedentary behaviour with age.

In Canada, Colley and colleagues' (2013) cross-sectional examination of children's accelerometer measured physical activity levels revealed that, on average, 14% of 5-year olds accrued at least 60 minutes of MVPA per day. Among older children (6-10-year olds), Colley et al. (2011) found that 9% of boys and 4% of girls accumulated the minimum 60 minutes of MVPA using the same protocol. These two studies also revealed that 5-year old children spent less time engaged in sedentary behaviour when compared to children 6-10-years of age. Approximately half of the waking hours (~6.5hrs) of 5-year olds were spent engaged in sedentary behaviour compared to 8.6-hours accrued by older children (6-10-year olds) (Colley et al., 2011; Colley et al., 2013). The trend toward lower levels of physical activity with increasing age is also apparent from middle childhood, to adolescence, to adulthood. For example, Troiano and colleagues' (2008) used accelerometers in a cross-sectional study to measure physical activity levels in childhood (6-11-years of age), adolescence (12-19-years of age), and adulthood (>20-years of age). Results indicated that MVPA levels were lower with increasing age. Specifically, 42% of children aged 6-11-years accumulated the recommended amount of at least one-hour of physical activity per day, whereas only 8% of adolescents and 5% of young adults met the guideline (Troiano et al., 2008).

Although cross-sectional studies examining physical activity and sedentary behaviours offer great insight into the activity levels of children at different ages, longitudinal and tracking studies monitor change among the same children over time. These types of studies help identify determinants of inactivity and how those factors may change at different stages of development (Telama, 2009). Tracking is defined as the tendency of individuals to maintain their rank or position within a group over time (Malina, 2001). Researchers suggest the strength of the tracking coefficients using objective measures for physical activity in early and middle childhood studies is weak to moderate (Janz et al., 2005; Janz, Dawson, & Mahoney, 2000; Jones et al., 2013; Kelly et al., 2007; Kristensen et al., 2008; Pate, Baranowski, Dowda, & Trost, 1996; Pate, Trost, Dowda, Ott, & Ward, 1999; Telama, 2009; Telama et al., 2005). The majority of

researchers report the strength of tracking with the use of either Spearman rank order correlational coefficients or intra-class correlation coefficients (Janz et al., 2005; Janz et al., 2000; Jones et al., 2013; Kelly et al., 2007; Kristensen et al., 2008; Pate et al., 1996; Pate et al., 1999; Telama, 2009; Telama et al., 2005).

Studies tracking physical activity across early childhood (pre-school aged and school aged) and middle childhood and also from early childhood to middle childhood have produced varying results in terms of the strength of tracking coefficients. Jones and colleagues' (2013) systematic review examined the degree that physical activity and sedentary behaviour tracked in early childhood as well as from early to middle childhood. Tracking using Spearman rank order correlational coefficients ranged from 0.27 – 0.57, with a mean tracking coefficient of 0.39, indicating that physical activity tracked moderately well (Jones et al., 2013). For sedentary behaviour, Jones et al. reported moderate – large tracking correlation coefficients with a mean tracking coefficient of 0.50. For physical activity, 60% of the tracking coefficients were moderate, 34% were small, and 4% of the tracking coefficients were large (Jones et al., 2013). For sedentary behaviour, 50% of the tracking coefficients were moderate, 33% were large, and 17% of the tracking coefficients were small (Jones et al., 2013). Overall, 83% of studies reported moderate or better levels of sedentary behaviour tracking compared to the 64% that reported moderate or better levels of tracking for total physical activity (Jones et al., 2013).

The inconsistencies in the level of tracking reported for physical activity and sedentary behaviour may be related to the methods and tools used to collect physical activity and sedentary data. For example, in early childhood Kelly et al. (2007) measured total physical activity, MVPA, and sedentary behaviour using accelerometers and found these intensities tracked modestly ( $r = .035$ ,  $r = .035$ , and  $r = .037$ , respectively). Pate et al. (1996) found physical activity tracked reasonably well over three years using the PAHR-50 index (activity > 50% of resting heart rate); Spearman rank order correlations ranged from  $r = .57$  -  $.56$  and the intraclass correlation coefficient ( $r$ ) for the three years was  $.81$ . For middle childhood, Janz et al. (2005) found moderate levels of tracking for moderate ( $r = 0.40$  and  $0.32$ ), vigorous ( $r = 0.39$ ) activity and sedentary ( $r = 0.41$  and  $0.44$ ) behaviour for boys and girls, respectively using accelerometry. In comparison,

Telford and colleagues (2009) used pedometers to measure physical activity in their study and found modest levels ( $r = 0.29$ ) of tracking step counts across three years. The discrepancies among tools used to collect both physical activity and sedentary data may have an influence on the levels of tracking when comparing results between studies using different research tools.

In addition to measuring physical activity levels over time, it is important to measure sedentary behaviour levels because of the adverse health outcomes associated with time spent in sedentary pursuits (Tremblay et al., 2011). Few studies have concurrently examined both physical activity and sedentary behaviours of children longitudinally. Of the fourteen studies examined in Jones and colleagues' (2013) systematic review, only two studies reported both physical activity and sedentary behaviour tracking coefficients (Janz et al., 2005; Kelly et al., 2007). Owen and colleagues (2010) suggested that meeting physical activity guidelines is necessary for optimal health benefits, but caution that even when meeting the activity guidelines, sitting and engaging in sedentary pursuits for sustained periods of time could have lasting effects on metabolic health. Only Janz and colleagues (2005) have tracked both physical and sedentary behaviour among school aged children. Over three years (from 5-to-8 years of age), children's total physical activity (light, MVPA) and sedentary behaviour were recorded. At follow up, Spearman rank-order correlation coefficients revealed that the children's sedentary behaviour tracked more consistently ( $r = 0.37 - 0.52$ ) than total activity ( $r = 0.18 - 0.39$ ).

Measuring both physical activity and sedentary behaviour provides researchers with a more comprehensive picture of the minutes accrued and how children spend the majority of their day. As previously noted, it is possible for children to meet the physical activity guidelines while simultaneously spending the majority of their day engaged in sedentary behaviour, a term referred by some as "the physically active couch potato" (Tremblay et al., 2010, p. 729). For example, a child may wake up and go to soccer for 2-hours in the morning, which is then followed by watching television or playing video games for the next 6-hours. Although these children are accumulating the necessary minutes of physical activity per day, prolonged amounts of sedentary behaviour without interruptions (e.g. standing up or moving briefly) is associated with adverse biomarkers

of cardiometabolic health, independent of total sedentary time (Healy et al., 2008). Although Healy and colleagues' (2008) work did not focus on children, their findings among healthy adults who were meeting physical activity guidelines highlight the importance of concurrently measuring sedentary behaviours and physical activity. These authors found negative dose-response relationships between the amount of time spent watching television and waist circumference and 2-hour plasma glucose for men and women. Further, greater television time was associated with increases in systolic blood pressure for men and women, as well as higher triglycerides and HDL-cholesterol in for women (Healy et al., 2008). These findings suggest that establishing healthy behaviours that include achieving both physical activity and sedentary behaviour guidelines is important for young children given the health implications associated with sedentary behaviour in adulthood (Healy et al., 2008; Viner & Cole, 2005). This may be particularly important since these behaviours are likely becoming less positive across childhood, while at the same time tracking to some degree. However, more longitudinal studies specifically looking at the levels of change over time are needed to simultaneously examine trajectories of physical activity and sedentary behaviour.

Cross-sectionally, the available evidence suggests that in early childhood (Cliff et al., 2009; Colley et al., 2013; Fisher et al., 2005b) and middle childhood (Troiano et al., 2008) levels of MVPA are low and children spend most of their waking hours engaging in sedentary activities. However, only one study has actually tracked both physical activity and sedentary behaviour from early to middle childhood (Janz et al., 2005). Moreover, as per Jones et al.'s (2013) suggestion, reporting both physical and sedentary behaviour levels and tracking coefficients will present a more complete picture of change in these health behaviours over time. Therefore, the aim of this study was to examine the levels of physical activity and sedentary behaviours sequentially from kindergarten to grade 2. Specifically, it is hypothesized that: 1) children's MVPA and total physical activity levels would decline from kindergarten to grade 2, 2) sedentary behaviour would increase from kindergarten to grade 2, 3) the cross-sectional sample would accumulate less physical activity and more sedentary minutes compared to the longitudinal sample, and 4) sedentary behaviour would track more consistently than MVPA or total physical activity.

## **Method**

The University Human Research Ethics Board and the school district granted approval for this study (see Appendix A). This study involved the comparison of two cohorts of participants in kindergarten and grade 2 cross-sectionally as well as longitudinally. Data were collected in sequence over a period of four school years from 2010 – 2014.

### **4.1) Participants**

Children were eligible to participate if they were attending one of eight consenting schools from one school district in the province of British Columbia, Canada (see Appendix B). Two cohorts of children were included in the study. The first kindergarten cohort (wave one) was collected during the 2010 – 2011 school year and the second cohort of kindergarten children (wave two) during the 2011 – 2012 school year. In grade 2, data on cohort one participants were collected during the 2012 – 2013 school year and during the 2013 – 2014 school year for cohort two. Ninety-six participants (M = 5years 7 months, 58% boys) in kindergarten and 94 participants (M = 7yrs 9 months, 52% boys) in grade 2 met the necessary wear time criteria of 10 hours of recorded physical and sedentary behaviour on at least three weekdays and one-weekend day. Twenty-one of those children (49.6% boys), had valid physical activity and sedentary behaviour data for both kindergarten and grade 2, and therefore comprised the longitudinal sample. The comparative cross-sectional sample was therefore 75 (96 – 21) in kindergarten and 73 (94 – 21) in grade 2.

### **4.2) Measures**

Physical activity levels were measured using the Actigraph GT1M accelerometer (ActiGraph, LLC, Fort Walton Beach, FL). This small electronic device, which is worn around the waist and positioned above the iliac crest on the right hip measures and records both frequency and intensity of acceleration or movement. This biaxial accelerometer collects pre-filtered data at a rate of 30 measurements per second (30Hz), which is then post-filtered into measurements known as epochs. In this study, 15-second epochs were used to record physical activity, and then converted to a metabolic equivalent (MET). Fifteen second epochs have been recommended in order to record the sporadic activity of younger children (Reilly et al., 2008). The Actigraph accelerometer

has been shown to be a valid indicator of energy expenditure and activity levels in children and youth (Eston, Rowlands, & Ingledeu, 1998; Pate, Almeida, McIver, Pfeiffer, & Dowda, 2006a; Puyau, Adolph, Vohra, & Butte, 2002). Pate and colleagues reported an intra-class correlation of  $r = 0.57$  between measured and predicted  $\text{VO}_2$  using accelerometers in young children and found accelerometer counts to be highly correlated with  $\text{VO}_2$  in young children.

### **4.3) Procedures**

Each accelerometer was initialized to begin recording physical activity data in 15-second epochs at the time of distribution. The accelerometer was placed on each child during school hours and an information package (see Appendix C) was sent home with each child. Parents/guardians were instructed that the accelerometer was to be worn for seven days, from when the child first woke up in the morning until he/she went to sleep, unless bathing or swimming. The above procedures that were completed with both cohorts of kindergarten children (wave one and wave two) were replicated again in grade 2. The minimum wear time criteria for participants to be considered valid was 10 hours per day for at least four days (including at least three week days and one weekend day) (Troost et al., 2005). Based on comparable studies (Evenson, Catellier, Gill, Ondrak, & McMurray, 2008; Troost et al., 2011), the recorded physical activity and sedentary behaviour was classified by intensity into the following categories: moderate and vigorous activity (MVPA) as  $\geq 4$ -METs and as  $\geq 3$ -METs; total physical activity as  $\geq 1.5$  METs; and sedentary behaviour as  $< 1.5$  METs. MVPA was classified at  $\geq 3$ - and  $\geq 4$ -METs because although  $\geq 4$ -METs is a more accurate cut point for MVPA than  $\geq 3$ -METs in children (Freedson, Pober, & Janz, 2005; Mattocks et al., 2007); many studies have classified children's MVPA at  $\geq 3$ -METs (Colley et al., 2011; Colley et al., 2013; Janz et al., 2005; Nettlefold et al., 2012). Including  $\geq 3$ -METs allows for easier comparisons with the existing literature. Total physical activity was classified as any activity that was not sedentary and therefore both light and MVPA were summed to represent total physical activity.

#### 4.4) Data Treatment and Analyses

Raw data from the accelerometers were downloaded using ActiLife software (Actigraph LLC) for subsequent data reduction. Kinesoft software (version 2.0.94, Kinesoft Software, New Brunswick, Canada) were used for analysis, extraction and processing of the physical activity data and all other subsequent data analyses were performed using IBM SPSS (Version 23.0) for Windows (IBM Corp, 2015). Descriptive statistics were computed for average minutes of physical activity per day at the following intensities: sedentary, MVPA, and total. Consistent with other tracking studies, the stability of physical activity was assessed using Pearson product-moment correlation coefficients as well as intra-class correlation coefficients (Jackson et al., 2003; Janz et al., 2005; Kelly et al., 2007; Telama et al., 2005). Multiple independent t-tests were computed to examine any differences in physical activity and sedentary behaviour among the kindergarten and grade 2 samples as well as to determine whether there were any differences between the cross-sectional and longitudinal samples. Repeated measures analyses of variance using grade level as the between-subject factor were used to examine the differences in physical activity and sedentary behaviour in the longitudinal sample. The alpha values for rejecting the null hypotheses in this study was set at  $< 0.05$  (Fisher, 1956).

### Results

#### 4.5) Cross-sectional physical activity and sedentary behaviour

Table 4 displays the cross-sectional descriptive statistics for physical activity (MVPA and total physical activity) and sedentary behaviour in minutes. Physical activity levels were generally high for children in both kindergarten and grade 2. Furthermore, children accumulated more minutes in sedentary behaviours than either MVPA or total physical activity in either grade level. For the entire cross-sectional sample of 148 participants, independent t-tests revealed that physical activity levels were significantly lower among the grade 2 students and sedentary behaviour was significantly higher. Specifically, MVPA  $t(141) = 6.506, p < .001$ ) and total physical activity  $t(141) = 6.419, p < .001$ ) was lower by grade 2, whereas sedentary behaviour was significantly higher in grade 2  $t(141) = -8.291, p < .001$ ). An independent samples t-test revealed there were no significant differences between the boys and girls in either kindergarten or grade 2.

Table 4 *Physical activity in minutes for the cross-sectional sample in kindergarten and grade 2*

Grade	Intensity (minutes)	Mean	Std. Deviation	Minimum	Maximum
Kindergarten N = 75	Sedentary (< 1.5 METs)	367.65	43.86	264.69	476.90
	MVPA 4-METs	133.17	29.00	65.55	210.50
	MVPA 3-METs	166.38	28.56	83.45	242.40
	Total physical activity	354.12	43.81	240.00	476.38
Grade 2 N = 73	Sedentary (< 1.5 METs)	443.21	58.68	322.06	642.30
	MVPA 4-METs	101.21	28.67	37.94	166.47
	MVPA 3-METs	135.20	28.32	69.76	192.30
	Total physical activity	291.78	42.65	193.39	463.67

#### 4.6) Longitudinal physical activity and sedentary behaviour

Table 5 provides the descriptive statistics for physical activity (MVPA and total physical activity) and sedentary behaviour in minutes for the longitudinal sample. Overall, physical activity levels were high in both kindergarten and grade 2, but declined over time. Sedentary behaviour accounted for more minutes than total physical activity and increased by grade 2.

Table 5 *Longitudinal sample (n = 21) physical activity and sedentary behaviour*

Grade	Intensity (minutes)	Mean	Std. Deviation	Minimum	Maximum
Kindergarten	Sedentary (< 1.5 METs)	367.55	37.23	304.58	424.46
	MVPA 4-METs	136.99	28.27	80.45	193.05
	MVPA 3-METs	169.24	29.39	86.54	260.32
	Total physical activity	363.78	54.47	240.00	476.38
Grade 2	Sedentary (< 1.5 METs)	435.33	47.16	348.55	505.69
	MVPA 4-METs	96.34	22.97	38.20	143.07
	MVPA 3-METs	132.21	26.22	63.67	190.03
	Total physical activity	291.88	42.70	210.00	367.42

Repeated measures analysis of variance revealed significant differences in both physical activity levels and sedentary behaviour over time in the longitudinal sample ( $n = 21$ ). Specifically, Wilks' Lambda ( $\lambda$ ) = 0.23,  $F(1,20) = 64.66$ ,  $p < .001$  for sedentary behaviour,  $\lambda = 0.37$ ,  $F(1,20) = 33.59$ ,  $p < .001$  for MVPA, and  $\lambda = 0.26$ ,  $F(1,20) = 65.85$ ,  $p < .001$  for total activity show that sedentary behaviour increased significantly while both MVPA and total physical activity decreased from kindergarten to grade 2. Pearson product-moment correlations revealed sedentary behaviour in kindergarten was significantly correlated ( $r = .56$ ,  $p < .01$ ) with sedentary behaviour in grade 2. Both MVPA ( $r = .23$ ,  $p < .05$ ) and total physical activity ( $r = .32$ ,  $p < .05$ ) tracked from kindergarten to grade 2. The intra-class correlation coefficients comparing kindergarten and grade 2 minutes were: .59 for total physical, .30 for MVPA, and .77 for sedentary behaviour.

#### **4.7) Differences between the cross-sectional sample and longitudinal sample**

Independent t-tests revealed that there were no significant differences between the cross-sectional sample and longitudinal sample in either kindergarten or grade 2. In kindergarten the t-tests showed no significant differences for MVPA  $t(94) = .531$ ,  $p = .597$ , total physical activity  $t(94) = -.281$ ,  $p = .779$ , and sedentary behaviour  $t(94) = .013$ ,  $p = .989$  in kindergarten. Similarly for grade 2, no significant differences between the samples were found for MVPA  $t(94) = .013$ ,  $p = .989$ , total physical activity  $t(92) = .048$ ,  $p = .962$ , or sedentary behaviour  $t(92) = -.795$ ,  $p = .429$ .

### **Discussion**

The aim of this study was to examine the changes in physical activity levels and sedentary behaviour from kindergarten to grade 2. For the cross-sectional sample, the results from the independent t-tests suggest that physical activity was lower in grade 2 than in kindergarten, while sedentary behaviour was higher in grade 2. Similarly, repeated measures analysis of variance showed that physical activity levels declined from kindergarten to grade 2, while sedentary behaviour increased in the longitudinal sample. Tracking coefficients for MVPA and total physical activity were low, while sedentary behaviour tracked more consistently from kindergarten to grade 2.

#### **4.8) Physical Activity and Sedentary Behaviour**

Overall, the physical activity levels of children in kindergarten and grade 2 were high. Both kindergarten and grade 2 children accumulated an average of 134 and 96 minutes (22% and 16% of the day) of MVPA per day, respectively. The average number of minutes per day spent in MVPA was similar for the longitudinal sample, which was 136 and 94 minutes of MVPA per day in kindergarten and grade 2. Fifty-nine percent of cross-sectional sample in kindergarten and 57% in grade 2 children met the Canadian physical activity guidelines. A slightly higher proportion of the longitudinal sample met the same guideline (63% in kindergarten and 60% in grade 2). The daily MVPA levels in this study were far higher than those examining 3 – 5 year old Scottish and Australian children, which time spent in MVPA ranged between 3 and 13% (approximately 23 minutes per day) (Cliff et al., 2009; Fisher et al., 2005; & Reilly, 2010). Furthermore, in comparison to Canadian 5-year olds, MVPA levels were almost twice those reported by Colley et al. (2013), but the MVPA in the grade 2 sample in this study were similar to those reported by Nettlefold et al. (2012). The differences between the present study and national sample may be the result of where the data were collected. Similar to Nettlefold and colleagues (2012), this study was conducted in British Columbia, Canada. In comparison to the majority of Canadian provinces, British Columbia has more sunshine and less snow during the year (Carson, Spence, Cutumisu, Boule, & Edwards, 2010; Statistics Canada, 2007). These environmental affordances may in part explain why the province has some of the lowest rates of obesity among the Canadian provinces and MVPA levels are typically 10% higher than the national average (Statistics Canada, 2013a, 2013b), and why physical activity levels were high. Future research comparing year-round activity levels may provide valuable information about seasonal variation in physical activity and sedentary behaviour levels among children in Canada.

Notwithstanding the potential seasonal influence on physical activity, the findings of the present study are very similar to those of Janz and colleagues (2005) from Iowa. The children in both studies were 5 years of age at baseline, and when MVPA at 3-METs was compared, the difference between studies was 4% of the day in kindergarten and 1% of the day at the end of the tracking period (3 years for Janz et al. and 2 years for the present study). These studies show a similarly large decline in MVPA from kindergarten

to the end of the tracking period; 26% to 17% for Janz et al. and 22% to 16%. These dramatic reductions in MVPA across the primary years were also evident in cross-sectional data from both Canada and the United States (Colley et al., 2011; Troiano et al., 2008).

Sedentary behaviour minutes were high in the current study. Specifically, children in kindergarten and grade 2 spent approximately 367 minutes and 439 minutes (60% and 72% of the day) engaged in sedentary behaviours, respectively. Similarly, the smaller longitudinal sample of children accrued approximately 366 minutes in kindergarten and 435 minutes in grade 2. In the present study, kindergarten children (cross-sectional and longitudinal) spent less time in sedentary behaviour in comparison to other Canadian 5-year olds, whose daily average of sedentary behaviour was 381 minutes (Colley et al., 2013). For older children, the 439 and 435 minutes of sedentary behaviour reported for the cross-sectional and longitudinal samples were similar to those reported by Colley et al. (2011). However, other studies examining Canadian children's sedentary behaviour using accelerometers and identical cut-points differed from the findings of this study. Herman and colleagues (2014) found much lower levels of sedentary behaviour (~360 minutes) among 8-10-year old normal weight and overweight boys and girls. However, the authors indicate that these findings may not have been generalizable to the rest of Canada, without explaining their reasoning. A study of the sedentary behaviour of somewhat older children in British Columbia by Nettlefold and colleagues (2012) found much higher levels of sedentary behaviour (539 minutes) than in the present study. It is possible that the higher rates of sedentary behaviour demonstrated by Nettlefold et al. among British Columbian 8 – 11 year olds compared to the British Columbian 7 year olds in grade 2 in the present study are indicative of the age-related increase in sedentary behaviour during childhood (Colley et al., 2011; Colley et al., 2013). While there is no definitive reason why sedentary behaviour increases, perhaps the school-time demands for sitting and recreational screen-time are greater in grade 2 than in kindergarten.

It has previously been suggested that with each passing school year, there is an increase in workload, homework, and school-time sitting (Janz et al., 2005). Efforts have been made to break up the amount of time in school children are sitting down. These efforts include standing desks (as opposed to sitting) (Reiff, Marlatt, & Dengel, 2012)

and physical activity breaks to interrupt the amount of time children are being sedentary. Outside of the school environment, watching television and other forms of screen-time has been directly linked to sedentary behaviour for children (Herman et al., 2009; Herman et al., 2014; Strasburger, 2010; Tremblay et al., 2011). While Herman and colleagues reported that of the 6-hours per day children were sedentary, more than one third of that time was spent watching television. A review by Strasburger (2010) suggests that older children and adolescents spend more than 7-hours per day engaged various forms of screen-time and emphasizes the amount of access children and youth have to be sedentary. For example, in the United States it is estimated that 93% of youth aged 12 – 17 have Internet access and over 70% have a cell phone. These studies show that as children age there are a variety of factors contributing to sedentary behaviours for children and youth.

Accelerometry was used to measure both physical activity and sedentary behaviour in the present study. While shown to be an effective measure, there continues to be issues surrounding the classification of MVPA. Specifically, using cut points that are too low may result in an overestimation of the amount of time spent in MVPA. This is because these low cut points may misclassify light intensity activity as being moderate (Hnatiuk et al., 2014; Pate et al., 2006b; Trost et al., 2011). Previously, researchers have examined the differences in measuring physical activity intensity among children comparing both the 3-MET and 4-MET values (Mattocks et al., 2007; Pate et al., 2006b). It was determined that using a more conservative approach to measuring MVPA (4.0 METs) yielded more accurate results for children (Pate et al., 2006b). For example, brisk walking, a form of moderate intensity activity, requires an energy expenditure of 4-METs in children (Mattocks et al., 2007; Riddoch et al., 2007; Trost et al., 2011). In the present study, MVPA was measured with both 3 and 4-METs to combat this issue and allow the results to be more generalizable. This approach yielded a significant difference in minutes accrued.

When 3-METs were used to define the MVPA cut-point, kindergarten children from the cross-sectional sample accumulated 33 more minutes than when using a 4-MET cut off, and grade 2 children accumulated 34 more minutes of MVPA. The results for the longitudinal sample were strikingly similar. Classifying MVPA at 3-METs resulted in 33

and 36 more minutes per day than when using 4-METs for kindergarten and grade 2 children, respectively. At 3-METs, the results of this study for grade 2 children (Mean age = 7.9 years) were similar to those of Nettefold et al. (2012) who also collected data in British Columbia using 3-METs as the cut off, but quite different from the nationally representative data of 8-9-years olds report by Colley et al. (2011). Children in the Colley et al. study accumulated 63 minutes of MVPA at 3-METs, compared to the 132-135 minutes per day of MVPA at 3-METs in this study. For the kindergarten children in this study, the MVPA minutes at 3-METs were more than double those reported by Colley et al. (2013) in a Canadian sample of 5-year old children. At 4-METs, Adams and colleagues (2012) reported slightly fewer minutes of MVPA per day for children in the United States in middle childhood. In their study, children accumulated approximately 85 minutes of MVPA per day, which is lower in comparison to the 96 minutes accumulated by participants in the present study. The differences in MVPA levels in the present study in comparison to Adam et al. may reflect the climate of some states in comparison to this study.

Reporting MVPA intensities using both 3- and 4-METs has not only made the findings more generalizable and comparable with other studies, but it also adds important information about the variability that exists between using 3- or 4-MET cut-points and the implications that can have on the findings. In the present study there was an increase in physical activity levels by more than 30 minutes when using the 3-MET cut-point versus the 4-MET cut-point. These differences, when equated to minutes, can be the difference in obtaining the required daily minimum of 60 minutes of MVPA per day. The continued debate regarding MET intensity thresholds for children and adolescents continues to be an issue with measuring MVPA for children (Harrell et al., 2005; Trost et al., 2011). While some calibration studies (Freedson et al., 2005; Puyau et al., 2002) used 3-METs to define moderate physical activity; brisk walking for children, which is a key behavioural indicator of moderate-intensity physical activity, is associated with an energy expenditure of 4-METs (Mattocks et al., 2007; Pate et al., 2006b; Ridley & Olds, 2008). Furthermore, Adam and colleagues' (2013) recent comparison of 3- and 4-METs for predicting accurate levels of MVPA among 6 – 11-year olds found that in using 3-METs you are more likely to overestimate MVPA levels in comparison to classifying MVPA

using 4-METs. Specifically, Adam and colleagues found over 95% of both boys and girls achieved 60 minutes of MVPA per day when 3-METs were used compared to the 68% of boys and girls achieving the same amount of MVPA per day using 4-METs. A more conservative approach to classifying moderate activity (4-METs) provides a more accurate portrayal of typical physical activity patterns for children. Moving forward, it is important for a consensus to be reached on how to classify intensity among children, but until then, future research using accelerometry should classify intensity of moderate activity using both 3- and 4-MET cut-points.

Despite the high levels of MVPA reported in the present study, the findings suggest that overall, physical activity decreased while sedentary behaviour increased from kindergarten to grade 2. Among the 21 participants whose physical activity levels were monitored longitudinally over two years, a significant decrease of approximately 42 minutes of MVPA was seen. Total physical activity decreased by more than 70 minutes while sedentary behaviour increased by almost 70 minutes in both the cross-sectional and longitudinal samples. These findings are consistent with previous research showing physical activity significantly declines over time while sedentary behaviours increase (Sallis et al., 2000, Telama & Yang, 2000, Trioano et al., 2008).

#### **4.9) Cross-sectional versus longitudinal**

My confidence in the representativeness of the tracking findings to larger samples of primary aged children are bolstered because the findings related to physical activity and sedentary behaviour from the longitudinal sample did not differ significantly from the results derived from the larger cross-sectional sample. This provides important information not only about the generalizability of the findings but also adds to the literature from a methodological standpoint. Cross-sectional studies provide useful descriptive information about the variables being measured but cannot be used to establish causality amongst variables. Despite these limitations, cross-sectional studies are often used as they are relatively short in duration, inexpensive to conduct, and are free of behavioural or testing effects (i.e. practice effects) that may exist in other study designs (Breakwell, Smith, & Wright, 2012). Longitudinal study designs by comparison, provide multiple measurements of the same participants and variables across time. They allow researchers to measure, track, and evaluate change within individuals over time

(Breakwell et al., 2012). However, the findings in the present study provide evidence that using cross-sectional methods to measure physical activity and sedentary behaviour at various age groups or time points (i.e. kindergarten and grade 2) can provide similar results to longitudinal methods, without facing some of the major limitations associated with longitudinal research (e.g. attrition and instrumentation). Therefore, the findings from the longitudinal sample suggest that the decline in physical activity and increase in sedentary behaviour from kindergarten to grade 2 may in fact be generalized to the larger cross-sectional sample and that cross-sectional comparison across different age groups may not have as many limitations as previously thought.

#### **4.10) Tracking**

Both physical activity and sedentary behaviour tracked significantly from early to the beginning of middle childhood. However, both MVPA and total physical activity tracked less consistently in comparison to sedentary behaviour from kindergarten to grade 2. This pattern is consistent with the findings of Jones and colleagues' (2013) systematic review of tracking studies in childhood. Specifically, two studies from the United Kingdom reported MVPA tracking coefficients (study duration ranged from 1 – 3 years) for 3 – 7 year old children ranged between  $r = .40 - .54$  (Jackson et al., 2003; Metcalf, Voss, Hosking, & Wilkin, 2008) and  $r = .39 - .45$  (Kelly et al., 2007); whereas, in the United States, Janz and colleagues (2005) reported slightly lower tracking coefficients for MVPA (i.e.  $r = .36$  for moderate and  $r = .39$  for vigorous) and  $r = .35$  for total physical activity among 5 – 8 year old children. By comparison, the tracking coefficient reported in the present study ( $r = .30$ ) for both MVPA and total physical activity highlight the importance of establishing physical activity behaviours in the early years to create positive lasting behaviours. Also, the variability among the tracking coefficients may suggest other factors that influence physical activity behaviour. For example, in the United States, an emphasis on English, math, and science has resulted in an overall decrease and in some cases, the cancellation of physical education classes, recess, and basic physical activity breaks throughout the day (Centers for Disease and Prevention, 2010). As a result, children are spending a large majority of their day sitting (Reiff et al., 2012). Similar to the findings reported by Jones et al. (2013), sedentary behaviour tracked more consistently ( $r = .56$ ) than total physical activity or MVPA in the

present study. Specifically, the Pearson product-moment correlation coefficient revealed moderate levels of tracking from kindergarten to grade 2, which are very similar to previous tracking studies examining similar age ranges (Janz et al., 2005; Kelly et al., 2007; Taylor, 2009).

#### **4.11) Tracking physical activity and sedentary behaviour**

To date few studies have tracked both physical activity and sedentary behaviour from early to middle childhood. Sedentary behaviour is defined as any activity characterized by low energy expenditure (e.g. television watching or other forms of screen time) (Tremblay et al., 2010). Pate et al. (2008) suggest that although many studies make claims about the health dangers associated with sedentary behaviour, few actually measure it. As previously mentioned, engaging in sedentary behaviour not only significantly increases the likelihood of becoming overweight or obese (Tremblay & Willms, 2003), positive correlations have been found between screen-time and the risk of the metabolic syndrome and hypertension (Mark & Janssen, 2008; Pardee et al., 2007; Tremblay et al., 2010). The findings in the present study show that sedentary behaviour tracked more consistently from kindergarten to grade 2 in comparison to MVPA or total physical activity. While it appears that children accumulated more than the required amount of daily physical activity as per the Canadian guidelines in both kindergarten and grade 2, the amount of time spent engaged in sedentary behaviour was far greater. Even when compared to total physical activity, sedentary minutes were higher.

From when children begin school (approx. 5-years of age), they spend a large portion of day their day sitting (Reiff et al., 2012). Creating opportunities for children to be active is important in order to combat the health related issues surrounding a sedentary lifestyle. For example, researchers have reported that the use of alternative desks (i.e. standing desks) can equate to expending an additional 20,461 kcal per year compared to using sitting desks (Reiff et al., 2012). Furthermore, in North America, programs and resources have become available in order to increase daily physical activity in schools, with a focus on the classroom (Centers for Disease and Prevention, 2013; Physical and Health Education Canada, 2014). Additionally, initiatives have been put in place to encourage children to engage in active forms of transportation (e.g. biking or skateboarding) to and from school if available (Active Healthy Kids Canada, 2014;

Government of Canada, 2014). Based on the findings of this study, there is a need to help find ways for children not only to continue to be active but also spend less time being sedentary. Continued research examining both physical activity and sedentary behaviour is important in order to better understand the health implications of living a healthy and unhealthy lifestyle and create strategies to support these issues.

#### **4.11) Limitations**

This study is not without limitations. Perhaps the most significant was the rate of attrition in the longitudinal sample. Participants were excluded from the study if they did not have at least 10-hours of wear time for at least 3-week days and 1-weekend day. This resulted in a loss of 51% of the recruited participants from this analysis. The reasons participants included in the cross-sectional sample were not part of the longitudinal cohort were due to factors such as: the child was no longer enrolled in the current school, the child was consented in kindergarten but not in grade 2 (or vice versa) or the child decided to stop wearing the accelerometer during the study due to the belt not being comfortable. However, given that there are no differences found between the cross-sectional sample and longitudinal one, the findings reported on the physical activity and sedentary behaviour patterns can be generalized more widely than the small longitudinal sample.

#### **Conclusion**

The findings of the current study suggest that both MVPA and sedentary time of children were high, and that sedentary behaviour tracked more consistently from early to middle childhood than MVPA. The findings suggest that from kindergarten to grade 2, there is a significant decline in children's physical activity patterns and increase in sedentary behaviour. However, contrary to my original hypothesis, there was no difference between physical activity or sedentary behaviour levels between the cross-sectional sample and longitudinal sample. Tracking physical activity using both 3- and 4-METs allows our findings to compare to a greater scope of studies, which provides greater evidence on the decline in children's activity habits. Continuing to track these behaviours with objective tools and identifying the root causes of the decline is important. Moreover, there is a critical need to invest in strategies to maintain higher

levels of physical activity across the primary years and reduce sedentary time since these behaviours are associated with positive and negative health outcomes, respectively.

**Chapter 5 – Study 3. The relationships between fundamental motor skills, physical activity, and perceived competence in middle childhood:  
A test of mediation**

**Abstract**

Despite the known physical and psychological benefits of being active, levels of physical activity among children and youth are low and decrease with age, while sedentary behaviours increase. To explain physical activity engagement patterns throughout childhood, Stodden and colleagues identified variables that may either directly or indirectly affect physical activity. This study examined whether one of those variables, perceptions of physical competence, mediated the relationship between motor competence (predictor) and physical activity and sedentary behaviour (outcome variables). Participants were 129 children (M = 8 years 3 months, 52% boys). The Test of Gross Motor Development – 2 was used to measure motor competence and Actigraph GT1M accelerometers were used to measure physical activity and sedentary behaviour. The Pictorial Scale of Perceived Competence and Social Acceptance for Young Children in grade 2 and The Self-Perception Profile for Children in grade 3 were used to assess perceptions of physical competence. The relationships between these variables were examined using a model of mediation. The direct path between object control skills and MVPA was significant, as were the paths between gender and both moderate-to-vigorous physical activity and sedentary behaviour. The path between sedentary behaviour and moderate-to-vigorous physical activity was also significant. However, perceptions of physical competence did not mediate the relationship between object control skills and moderate-to-vigorous physical activity or sedentary behaviour. These findings show that object control skills predicted MVPA, perhaps because object control skills are used in activities of moderate or higher intensity. However, as perceived physical competence was not significantly related to either sub-test of the TGMD-2 or to physical activity, it is clear that factors other than motor skill proficiency influence children's perceptions of physical competence, and these perceptions were not mediating the relationship between motor competence and physical activity at this age.

## Introduction

The Canadian physical activity guidelines recommend that children (5 – 11 years) accumulate a minimum of 60 minutes of moderate-to-vigorous intensity physical activity (MVPA) per day, and participate at least three days per week in both activities that strengthen muscles and bones and vigorous physical activities (CSEP, 2011). Furthermore, sedentary guidelines suggest that children and youth should engage in fewer than 2-hours per day of sedentary types of behaviour (e.g. screen time or television watching) (CSEP, 2011). These guidelines were developed for the Public Health Agency of Canada via a rigorous process that included a systematic review of the volume, intensity, and type of physical activity necessary to achieve minimal and optimal health benefits and a subsequent international meeting and debate to reach consensus for the guidelines (Tremblay, Kho, Tricco, & Duggan, 2010). The systematic review for school-aged children and youth was limited to seven key indicators, specifically: high blood cholesterol, high blood pressure, the metabolic syndrome, obesity, low bone density, depression, and injury (Janssen & LeBlanc, 2010).

Janssen and LeBlanc's (2010) review findings are generally consistent with the findings of an earlier systematic review conducted to establish the physical activity guidelines for school-aged children in the United States (Strong, Malina, Blimkie, Daniels, & Dishman, 2005). Both reviews demonstrated mostly positive effects of participation in physical activity on bone density, blood pressure, depression, overweight/obesity, blood cholesterol and blood lipids, as well as indices of the metabolic syndrome (Janssen & LeBlanc, 2010; Strong et al., 2005). However, it should be noted that the experimental evidence of the positive effects of physical activity on the metabolic syndrome, high blood pressure, and high blood cholesterol and lipids in both of those systematic reviews was largely based on studies of children and youth affected by these conditions e.g. overweight or mildly hypertensive individuals. In addition to the variables examined by Janssen and LeBlanc (2010), Strong et al. (2005) examined the effect of participation in physical activity on academic performance, asthma, anxiety, and self-concept. Strong and colleagues concluded that higher levels of physical activity were associated with better concentration, memory, classroom behaviour, perceived competence or self-concept, and lower levels of anxiety; no consistent relationship was

found with symptoms of asthma. Although both reviews examined the relationship between participation in physical activity and injuries, the findings of the reviews differed. According to Strong et al., the available evidence was too disparate to synthesize. However, Janssen and LeBlanc concluded that there was evidence of a dose-response relationship between higher levels of physical activity and higher rates of injuries among three observational studies included in their review of injuries.

Sedentary behaviour is another important health behaviour to examine. Sedentary behaviour is an independent predictor of adverse health outcomes (Tremblay et al., 2010). This is of particular concern since high levels of sedentary behaviour and physical activity can coexist. Herman and colleagues (2014) found that 60% of 8-10-year old Canadian boys who were classified as 'active' simultaneously accumulated more than the recommended maximum of 2-hours of screen time per day. Thus, despite being physically active, these 'active couch potatoes' (Tremblay et al., 2010) may be still at risk for the negative effects of a sedentary lifestyle.

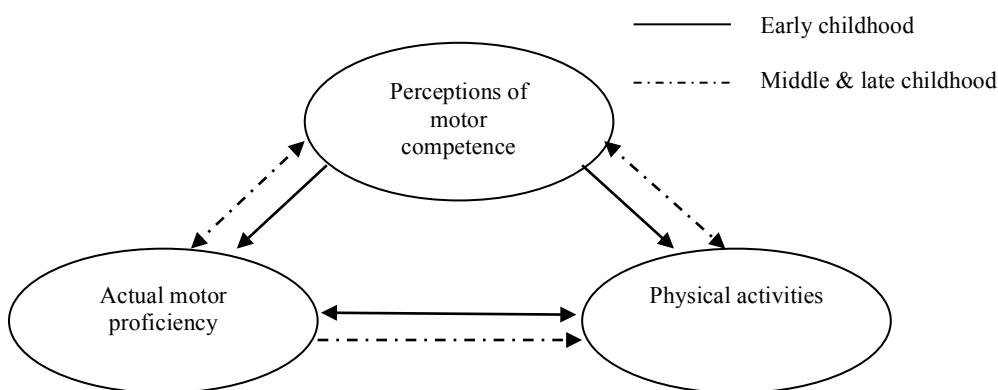
Despite the evidence that physical activity during childhood and adolescence generally has physical and psychological benefits, levels of physical activity are typically low and they decrease with age, while sedentary behaviours increase (Colley et al., 2011; Colley et al., 2013; Nader et al., 2008; Troiano et al., 2008). Longitudinal research has revealed that physical activity decreases from kindergarten to grade 1 (Trost et al., 2002), from early childhood to middle childhood (Jones et al., 2013), and from childhood to adolescence (Janz et al., 2000). The findings of these longitudinal studies are supported by cross-sectional data that also demonstrate older children and adolescents appear to be less active compared to younger children (Colley et al., 2011; Colley et al., 2013; Troiano et al., 2008). In a nationally representative U.S. sample, Troiano and colleagues found that 42% of children (6 – 11 years) met the national guideline of at least 60 minutes of MVPA per day, whereas only 8% of adolescents (12 – 19 years) met that same guideline. It was also reported that 6 – 11 year old children accrued as much as 30 more minutes of MVPA per day compared to 12 – 19 year olds. This trend is also apparent in nationally representative Canadian data. Colley et al. (2011) found that 11 – 14-year olds participated in 40 minutes less light physical activity per day and 10 minutes less MVPA per day than 6 – 10-year old children, demonstrating the lower physical activity levels

among older children. Similarly, Ridloch et al. (2004) found that for total activity, children in middle and late childhood from Denmark, Estonia, Norway, and Portugal were approximately 30% more active in comparison to adolescents. Furthermore, these same children were approximately 100% more active than adolescents when moderate-intensity physical activity was examined.

The apparent drop off in physical activity from childhood to adolescence is of great concern given the benefits that can be derived from participation (Janssen & LeBlanc, 2010; Warburton, Nicol, & Bredin, 2006). In an effort to inform our understanding of this phenomenon as children transition from early to middle to late childhood experts in motor development and physical activity created a developmental model (Stodden et al., 2008). At the heart of this model (see Figure 1) is the dynamic and evolving relationship between motor skill competence and participation in physical activity and potentially a further effect of children's perceptions of their own motor proficiency. Specifically, two mechanisms of action between motor skill proficiency and participation in physical activity are evident within the model: 1) the direct relationship between physical activity and fundamental motor skills (mechanism one) and 2) an indirect relationship (mechanism two), where perceptions of physical competence mediate the relationship between motor skill proficiency and participation (Stodden et al., 2008). For mechanism one, the authors proposed that in early childhood there was a reciprocal relationship between physical activity engagement and motor competence; where in early childhood, participation in physical activity drove improvements in motor competence through neuromotor development (Stodden et al., 2008). At the same time, the child's actual movement repertoire allowed them to participate in physical activities (Stodden et al., 2008). However, Stodden and colleagues (2008) suggested that higher levels of motor competence during middle and late childhood lead to more physical activity engagement, but unlike early childhood, the relationship was not reciprocal.

Higher levels of motor competence may lead to more enjoyment of activities. These positive feelings are more likely to encourage children to continue to engage in various forms of activity and master motor skills, which in turn results in positive perceptions, which continues on in what Stodden and colleagues (2008) referred to as a positive spiral of engagement. In contrast, low motor skill may lead to a lack of

enjoyment in activities, which in turn may lead to lower perceptions of physical competence and create a spiral of disengagement from participation in physical activity (Stodden et al., 2008). Positive relationships between higher levels of perceived physical competence and participation in physical activity among older children and youth have been consistently reported (Barnett et al., 2008; Crocker et al., 2000; Crocker et al., 2006) and lower perceptions of competence are associated with avoidance of physical education (Gibbons, 2008) and drop-out from sport (Crane & Temple, 2015). This suggests that children with lower levels of perceived physical competence are at a higher risk of becoming disengaged from physical activity as they downplay the importance of participation to protect their self-esteem (Harter, 2012). This disengagement from physical types of activities may not only cause children to accumulate less physical activity but may also lead to children spending more time engaged in activities that foster sedentary behaviour.



*Figure 1.* Extract of a model developed by Stodden and colleagues (2008) illustrating developmental mechanisms influencing physical activity trajectories of children.

### 5.1) Direct relationships between motor skill proficiency and physical activity

To date, four early childhood studies have demonstrated significant positive relationships between fundamental motor skills and physical activity. Robinson et al. (2012) and Temple et al. (2014) found that locomotor skill scores predicted participation in physical activities ( $R^2 = .21$  and  $R^2 = .26$ , respectively), while Cliff et al. (2009) and Crane et al. (2015) found that object control skill scores predicted MVPA ( $R^2 = .17$  and

$R^2 = .08$ , respectively). However, both Cliff et al. and Temple et al. reported that the relationship between motor skill proficiency and participation was only significant for boys. Both Crane et al. and Temple et al. examined whether certain physical activities predicted motor skill proficiency (i.e. the reciprocal relationship) among kindergarten children from the same dataset. Using survey methodology to assess participation, Temple et al. found that among boys, participation in organized sport predicted static balance, participation in physical activities predicted locomotor proficiency, and participation in physical activities and organized sport predicted object control proficiency. Similarly, Crane et al. (2015) found that participation in accelerometer measured physical activity was a significant predictor of object control skills ( $R^2 = .104$ ), but the relationship between locomotor skill scores and physical activity was not significant. However, as Crane and colleagues did not stratify their sample by gender; it is not possible to determine whether there may have been gender differences as shown in Temple et al. (2014) and Cliff et al. (2009). The single study that has examined these relationships in middle childhood revealed that motor skill proficiency explained 8.7% of the shared variance in total physical activity after gender, socio-economic status, number of children and televisions in the home, child and parent body mass index, and perceived competence were controlled for (Wrotniak et al., 2006).

## **5.2) An indirect relationship between motor skill proficiency and physical activity**

The model (Figure 1) illustrates a second mechanism that is thought to influence participation in physical activities, and this is also believed to change from early to middle childhood. This second mechanism involves children's perceptions of their physical competence. As Figure 1 illustrates, perceived physical competence is related to both motor skill development and participation in physical activity in early childhood. Young children tend to have unrealistically high perceptions of their physical competence (Horn, 2004) because: 1) they are unable to differentiate between competence and effort, or to compare their own performances to those of their peers, and 2) they often rely on feedback from significant individuals, which is generally very positive (Harter, 2012). It is these inaccurate beliefs that help children continue to be physically active and persist with activities that nurture motor skill proficiency (Stodden et al., 2008). These relationships in early childhood have not been fully examined in the literature,

particularly the relationship between perceptions of competence and participation in physical activity. Only Crane et al. (2015) have examined whether perceptions of physical competence predicted participation in physical activity and whether these perceptions mediated the relationship between motor skill proficiency and participation among young children. Crane and colleagues found neither of these relationship pathways were significant. However, empirical research does support the existence of significant positive relationships between motor skill proficiency and perceptions of physical competence among young children (Crane et al., 2015; LeGear et al., 2012; Robinson, 2010). The strongest relationships were between object control skills and perceptions of competence, although Robinson (2010) and LeGear et al. (2012) reported a positive relationship between perceived physical competence and locomotor skill proficiency.

As children transition from early to middle childhood, their perceptions of competence should become reciprocally related to their motor skill proficiency (see Figure 1) as they begin to more accurately assess their own physical competence (Harter, 2012; Horn, 2004). This increased accuracy is related to the development of higher cognitive functions (Shonkoff & Phillips, 2000) such as working memory and cognitive control processes (Paz-Alonso et al., 2014). These enhanced cognitive abilities allow children to be more aware of their own competence and performances, compare their performances to their peers' performances, and analyze the reasons for their successes and failures (Harter, 2012; McKiddle & Maynard, 1997). These more accurate perceptions suggest that children with less proficient skills are more likely to have less favourable perceptions of their physical competence (Stodden et al., 2008). Despite the logic of this premise, the relationship between perceived physical competence and actual motor competence during middle and late childhood has received very little attention (Robinson et al., 2015; Spessato et al., 2012; Wrotniak et al., 2006) and the findings are mixed. Wrotniak and colleagues found a significant positive relationship between perceived competence and both gross and fine motor skills among 9-year old children; whereas Spessato et al. found the relationship between motor skills and perceptions were not significant among 7-year old participants. Although Spessato et al.'s study may have been limited by a small sample ( $n = 32$ ), it is also possible that 7-year old children are not

differentiating between effort and performance or becoming more realistic and accurate in their perceptions as suggested by developmental theory of the self (Harter, 2012).

Perceptions of physical competence are thought to influence participation in physical activity via the choices children and youth make to participate or not to participate (Stodden et al, 2008). The literature clearly demonstrates that positive perceptions of physical competence are associated with greater participation in physical activity among adolescents (Biddle et al., 2005; Sallis et al., 2000) and lower levels of perceived competence are associated with avoidance of physical education (Gibbons, 2008) and dropout from organized sport among children and youth (Crane & Temple, 2015). When a child is not succeeding in an activity, they may perceive their competence less favourably and discount the importance of, or withdraw from, physical activities in order to protect their self-esteem (Horn, 2004); processes that Harter (2012) refers to as self-protection strategies. While children begin to distinguish between the sub-domains of self-concept (e.g. athletic versus scholastic) during middle childhood, they may put greater emphasis on the importance of particular sub-domains or engage in certain sub-domains more than others to characterize the 'self' (Harter 2102). Children who do not feel competent in a particular sub-domain, may downplay the importance of that sub-domain and disengage from these types of activities rather than display their insufficiencies to themselves and their peers as a means of protecting their overall self-esteem (Ebbeck & Stuart, 1993; Harter, 2012).

Evidence of the relationship between perceptions of physical competence and physical activity in older children is limited. To date, only two studies examined the relationship and found positive and significant relationships (Carroll & Loumidis, 2001; Crocker et al., 2000) among older children (10 – 11 years and 10 – 14 years, respectively). Crocker and colleagues (2000) reported that 27 – 29% of the variance in physical activity could be explained by perceived physical competence, and Carroll and Loumidis (2001) found that children with higher levels of perceived competence accumulated significantly more minutes of physical activity per day compared with children with low levels of perceived competence. There have been no studies examining the relationship between perceived physical competence and physical activity levels in middle childhood.

### **5.3) The addition of gender and sedentary behaviour to the model**

Stodden and colleagues (2008) identify factors that may influence physical activity engagement or disengagement patterns directly or indirectly throughout the various stages of childhood (early, middle, and late) in their model. They suggest that the strength of these relationships (positive, negative, or no relationship) create either a positive spiral of engagement to physical activity or a negative spiral of disengagement from physical activity. However, Stodden and colleagues (2008) do not mention the role that gender may play in relation to the variables. Similarly, they do not take into account the direct or indirect influences these variables may have on sedentary behaviour.

Gender differences have been previously found for fundamental motor skills. Previous evidence shows boys have significantly better object control skills in comparison to girls (Barnett et al., 2008; LeGear et al., 2012; Robinson, 2010). For locomotor skills, however, the findings are mixed. While some studies found that girls have better locomotor skills than boys (Barnett et al., 2008; LeGear et al., 2012; van Beurden et al., 2002), other studies have reported no differences between boys and girls (Hume et al., 2008).

For perceptions of physical competence, there are mixed findings in early childhood (Goodway & Rudisill, 1997; LeGear et al., 2012; Robinson, 2010). LeGear and colleagues (2012) found 5-year old girls had higher levels of their perceived physical abilities in comparison to boys, while two other studies examining 3 – 4 year olds reported mixed results. Robinson (2010) found 4 year old boys had higher perceived physical competence compared to girls, which differed from Goodway and Rudisill (1997) who found that perceptions of physical competence for 3 – 4 year old boys and girls were the same. Overall, the mixed findings and limited number of studies examining gender differences for perceptions of physical competence highlight the need to explore this relationship further.

The literature consistently shows that boys are more active than girls across childhood (Chung et al., 2012; Dumith et al., 2010; Stratton et al., 2007; Trost et al., 2002; Van der Horst et al., 2007). In both Canada and the U.S., national cross-sectional studies among children and youth show that boys are more active than girls across all age groups (Colley et al., 2011; Troiano et al., 2008). In a sample of school children and

youth (grades 1 – 12), Trost and colleagues (2002) found that boys were more active than girls in every grade level, and that major differences in activity were related to physical activity intensity. While, a 45% gap in vigorous physical activity was evident, in favour of boys, the average gender-based difference for MVPA was approximately 11%. These data illustrate that boys' and girls' participation in moderate physical activity was similar, but the boys participated in much more vigorous physical activity. These findings also highlight the importance of using objective tools to measure physical activity that can provide information about both the volume and intensity of physical activity. In sum, the available evidence suggests there are gender-based differences in object control skills, physical activity, and the relationship between motor skills and participation (e.g. Temple et al., 2014). The extent to which there are differences in boys' and girls' perceptions of physical competence and locomotor skills are somewhat unclear. However, there is sufficient evidence to warrant the extension of the Stodden et al. (2008) model by including gender as a variable.

The Stodden et al. (2008) model does not explicitly examine sedentary behaviour as an outcome variable. Rather, physical activity is the health behaviour variable included in the model; with physical activity precipitating either positive or adverse weight status depending on whether physical activity is high or low, respectively. However, high and low are relative terms. Sedentary behaviour assessed via accelerometry has been previously classified as a lack of MVPA (Healy et al., 2008; Owen et al., 2010), which is not the same as being sedentary. Sedentary behaviours are pursuits that require a low amount of energy expenditure such as sitting down at a table or using an electronic device (Tremblay et al., 2010). This type of behaviour is characterized by low metabolic equivalents, and these have been operationalized as  $< 1.5$  METs (Owen et al., 2010; Tremblay et al., 2010; Trost et al., 2011). An absence of MVPA on the other hand could mean that slow walking or other forms of light activity ( $\geq 1.5$  to  $< 4$  METs) could be included as 'sedentary' behaviours. To more fully understand the relationships between motor skills, perceptions of competence, and participation in activities, both MVPA and sedentary behaviour have been included in the conceptualized model in this study.

To date, few studies have examined the relationship between fundamental motor skills and sedentary behaviour during childhood. Both studies that examined this relationship in early childhood found that neither the relationship between sedentary behaviour and locomotor skills or sedentary behaviour and object control skills were significant (Cliff et al., 2009; Williams et al., 2008). In middle childhood, Wrotniak and colleagues (2006) found a significant negative relationship between sedentary behaviour and fine and gross motor skills among 8-10-year old children using the Bruininks-Oseretsky Test of Motor Proficiency-Short Form (BOT; Bruininks, 1978). However, because the BOT includes fine motor skills, it is difficult to interpret what this finding means about the relationship between fundamental motor skills and sedentary behaviour. It is quite possible that high levels of sedentary behaviour e.g. video games, iPhone engagement etc. actually enhance fine motor skill development as has been demonstrated with adults (Borecki, Tolstych, & Pokorski, 2013), thereby confounding the motor skill results. Currently, no study has examined the relationship between sedentary behaviour and perceived physical competence in either early childhood or middle childhood. Recognizing that sedentary behaviour differs from physical activity, it is important to examine the relationships between sedentary behaviour, perceived physical competence, and motor skills as this may shed light on our understanding of the negative spiral of disengagement purported by Stodden et al. (2008).

#### **5.4) Mediation**

Mediation occurs when the relationship between a predictor variable and an outcome variable is influenced by an intermediary variable, or mediator (Field, 2013). In the motor development literature there is a growing belief, but only a modicum of evidence, that how an individual perceives their abilities (perceived competence), influences the relationship between actual motor skill proficiency and participation in physical activities (Robinson et al., 2015; Stodden et al., 2008). However, it is possible that this relationship differs by type of motor skill. Barnett and colleagues (2008) found that the relationship between childhood object control skills (predictor) and physical activity levels (outcome) was mediated by adolescents' perceived sport competence. These authors found that 18% of the variance in physical activity levels was attributed to the mediation model. When the adolescents' current motor skill proficiency was entered

into the mediation model, Barnett et al. (2011) again found the relationship between object control skill proficiency and MVPA was mediated by perceptions of competence. Further, perceived sport competence mediated the relationship between locomotor skill proficiency and physical activity, but only when locomotor skill proficiency was the outcome variable (Barnett et al., 2011). To date, the work of Barnett and colleagues are the only studies to show that perceived competence mediates the relationship between physical activity and actual competence. A single study has tested this mediation model in early childhood (Crane et al., 2015). These authors examined these relationships among 5-year old children in their first year of school. As these authors expected among young children who tend to have inflated self-perceptions, perceived competence did not mediate the relationship between motor competence and physical activity. However, Crane et al. did find modest positive relationships between object control skills and physical activity as well as between object control skills and perceived physical competence. Other research suggests perceptions of physical competence are related to participation in physical activity among 10-year olds (Carroll & Loumidis, 2001; Crocker et al., 2000), but whether these relationships in part reflect mediation between actual competence and participation has not been tested. There is virtually no evidence of the relationships between perceptions of competence, actual competence, and participation in physical activity in middle childhood (6 – 9 years), so it is not possible to determine whether mediation is occurring at this stage of development.

It appears that in early childhood, perceptions of physical competence do not mediate the relationship between motor skill proficiency and participation in physical activities (Crane et al., 2015); but by adolescence, current perceptions of physical competence mediate the relationship between childhood motor skill proficiency and physical activity (Barnett et al., 2008) as well as between adolescent motor skill proficiency and physical activity (Barnett et al., 2011). Addressing a gap between what is known for early childhood and what is known for adolescence, this study examined whether perceptions of physical competence mediate the relationship between motor competence as the predictor variable and both physical activity and sedentary behaviour as dependent variables among children in grade 2 or 3 who were 7 years of age or older. The following research questions were addressed: 1) What were the physical activity,

motor skill, and perceptions of physical competence levels of children? 2) What was the relationship between fundamental motor skills and physical activity and sedentary behaviour? 3) What was the relationship between perceived physical competence and physical activity and sedentary behaviour? 4) What was the relationship between perception of competence and motor skill proficiency? 5) Did perceived physical competence mediate the relationship between fundamental motor skill proficiency and physical activity using a path model?

## **Method**

### **5.5) Participants**

The University Human Research Ethics Board and the school district granted approval for this study. A two-level consent process (see Appendix B) was implemented in the current study. Parents/guardians were given the option to consent to the at-school portion of the study that involved the assessment of both fundamental motor skills and perceptions of physical competence. In addition, parents/guardians could allow their child to participate in the physical activity portion of the study that involved measuring levels of physical activity through accelerometry (see Appendix C). Two cohorts of children were included. Cohort one of grade 2 data were collected during the 2012 – 2013 school year and the same cohort of children in grade 3 were collected during the 2013 – 2014 school year. Cohort two consisted of children in grade 2 that was collected during the 2013 – 2014 school year. In order to participate in the present study, children must have met the following eligibility criteria to be included: 1) children must be in grade 2 or grade 3 from one of eight consenting schools, 2) parental consent must be given for the physical activity portion of the study (see Appendix C), 3) the wear-time criteria was met, and 4) there were complete fundamental motor skills and perceived competence testing data.

### **5.6) Measures**

The Test of Gross Motor Development-2<sup>nd</sup> Edition [TGMD-2] (Ulrich, 2000) was used to assess the fundamental motor skill competence of participants. The TGMD-2 (see Appendix D) is a criterion and norm-referenced test that measures locomotor and object control skills. Specifically, the 12-item tool measures six locomotor skills: run, jump,

hop, slide, gallop, and leap; and six object control skills: throw, roll, kick, strike, catch, and dribble. The TGMD-2 has established content-, predictive-, and construct-validity (Ulrich, 2000). Three content experts judged that the twelve skills were consistent with skills frequently taught to children in preschool and early elementary grades and item-analysis demonstrated acceptable item difficulty for children aged 3 – 10 years. The TGMD-2 demonstrated adequate predictive-validity with the basic Motor Generalization subtest of the Comprehensive Scales of Student Abilities (Hammill & Hresko, 1994) in a sample of elementary school students, and the construct of motor proficiency was demonstrated by establishing that, as hypothesized, the TGMD-2 differentiated between younger and older children, as well as between children with typical development and children with Down syndrome. Scores for the TGMD-2 locomotor and object control subtests for both boys and girls were strongly related to age with mean raw scores progressively increasing from 3 – 10 years of age. Exploratory and confirmatory factor analyses also supported that there were two subtest constructs (locomotor and object control). Goodness-of-fit index ranged from .90 to .96 (for full details see Ulrich, 2000).

Reliability of the TGMD-2 was established by examination of scale internal consistency scores, test-retest reliability, and inter-scorer differences (Ulrich, 2000). The alpha ( $\alpha$ ) coefficients (Cronbach, 1951), representing internal consistency of the two subtests were strong for the overall sample: locomotor  $\alpha = .85$  and object control  $\alpha = .88$ . For 7- and 8-year old children the locomotor subtest coefficients were  $\alpha = .82$  and  $\alpha = .76$ , respectively; and for object control subtest were  $\alpha = .87$  and  $\alpha = .85$ , respectively. Test-retest of 75 children aged 3 – 10 years (2 weeks between measurements) revealed  $r$ -values of .88 for the locomotor subtest and .93 for the object control subtest. Results for the 6 – 8 year old subset of children ( $n = 13$ ) revealed reliability coefficients of .94 (locomotor) and .96 (object control). Finally, two research assistants independently scored 30 completed tests. Inter-scorer reliability for each of the subtests was very high,  $r = .98$  for both subtests (see Ulrich, 2000).

Physical activity was measured using Actigraph GT1M accelerometers (ActiGraph, LLC, Fort Walton Beach, FL). The GT1M is an electronic device that measures and records acceleration or movement. Pre-filtered data is collected by the uni-axial device at a rate of 30 measurements per second (30Hz), which is then post-filtered

into measurements known as epochs. The accelerometer is worn around the waist, with the device positioned on the right hip. For the present study, 15-second epochs were used to record physical activity as suggested by Reilly et al. in order to record the sporadic activity of children (Reilly et al., 2008), before being converted to a metabolic equivalent (MET). The Actigraph accelerometer has been shown to be a valid indicator of energy expenditure and activity levels in children and youth (Eston et al., 1998; Puyau et al., 2002). Specifically, Puyau and colleagues measured the validity of actigraph accelerometers among participants aged 6 – 16 years of age and validated against 6-hour energy expenditure measurements that included resting activities (e.g. video games) and high intensity activities (e.g. running). Correlations between accelerometer placement for the hip and energy expenditure activities was  $r = 0.66$  proving the device to be a valid measure for physical activity (Puyau et al., 2002).

For grade 2 and 3 children, the Pictorial Scale of Perceived Competence and Social Acceptance for Young Children (Harter & Pike, 1984) and The Self-Perception Profile for Children (SPPC) (Harter, 1985) were used to assess perceptions of physical competence. The pictorial scale (grade 2 children) has demonstrated both reliability and validity for grade 1 and grade 2 children (Harter & Pike, 1984). Internal consistency reliability was established for grade 1 and grade 2 children at .86 for total scale and .55 for the physical domain. Further, convergent validity was determined in the physical domain as children could provide concrete reasons for their competency. The 24-item scale is divided into 4 subscales that are: Cognitive Competence, Physical Competence, Peer Acceptance, and Maternal Acceptance. For the purposes of this study, only the perceptions of physical competence sub-scale will be used. Administration of the scale is in the form of bipolar statements that are supplemented by a picture. For example, two photos display a child bouncing a ball, which are followed by a statement describing the child's ability (e.g. 'this girl is pretty good at bouncing the ball' and 'this girl isn't very good at bouncing the ball'). The child then, selects a picture, which then prompts a follow up question to determine the degree of competence (e.g. 'Are you'; 'really good at bouncing the ball' or 'pretty good'). Each item is scored on a four-point scale, where a 4 indicates the highest degree of perceived competence and 1 the lowest.

For grade 3 participants, the Self-Perceptions Profile for Children has demonstrated both acceptable reliability and validity for children 8 years or older (Harter, 1982). Subscale reliability for the physical domain was .83. Further, convergent validity was determined in the physical domain by correlations between the physical educator's rating of the students' physical competence and the students' ratings of his or her physical competence. The scale consists of 36-items subdivided into a global self-worth scale and five subscales (6 statements each) that are: Scholastic Competence, Social Competence, Athletic Acceptance, Physical Acceptance and Behavioural Acceptance. For the purposes of this study, only the perceptions of physical competence sub-scale were used. Each item in the subscale is phrased to the child in a 'structure alternative format'. For example, children are read two statements and asked to choose, which statement was more closely resembles them (e.g. 'Some kids do very well at all kinds of sports' BUT 'Other kids don't feel that they are very good when it comes to sports'). Once the child has selected the statement that resembles them, a second question is asked to determine the level of competence (i.e. 'Is that' 'really true for me' or 'sort of true for me'). In accordance with the previous scale, each item is scored on a four-point scale, where a 4 indicates the highest degree of perceived competence and 1 the lowest.

### **5.7) Procedures**

Accelerometers were initialized to record physical activity on the first day of motor skill testing. Each accelerometer was placed on the child immediately following administration of the TGMD – 2. The accelerometer is to be worn for seven days from when the child first wakes up in the morning until he/she goes to sleep, unless bathing or swimming. In accordance with previous studies with young children, the minimum wear time criteria to be considered a valid physical activity record was 10 hours per day for at least four days that includes at least three weekdays and one weekend day (Troost et al., 2005).

The TGMD-2 was administered (see Appendix D) during scheduled physical education class in accordance with the testing procedure outlined in the Examiner's Manual (Ulrich, 2000). Before entering the gymnasium, consented children were divided into four groups consisting of 3 – 5 children by the program coordinator. A research team consisting of 10 research assistants and three program coordinators were used throughout

the data collection period. Children performed two trials of each skill at their station before rotating to the next station. Data were collected over multiple visits to each school because of time constraints (e.g. physical education lessons ranged in duration from 30 – 60 minutes) and scheduling issues (e.g. absentees and holidays). Digital video was used to record consented children performing six locomotor skills (gallop, hop, jump, leap, run, and slide) and six object control skills (catch, dribble, kick, roll, strike, and throw). Following the motor skill testing session, a trained research assistant administered the Pictorial Scale of Perceived Competence and Social Acceptance for Young Children or the Self-Perception Profile for Children (Harter, 1982; Harter & Pike, 1984) in a quiet area to each child.

### **5.8) Data treatment**

The investigators scored the behavioural components of the locomotor skills and object control skills for each child from the digital video. For motor skills, each child was given a raw score out of a possible 48, which corresponds to the number of components completed correctly for each subtest. The inter-observer reliability was established by two investigators re-scoring 15% of the digital videos for each of the classes (Baumgartner, Strong, & Hensley, 2002; LeGear et al., 2012). Percent agreement in the present study reported a mean of 89.4%. These raw scores were then converted into subtest standard scores (out of 20), to allow for comparisons across subtests. Similarly, the items of both perceived competence scales assessing the physical domain were scored on a scale of 1 – 4 for each item. Raw scores (out of 24) were obtained by summing the six items from the physical competence scale.

Raw data from the accelerometers were downloaded using ActiLife software (Actigraph LLC) for subsequent data reduction. Kinesoft software (version 2.0.94, Kinesoft Software, New Brunswick, Canada) was used to inform the analysis, as well as for extraction and processing of the physical activity data. Physical activity and sedentary behaviour was classified into the following intensities based on previous studies with children (Crane et al., 2015; Evenson et al., 2008; Trost et al., 2011): Sedentary behaviour < 1.5 METs and moderate and vigorous physical activity (MVPA)  $\geq$  4.0 METs. Once each file has been properly analyzed they are placed into a ‘batch report’ that comes in the form of a spreadsheet that is used for data entry.

## **5.9) Statistical analyses**

Descriptive statistics were computed for raw scores and standard scores for both subscales of the TGMD – 2 skills, raw scores for perceived physical competence, average minutes of physical activity per day (MVPA and total physical activity), and sedentary behaviour. Descriptive analyses were performed using IBM SPSS (Version 23.0) for Windows (IBM Corp, 2015).

In the present study, a path analysis was conducted using Mplus (Version 6.12) (Muthén & Muthén, 1998-2012) to investigate whether perceived physical competence mediated the relationship between fundamental motor skill proficiency (locomotor and object control) and MVPA and/or sedentary behaviour. Specifically, the path analysis examined the directional relationships between model variables directly and indirectly. Due to the complexity of path analysis, the process consisted of multiple stages that were to: 1) Construct a conceptual model based on theory and the literature. 2) Identify direct and indirect paths for both dependent and independent variables. 3) Test the model to determine that it is of good fit. 4) Report findings, fit indices, and results from model. 5) Re-specify the conceptual model if warranted and report findings, fit indices, and results from the re-conceptualized model. The alpha values for rejecting the null hypotheses in this study was set at  $< 0.05$  (Fisher, 1956).

### **5.9.1) Constructing a conceptual model.**

Stodden and colleagues' (2008) theoretical model of developmental mechanisms influencing physical activity aims to explain engagement and disengagement throughout childhood. Stodden and colleagues (2008) identified directional and bi-directional relationships between motor competence, physical activity, and perceived physical competence in early childhood and how those relationships change as children transition into middle and late childhood and ultimately result in either a positive spiral of engagement in physical activity or a negative spiral of disengagement in physical activity. They also suggested perceived physical competence may mediate the relationship between motor competence and physical activity. Stodden and colleagues' (2008) model does not however, identify gender or sedentary behaviour as variables within their model.

Adding gender to this model may provide insight about gender differences in the developmental patterns. These gender-based differences have been found for object control skills (Barnett et al., 2008; LeGear et al., 2012; McKenzie et al., 2002; Robinson, 2010; van Beurden et al., 2002; Wrotniak et al., 2006), locomotor skills (Barnett et al., 2008; LeGear et al., 2012; van Beurden et al., 2002), physical activity (Chung et al., 2012; Colley et al., 2011; Troiano et al., 2008), and perceived physical competence (LeGear et al., 2012; Robinson, 2010).

Furthermore, although not defined in Stodden and colleagues' (2008) model, the negative spiral of disengagement not only represents a decrease in physical activity; but perhaps it may also represent an increase in sedentary behaviour. A recent study by Bai, Chen, Vazou, Welk, and Schaben (2015) supported this theory with evidence showing a significant negative relationship between perceived physical competence and sedentary behaviour among elementary school children. Furthermore, in middle childhood, Wrotniak and colleagues (2006) found a significant negative relationship between sedentary behaviour and fine and gross motor skills among 8-10-year old children. While motor competence and perceived physical competence have been consistently identified as correlates of physical activity engagement (Sallis et al., 2000; Van der Horst et al., 2007), there is little research examining these relationships with sedentary behaviour. Therefore, adding both gender and sedentary behaviour to the developmental model better reflects the extant literature.

The present study extends the work of Stodden and others (2008) by using a robust mediation analysis and testing the associations in middle childhood. At the heart of their model is the relationship between motor competence and physical activity. While this is important, researchers have found that the relationship between motor competence and physical activity is different for object control skills and locomotor skills (Barnett et al., 2008; Cliff et al., 2009; Crane et al., 2015; Fisher et al., 2005b; Williams et al., 2008; Wrotniak et al., 2006). Further, Stodden et al. do not specify intensity when referring to 'physical activity' in their model, which is important because of the evidence showing the positive relationship between fundamental motor skills and MVPA (Barnett et al., 2008; Barnett et al., 2009; Crane et al., 2015; Fisher et al., 2005b; Williams et al., 2008). Further, because the strength of the relationship between physical activity and motor

competence is dependent on physical activity intensity (e.g. light physical activity vs. MVPA), classifying physical activity intensity is important from a methodological standpoint.

Finally, examining perceived physical competence as a mediator in this model reflects the findings of two previous studies exploring this indirect relationship (Barnett et al., 2008; Crane et al., 2015) as well as the theory posed by Stodden and colleagues (2008). Barnett and colleagues revealed that perceived competence mediated the relationship between physical activity and actual competence in adolescence. Whereas Crane et al. had previously found that perceived physical competence did not mediate the relationship between physical activity and motor competence in early childhood. This study was grounded in the developmental literature, which suggests that in young children have inflated perceptions of their own abilities and therefore perceived competence should not mediate the relationship between motor competence and physical activity (Harter, 2012; Horn, 2004). However, as a result of the developmental advances that occur as children transition into middle childhood, mediation should theoretically start to occur during middle childhood. Therefore, a new conceptualized model was developed (see Figure 2) with directional arrows to model the relationships between the variables and also to test whether perceived physical competence mediated the relationship between motor competence and MVPA and/or sedentary behaviour.

### **5.9.2) Identifying the directional arrows for the proposed new model.**

Specifically the new model (Figure 2) examined: 1) the relationships between locomotor and object control skills separately with MVPA, sedentary behaviour and also with perceived physical competence. 2) The relationship between perceived physical competence and MVPA and sedentary behaviour. 3) The indirect influence that perceived physical competence had on the relationship between motor competence and MVPA. 4) The relationship between gender and both MVPA and sedentary behaviour.

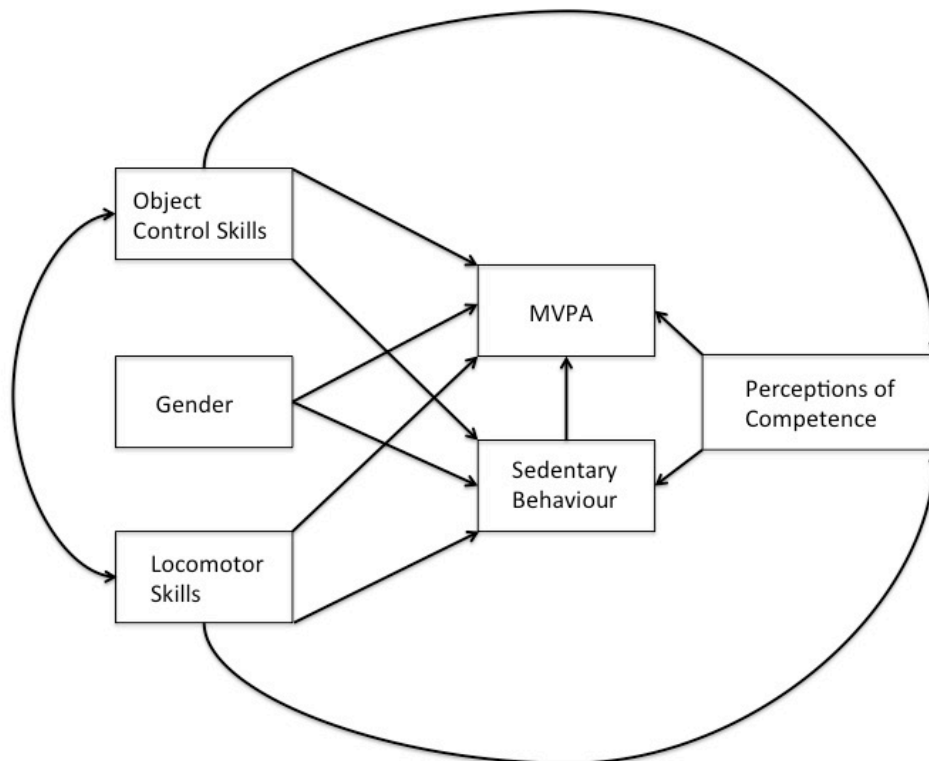


Figure 2. The specified model.

### 5.9.3) Testing the proposed model.

The path model was tested using maximum likelihood estimation with bootstrapped (1000 iterations) standard errors and confidence intervals. This analysis provided a comprehensive depiction of the associations between the predictor and dependent variables of interest. The path model consisted of three observed independent variables (locomotor skills, object control skills, and gender) and three observed dependent variables (perceived physical competence, MVPA, and sedentary behaviour). In determining the overall fit of path model, the chi-square test, Comparative Fit Index (CFI), and Standardized Root Mean Square Residual (SRMR) were used to assess how well the model fit the data (Hooper, Coughlan, & Mullen, 2008). The CFI values should be between 0 and 1, with values more than .95 considered to be a good fit for the data (Hooper et al., 2008; Kline, 2005). For the SRMR, a value of less than .05 indicates a close fit (Hooper et al., 2008; Kline, 2005). An SRMR of 0 indicates perfect fit but it must be noted that SRMR will be lower when there is a high number of parameters in the model and in models based on large sample sizes.

## Results

A total of 129 participants ( $M = 8$  years 3 months, 52% boys) met the wear-time criteria for accelerometry and had their motor competence and perceived physical competence measured in the present study. Descriptive statistics for all participants and also by gender for fundamental motor skills, perceived physical competence, physical activity (MVPA), and sedentary behaviour are reported in Table 6 and Table 7. The locomotor and object control skill scores were very similar and participants scored in the middle range. Also, perceptions of physical competence were generally positive and physical activity levels high. Children in this study achieved an average of 30 minutes more than the Canadian recommendation of at least 60 minutes of MVPA per day and accumulated approximately 460 minutes of sedentary behaviour per day.

Table 6 *Descriptive statistics for motor skills, perceived physical competence, and physical activity for all participants ( $n = 129$ )*

Variable (range/units of measure)	Mean	SD	Min	Max
Locomotor skills (0 – 48)	32.0	5.3	13.0	44.0
Object control skills (0 – 48)	32.8	6.7	17.0	46.0
Locomotor standard scores (0 – 20)	5.6	2.1	1.0	16.0
Object control standard scores (0 – 20)	6.0	1.6	1.0	13.0
Perceptions of physical competence (6 – 24)	18.6	3.7	9.0	24.0
MVPA (min/day)	92.6	24.7	37.9	170.9
Sedentary behaviour (min/day)	463.7	53.9	339.0	642.0

Table 7 Descriptive statistics for motor skills, perceived physical competence, and physical activity for boys ( $n = 67$ ) and girls ( $n = 62$ )

Variable (range/units of measure)	Boys		Girls	
	Mean	SD	Mean	SD
Locomotor skills raw scores (0 – 48)	31.4	5.6	32.4	5.1
Object control skills raw scores (0 – 48)	36.3	6.4	29.5	5.2
Locomotor standard scores (0 – 20)	5.2	1.6	6.2	2.2
Object control standard scores (0 – 20)	5.8	2.7	6.2	2.5
Perceptions of physical competence (6 – 24)	18.2	3.5	18.9	3.1
MVPA (min/day)	103.9	23.3	82.2	21.2
Sedentary behaviour (min/day)	454.5	49.6	472.2	66.4

### 5.10) Path model analysis for the specified model

The results of the path analysis with the standardized coefficients for each variable are presented in Figure 3.

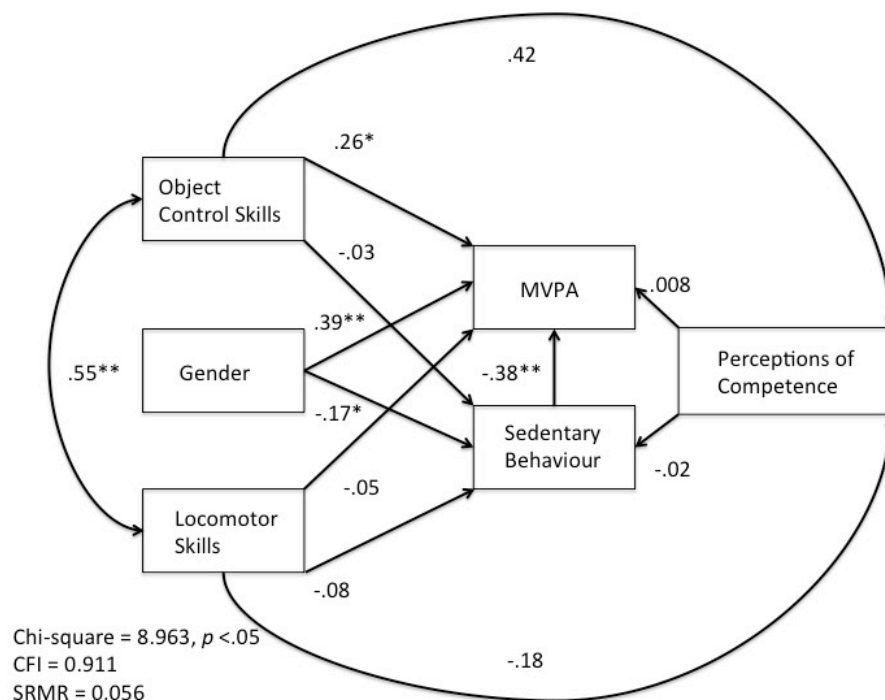


Figure 3. Path model depicting the relationships in a new model of developmental trajectories ( $n = 129$ ) \* $p < .05$  \*\* $p < .001$ .

The model satisfied the chi-square specifications  $\chi^2 = 8.963$  ( $df = 2, p < .05$ ), however, it did not satisfy the fit indices for either the CFI = 0.911 or SRMR = 0.056. This suggests the overall fit of the model is relatively poor. Based on these results, the model needed to be re-conceptualized and re-specified. Gender was removed from the model on the basis that for each variable measured; researchers have continuously shown that the strength of the relationships that exist among these variables are different for boys and girls. Furthermore, the descriptive statistics revealed that boys and girls differed in motor skill levels and by the number of minutes spent per day of MVPA and sedentary behaviour. Therefore, in re-specifying the model, two identical models were created for boys (Figure 4) and (Figure 5) for girls, which became the final specified models in this study.

#### **5.20) Path model analysis for the re-specified models**

The re-specified model for boys displayed an overall good fit. The chi-square specifications  $\chi^2 = 0.000$  ( $df = 0, p < .001$ ), the CFI = 1.000 and SRMR = 0.000, suggest the re-specified model has an excellent fit. The results from model 1 suggest that object control skills have a significant direct effect on MVPA ( $\beta = 2.980, SE = 1.220, \beta^* = 0.341, p < .05$ ). Furthermore, sedentary behaviour ( $\beta = -0.173, SE = 0.071, \beta^* = -0.368, p < .001$ ) directly and negatively affected MVPA. Finally, there was also a significant relationship between locomotor and object control skills ( $\beta = 1.866, SE = 0.580, \beta^* = .431, p < .001$ ). However, no other direct effects or relationships were established through the path analysis (see Appendix E). The unstandardized indirect effect for MVPA was .028 and the 95% confidence interval (CI) = [-2.372, 2.428], indicating that the indirect effect was not significant. The unstandardized indirect effect for sedentary behaviour was also not significant -0.086, 95% CI = [-3.381, 3.209], again revealing there was not an indirect effect.

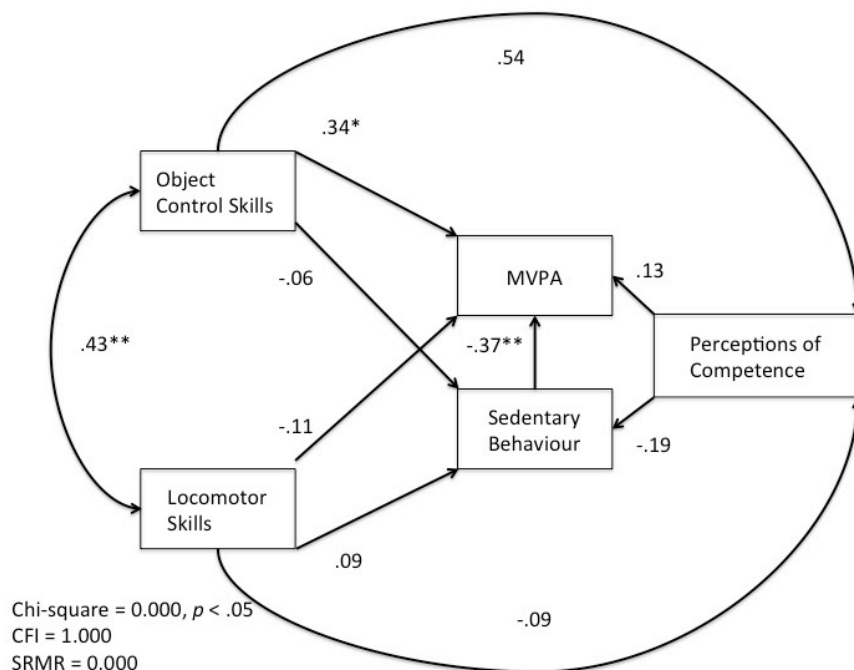


Figure 4. The re-specified path model depicting the relationships in a new model of developmental trajectories for boys ( $n = 67$ ) \* $p < .05$  \*\* $p < .001$ .

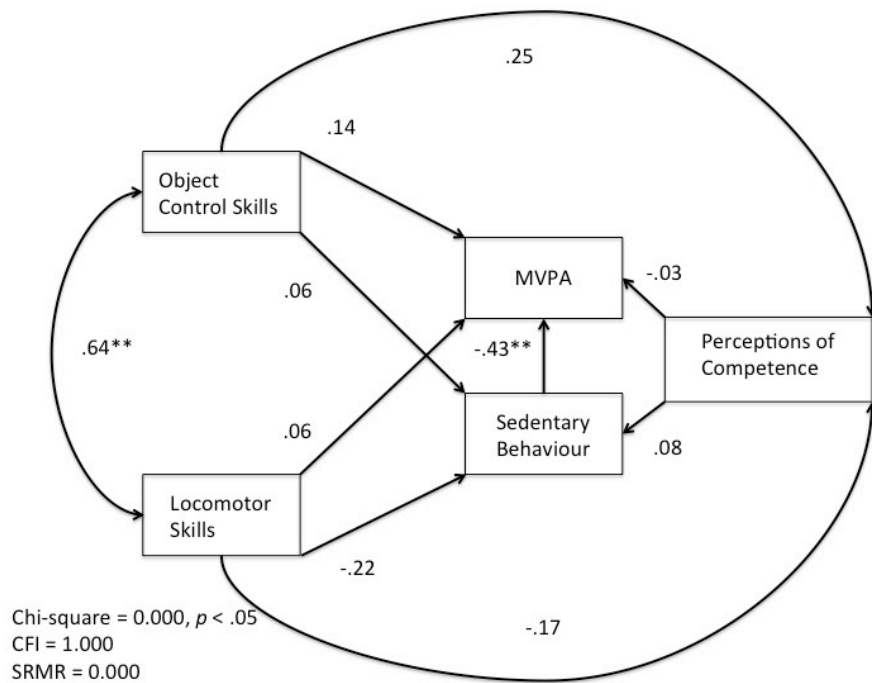


Figure 5. The re-specified path model depicting the relationships in a new model of developmental trajectories for girls ( $n = 62$ ) \* $p < .05$  \*\* $p < .001$ .

The second specified model for girls also displayed an excellent overall fit. The chi-square specifications  $\chi^2 = 0.000$  ( $df = 0$ ,  $p < .001$ ), the CFI = 1.000 and SRMR = 0.000 demonstrate that all fit indices were satisfied. The results from the model suggest that sedentary behaviour ( $\beta = -0.136$ ,  $SE = 0.035$ ,  $\beta^* = -0.426$ ,  $p < .001$ ) has a direct negative effect on MVPA. There was also a positive and significant relationship between locomotor and object control skills ( $\beta = 3.532$ ,  $SE = 0.987$ ,  $\beta^* = .641$ ,  $p < .001$ ). However no other direct effects or relationships were established through the path analysis (see Appendix E). For the indirect effect for MVPA, the unstandardized indirect effect was -0.029, and the 95% CI [-1.042, 0.985], suggesting the indirect effect was not significant. For sedentary behaviour, the unstandardized indirect effect was 0.051, and the 95% [-4.154, 4.256,], which suggest there was not an indirect effect.

### Discussion

The aim of this study was to examine whether perceived physical competence mediated the relationship between fundamental motor skill proficiency and physical activity and/or sedentary behaviour in middle childhood. The first hypothesized model (Figure 2) did not fit the data statistically. That model originated from the ‘Model of Developmental Mechanisms Influencing Physical Activity Trajectories of Children’ (Stodden et al., 2008, p.294), and was extended to include gender and sedentary behaviour. Based on the evidence from the literature these factors were added to the model because both gender and sedentary behaviour are associated with motor skill proficiency (e.g. Barnett et al., 2008; LeGear et al., 2012), perceptions of physical competence (e.g. LeGear et al., 2012; Mirjifari, 2015), and physical activity levels (Chung et al., 2012; Dumith et al., 2010; Stratton et al., 2007; Trost et al., 2002; Van der Horst et al., 2007). However, when the significance of the path model model was tested, the overall fit with the data collected for this study was poor. As a result, separate models for boys and girls were created. Consistent with the suggested ‘fit indices’ recommended by Hooper and colleagues (2008), the re-specified models showed excellent fit overall.

There are two aspects of the findings that are important to discuss. The first concerns with what has been demonstrated by both models, and the second focuses on the specific relationships (or absence of a relationship) between variables. Before discussing

the models generally and the specific relationships, I will characterize the findings of each variable in terms of its actual and relative level/strength.

### **5.21) Physical activity and sedentary behaviour**

The number of minutes of MVPA accrued by the children in this study was high. On average, participants engaged in 91 minutes (12.7% of the day) of MVPA at 4 METs per day and 127 minutes per day of MVPA at 3 METs. These physical activity levels are higher than those of a majority of Canadian children (Colley et al., 2011), but similar to other children at a similar age in British Columbia (Nettlefold et al., 2012).

Approximately 50% of children in this study met Canada's physical activity guidelines of at least 60 minutes of MVPA per day (CSEP, 2011). Further, 80% of participants met Canada's guidelines of least 5-days per week and an even higher 88% for 3-days per week. Consistent with most literature on MVPA of boys and girls at this age (Colley et al., 2011; Troiano et al., 2008), the descriptive statistics displayed in Table 7 reveal that the boys spent more time in MVPA, and less time per day in sedentary behaviour, than the girls.

On average, the children accumulated 463 minutes (66% of the day) of sedentary time daily. The minutes of sedentary behaviour in this study were higher than those reported by Colley and colleagues (2011), but slightly lower than Nettlefold and colleagues' (2012) findings. It is worth noting that the participants in the Nettlefold and colleagues' study were 1 – 2-years older than those in the present study. Given that younger children tend to be less sedentary than older children (Colley et al., 2011; Colley et al., 2013), this may in part explain why children in the current study accumulated less sedentary time than Nettlefold's et al.'s previous work in British Columbia.

### **5.22) Motor skills proficiency**

Despite differences in raw locomotor and object control skill scores for the boys and girls as depicted in Table 7, when converted into gender- and age-matched normative percentile ranks using the TGMD-2 Examiner's Manual (Ulrich, 2000), the differences faded. The raw locomotor skill scores translated to the 5th percentile for both the boys and the girls, and object control raw scores translated to the 9<sup>th</sup> percentile for both genders. When the children from the same data set as this study were in kindergarten

(LeGear et al., 2012), the locomotor skill percentile ranks were 18 for boys and 24 for girls, and the object control skill percentile ranks were 18 for boys and 16 for girls. These normative comparisons serve to illustrate that the gross motor proficiency of both the boys and the girls in this grade 2/3 sample were generally low and when compared to the kindergarten sample, had not improved relative to the children's age.

### **5.23) Perceptions of physical competence**

Perceptions of physical competence were high for both boys and girls, and almost identical. In relation to developmental psychology literature, these high levels of perceived physical competence at this age were unexpected (Harter, 2012; Horn, 2004). These perceived competence levels were also very similar to those found for younger children from the same schools (see Chapter 3). In kindergarten the percent of maximum possible scores (POMP) for perceived physical competence ranged from 76% - 80% of the highest achievable score, and in this analysis the POMP scores ranged from 76% to 79%. This comparison illustrates that perceived physical competence among the grade 2/3 children in this study were high and very likely inflated judgements of actual abilities.

### **5.24) The conceptual model**

The three commonly used indices (chi-square, CFI, and SRMR) employed to measure the fit of the data (Hooper et al., 2008; Kline, 2005), demonstrated that the initial model had an overall poor fit. As a result, the model was re-specified as two separate models, one for boys and one for girls. Both of the new models (Figure 4 and Figure 5) had excellent fit.

The most important finding, demonstrated in for both genders was that perceived physical competence did not mediate the relationship between motor skill proficiency and MVPA, or between motor skill proficiency and sedentary behaviour. Mediation occurs when the relationship between a predictor variable and an outcome variable is influenced by an intermediary variable, which did not happen in this study. This was determined for MVPA and sedentary behaviour from the confidence intervals for the bootstrapped unstandardized indirect effect. Because the range of the confidence interval crossed zero, it was determined that perceived physical competence was not mediating either

relationship at this age. This finding was unexpected, but adds valuable information about perceptions of physical competence from a developmental perspective.

Developmental theorists have suggested that as children transition to middle childhood the accuracy of their perceptions should start to improve and become less inflated (Harter, 2012). This increased accuracy is related to the development of higher cognitive functions (Shonkoff & Phillips, 2000) such as working memory and cognitive control processes (Paz-Alonso et al., 2014). These enhanced cognitive abilities allow children to be more aware of their own competence and performances (Kipp & Weiss, 2013), compare their performances to their peers' performances, analyze the reasons for their successes and failures, and internalize feedback they receive (Harter, 2012; Horn & Hasbrook, 1987; McKiddle & Maynard, 1997). It might be expected in middle childhood that ratings of abilities would decrease as judgements become more realistic (Ferrer-Caja & Weiss, 2000; Rudisill et al., 1993; Weiss & Amorose, 2005). However, in contrast to what might have been expected, perceived physical competence levels for both the boys and the girls were very high, and similar to the levels demonstrated in kindergarten (see Chapter 3). This suggests that the more sophisticated cognitive processes described above have not begun to influence perceptions of physical competence of these grade 2 and 3 children. It is interesting to note that Barnett et al. (2008) found that adolescent perceptions of sport competence mediated the relationship between childhood motor skills proficiency and adolescent physical activity. This suggests that childhood motor skills influence perceptions and participation, but later childhood or adolescence is when mediation may occur. These age-related relationships need further exploration as lower levels of perceived competence are associated with avoidance of physical education (Gibbons, 2008) and dropout from organized sport among children and youth (Crane & Temple, 2015).

Another consistent finding of both models was that sedentary behaviour was a significant negative predictor of MVPA. The negative direct relationship between sedentary behaviour and MVPA shows that for both boys and girls who are engaging in higher levels of sedentary pursuits are also spending less time in MVPA. Some children in this study were spending as little as 30 minutes engaged in MVPA per day and as much as 10 hours per day in sedentary behaviour. These findings contrast the 'active

couch potato' trend previously used to identify children who simultaneously meet daily physical activity guidelines, while still spending the majority of the day sedentary (Tremblay et al., 2010). This study shows that the children who are highly sedentary are also achieving low levels of MVPA per day. Given the positive correlation between sedentary behaviours the metabolic syndrome and hypertension (Mark & Janssen, 2008; Pardee et al., 2007; Tremblay et al., 2010), efforts need to be made to reduce the amount of time spent sedentary and increase physical activity levels.

The relationships between motor skill proficiency and MVPA and motor skill proficiency and sedentary behaviour were vastly different for boys and girls in this study. For boys, object control skills significantly predicted MVPA levels. This positive relationship was consistent with previous evidence examining this relationship (Barnett et al., 2008; Crane et al., 2015). Interestingly, although locomotor skills and object control skills were related in this study, locomotor skills did not predict MVPA. Barnett and colleagues' (2008) study of mediation similarly found that while locomotor skills and object control skills were related, their model of mediation included object control skills as a predictor of physical activity. Also, in the present study neither locomotor skills nor object control skills were related to sedentary behaviour (see Appendix E). To date, only Wrotniak and colleagues (2006) have examined the relationship between motor skill proficiency and sedentary behaviour in middle childhood. Like the findings of this study, Wrotniak et al. found that the relationship between sedentary behaviour and fine and gross motor skills was negative. Although there is only a modicum of evidence, it appears that while object control skills predicted MVPA of boys, motor skill proficiency does not affect boys' sedentary time at this age.

For girls, although the relationship between locomotor skills and object control skills was significant and positive, motor skill proficiency was not associated with MVPA or sedentary behaviour (see Appendix E). These findings are somewhat difficult to explain. Cliff and colleagues (2009) suggest that these relationships are absent or negative for girls because it is possible that the skills they typically develop are not properly represented in motor skills assessments. This thought is supported to some degree by Temple and colleagues (2014), who, after finding no significant relationships between girls' motor skills and questionnaire measured physical activities, examined the

relationship between the TGMD-2 leap (a locomotor skill common in dance and gymnastics) and participation. These authors found that the leap was significantly correlated with girls' participation in both physical activities and active physical recreation. This finding suggests that additional research about the best approach to measure girls' skilfulness, and perhaps their MVPA, are needed.

Although it is possible that the TGMD-2 does not assess the motor skills used by girls when they are active, it is also possible that factors other than the ones included in the model are far more important predictors of girls' participation. For example, among 8 – 10 year olds, Seabra and colleagues (2012) found that perceived acceptance into games and sports and parental encouragement were particularly important facilitators of girls' physical activities. It is also possible that the girls with better motor skills don't perceive themselves as skillful, or the reverse, that less skillful girls do not perceive themselves as less physically competent. What is clear is that the re-specified model does not explain girls' participation in MVPA or sedentary time and that more research is needed to identify factors influencing girls' participation in middle childhood.

### **5.25) Limitations**

A limitation in the current study was the loss of participants for whom valid accelerometer data were available. The accelerometer wear-time criterion was 600 minutes of wear time per day for three week days and one weekend day. This resulted in 35% of participants being lost. Parents and guardians also indicated that children often forgot to wear the accelerometer or would take it off due to comfort issues. Furthermore, participants in this cohort were part of a larger study and there is a possibility that those parents and guardians who consented may be more engaged in physical activity than families who did not consent in the present study. Also, in specifying and re-specifying the models in this study, sedentary behaviour predicted MVPA levels for both boys and girls, however MVPA was not regressed on sedentary behaviour because of the limited sample size. Therefore whether there was a reciprocal relationship between the two variables has not been established with these data.

### Conclusion

In conclusion, perceived physical competence did not mediate the relationship between motor skill proficiency and physical activity or sedentary behaviour in middle childhood for boys or for girls. On the whole, the participants could be characterized as having high physical activity and sedentary behaviour levels, and high perceptions of physical competence. But their actual proficiency, as assessed by the TGMD-2 was quite low for their age. The relative levels (i.e. high or low) for each variable in the specified models, may in part, explain the findings. It might be expected that at grade 2/3 the children's perceptions of physical competence would be becoming more accurate (and thereby lower) than when they were younger. However, the findings of this study show that this is not the case, with perceptions of physical competence being quite high. These findings illustrate that factors other than motor skill proficiency are influencing the children's perceptions of physical competence in middle-childhood, and that the children's perceptions of their abilities are not influencing their participation. It is possible that the children are not using peer comparisons and performance outcomes to form their perceptions at this age, but it is also possible that other factors (e.g. parents enrolling their children in sports) are more powerful influences on participation.

The negative relationship between MVPA and sedentary time in both models in this study is notable. Unfortunately the boys and girls with higher sedentary time were also more likely to have low levels of MVPA. This pattern is not what Tremblay et al. (2010) referred to as "the physically active couch potato", where children may meet physical activity guidelines, but also have high levels of sedentary behaviour. In this study, the negative path between sedentary time and MVPA show that there is not this 'balance', rather, the less active children are more sedentary, and vice versa.

Like the majority of research examining the relationship between motor skills and physical activity among boys, object control skills predicted MVPA levels. It appears that these are the 'tools' being used by boys when they are active. The complete absence of significant paths between motor skills (locomotor or object control) and MVPA and girls is somewhat difficult to explain. It is possible that the TGMD-2 does not assess the motor skills used by girls when they are active. It is also possible that there are other influences on girls' participation, or both dynamics may be at play. What is clear is that

the re-specified model does not explain girls' participation in MVPA or sedentary time and that more exploratory work is needed to identify more salient factors.

## Chapter 6 – General Discussion

This dissertation examined the developmental trajectories of fundamental motor skill proficiency, perceptions of physical competence, physical activity, and sedentary behaviour longitudinally from kindergarten to grade 2. I also examined whether perceptions of physical competence mediated the relationship between motor skill proficiency and participation in physical activity and sedentary behaviours among grade 2 and grade 3 children.

### 6.1) Rationale for these studies

Convincing accelerometry data from a nationally representative sample of Canadian children and youth have found that only 7% of 5 – 11-year olds and 4% of 12 – 17-year olds meet the recommendation of at least 60 minutes of moderate-to-vigorous (MVPA) per day. The importance of consistent engagement in MVPA has garnered a lot of attention because of the health benefits associated with regular participation (Biddle et al., 2004; Dencker et al., 2006; DuRant, 1996; Ekelund et al., 2006; Sallis, 2000; Tremblay et al., 2011; Trost et al., 2001). Participating in physical activity regularly has musculoskeletal and cardiovascular health benefits (Ekelund et al., 2006; Janssen & LeBlanc, 2010; Sallis et al., 2000; Strong et al., 2005; Tremblay et al., 2010; Tremblay et al., 2011), decreases the likelihood of becoming overweight or obese (Tremblay & Willms, 2003), and has been linked to reductions in blood pressure among children and youth (Janssen & LeBlanc, 2010). By comparison, high levels of sedentary behaviour have adverse health outcomes. Tremblay and Willm's (2003) study of the sedentary behaviours (e.g. television watching) of Canadian children (7 – 11 years old) found that sedentary time significantly increased the likelihood of becoming overweight or obese and the risk of being at risk of developing hypertension or the metabolic syndrome (Mark & Janssen, 2008; Pardee et al., 2007; Tremblay et al., 2010).

Children experience many changes as they transition from early to middle childhood. Children's motor and perceptual systems are developing rapidly (Gabbard, 2012) and their cognitive skills are becoming more mature (Harter, 2012). Furthermore, there is an increase in formally structured time both at-school and outside of school (Sigmund, Croix, Miklankova, & Fromel, 2007; Taylor et al., 2013). Stodden and

colleagues (2008) suggest that the interaction between personal and environmental changes affect both the patterns and levels of physical activity throughout childhood. These authors modelled some of these interactions in a seminal motor development paper (Stodden et al., 2008). They proposed that children's motor skill proficiency and their perceptions of physical competence affect children's participation in physical activity, and that the relationships between these variables changed with age. They identified two mechanisms by which motor skill proficiency influenced physical activity levels. The first mechanism was the direct influence of fundamental motor skill proficiency on physical activity and the second mechanism is the influence of motor skills on children's perceptions of physical competence, which in turn influence the children's desire to be active (Stodden et al., 2008).

The direct relationship between fundamental motor skill proficiency and physical activity levels (mechanism 1) was purported to change from early to middle childhood (Stodden et al., 2008). In early childhood, regular participation in physical activity stimulates neuromotor activity, which fuels the development of motor skills. At the same time, motor skills are the tools children use to participate in activities (Stodden et al., 2008), and therefore the relationship is reciprocal among young children. By middle childhood, Stodden et al. purported that the relationship between motor proficiency and physical activity would be stronger in comparison to early childhood, but unidirectional (Stodden et al., 2008). With higher levels of motor competence leading to greater participation in organized and unorganized forms of activity; whereas, lower levels of motor competence lead to lower levels of physical activity (Stodden et al., 2008).

The second mechanism identified in Stodden et al.'s (2008) model is the indirect influence that perceived physical competence has on the relationship between motor skill proficiency and physical activity. Similar to mechanism 1, this relationship is expected to change from early to middle childhood. In early childhood, perceptions of physical competence directly influence motor competence and physical activity (Stodden et al., 2008). Young children have unrealistically high perceptions of their physical competence as a result of the inability to differentiate between competence and effort or compare their own performances to their peers (Harter, 2012; Horn, 2004). Because of this, children rely on feedback (usually positive) from significant others, which results in children's

perceptions being high (Harter, 2012; Horn, 2004). These high perceptions of their abilities encourage children to persist with their tasks and thereby develop greater motor skills proficiency, which supports engagement in physical activities (Cliff et al., 2009; Crane et al., 2015; Williams et al., 2008). As children transition from early to middle childhood, their perceptions of competence should become reciprocally related to their motor skill proficiency as they begin to more accurately assess their own physical competence (Harter, 2012; Horn, 2004). Enhanced cognitive processes (Paz-Alonso et al., 2014) in comparison to early childhood allow children to be more aware of their own abilities, and are better able to compare their performances to their peers' performances, and identify reasons for their successes and failures (Harter, 2012; Horn, 2004). Positive perceptions of physical competence are associated with greater engagement in physical activity in adolescence (Biddle et al., 2005; Sallis et al., 2000), while lower levels of perceived competence are associated with avoidance of performing in physical education (Gibbons, 2008) and disengagement from sport (Crane & Temple, 2015).

Gender was not included in Stodden and colleagues' (2008) developmental model. However, gender significantly affects several variables depicted in their model, and gender-based differences or similarities are unclear for several other model variables. Boys are consistently more active (Chung et al., 2012; Colley et al., 2011; Troiano et al., 2008) and have significantly better object control skills in comparison to girls (Barnett et al., 2008; LeGear et al., 2012; Robinson, 2010). However, it is unclear whether the locomotor skills of boys and girls differ. A few studies show girls perform better (Barnett et al., 2008; LeGear et al., 2012; van Beurden et al., 2002), while others have reported no differences between boys and girls (Hume et al., 2008). The findings are also mixed for gender-based differences in perceived competence levels. LeGear and colleagues (2012) found 5-year old girls' perceived physical competence was higher in comparison to boys, while Robinson and colleagues (2010) found that 4-year old boys had higher perceived physical competence than girls. Finally, Goodway et al. (1997) found no gender-based differences in perceptions of physical competence among 3 – 4-year olds.

Although there are pockets of empirical findings to support aspects of the Stodden et al. (2008) model, there are many more gaps in our knowledge. Some of this dearth of knowledge is related to the transitions points in the model, and transitions are best

investigated with longitudinal data (Breakwell et al., 2012). To that end, this dissertation consisted of three related studies focused on childhood engagement in physical activities and the relationships with motor competence and perceived physical competence as children transitioned from early childhood to the beginning of middle childhood. Each study had an overarching question that was: 1) Does the relationship between fundamental motor skill proficiency and physical activity levels strengthen as children transition from early to middle childhood? 2) To what extent do physical activity levels and sedentary behaviour levels track from kindergarten to grade 2? 3) Does perceived physical competence mediate the relationship between fundamental motor skill proficiency and physical activity or sedentary behaviour in middle childhood?

## **6.2) Summary of the findings**

Study 1 examined the relationship between fundamental motor skill proficiency and perceptions of physical competence from early childhood to the beginning of middle childhood. Specifically, three hypotheses were tested: 1) That motor skill proficiency levels would increase from kindergarten to grade 2, 2) That perceptions of physical competence levels would decrease from kindergarten to grade 2, and 3) That the relationship between motor competence and perceived competence would strengthen from kindergarten to grade 2. Consistent with the first hypothesis, there was a significant improvement in locomotor skills and object control skills from kindergarten to grade 2. There were also gender differences in motor skill proficiency. Boys object control skills were higher at both grade levels, and although girls had significantly higher locomotor skills in kindergarten, there were no differences in grade 2 for locomotor skills.

For the second hypothesis, the overall change in perceptions of physical competence from kindergarten to grade 2 was significant; however the change was small and was unexpectedly positive. The increase in perceptions of physical competence was not consistent with developmental theory (Harter, 2012; Horn, 2004; Stodden et al., 2008). Theory suggests that older children's perceptions would decrease from kindergarten to grade 2, perhaps as they compared their own performance with those of their peers, or compared their performance with other standards such as game outcomes (Koka & Hein, 2003). The third hypothesis was somewhat supported. The relationship between fundamental motor skills and perceived physical competence strengthened for

boys from kindergarten to grade 2, but weakened for girls. This suggests the girls' perceptions of their motor skill abilities are not the foundation of their perceptions of physical competence in grade 2. It is also possible that the girls with better motor skills don't perceive themselves as skillful, or the reverse, that less skillful girls do not perceive themselves as less physically competent.

Study 2 examined the physical activity levels and sedentary behaviours sequentially (longitudinally and cross-sectionally) from kindergarten to grade 2. It was hypothesized that: 1) children's MVPA and total physical activity levels would decline from kindergarten to grade 2, 2) sedentary behaviour would increase from kindergarten to grade 2, 3) the cross-sectional sample would accumulate less physical activity and more sedentary minutes compared to the longitudinal sample, and 4) sedentary behaviour would track more consistently than MVPA or total physical activity. As predicted in the first and second hypotheses, both MVPA and total physical activity declined while sedentary behaviour increased. The third hypothesis was not supported. There were no differences in physical activity or sedentary behaviour between the longitudinal and cross-sectional samples. This finding is important since age-related differences in children's physical activity levels and sedentary behaviour are often examined in health-related research. However cross-sectional data have been criticized from a methodological standpoint. The absence of significant differences between the two groups for both sedentary behaviour and MVPA at both grades levels lends support to the use of cross-sectional research designs to identify age-related distinctions in these behaviours. Consistent with the fourth hypothesis, sedentary behaviour tracked more consistently than physical activity from kindergarten to grade 2.

The third study examined whether perceptions of physical competence mediated the relationship between motor competence as the predictor variable and physical activity and also sedentary behaviour as separate dependent variables among children in grade 2 and 3 (Mage = 8.3 years). The following questions were addressed; 1) What are physical activity and sedentary behaviour, motor skill, and perceptions of physical competence levels of children 7 – 9-year olds? 2) What is the relationship between fundamental motor skills and physical activity? 3) What is the relationship between perceived physical competence and physical activity? 4) What is the relationship between perception of

competence and motor skill proficiency? 5) Does perceived physical competence mediate the relationship between fundamental motor skill proficiency and physical activity or sedentary behaviour? Children in this study achieved more MVPA per day than the minimum recommended in the Canadian physical activity guidelines. However, the majority of the day was spent in sedentary behaviours. Gross motor proficiency of both the boys and the girls in this grade 2/3 sample were generally low and had not improved relative to the children's age since kindergarten. Perceptions of physical competence were high for both boys and girls, and very likely inflated and inaccurate. While the first path analysis demonstrated that the initial conceptual model had an overall poor fit to the data. The re-specified models for boys and girls satisfied the fit indices tests. In contrast to the overall purpose and expected outcomes of this study, perceived physical competence did not mediate the relationship between motor skill proficiency and MVPA or between motor skill proficiency and sedentary behaviour. However, individual paths revealed that object control skills significantly predicted MVPA levels for boys, but fundamental motor skills were not related to MVPA for girls. Also, neither motor skills nor perceptions of competence predicted sedentary behaviour, but there was an inverse relationship between MVPA and sedentary time.

### **6.3) Associations between studies one, two, and three**

Collectively, studies one and two underline the changes in physical activity, sedentary behaviour, fundamental motor skills, and perceptions of physical competence from kindergarten to grade 2. I will briefly report the findings for first two studies before discussing study 3.

#### **6.3.1) Physical activity and sedentary behaviour**

The number of minutes of MVPA accumulated by the children in this study was high. On average, participants engaged in an hour and a half of MVPA at 4 METs per day. However, physical activity levels significantly declined from kindergarten to grade 2. At the same time, there was a significant increase in sedentary behaviour time. Overall, sedentary behaviour was higher than both MVPA and total physical activity in both kindergarten and grade 2. These findings are troubling because of the known adverse effects of a sedentary lifestyle. Specifically, studies among North American children

(including Canadians) have found that time spent in sedentary behaviours is positively associated with hypertension, the metabolic syndrome, and increases the likelihood of becoming overweight or obese with age.

### **6.3.2) How does this relate to previous studies?**

The findings are consistent with previous cross-sectional studies that physical activity in children is lower with increasing age (Colley et al., 2011; Troiano et al., 2008) and minutes of sedentary behaviour increase (Colley et al., 2011). The findings of this study are very consistent with the one other study that has examined physical activity and sedentary behaviour longitudinally from 5 to 8 year of age (Janz et al., 2005). Although the Janz et al. study and the present study are separated by a decade, the drop in daily MVPA from 26% in early childhood to 17% in middle childhood in the Janz et al. study are strikingly similar to the drop from 22% to 16% in this study.

### **6.3.3) What does this study add to the literature?**

This is the first study to track physical activity and sedentary behaviour longitudinally in a sample of Canadian children. To date, the majority of studies examining physical activity levels in Canada have used cross-sectional methods (Colley et al., 2011; Colley et al., 2013; Crane et al., 2015; Nettlefold et al., 2012), which provide a snapshot of physical activity and sedentary behaviour at various age groups. However, cross-sectional designs do inhibit some level of interpretation since it is not clear whether there is a cohort effect (Atingdui, 2011) of having been born in a particular period, or whether physical activity levels decrease as a child transitions from one stage of childhood to another.

### **6.3.4) What are the implications?**

These findings are important for parents, teachers, and school administrators. The sharp decline in MVPA and increase in sedentary time from kindergarten to grade 2 are worrisome. Previous research has shown that as children begin school, playtime schedules and the majority of the child's day are becoming more structured and demanding (Sigmund et al., 2009; Taylor et al., 2013). Time demands and school workload increases each year, which results in children spending more time in school and also doing homework outside of school (Janz et al., 2005). In the U.S. for example, the

increased emphasis on English, math, and science has resulted in an overall decrease, and in some cases, the cancellation of physical education classes, recess, and basic physical activity breaks throughout the day (Centers for Disease and Prevention, 2010). This equates to less opportunities for children to be physically active during or after school, and results in children sitting for the majority of their day (Reiff et al., 2012).

The findings of this study need to be mobilized to inform teachers, administrators and parents that from kindergarten to grade 2, MVPA decreased by 30 minutes per day, while sedentary time increased by 75 minutes. Education about the importance of regular participation in physical activity and reducing sedentary behaviour time are of the utmost importance. The Action Schools! BC program (that will be administered by DASH BC in 2016-17) is one initiative that has the potential to break up the amount of time children are sedentary in the classroom and increase daily physical activity (Action Schools! BC, 2016). Their model aims to assist elementary and middle schools in creating and implementing individualized action plans to promote an overall healthy lifestyle in a school environment. Furthermore, they offer workshops, mentorship programs, and other resources to help teachers promote healthy and active living in the school and also the classroom (Action Schools! BC, 2016). For example, as part of their ‘classroom action’, teachers are encouraged to regularly incorporate activities throughout the day to get children up from their desks. Avoiding sitting for extended periods of time is important because of the impact sitting and engaging in sedentary pursuits can have lasting effects on metabolic health (Owen et al., 2010). Therefore, administrators need to ensure physical activity; including physical education, is maintained across the elementary years.

#### **6.4) Fundamental motor skills**

Fundamental motor skill scores in both kindergarten (5.8 years) and grade 2 (7.7 years) fell in the middle range of the Test of Gross Motor Development – 2. Overall there was a significant increase in raw locomotor skills and object control skills from kindergarten to grade 2. However, the percentile ranks indicate that both the locomotor skills and object control skills were not developing well as the children age. Furthermore, there were gender-based differences. Specifically, boys in this study had higher object control skills compared to girls in both kindergarten and grade 2, while girls’ locomotor skills were higher in comparison to boys.

#### **6.4.1) How does this relate to previous studies?**

The findings in this study are consistent with previous evidence that demonstrate that the trajectory of change in motor skill scores are generally in a positive direction during childhood (Livesey et al., 2007; Psotta, Hendl, Kokstejn, Jahodova, & Elfmark, 2014; Temple & Foley, in press; Ulrich, 2000; Westendorp et al., 2014). Although, similar to the findings of Zask et. al (2012), there seems to be a modest plateau effect. Similar to the majority of evidence (Barnett et al., 2008; LeGear et al., 2012; McKenzie et al., 2002; Robinson, 2010; van Beurden et al., 2002; Wrotniak et al., 2006) object control skills were higher for boys in both kindergarten and grade 2. Although, the findings in the literature are mixed for locomotor skills, this study supports the trend of girls having better locomotor skills than boys (Barnett et al., 2008; LeGear et al., 2012; van Beurden et al., 2002).

#### **6.4.2) What does this add to the literature?**

This study provides unique evidence about the fundamental motor skills of young Canadian children cross-sectionally and longitudinally. To date, there is very little evidence about the fundamental motor skills of young Canadian children (Crane et al., 2015). Identifying the level of motor skills in the early years and any gender-based differences that may exist is important because of the positive relationship that fundamental motor skill proficiency, particularly object control skills, has on physical activity levels (Barnett et al., 2008; Cliff et al., 2009; Crane et al., 2015; Fisher et al., 2005b; Williams et al., 2008; Wrotniak et al., 2006).

#### **6.4.3) What are the implications?**

Although change in motor skill proficiency was in a positive direction, the percent of maximum possible scores and the percentile ranks illustrated that in grade 2 the motor skills were generally poor for the children's age, and not as well developed as they could be. Similar to the need to mobilize the findings of this study in relationship to physical activity and sedentary behaviour, the lack of age-related improvement in motor skills need to be communicated to teachers, administrators, and parents. As mentioned previously, motor skill proficiency is a predictor of (Barnett et al., 2008; Crane et al., 2015), and positively related to (Cliff et al., 2009; Fisher et al., 2005b; Williams et al., 2008; Wrotniak et al., 2006) MVPA. This is because activities that are physical promote

neuromotor development in children and therefore help in the development of motor skills. Similarly, continued experience and opportunities with various motor skills result in engagement in being physically active. Therefore, teachers, administrators, and parents/guardians should be focusing on providing lots of opportunities for children to master these types of skills through games and activities both in school and out of school.

The findings of this study also need to be mobilized to inform pre-service teachers that despite having resources readily available (i.e. physical education class, recess and lunch time), children's fundamental motor skills are not improving. The British Columbia Ministry of Education's Integrated Resource Package 2006 (BC Ministry of Education, 2006) identifies the importance of the development of movement skills as part of the kindergarten to grade 7 physical education curriculum. More recently, the Ministry of Education released its new provincial curriculum (BC Ministry of Education, 2015), which identifies fundamental motor skills as a main focal point of the curriculum competencies. In addition, the Ministry recommends that physical education class should make up approximately 10% of all teaching. Notwithstanding these curriculum directives, children in this study did not improve their motor skill levels and also, their physical activity levels declined.

The vast majority of those teaching physical education in British Columbia elementary schools are generalist teachers rather than trained physical education specialists. This distinction has been shown to have an impact on the delivery and effectiveness of physical education classes (Breslin, Murphy, McKee, Delaney, & Dempster, 2012; Faulker et al., 2008). For example, Breslin et al. (2012b) found that physical education specialists were more intrinsically motivated toward exercise and being physically active themselves, and they also have more effective instructional strategies and classroom management skills. Furthermore, Faulker et al. (2008) found that Canadian generalist teachers were fearful about teaching physical education, and these fears were centered around their perceived ability to provide high quality instruction. The findings of both Breslin et al. and Faulker et al. suggest that pre-service teachers need better preparation to teach physical education. Fletcher (2012) has stressed that when preparing pre-service teachers to teach physical education, that in addition to focusing on pedagogical practices, other factors must be taken into consideration. Fletcher

specifically suggests that by unpacking previous experiences with physical education and any pre-conceived feelings about the subject is an important step to establishing an identity as a physical educator. Fletcher also suggests that it is important to observe an expert in the field. These processes will help pre-service better understand the outcomes and goals of physical education and feel competent and confident about teaching physical education.

### **6.5) Perceived physical competence**

Perceptions of physical competence scores were high in kindergarten and stayed high in grade 2. Gender-based differences were also found for boys and girls. Specifically, girls in this study had higher perceptions of their physical competence in both kindergarten and grade 2. Furthermore, there was a significant increase in perceptions of physical competence from kindergarten to grade 2. The increase in perceived physical competence contrasts with developmental theory, which suggests that perceived competence should be becoming more accurate with age.

#### **6.5.1) How does this relate to previous studies?**

The high perceptions in this study in kindergarten and grade 2 were similar to those reported by Spessato et al. (2012). However, Spessato did not separate their findings by gender. This study adds to the literature in that girls' perceptions were higher than boys in both grades, which supports LeGear and colleagues' (2012) findings for kindergarten. Perhaps this is not surprising because the LeGear et al. study and this study used the same cohorts of children.

#### **6.5.2) What does this study add to the literature?**

This study was the first to examine perceptions of physical competence during an important transition from early to middle childhood. While, developmental theory suggests that the transition into middle childhood marks an important period when perceived physical competence should be lower (Stodden et al., 2008), this study showed that perceptions actually increased as children transitioned into middle childhood. Also, this study sheds light on change in the relationship between fundamental motor skill proficiency and perceived physical competence over time. In kindergarten, the relationships between motor skills and perceptions were modest but significant for both

types of motor skills among the boys and the girls. However, in grade 2 the relationships had strengthened for boys but diminished for girls. This suggests that factors other than motor skill proficiency are influencing the girls' perceptions. The unexpected positive increase in perceived physical competence and the non significant relationship between motor skills and perceived physical competence for girls in grade 2 leaves unanswered questions about when perceptions begin to decrease and the development of perceptions of physical competence for girls in comparison to boys.

#### **6.6) A new model of development**

Stodden and colleagues' (2008) model of the developmental mechanisms influencing physical activity trajectories of children aimed to explain physical activity engagement and disengagement throughout childhood. The model depicted relationships between motor competence, physical activity, and perceived physical competence and how those relationships change as children transition from early childhood to middle and late childhood. However, the model did not take gender into account. Based on gender-based differences previously found for fundamental motor skills, object control skills (Barnett et al., 2008; LeGear et al., 2012; McKenzie et al., 2002; Robinson, 2010; van Beurden et al., 2002; Wrotniak et al., 2006), and locomotor skills (Barnett et al., 2008; LeGear et al., 2012; van Beurden et al., 2002), physical activity (Chung et al., 2012; Colley et al., 2011; Troiano et al., 2008), and perceived physical competence (LeGear et al., 2012; Robinson, 2010), as well as in study one of this dissertation, I believed it was important to add gender into the model to gain a better understanding of the similarities and differences between boys and girls.

Stodden and colleagues (2008) did not model sedentary behaviour. In children and youth, sedentary behaviours have been positively correlated with being at risk of the metabolic syndrome and hypertension (Mark & Janssen, 2008; Pardee et al., 2007; Tremblay et al., 2010) and decreased cardiorespiratory fitness (Santos et al., 2014). Independent of physical activity levels, there is a dose-response relationship between higher levels of screen-time and increased risk of the metabolic syndrome (Mark & Janssen, 2008) and between minutes of sedentary behaviour and lower 20 metre shuttle run performance. This independent relationship is partially explained by physiological responses to sedentary behaviour compared with physical activity (Tremblay et al.,

2010). Sedentary behaviour reduces the responsiveness of lipoprotein lipase, which increases circulating triglyceride levels, decreases HDL cholesterol levels, and increases the risk of cardiovascular disease (Tremblay et al., 2010). However, it should be noted that Ekkelund et al. (2009) found that time spent in MVPA, but not light physical activity or sedentary behaviour, was significantly associated with improved insulin sensitivity among adults. As Katzmarzyk (2010) suggests, our understanding of the relationship between sedentary behaviour and health is still emerging.

Separate from the physiological responses to sedentary behaviour, two studies have previously found a significant negative relationship with higher sedentary time and lower motor skill proficiency and perceived physical competence levels (Bai et al., 2015; Wrotniak et al., 2006). Although sedentary behaviour is not synonymous with Stodden and colleagues' (2008) negative spiral of disengagement, there is sufficient evidence of unfavorable outcomes in relation to sedentary behaviour for its inclusion into the model.

Finally, Stodden and colleagues (2008) identified motor competence in general as the catalyst for physical activity engagement or disengagement. However, the literature consistently demonstrates that the relationship between motor skills and physical activity is different for object control skills and locomotor skills. Object control skills are the stronger predictor of physical activity levels among children and youth (Barnett et al., 2008; Cliff et al., 2009; Crane et al., 2015; Fisher et al., 2005b; Williams et al., 2008; Wrotniak et al., 2006). Therefore, the new model examined: 1) the relationships between locomotor and object control skills separately with MVPA, sedentary behaviour, and perceived physical competence. 2) The relationship between perceived physical competence and MVPA. 3) The indirect influence that perceived physical competence had on the relationship between motor competence and MVPA and/or sedentary behaviour. 4) To what extent gender interacted with each variable.

### **6.6.1 What I found**

The conceptualized model displayed a relatively poor fit to the data. Therefore gender was removed as a variable from the model. But as the weight of evidence consistently demonstrated differences in the model variables between boys and girls as well as gender-based differences in the relationships, separate models were estimated for boys (Figure 4) and for girls (Figure 5). Both of the re-estimated conceptualized models

satisfied the fit indices tests, but the significance and strength of the paths weights in the models differed.

In contrast to the overall purpose and expected outcomes of Study 3, perceived physical competence did not mediate the relationship between motor skill proficiency and MVPA or between motor skill proficiency and sedentary behaviour in either model (boys and girls). Notwithstanding what was expected developmentally, the findings from this study showed that perceived physical competence levels of the grade 2/3 children were still very high, and these very positive perceptions did not predict MVPA or sedentary behaviour.

In both of the re-specified models, sedentary behaviour significantly predicted MVPA. The negative relationship shows that children with higher levels of sedentary behaviour spent less time in activities of moderate or vigorous intensity. This evidence is of particular concern since it suggests that a proportion of the children are not meeting either public health guideline (Canadian Society for Exercise Physiology, 2012). This puts this group at particular risk of foregoing the positive benefits that physical activity can afford and experiencing adverse health outcomes associated with sedentary time (Mark & Janssen, 2008; Pardee et al., 2007; Tremblay et al., 2010). To explore the concurrent pattern of sedentary behaviour and MVPA in the current study, participant sedentary behaviour data for Study 2 were compared for those who had, and had not, met the Canadian physical activity guideline for daily MVPA. This analysis using ANOVA revealed that children who did not meet the physical activity guideline had significantly higher minutes of sedentary behaviour per day (~75 minutes) compared to the children who met the physical activity guideline.

Finally, the relationships between motor skill proficiency and MVPA and motor skill proficiency and sedentary behaviour were vastly different for boys and girls in this study. Boys' object control skills significantly predicted MVPA levels in this study, which was consistent with previous evidence examining this relationship (Barnett et al., 2008; Crane et al., 2015). Although locomotor skills and object control skills were related in this study, similar to the findings of Barnett and colleagues' (2008) locomotor skills were not a predictor of physical activity. Additionally, neither locomotor skills nor object control skills were related to sedentary behaviour (see Appendix E). Motor skill

proficiency levels had no bearing on the amount of time the boys were sedentary, while being proficient at object control skills predicted the boys' MVPA levels. These findings are consistent with thoughts raised in previous studies suggesting that object control skills are often used in sports that require intense bouts of physical activity (Barnett et al., 2009; Cohen, Morgan, Plotnikoff, Callister, & Lubans, 2014; Raudsepp & Pall, 2006) and literature that shows that there is a significant relationship between participation in sport and MVPA levels (Leek, Carlson, Cain, & Henrichon, 2011; Marques, Ekelund, & Sardinha, 2016; Trost et al., 1997; Wickel & Eisenmann, 2007).

For girls, there were no significant relationships between motor skill proficiency levels and MVPA or between motor skill proficiency levels and sedentary behaviour (see Appendix E). These findings are somewhat difficult to explain. Cliff and colleagues (2009) suggest that these relationships are absent or negative for girls because it is possible that the skills they typically develop are not properly represented in motor skills assessments. Although it is possible that the TGMD-2 does not assess the motor skills used by girls when they are active, it is also possible that factors other than the ones included in the model are far more important predictors of girls' participation. Parental encouragement and perceptions of acceptance into games and sports seem to be particularly important for girls' physical activities. It is also possible that the girls with better motor skills don't perceive themselves as skillful, or the reverse, that less skillful girls do not perceive themselves as less physically competent. What is clear is that the re-specified model does not explain girls' participation in MVPA or sedentary time and that more research is needed to identify factors influencing girls' participation in middle childhood.

### **6.6.2 What the new models add to the literature**

The process of specifying and re-specifying the path models serve to illustrate that it is difficult to include gender as a dichotomous variable in a single model because the relationships between the modelled variables were so different for boys and girls. However, consistent with my previous mediation model among both male and female kindergarten children (Crane et al., 2015), perceptions of physical competence were not mediating the relationship between motor skills and physical activity. For boys, similar to the kindergarten mediation model, object control skills predicted MVPA. However,

unlike the kindergarten model where perceptions of competence and object control skills were significantly, albeit modestly related ( $\beta = .081$ ), the relationship between object control skills and perceptions was not significant. At the moment, the only variable in the girls' model that significantly predicted MVPA was sedentary behaviour. The relationships in the re-specified model have not been previously examined in the literature, and may provide a distinctive starting point for future examination of these unanticipated null findings among the girls.

Separating motor competence into object control skills and locomotor skills proved to be worthwhile, as object control skills but not locomotor skills predicted MVPA levels among the boys. This has previously been reported in two other studies (Barnett et al., 2008; Crane et al., 2015), but as neither of those studies stratified their samples by gender, it was somewhat difficult to compare the findings. Although the relationships between motor skill subtypes, activity levels, and perceptions of competence were not significant for the girls, at least now these relationships are not unexamined.

Recent efforts to model the effect of motor competence on health-related developmental trajectories have suggested that "...a positive relationship exists between motor competence and physical activity across childhood" (Robinson et al., 2015 p. 1273). However, a statement such as offered by Robinson et al. is too sweeping since both gender and type of motor skill are very important in more fully understanding these developmental trajectories. As far back as 16 years ago, Sallis (2000) pointed out that there might be different correlates of physical activity for boys and girls. He also stated that "...there are two few studies using the same variables to permit sex [based] comparisons" (Sallis, 2000 p.970). Future studies would benefit from ensuring that they have a sufficiently large sample to allow gender and type of skill comparisons in studies of this nature.

### **6.6.3 What are the implications?**

According to developmental theorists, by middle childhood perceived competence levels are thought to be changing, particularly becoming more accurate (Harter, 2012; Horn, 2004). The mean age of participants involved in this study was approximately 8 years of age, which is near the beginning of middle childhood. This might explain why

participants' perceptions of their own physical competence were still high and why perceived competence did not act as a mediator. However, for teachers, parents/guardians this finding is encouraging. The findings suggest that perceived physical competence is not yet influencing physical activity or sedentary behaviour patterns in the primary years. These positive perceptions may help parents and teachers encourage children to be physically active and persist with activities that nurture motor skill proficiency (Stodden et al., 2008). Mastering these motor skills subsequently provides children with the tools to be physically active. Prospective studies examining the change in perceived competence longitudinally from early childhood to the end of late childhood may be necessary to better identify when children's perceived physical competence become more accurate and also to understand the complexity associated with perceived physical competence.

### **6.7 Methodological advances**

In addition the major research questions addressed in this study, this dissertation provides two methodological contributions to the literature. First, in study 2, I classified MVPA using both 3- and 4-METs and found the difference in estimates was approximately 30 minutes per day. This difference is large and meaningful and adds important information about the variability that exists between using 3- or 4-METs. Researchers continue to debate whether MET intensity thresholds for children and adolescents should be set at 3-METs or 4-METs (Harrell et al., 2005; Trost et al., 2011). Some of the original calibration studies (Freedson et al., 2005; Puyau et al., 2002) used 3-METs to define moderate physical activity; while more recently, 4-METs have been used (Mattocks et al., 2007; Pate et al., 2006b; Ridley & Olds, 2008) after identifying that brisk walking for children, which is a key behavioral indicator of moderate-intensity physical activity, is associated with an energy expenditure of 4-METs. While I believe that using 4-METs to classify moderate activity provides a more accurate portrayal of physical activity patterns, future research using accelerometry should classify intensity of moderate activity using both 3- and 4-MET values until there is a general consensus on how to classify moderate intensity activity.

Also in study 2, I conducted independent *t*-tests to determine if there were any statistical differences between the cross-sectional and longitudinal samples physical

activity and sedentary behaviour levels. The results of the independent *t*-tests revealed that the longitudinal sample did not differ significantly from the results derived from the larger cross-sectional sample. This finding sheds light on the generalizability of the findings in this study as well as cross-sectional research designs in general. Cross-sectional studies provide useful descriptive information and are often used because they are relatively short in duration, inexpensive to conduct, and are free of behavioural or testing effects (i.e. practice effects) that may exist in other study designs (Breakwell et al., 2012). In comparison, longitudinal research designs allow researchers to measure, track, and evaluate change within individuals over time (Breakwell et al., 2012). However, longitudinal research has major limitations, particularly in relation to attrition or dropout from the study. The findings in the this study provide evidence that using cross-sectional methods to measure physical activity and sedentary behaviour at various age groups (i.e. kindergarten and grade 2) provide similar results to a longitudinal sample without suffering some the major limitations associated with longitudinal research.

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## Appendix A – Ethics



**Human Research Ethics Board**  
 Office of Research Services  
 Administrative Services Building  
 PO Box 1700 STN CSC  
 Victoria, British Columbia V8W 2Y2, Canada  
 Tel: 250-473-4545, Fax: 250-721-8960  
 Email: ethics@uvic.ca Web: www.research.uvic.ca

### Certificate of Renewed Approval

<b>PRINCIPAL INVESTIGATOR:</b> Vivienne Temple	<b>ETHICS PROTOCOL NUMBER</b> 10-246
<b>UVic STATUS:</b> Faculty	Minimal Risk - Delegated
<b>UVic DEPARTMENT:</b> EPHE	<b>ORIGINAL APPROVAL DATE:</b> 23-Jun-10
	<b>RENEWED ON:</b> 07-May-13
	<b>APPROVAL EXPIRY DATE:</b> 22-Jun-14
<b>PROJECT TITLE:</b> Physical activity and motor skills: A study of child development	
<b>RESEARCH TEAM MEMBERS:</b> Co-Investigators: Dr. PJ Naylor (UVic), Dr. F. Bell (UVic) Research Coordinator: Mrs. Buffy Williams (UVic) Student/Research Assistants: Jeff Crane, Elnaz Mirjafari, Paul Meakin	
<b>DECLARED PROJECT FUNDING:</b> IRG/SSHRC (2010); SSHRC (2012-2013); SSHRC funding received: Processes of sport development among young children	
<b>CONDITIONS OF APPROVAL</b>	
This Certificate of Approval is valid for the above term provided there is no change in the protocol.	
<p><b>Modifications</b>          To make any changes to the approved research procedures in your study, please submit a "Request for Modification" form. You must receive ethics approval before proceeding with your modified protocol.</p> <p><b>Renewals</b>          Your ethics approval must be current for the period during which you are recruiting participants or collecting data. To renew your protocol, please submit a "Request for Renewal" form before the expiry date on your certificate. You will be sent an emailed reminder prompting you to renew your protocol about six weeks before your expiry date.</p> <p><b>Project Closures</b>          When you have completed all data collection activities and will have no further contact with participants, please notify the Human Research Ethics Board by submitting a "Notice of Project Completion" form.</p>	
<b>Certification</b>	
This certifies that the UVic Human Research Ethics Board has examined this research protocol and concluded that, in all respects, the proposed research meets the appropriate standards of ethics as outlined by the University of Victoria Research Regulations Involving Human Participants.	
Dr. Rachael Scarth Associate Vice-President, Research	

10-246 Temple, Vivienne

Certificate Issued On: 07-May-13

## Appendix B – Consent Forms



University  
of Victoria

School of Exercise Science,  
Physical & Health Education

### Physical activity and motor skills: A study of child development

Your child is being invited to participate in a study entitled “Physical Activity and Motor Skills: A Study of Child Development.” This study is being conducted by Drs Vivienne Temple, Rick Bell, and PJ Naylor from the School of Exercise Science, Physical and Health Education at the University of Victoria. If you have further questions you may contact or Vivienne at 250-721-7846 or [vtemple@uvic.ca](mailto:vtemple@uvic.ca) or Rick at 250-721-8373 [fbell@uvic.ca](mailto:fbell@uvic.ca). This research was funded in part by an Insight Development Grant from the Social Sciences and Humanities Research Council of Canada, grant #430-2012-0343.

#### Aim and Objectives

The aim of this research is to understand the relationships between elementary children’s gross motor skills, perceptions of motor competence, physical activity levels, and aspects of health-related fitness. We want to see whether children’s actual gross motor competences, or their perceptions of their competence, influence their participation in physical activity and health-related fitness in Kindergarten, Grade 2/3, and in Grade 5.

#### Importance of this Research

Less than 15% of children in British Columbia meet Canada’s physical activity guidelines for children and a study published last year entitled the *Fitness of Canadian Children and Youth* indicates that the fitness levels of children have declined since 1981, regardless of age or sex. These statistics are alarming and point to an urgent need to help children’s stay engaged in physical activity.

Research suggests that actual motor skill competence and how children feel about their skills is the key to understanding participation (or not) in physical activity. Children’s actual skills and their feelings about their gross motor skills changes from early childhood (i.e. kindergarten) to middle and later childhood. However, the influence of this on participation in physical activity has not been studied over an extended period of time.

This research will be the first in the world to describe these relationships as children develop during elementary school. Ultimately, our intent is to help teachers, schools, and school districts enhance physical activity participation by helping children optimize their fundamental motor skills (competence) and how they feel about their skills.

#### Participants Selection

Your child is being asked to participate in this study because she/he is in Grade 2 in a School District 61 school.

#### What is involved

During scheduled physical education time your child will be videotaped performing 14 fundamental motor skills. These are the: run, hop, gallop, leap, slide, jump, catch, kick, throw, underhand roll, t-ball strike, bounce, dodge, and balance. We videotape the skills so that we can accurately record the parts of each skill and to minimize the time it takes to complete all of the skills during physical education. Your child will also complete three questionnaires. One questionnaire focuses on how your child feels about his/her motor skills, the second examines your child’s interest in sports, and the third is a picture-based questionnaire about their physical activity participation. Height and weight will be measured. We are also asking you about your child’s age, gender, whether he/she was born prematurely, and whether your child has a disability as these factors can influence motor skill development and participation in physical activity.

**You and your child may also choose to**

We are also asking for volunteers to wear a motion sensor (accelerometer) for 7-days. An accelerometer is similar to a pedometer and accurately records your child's level of physical activity. The accelerometer is unobtrusively worn on the hip via an elastic belt. It is removed at night or when bathing or swimming.

**Inconvenience**

Approximately 30 minutes of class time and three of your child's physical education lessons will be devoted to this project. Plus if you and your child choose to participate in the motion sensor part of the project we would ask that your child wear the device for 7-days. Some parental assistance will be needed to record when the device was worn and to help the children put on the accelerometer.

**Risks**

It is possible that children will be embarrassed by having their weight recorded. To minimize this risk weight will be measured in a private space on a scale with the display covered with a flap. Only the research assistant will see the display. If a child doesn't want to be weighed that will be okay; only their height will be measured.

**Benefits**

Your child's participation in this research will help us better understand the role that motor skill development plays in physical activity participation; and may help reverse the decline in fitness/physical activity among Canadian children. The fundamental motor skill test results will also help your child's teacher plan their physical education curriculum.

**Voluntary Participation**

Your child's participation in this research must be completely voluntary. Choosing not to participate in this study will in no way effect your child's physical education lessons. All children in the class will do the fundamental motor skills in physical education, but only the data from consented children will be used for research purposes. If your child does participate, she/he may withdraw at any time without any consequences or any explanation. If she/he does withdraw from the study her/his data will not be used in the study and will be destroyed.

**On-going Consent**

One of the goals of this project is to track the development of motor skills and physical activity participation across the elementary years. Your child may have been involved in this project in kindergarten. Rather than assuming your ongoing consent, we will seek your and your child's consent again when he/she enters grade 3.

**Anonymity and Confidentiality**

Your child's participation will not be anonymous as the fundamental motor skill data will be collected during physical education. There will be many small groups of children performing motor skills at the same time; therefore your child will only be performing in front of a few children. The data we collect will be entered into the computer without names and all presentations will refer only to group data. You will not be asked to enter your child's name online; rather we will email you the code that we use for your child so that we connect the survey responses to your child's other data.

**Dissemination of Results**

Aggregated data from this project will be presented to School District 61 and at professional meetings. Additionally, articles will be published and graduate students will use the data for their theses. The fundamental motor skill data will also be provided to your child's class teacher and to the school. Your child's teacher will receive information about each child's motor skills and the school will receive scores and for the class as a whole.





**University  
of Victoria**

School of Exercise Science,  
Physical & Health Education

### **Physical activity and motor skills: A study of child development**

*A complete copy of this consent form is available to download as a PDF at  
<http://www.educ.uvic.ca/faculty/temple/pages/research.htm>.*

If you have any questions you may call or email the following people in the School of Exercise Science, Physical and Health Education at the University of Victoria.

Dr Vivienne Temple      PH: 250-721-7846      [vtemple@uvic.ca](mailto:vtemple@uvic.ca)

Dr Rick Bell              PH: 250-721-8373      [fbell@uvic.ca](mailto:fbell@uvic.ca)

In addition, you may verify the ethical approval of this study, or raise any concerns you might have, by contacting the Human Research Ethics Office at the University of Victoria (250-472-4545 or [ethics@uvic.ca](mailto:ethics@uvic.ca)).

## Appendix C – Accelerometry Notes to Parents/Guardians



### Note to Parents/Guardians



To the parents or guardians of \_\_\_\_\_, today your child was fitted with an accelerometer (motion sensor) to be worn for the home based portion of the physical activity and motor skills project that you and your child opted into.

The accelerometer is a pedometer like device which measures physical activity. The accelerometer is activated by motion and it will provide us with an idea of the activity patterns of the children in School District 61. The motion sensor is safe and has been used in research with children around the world.

We would like your child to wear the motion sensor until bedtime today. For the following 6 days, we would request your child wear the device for 12 hours each day, ideally between 8:00am and 8:00pm.

Attached to this letter is an activity log and wear instructions.

Thank you for consenting to this portion of the motor skills and physical activity study. Should you have any questions please contact Jeff Crane by phone at the University on 250-853-3144 (work), 778-677-0155 (cell), or via email at [jeffrcra@uvic.ca](mailto:jeffrcra@uvic.ca).

Thank you for your participation in this portion of the project

Vivienne A. Temple PhD

## Appendix D – Test of Gross Motor Development Notes and Procedures

### TGMD-2

#### Equipment

Measuring tape up to 50-60ft	Batting tee
Tape	8" playground ball
Cones	4" bean bag
Rope	Tennis ball
4" plastic ball	

#### Space Required

Skill	Distance/Space (ft)
Run	60
Gallop	25
Hop	15
Leap	20
Horizontal Jump	10
Slide	25
Strike Stationary Ball	30
Stationary dribble	Hard/flat surface
Catch	15
Kick	30
Overhand Throw	20
Underhand Roll	25

#### Instructions

1. Set up station and cameras
2. Ensure you have a list of children with names and code numbers; check names
3. Determine preferred hand and foot for each child (if relevant to the station)
4. Check that the children are wearing rubber soled shoes or bare feet vs. socks.
5. For the video; write clearly on the dry/erase board. DATE, SCHOOL, SKILL, CHILD CODE NUMBER
6. Provide an accurate demonstration and verbal description of the skill to be performed.
7. Administer 2 test trials and score each performance.
8. Write new CHILD CODE NUMBER on dry/erase board.

#### Notes:

- A complete testing time is approximately 15-20 minutes for 1 child. We will test over several lessons with 4 stations and children in groups of approximately 5 children.
- Pause the camera between groups.

### Locomotor Subtest

Skill	Materials	Directions	Performance Criteria
<b>Run</b>	60ft space 2 cones	Place 2 cones 50ft apart. Have 8-10ft of space beyond the second cone. Tell the child to run as fast as they can from 1 cone to the other when you say go. Repeat a 2 <sup>nd</sup> trial.	<ol style="list-style-type: none"> <li>1. Arms move in opposition to legs, elbows bent.</li> <li>2. Brief period when both feet are off the ground.</li> <li>3. Narrow foot placement landing on heel or toe (not flat footed).</li> <li>4. Nonsupport leg bent approx. 90 degrees (close to buttocks).</li> </ol>
<b>Gallop</b>	25ft space tape 2 cones	Mark off 25ft with 2 cones or tape. Tell the child to gallop from one cone to the other. Repeat a 2 <sup>nd</sup> trial going back to the original cone.	<ol style="list-style-type: none"> <li>1. Arms bent and lifted to waist level at take-off.</li> <li>2. A step forward with the lead foot followed by a step with the trailing foot to a position adjacent to or behind the lead foot.</li> <li>3. Brief period when both feet are off the floor.</li> <li>4. Maintains a rhythmic pattern for four consecutive gallops.</li> </ol>
<b>Hop</b>	15ft space	Tell child to hop three times on his/her preferred foot (established before testing) and then repeat 3x on the other foot. Repeat a 2 <sup>nd</sup> trial.	<ol style="list-style-type: none"> <li>1. Non-supported leg swings forward in a pendular fashion to produce force.</li> <li>2. Foot of non-support leg remains behind body.</li> <li>3. Arms flexed and swing forward to produce force.</li> <li>4. Takes off and lands 3 consecutive times on preferred foot.</li> <li>5. Takes off and lands 3 consecutive times on non-preferred foot.</li> </ol>
<b>Leap</b>	20ft space bean bag tape	Place a beanbag on the floor. Attach a piece of tape on the floor so it is parallel to and 10ft away from the beanbag. Have the child stand on the tape and run up and leap over the beanbag. Repeat a 2 <sup>nd</sup> trial.	<ol style="list-style-type: none"> <li>1. Take off on one foot and land on the opposite foot.</li> <li>2. A period where both feet are off the ground longer than running.</li> <li>3. Forward reach with the arm opposite the lead foot.</li> </ol>
<b>Horizontal Jump</b>	10ft space tape	Mark off a starting line on the floor. Have the child start behind the line. Tell the child to jump as far as he/she can. Repeat 2 <sup>nd</sup> trial.	<ol style="list-style-type: none"> <li>1. Preparatory movement includes flexion of both knees with arms extended behind body.</li> <li>2. Arms extended forcefully forward and upward reaching full extension above the head.</li> <li>3. Take off and land on both feet simultaneously.</li> <li>4. Arms are thrust downward during landing.</li> </ol>
<b>Slide</b>	25ft space, straight line two cones	Place cones 25ft apart on top of a line. Tell the child to slide from one cone to the other and back. Repeat a 2 <sup>nd</sup> trial.	<ol style="list-style-type: none"> <li>1. Body turned sideways so shoulders are aligned with the lines on the floor.</li> <li>2. A step sideways with lead foot followed by a slide of the trailing foot to a point next to the lead foot.</li> <li>3. A minimum of 4 continuous step-slide cycles to the right.</li> <li>4. A minimum of 4 continuous step-slide cycles to the left.</li> </ol>

Object Control Subtest			
<b>Striking a stationary ball</b>	4" lightweight ball	Place the ball on the batting tee at the child's belt level. Tell the child to hit the ball hard. Repeat a 2 <sup>nd</sup> trial.	<ol style="list-style-type: none"> <li>1. Dominant hand grips bat above non-dominant hand.</li> <li>2. Nonpreferred side of body faces the imaginary tosser with feet parallel.</li> <li>3. Hip and shoulder rotation during swing.</li> <li>4. Transfer body weight to front foot.</li> <li>5. Bat contacts ball.</li> </ol>
<b>Stationary dribble</b>	8" playground ball	Tell the child to dribble the ball 4x without moving his/her feet, using 1 hand and then stop by catching the ball. Repeat 2 <sup>nd</sup> trial.	<ol style="list-style-type: none"> <li>1. Contacts ball with 1 hand at about belt level.</li> <li>2. Pushes ball with fingertips (not a slap).</li> <li>3. Ball contacts surface in front or to the side of the foot on the preferred side.</li> <li>4. Maintains control of ball for 4 consecutive bounces without having to move the feet to retrieve it.</li> </ol>
<b>Catch</b>	4" plastic ball 15ft space tape	Mark off 2 lines 15ft apart. The child stands on 1 line and the tosser on the other. Toss the ball underhand directly to the child with a slight arc aiming for his/her chest. Tell the child to catch the ball with both hands. Only count those tosses that are between the shoulder and belt. Repeat 2 <sup>nd</sup> trial.	<ol style="list-style-type: none"> <li>1. Preparation phase where hands are in front of the body and elbows are flexed.</li> <li>2. Arms extend while reaching for the ball as it arrives.</li> <li>3. Ball is caught by hands only.</li> </ol>
<b>Kick</b>	8" playground ball, bean bag, tape 30ft space,	Mark off 1 line 20ft and 30ft away from the wall. Tell the child to stand on the other line. Tell the child to run up and kick the ball hard toward the wall. Repeat a 2 <sup>nd</sup> trial.	<ol style="list-style-type: none"> <li>1. Rapid continuous approach to the ball.</li> <li>2. An elongated stride or leap immediately prior to ball contact.</li> <li>3. Non-kicking foot placed even with or slightly in back of the ball.</li> <li>4. Kicks ball with instep of preferred foot (shoelaces or toes).</li> </ol>
<b>Overhand throw</b>	Tennis ball Wall Tape 20ft space	Attach a piece of tape on the floor 20ft from the wall. Have the child stand behind the 20ft line facing the wall. Tell the child to throw the ball hard at the wall. Repeat a 2 <sup>nd</sup> trial.	<ol style="list-style-type: none"> <li>1. Windup is initiated with downward movement of hand/arm.</li> <li>2. Rotates hip and shoulders to a point where the non-throwing side faces the wall.</li> <li>3. Weight is transferred by stepping with the foot opposite the throwing hand.</li> <li>4. Follow through beyond ball release diagonally across the body toward the non-preferred side.</li> </ol>
<b>Underhand roll</b>	Tennis ball 2 cones tape 25ft space	Place 2 cones against a wall so they are 4ft apart. Attach a piece of tape on the floor 20ft from the wall. Tell the child to roll the ball hard so that it goes between the cones. Repeat 2 <sup>nd</sup> trial.	<ol style="list-style-type: none"> <li>1. Preferred hand swings down and back, reaching behind the trunk while chest faces cones.</li> <li>2. Strides forward with foot opposite the preferred hand toward the cones.</li> <li>3. Bends knees to lower body.</li> <li>4. Releases ball close to the floor so ball does not bounce more than 4" high.</li> </ol>

## Appendix E – Results from Path Model Analyses

Below are the non-significant results from the re-specified path models (see Figure 4 and 5) for boys and girls. These tables display the unstandardized beta ( $\beta$ ), standard error (SE), standardized beta weight ( $\beta^*$ ), and significance value ( $p$ ) for each path.

Table 8 *Non-significant results of the path model analysis for boys*

		$\beta$	SE	$\beta^*$	$p$
Locomotor skills	MVPA	-1.528	1.943	-0.108	.432
Locomotor skills	Sedentary behaviour	2.593	4.565	0.086	.570
Locomotor skills	PPC	-5.923	6.940	-0.088	.393
Object control skills	Sedentary behaviour	-1.193	3.038	-0.061	.708
Object control skills	PPC	22.381	16.338	0.537	.171
PPC	MVPA	0.028	0.932	0.133	.976
PPC	Sedentary behaviour	0.086	1.279	-0.194	.946

*Note.* PPC, Perceived physical competence

Table 9 *Non-significant results of the path model analysis for girls*

		$\beta$	SE	$\beta^*$	$p$
Locomotor skills	MVPA	0.558	1.294	0.058	.666
Locomotor skills	Sedentary behaviour	-6.539	4.412	-0.217	.138
Locomotor skills	PPC	-7.765	8.049	-0.167	.335
Object control skills	MVPA	1.172	1.228	0.141	.340
Object control skills	Sedentary behaviour	1.484	4.136	0.057	.720
Object control skills	PPC	10.088	9.830	0.249	.305
PPC	MVPA	-0.029	0.393	-0.140	.942
PPC	Sedentary behaviour	0.051	1.632	0.079	.975

*Note.* PPC, Perceived physical competence