

Fundamental Motor Development and Physical Activity Levels of Kindergarten Children  
in School District 61 Victoria, BC

by

Ryan Cook

B.H.K., University of British Columbia, 2005

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

Masters of Science

in the School of Exercise Science, Physical & Health Education

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## Abstract

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Currently one-quarter of Canadian children are meeting the minimal Canadian Physical Activity Guidelines of 60 minutes of moderate-to-vigorous intensity physical activity (MVPA) daily. These alarming data suggest there is an urgent need to examine factors associated with children's engagement in physical activity. Motor skill proficiency is associated with time spent in MVPA and predictive of participation in organized sport among adolescents. The aim of this study was to examine the relationship between motor skills and physical activity of children in their first year of school. As gender-based differences in motor skill proficiency and physical activity are common, the influence of gender was also examined. Motor skills were assessed using the Test of Gross Motor Development – 2 and physical activity measured with accelerometers (Actigraph GT1M). Of the 106 (mean age = 6y3m) consented kindergarten children, 58% met the accelerometer wear-time inclusion criteria of 10 hours per day on at least 4 days. A MANCOVA revealed no significant gender based differences in motor skills or physical activity; therefore subsequent analyses included all children. Mastery of individual components of each skill as a percentage, were 54.1% of locomotor and 42.3% of object control skills. Using a cut-point of 4 metabolic equivalents, all of the children achieved 60-minutes of daily and weekday MVPA, and 82% of children achieved 60-minutes per day on the weekend. Both object control and locomotor skills were significantly related to the intensity of recorded activity. However, linear regression revealed that total motor skills predicted more variance in MVPA (9%) than either locomotor skills or object control skills independently. The findings of this study reveal

that the kindergarten children engaged in MVPA at a rate equivalent to, or higher than, the minimum recommendations for Canadian children. However, motor skill proficiency was somewhat low. Children's motor skill proficiency predicted a small, but significant, proportion of children's physical activity.

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## **Dedication**

I would like to dedicate this Thesis to the following influencers of my life.

Margaret Edith Cook R.I.P. who was always an inspiration to me throughout my life, and whose footsteps I am gladly following.

To my partner in life Amie Dawe-Cook with whom life, past, current, and future begins. She is the most important person beyond description.

## Chapter 1 Introduction

Physical activity positively influences musculoskeletal health, cardiovascular health, and body weight among young children (Janssen & LeBlanc, 2010; Strong et al., 2005; Tremblay & Whims, 2003). Children's participation in both organized and unorganized physical activity is associated with a 50-70% reduction in the odds of being overweight or obese (Tremblay & Whims, 2003) and engaging in moderate-vigorous intensity aerobic activity is associated with a 6% - 11% reduction in blood pressure among children (Janssen & LeBlanc, 2010). In contrast, a high level of sedentary behaviour is associated with increased risk for obesity, coronary heart disease, Type 2 diabetes, hypertension, colon cancer, and osteoporosis (Colley et al., 2011; Froberg & Andersen, 2005; Pate, Pflieffer, Trost, Zeiger, & Dowda, 2004). Inactive children have shown to be between one to four times more likely to have unfavourable HDL blood cholesterol and blood pressure (Janssen & LeBlanc, 2010; Sallis, McKenzie, Alcaraz, Faucette, & Hovell, 1997). A systematic review of the literature demonstrated that lowering the level of sedentary behaviour reduces health risks in children and youth (Tremblay et al., 2011b). The Tremblay et al. (2011b) analysis demonstrated that a two hour daily reduction in sedentary activity (e.g. screen time) was associated with lower negative health outcomes, such as elevated BMI.

A growing body of evidence is emerging that shows a strong link between childhood mastery of fundamental motor skills (FMS) and childhood and adolescent physical activity patterns. Children and adolescents who demonstrate greater proficiency in FMS have shown greater levels of measured or reported physical activity (Barnett, Morgan, van Beurden, & Beard, 2008; Okely, Booth, & Patterson, 2001). According to a model proposed by Stodden et al. (2008) FMS are prerequisites to the development of strong perceptions of motor competence, fitness and consequently physical activity. Early proficiency in FMS in this model is the driving force by which a child will be either positively or negatively influenced towards continued physical activity. Children with high proficiency levels in FMS will continue to engage in physical activity. Participation in physical activity in and of itself will expedite the acquisition and refinement of FMS. Increased refinement and acquisition of FMS will further increase children's perceptions of motor competence, and therefore increase physical activity levels.

Conversely, low proficiency in FMS will negatively influence a child's pattern of engagement in physical activity. According to Stodden et al. (2008) low proficiency in FMS negatively influences a child's motor competence and deters physical activity. This creates a

negative engagement pattern (withdrawing from activity) and further diminishing acquisition of FMS. Diminished motor competence perpetuates a negative pattern of physical activity, limiting refinement and mastery of skill sets, and the ability to apply these skills to more complex games and sport.

This becomes particularly important in light of recent evidence that shows a decline in fitness of Canadian children compared to previous measurements in 1981 (Tremblay, Shields, Laviolette, Craig & Janssen, 2009). Alarming, Canadian children and youth are spending an average of 8.6 hours per day, or 62% of their waking hours, being sedentary (Colley et al., 2011). These concerns have prompted researchers to suggest there is a need to further understand the determinants of inactivity. Both FMS (Stodden et al., 2008) and gender (Pfeiffer, Dowda, McIver, & Pate, 2009) have been identified potential determinants of participation in physical activity.

Physical activity levels and gross motor skill proficiency have been shown to be influenced by gender. Boys tend to be more active (Pfeiffer et al., 2009) and have more developed object control skills than girls (Barnett, Morgan et al., 2008, Beurden, Zask, Barnett, & Dietrich, 2002; Robinson, 2010). However, boys' locomotor proficiency has been reported as lower (Barnett, Morgan et al., 2008; Beurden et al., 2002), equivalent to (Goodway & Rudisill, 1997), or higher (Robinson, 2010) than girls.

Currently there are no studies examining the relationships between FMS and physical activity levels in Canadian children. Thus the primary purpose of the research was to describe the fundamental motor skill proficiency and physical activity levels of Canadian children in kindergarten. The secondary purpose was to further examine the relationship between gender motor skill proficiency and physical activity.

### **Research Questions**

The current study specifically addressed the following questions regarding FMS and physical activity within kindergarten children of School District 61:

1. What was the fundamental motor skill proficiency of kindergarten children?
2. What were the physical activity levels of kindergarten children?
3. Was there a gender-based difference in fundamental motor skills and physical activity participation of kindergarten children?
4. Does proficiency in fundamental motor skills predict physical activity levels?

## **Delimitations**

This study is delimited to children in kindergarten, 5-6 years old, in School District 61, Victoria, British Columbia

## **Operational Definitions**

The following operational definitions have been used in this study:

### **Fundamental motor skills.**

Fundamental motor skills are a diverse motor repertoire which allow for later learning of adaptive, skilled actions that can be flexibly tailored to a variety of movement contexts (Stodden et al., 2008). Fundamental motor skills are often classified as locomotor, non-locomotor, and object control. In this study, fundamental motor skills were limited to object control skills and locomotor skills as stipulated by the TGMD-2 (Ulrich, 2000).

### **Object control skills.**

Object control skills are movements in which the objective is to manipulate a game or sports object, such as a ball (Payne & Issacs, 2008; Ulrich, 2000).

### **Locomotor skills.**

Locomotor skills are movements in which the objective is to control one's body in space while moving in linear, multi-linear, or vertical directions (Payne & Issacs, 2008; Ulrich, 2000).

### **Physical activity.**

Physical activity is defined as the accumulation of frequency and intensity of movements as measured and collected by an Actigraph GT1M accelerometer (Pensacola, FL, USA), affixed to the hip (LaPorte, Montoye, & Caspersen, 1985). For the current study the physical activity patterns were defined in the terms of physiological energy expenditure or MET's, one MET being equivalent to 3.5 ml O<sub>2</sub> per Kg per minute (McArdle, Katch, & Katch, 2001). For this study the physical activity is specifically defined by energy expenditure as follows; sedentary activity (< 1.5 METs), light activity ( $\geq$  1.5 METs and < 4 METs), moderate activity ( $\geq$  4 METs and < 6METs), and vigorous activity ( $\geq$  6 METs), previously validated

with the Actigraph GT1M accelerometer by Trost, Loprinzi, Moore, and Pfeiffer (2010) within the age range of this study.

## **Chapter 2 Literature Review**

The following literature review provides a rationale for examining fundamental movement skills in relation to physical activity. The following sections describe 1) Typical patterns of fundamental motor skill development, 2) Current physical activity concerns for Canadian children, 3) The relationships between FMS and physical activity and 4) The potential influential relationship between FMS and physical activity.

### **Development of Motor Patterns in Children**

Motor development is a rapid process of change in the observable motor behaviours during the early years of growth and maturation (Haywood & Getchell, 2010; Payne & Issacs, 2008). During early infancy, involuntary reflexes set a foundation of motor behaviour. These reflexes are vital for infant survival and successful acquisition of voluntary motor control (Haywood & Getchell, 2010). Over the first year of life, sub cortical reflexes are replaced with increased voluntary control, or cerebral cortical motor control, dictated by neural development (Haywood & Getchell, 2010). In comparison to a fully developed brain, an infant's brain is approximately 25% of the size of adults, reaching 80% by 4 years of age (Haywood & Getchell, 2010; Payne & Issacs, 2008). Coinciding with the rapid cerebral development is the increase in the number of dendrites per neuron, myelination, and development of neuromuscular synapses (Haywood & Getchell, 2010); these changes allow for improved motor coordination. The enhanced nerve conduction rates following myelination also increases the ability of individuals to voluntarily control motor responses (McArdle et al., 2001).

During preschool and early elementary years, gross motor capabilities are refined. It is during these years the nervous system is initially capable of integrating the neuromuscular patterns required for skillful execution of motor skills. The span of development during elementary school years is very important for motor development. During these years mastery of gross motor skills is necessary for progression into more complex games, physical activities and sport form (Ulrich, 2000). The following section details the expected motor development of both object control and locomotor capabilities.

### **Gross Motor Skill Development**

Gross motor movements, the observable result of motor development, involve a cumulative effort of larger muscle groups (Haywood & Getchell, 2010). Examples of gross

motor movements are running, jumping, throwing, and catching. Fine motor skills, though not often measured in the field of kinesiology, are essential to the progression of gross motor skills. Throwing a ball for example, is initially controlled by gross motor control, and improves as fine motor control, such as finger dexterity or control of the rotator cuff, allows for improved accuracy and precision (Payne & Issacs, 2008).

Early mastery of object control, and locomotor skills have shown to be predictive of both the intensity and habitual participation in physical activity during adolescents (Barnett et al., 2009). The following paragraphs discuss the expected development of locomotor and object skill development.

### **Locomotor skill development.**

***Development of walking.*** Walking, the pre-requisite skill to: running, jumping and skipping, is a developmental process which begins between 9-17 months of age, and matures over a period of 2-6 years (Payne & Issacs, 2008). The most notable increase in walking capabilities is in the rapid increase in speed over the first 6 months of walking, which has been associated with increases and proficiency in walking gait (Haywood & Getchell, 2010). Running, the natural progression of walking, initially develops between 1.5-2.5 years of age, with a large percentage of children acquiring a mature motor pattern (e.g. running) by age 10 (Haywood & Getchell, 2010; Payne & Issacs, 2008).

***Development of jumping.*** Jumping, the upward propulsion of the body, initially develops in the form of the standing long jump, between the ages of 1.5-2 years. Inexperienced jumpers lack an appropriate preparatory phase and display difficulty efficiently absorbing impact during landing (Payne & Issacs, 2008). Improvements in jumping capabilities usually appear between 6-9.5 years of age in conjunction with greater muscular strength and coordination of both the upper and lower body. By 10 years, a mature pattern is typically achieved (Payne & Issacs, 2008).

***Development of hopping.*** The skill of hopping is the repeated upward propulsion of the body on one foot (Ulrich, 2000). Hopping is a more challenging variation of jumping due to the additional challenge of balance and leg strength. Hopping is most often accomplished in the advanced form by 5-7 years of age. Girls typically develop hopping capabilities approximately six months before of boys (Haywood & Getchell, 2010). This early skill development of girls has been speculated to be the result of environmental influence or socialization (Wrotniak,

Epstein, Dorn, Jones, & Kondilis, 2006). Few children under age 3 years develop the capability to continually hop on one leg in one continuous bout. Hopping is a skill that develops during and past the kindergarten years (Haywood & Getchell, 2010).

***Development of galloping, sliding, and skipping.*** Galloping, sliding, and skipping are asymmetric FMS, which consist of combinations of stepping, hopping, or leaping (Payne & Issacs, 2008). The gallop is often the first skill attempted. Aspects of the gallop emerge shortly after running at approximately 2 years of age, prior to the development of hopping ability at age 3-4, and shortly followed by sliding. Mastery of the gallop, hop, and slide, begins to develop in the dominant leg first, progressing into unilateral control (Haywood & Getchell, 2010). Skipping ability develops at approximately 4-7 years of age although challenges in the performance of skipping are commonly seen throughout the kindergarten years (Haywood & Getchell, 2010). The late development of skipping is most likely due to the required motor coordination and combination of a forward step and a hop on the same foot, while alternating the lead foot (Haywood & Getchell, 2010; Payne & Issacs, 2008).

#### **Development of object control skills.**

Object control skills begin to develop early in infancy. With the ability to walk upright and independently, manipulation skills begin to be refined as the hands become free to explore the surrounding environment. Early on in FMS development the skills of manipulation or object control develop with improvements in both eye-hand, and eye-foot coordination (Payne & Issacs, 2008). Fundamental manipulative or object control skills include throwing, catching, striking, dribbling, and kicking. The following sections will describe the development of object control motor skills measured in the TGMD-2 (Ulrich, 2000).

***Development of throwing.*** Throwing, the most complex of the skills listed, can be accomplished underhand, side arm, or overhand. Developmentally, the primary adaptations in ability involve a purposeful and coordinated preparatory phase (Payne & Issacs, 2008). Initial attempts of throwing emerge between 1.5-3 years, with mature capabilities developing by 5.5-8.5 years (Haywood & Getchell, 2010). As a child approaches a mature motor pattern, an improved coordination between the back swing, torso rotation, and a progression from homolateral to an oppositional leg movement develops (Haywood & Getchell, 2010; Payne & Issacs, 2008).

***Development of catching.*** Early attempts of catching occur between the ages of 1.5-3.5, with improvements occurring by 5 years of age, and advanced patterns developing between 5.5-7 years (Haywood & Getchell, 2010). The most notable progression of catching is the ability to anticipate the objects trajectory, while maintaining control over the object as it enters the arms (Haywood & Getchell, 2010).

***Development of striking and kicking.*** The skills of striking and kicking are fundamental movements which involve the projection of an object such as a ball, with a part of the body or an external implement. The skill of kicking utilizes the lower leg to propel an object. The skill of striking utilizes an external implement such as baseball bat, or racquet to project another object. Striking capability usually begins between the ages of 2-3 years, improving between 3-7 years, and advanced mature patterns developing between 7-9 years.

The skill of kicking as measured by the TGMD-2 (Ulrich, 2000) is a coordinated skill of striking a ball with the foot and running. Kicking capabilities begin with initial attempts occurring between 1.5-4 years, and advanced mature patterns developing by the age of 6.5-8.5 (Payne & Issacs, 2008). In the development of both kicking and striking, initial attempts are marked with ineffective preparatory back swings, and an absence of coordination between the upper and lower body (Haywood & Getchell, 2010).

***Development of dribbling.*** Dribbling, in the most advanced form, is accomplished with the ball being pushed with the hand, and the arm remaining out- stretched to meet and absorb the ball on the return bounce (Payne & Issacs, 2008). During inexperienced early attempts, between 5-8 years, the child strikes or slaps the ball instead of pushing the ball to the ground. The slapping pattern at the inexperienced level leads to an uncontrollable flight pattern of the ball, and difficulties maintaining control (Payne & Issacs, 2008).

### **Measures of Physical Activity**

A variety of methods have been used to examine the influence of FMS on the intensity and duration of participation in physical activity by children (Okely et al., 2001; Fisher et al., 2005; Wrotniak et al., 2006). However, for young children, indirect measures with the children themselves or their parents/teachers are not valid (Sirard & Pate, 2001; Trost et al., 2002). In a review of physical activity assessments, Sirard and Pate showed that the relationship between parental or teacher proxy reports of activity following direct observation of young children (3 – 6 years) ranged between -.19 to.06.

### **The measurement of physical activity via accelerometry.**

An accelerometer is a device, which evaluates physical activity by measuring movement of a body segment. More specifically, accelerometers measure the velocity of movement (Freedson, Prober, & Janz, 2005). The Actigraph GT1M (Pensacola, FL, USA) is a biaxial accelerometer measuring movements in both vertical and horizontal planes. Data is collected by the accelerometer at a rate of 30Hz, or 30 measurements per second, and all data is pre-filtered prior to storage in memory. Post-filtered and accumulated data is typically in units, or measurement durations known as “epochs.” ActiGraph GT1M motion sensors allow epochs length to be set between 1 and 120 seconds. Sampling at 30 Hz with 15 second epochs, the accelerometer will store 450 accumulated samples of movements ( $30\text{Hz} \times 15 \text{ sec epoch} = 450$ ). The participant’s recorded physical activity levels (counts per epoch) are then converted to a metabolic equivalent (MET). One MET equates to  $3.5 \text{ mlO}_2/\text{kg}/\text{min}$  (McArdle et al., 2001). The conversion of raw data into MET values is accomplished via regression equations, which have been validated against laboratory-controlled assessments of oxygen consumption (Freedson et al., 2005).

Accelerometer validations have been previously accomplished within the target age group of this study (Trost, Loprinzi, Moore, & Pfeiffer, 2010). Puyau, Adolph, Vohra, and Butte (2002) validated accelerometer recording in children between the ages of 6-16 years, measuring oxygen consumption during: sedentary videogame play, arts and crafts, light activity of walking at 2.5mph, moderate activity of walking between 3.5-4 mph, vigorous activity of jogging 4.5mph, jumping rope, and soccer (Puyau et al., 2002). In validating accelerometer recordings and physical activity, the activity energy expenditure, (AEE) was calculated which is the product of (Energy expenditure) - (Resting metabolic rate). By comparing resting energy expenditure to active energy expenditure Puyau et al. were able to separate sedentary behaviour from light activity. The appropriate definitions for intensity of physical activity have been debated. Recent studies indicated that for children between 5-10 years of age, physical activity intensities should be defined as: Sedentary physical activity (SED) as  $< 1.5 \text{ METs}$ , Light activity (LPA) as  $\geq 1.5 \text{ METs}$  and  $< 4 \text{ METs}$ , Moderate activity (MPA) as  $\geq 4 \text{ METs}$  and  $< 6 \text{ METs}$ , and Vigorous activity (VPA) as  $\geq 6 \text{ METs}$  (Trost et al., 2010).

## **The Current Physical Activity Levels of Young Children**

Between 2007 and 2009, Statistics Canada initiated the Canadian Health Measures Survey in response to a gap in data pertaining to the current fitness levels of Canadian children. Previously (in 1981), the fitness of Canadian children had been measured through the Canadian Fitness Survey (Tremblay et al., 2009). In a representative sample of male and female Canadian children, between the ages of 6 and 19 years of age, children assessed between 2007-2009 were less healthy than the previously reported levels of 1981 in all the following measures of fitness: muscular strength, flexibility, and anthropometric measurements. In terms of body mass, the percentage of children classified as either overweight or obese has increased by 8% in females and 17% in males (Tremblay et al., 2009).

Current literature investigating physical activity measured via accelerometry of young children outside of Canada has reported a decline of physical activity with age. In a representative sample of pre-school children, 4 and 5 year old children were significantly more sedentary than their 3- year-old peers (Reilly et al., 2004). On average, Reilly et al. report children between 3-5 years total activity time to be between 20-25 minutes a day while spending 76-81% of their time in sedentary activity (Reilly et al., 2004). Nader, Bradley, and Houts (2008) report similar diminishment in physical activity in data from the National Institute of Child Health and Human Development (NICHD) longitudinal birth cohort of early childhood and youth development. Nader et al. tracked activity MVPA in children from 9 to 15 years of age. At nine years of age, 80% and 90% of children accumulated  $\geq 120$  minutes MVPA during weekend and weekdays respectively. By age 15, 28% of youth accumulated  $\geq 60$  minutes of daily weekday activity, with 14% meeting the recommended guidelines on weekend days (Nader et al., 2008). From this evidence it appears that there is a trend of diminishing activity levels from childhood to adolescence. Nader et al. (2008) followed a representative sample of children across a six year span, finding a significant decline in MVPA with age.

The Canadian physical activity guidelines have been recently updated (Tremblay et al., 2011a). The new guidelines recommend that children between the ages of 5-11 years accumulate a minimum of 60-minutes of daily MVPA (Tremblay et al., 2011a). These guidelines also state that children should participate in vigorous activity at least three days per week, and engage in activities aimed at strengthening skeletal structure and muscular strength three times per week.

Current literature indicate that Canadian children's physical activity levels are below the minimal recommendations of daily MVPA. The most recent Canadian data indicates that less than 10% of youth 6-19 years of age were accumulating 60-minutes of daily MVPA (Tremblay et al., 2011b). A larger percentage (79.8%) were achieving the 60- minutes of MVPA on at least one day a week, 44.4% achieved this level on three days per week, and 16.6% achieved the appropriate volume and intensity on a minimum on six days per week (Tremblay et al., 2011b). Through further analysis, Colley et al. (2011) revealed that 75% of Canadian children accumulate 30-minutes of MVPA three days a week and 25% accumulated the same volume of activity six days a week. Moreover, those who accumulated the recommended volume of MVPA, 97% of the activity were within the moderate-intensity, rather than vigorous-intensity range. Of the activity that was vigorous, 37% of children achieved 20-minutes on at least one day a week, and only 4% achieved the same duration at least three days a week (Colley et al., 2011).

The literature suggests that levels of physical activity among children are quite low. Increasing our understanding of the determinants of physical activity and ways to increase participation in physical activity is important. Inactivity during childhood has detrimental effects similar to the effects noted in adult populations (Sallis et al., 1997). Increasing daily or weekly physical activity will be beneficial, as a more active child and youth population may potentially reduce or reverse the current negative reported health status in Canadian children (Tremblay et al., 2009).

## **Relationships between FMS Proficiency and Physical Activity Levels**

### **Fundamental motor skills.**

Evidence to date indicates childhood proficiency in FMS may influence physical activity levels in childhood and track into adolescence. A significant and positive relationship has been reported between FMS and both habitual participation in and the intensity of physical activity. Fisher et al. (2005) report FMS proficiency of children 5-6 years old, significantly related to habitual physical activity ( $r=0.10$ ) and the time spent in MVPA ( $r = .18$ ). Wrotniak et al. (2006) also reported a significant relationship between FMS and time spent in moderate and moderate- vigorous physical activity among 8-10 year old children ( $r = .36$  and  $r = .30$ , respectively). According to Wrotniak et al. FMS proficiency explained 8.7% of variance in physical activity. FMS have also been reported to have a significant relationship to time spent

in organized physical activity, although explaining only 3% of the variance (Okely et al., 2001). This may be because of measurement issues; the study utilized retrospective self-reported recall of activity of typical weekly activity patterns. More recent research using objective measures has shown stronger associations between childhood proficiency in FMS and adolescent physical activity and fitness, explaining between 12-30% of the variance (Barnett et al., 2008, 2009).

### **Relative influence of locomotor and object control skills.**

The evidence discussed thus far has been limited to the relationship between FMS skill level and participation in physical activity. In comparing the influence of locomotor and object control on physical activity, object control appears to have a stronger association to participation patterns through childhood and adolescence (Barnett et al., 2008, 2009). Barnett et al. (2009) investigated the predictive capability of childhood proficiency in FMS and levels of physical activity during adolescence. Barnett et al. originally measured 1045 children in 2000, reassessing both physical activity and FMS proficiency in 2006/2007. Data from follow-up measurements indicated object control positively correlated with time spent in physical activity and adolescent fitness levels. Object control accounted for 12.7% of the variance in physical activity, and 18.2% of time spent in MVPA. Moreover, children with high proficiency in object control had a 20% greater chance of participating in MVPA in adolescents, compared to the <5% chance for those with low childhood object control proficiency (Barnett et al., 2008, 2009). Beyond participation, object control is significantly associated with adolescent fitness levels, accounting for 25.9% variance in adolescent fitness levels regardless of gender (Barnett et al., 2009). These data indicate that skills of object control are very important for continual participation in physical activity.

### **Fundamental motor skills and gender.**

The extant literature has consistently demonstrated a gender-based difference in motor skill proficiency (Barnett et al., 2008; Booth et al., 1999; Okely et al., 2001; Van Beurden et al., 2002; Wrotniak et al., 2006). Boys tend to have more developed object control skills than girls (Barnett, Morgan et al., 2008, Beurden, Zask, Barnett, & Dietrich, 2002; Robinson, 2010). However, boys' locomotor proficiency has been reported as lower (Barnett, Morgan et al., 2008; Beurden et al., 2002), equivalent to (Goodway & Rudisill, 1997), or higher (Robinson,

2010) than girls. For example, Van Beurden and colleagues (2002) reported that boys in grades 2 and 3 significantly outperformed girls by 20% - 40% in the abilities of running, throwing, catching, kicking and striking.

Female participation in organized physical activity during adolescence appears to be more closely tied to proficiency levels of FMS than males (Okely et al., 2001). When FMS skill was compared separately by gender and activity was categorized from very low to very high a significant relationship between mastery of FMS and participation in organized activity was found (Okely et al., 2001). Specifically, Okely et al. found adolescent females that were rated as very low in FMS were significantly less active compared to adolescent males rated as high in skill level. The significant relationship between FMS skill level and physical activity was not a consistent trend. In the very low quintile, male's physical activity levels were greater than females by 50 minutes weekly. As female skill level increased, from medium and very high, female physical activity increased and in fact ranged from 50-100 minutes more per week than males (Okely et al., 2001).

In comparing male activity trends, a significant difference in participation in organized physical activity was also found between the highly skilled and less skilled males (Okely et al., 2001). Male physical activity levels increased as their skill rating increased. However, as mentioned previously, male physical activity was continually lower when compared to equally skilled females (Okely et al., 2001).

These findings suggest that skill does influence participation among both boys and girls. However, the findings also suggest that the influence is greater for adolescent females. If females are less active on average (Barnett et al., 2008, 2009; Booth et al., 1999; Okely et al., 2001) and object control is a significant influence on continued participation in physical activity as reported by Barnett et al. then early emphasis and early screening of FMS proficiency may be an important pre-emptive measure. A focus on object control skills during early childhood may increase the likelihood of both sexes continuing to be active throughout childhood, and adolescence. The mechanism for this effect is not well understood however.

### **The potential influence of early motor skill screening and early detection of developmental difficulties.**

Both habitual physical activity and time spent in MVPA have been linked with childhood proficiency in FMS (Barnett et al., 2009; Okely et al., 2001). Early motor screening

may not only aid in the healthy development of fitness and enjoyment of physical activity, but also aid in detection of motor impairments. A common motor impairment is Developmental Coordination Disorder (DCD), a condition where children experience difficulties in motor tasks which are disproportionate to their general development with no known medical or neurological diagnosis (Schott, Alof, Hultsch, & Meermann, 2007). Evidence to date indicates childhood impairments in proficiency of FMS will track throughout childhood into adolescence.

Hands (2008) investigated changes in both motor skill and fitness in 19 children with DCD. Over a period of five-years, Hands followed students with high-motor competence, and low-motor competence, reassessing each child once per year for the duration of the 5-year study. Those with low motor competence were consistently worse than their peers with higher levels of motor proficiency in all measures of fitness (Hands, 2008). Hands reported slower run times, poorer balance, and lower cardio-respiratory endurance. Cantell, Smyth, and Ahonen (2003) followed children with DCD from age 5-17 years, finding those children previously diagnosed with DCD, continued to underperform their peers. Similarly, Schott et al. (2007) examined motor skill proficiency, measures of fitness, and body mass in children with DCD (ranging from moderate to severe diagnosis). Overall 40% of 4-6 year, and 50% of 12 year old children diagnosed as severe in DCD were overweight or obese. Hands (2008) noted the largest differences in cardio- respiratory fitness levels were between students who had high and low levels of motor competence. Measures indicated that participants with low levels of motor competence had predicted aerobic power 5 ml/kg/min lower in year one and 13.39 ml/kg/min. in year 5. Hands suggested that the poorer fitness measures in adolescents with low motor competence might be the result of under- developed coordination capabilities, and the erratic movements may have negatively influenced performance.

Based on the findings of the studies discussed above, in conjunction with the relationships discussed between FMS and physical activity, screening of motor capabilities during early childhood is important. Early detection of delayed development or motor impairment in conditions such as DCD, could aid in prescriptive physical education.

### **The potential reciprocal nature of motor skill and physical activity.**

The existing evidence indicates a relationship exists between proficiency in FMS and physical activity. The mechanisms through which this relationship is established and the

direction of influence needs to be further elucidated. FMS may influence physical activity, or physical activity may influence FMS. It has not yet been determined if higher skill levels create the opportunity for active pursuits or if participation in physical activity increases proficiency of motor skills (Okely et al., 2001). Stodden et al. (2008) proposed that the levels of physical activity participation are both a result of and facilitate the development of FMS abilities. Stodden et al. hypothesize that FMS abilities lead to perceptions of motor competence and fitness, thus negatively or positively influencing future activity patterns. Physical activity then leads to greater motor competence and may prove to be the key variable for positive neuromotor development, greatly increasing FMS in young children and facilitating continued participation in increasingly difficult forms of physical activity.

## Summary

A majority of Canadian children are not achieving the recommended level of 60-minutes of MVPA daily. A growing body of evidence suggests a strong link between childhood mastery of fundamental motor skills and childhood and adolescent physical activity patterns. Children and adolescents who demonstrate greater proficiency in FMS have shown greater levels of measured or reported physical activity. Object control skill proficiency appears to influence participation in physical activity. The weight of evidence also suggests that girls' object control skills are lower than boys; and during adolescence, participation in organized physical activity is more closely tied to proficiency levels of FMS for females than males. No studies have examined the relationships between participation in physical activity, FMS, and gender in Canada.

## **Chapter 3: Method**

### **Study Design**

A cross-sectional research design was employed to describe the current fundamental motor skill proficiency and physical activity levels in a sample of kindergarten children. The relationship between FMS and physical activity was examined, and gender-based differences were explored.

### **Participants**

#### **Recruitment.**

The sampling frame was children in kindergarten in School District 61 Victoria BC during the 2010-2011 school year. The potential recruitment pool was 1294 children. Permission was sought from, and granted by, the Superintendent of School District 61. Subsequently, a presentation was made to the principals of the elementary schools of District 61 by the lead investigators, Dr. Vivienne Temple and Dr. Rick Bell, about the motor development and physical activity project.

Following the presentation, the project coordinator, Buffy Williams, contacted eight schools whose principals had expressed interest. These eight schools had 341 potential kindergarten participants. Advertisements were placed in school newsletters of the eight elementary schools and consent materials (Appendix A) were prepared and delivered to the individual kindergarten teachers by the project coordinator. Consent forms were then distributed to the parents of the potential kindergarten participants' parents by the individual teachers. Consent for participation in the study was a two level process. Level one involved inclusion into the assessment of: FMS utilizing the TGMD-2, perceptions of physical competence, and the Childhood Assessment of Participation and Enjoyment (CAPE). Level two; parents could opt for the assessment of physical activity patterns of their children via accelerometer recordings. Of the 341 potential participants, 267 consented into level one, and of those 106 opted for level two.

## **Instruments.**

Two instruments, the Test of Gross Motor Development-2 (TGMD-2, Ulrich, 2000) and Actigraph GT1M accelerometer (Pensacola, FL, USA) accelerometer, were employed in the measurement of FMS, and physical activity levels, respectively.

### **Fundamental motor skill proficiency.**

*The test of gross motor development, TGMD-2 (Ulrich, 2000).* The TGMD-2 is a process-oriented assessment tool which includes both norm-referenced and criterion-referenced features. The TGMD-2 is a 12-item assessment of gross motor development in children between the ages of 3.0-10.11 years (Cools, Cools, Martelaer, Samey, & Andries, 2008; Ulrich). The TGMD-2 is designed to 1) identify children who are significantly behind their peers in motor development, 2) to aid in the planning of instructional activities, 3) to be used as a continual assessment tool for the assessment of improvements, and 4) to be used as a research tool (Ulrich, 2000).

The TGMD-2 is composed of the two sub-tests of skills: locomotor and object control. Comparison of the expected level of development is accomplished by the TGMD-2 qualitative measurement of each gross motor task tested (Cools et al., 2008). The locomotor tasks include the following skills; run, gallop, hop, leap, horizontal jump, and a slide. The object control tasks include the following; striking a stationary ball, stationary dribbling, catching, kicking, overhand throw, and an underhand roll (Ulrich, 2000). Reliability is reported as 0.91 for locomotor, 0.88 for object control, and an overall gross motor quotient reliability of 0.91 (Cools et al., 2008).

As a research tool, the TGMD-2 has been used for a variety of purposes with young children, including: examining the outcomes of a community-based physical activity motor development program for overweight and obese children (Cliff, Wilson, Okely, Mickle, & Steele, 2007); as well as associations between FMS and physical activity (Fisher et al., 2005; Hardy et al., 2010) and FMS and perceptions of competence (LeGear et al., 2012).

### **Physical activity.**

Physical activity was measured using Actigraph GT1M accelerometers (Pensacola, FL, USA). A protocol established by Reilly (2006) for children in the age range of the current study was employed. Accelerometer data were recorded for a total of 7 days, with the epoch set to a 15-second sampling interval (Reilly, 2006). Fifteen seconds has been found to be more reliable when recording physical activity patterns of young children (Reilly, 2006). Due to the general activity pattern of young children being more sporadic and random, the usual 1-minute interval may potentially mask the true activity pattern of the participants (Cliff, 2009).

## **Procedures**

### **Measurements.**

The University of Victoria research team conducted all assessments in the physical education and meeting spaces of each school. Assessment of height and weight and 12 motor skills occurred across two to four days during scheduled physical education.

### **Measurement of Fundamental Motor Skills.**

Each kindergarten class was divided into four smaller groups for FMS assessment. These groups progressed through the individual skill stations in a predetermined manner. Two investigators or research assistants provided instruction and administered each station. Instructions provided at each station were consistent with the scripts provided in the TGMD-2 examiner's manual (Appendix B-2). These instructions were followed by a demonstration of each skill. Each skill was digitally video recorded to allow for more accurate coding of skill components.

Coding of the digital video was completed by the research team at University of Victoria in the Movement Skills Research Laboratory of the Institute of Applied Physical Activity & Health Research. The components of each skill were scored dichotomously by the investigators; 0 or 1 depending on whether the component was completed correctly. The Percent Agreement Method ( $\text{Number of Agreements} / (\text{Number of Agreements} + \text{Disagreements}) \times 100$ ) was used to examine inter-observer reliability. We aimed to assess a minimum of 15% of the video recordings from each class. In total, 17.6% of the video were coded by two investigators. Percent agreement ranged from 80.2% to 94.8%, with a mean of 87.8%.

***Demographic information and height and weight.*** Information about disability and prematurity status, date of birth, and gender were collected from parents along with the consent materials. Some of these variables were used in other aspects of the broader study. Height was assessed to the nearest centimetre via a portable stadiometer and weight was measured to the nearest 0.1kg using a portable digital scale.

### **Measurement of Physical Activity.**

***Accelerometer recordings.*** On the first day of assessment, participants were fitted with an accelerometer via an elastic belt around the waist. A note outlining how to log activity, how

to fit the accelerometer, and the date of return was sent home to the parents (see Appendix C-1). The note indicated that over the 7-day period the accelerometer should be worn for 12 hours, ideally between 8:00am -8:00pm. An activity log (Appendix C-2) was also sent home and parents were asked to record when the accelerometer was put on and taken off, and to record when and why the accelerometer was removed.

### **Data Reduction.**

Accelerometer data was downloaded into Kinesoft software and all files were screened for acceptable volume of recorded physical activity. Accelerometry files were considered valid, if there was an accumulation of at least 10 hours of activity (Reilly et al., 2006) on a minimum of four days, ideally with at least one weekend day. Activity log books completed by parents were scanned for instances where the child may have been active but was unable to wear the accelerometer such as when a child went swimming.

All valid files were analyzed for time spent in sedentary, light, moderate, and vigorous activity. Accelerometer recordings were converted into a MET values, 1 MET being equivalent to 3.5ml/O<sub>2</sub>/kg/min (McArdle et al., 2001). Consistent with Trost et al. (2010), intensity of activity was defined as: Sedentary activity (SED) <1.5MET's, Light physical activity (LPA) ≥1.5MET's and < 4MET's, Moderate physical activity (MPA) as ≥4 MET's and < 6 METS, and Vigorous physical activity (VPA) as > 6 METS's. The determination of accumulated intensities of activity will be performed via the following calculation; Counts Per Min = (METs - 2.757 + (0.08957 x Age(years)))/(0.0015 - (0.000038 x Age(years))) (Trost et al., 2002). Utilizing the MET values of Trost et al. (2002, 2010) equate to the following counts per minute: Sedentary 0-153, LPA = 153-1007, MPA = 1400-2971, and VPA ≥ 2971.

### **Data analysis.**

All statistical analyses were performed using SPSS 19 for Windows (SPSS Inc., 2010). The following statistical procedures were utilized in order to answer the following questions. 1) what are the fundamental motor capabilities of kindergarten children as measured by the TGMD-2 (Ulrich, 2000)? 2) What are the physical activity levels of kindergarten children in School District 61, as measured via accelerometer recordings? 3) Are there gender-based differences fundamental motor skill proficiency and physical activity? And 4) Does proficiency in fundamental motor skills predict physical activity?

**Question #1.** Motor skills were expressed in terms of mean values  $\pm$  the standard deviation for total skills, object control skills, and locomotor skills. Mastery of locomotor and object control skills was also expressed in terms the Ulrich (2000) normative percentile ranks and as a percentage of the components mastered.

**Question# 2.** Total physical activity was expressed in total minutes and percent of total recorded mean time spent in sedentary, light, moderate, vigorous, and MVPA. MVPA was also reported as percent time spent in moderate vs. vigorous activity, and as a percent of the total sample who successfully accumulated  $\geq 60$ , or between 40-60, or 20-40 minutes of MVPA. Physical activity was also examined per day, by weekday, and by weekend day.

**Question# 3.** Gender differences in raw object control and locomotor skills were examined using multivariate analyses of covariance (MANCOVA) with age in months as a covariate. A separate MANCOVA was performed for physical activity.

**Question# 4.** Pearson Product-Moment Correlation Coefficients ( $r$ ) were computed to assess the strength of the relationships between motor skill proficiency (locomotor and object control skills), and percentage time in sedentary, light, moderate, vigorous, and MVPA. To assess the extent to which motor skill proficiency predicts physical activity; linear stepwise regression was utilized with MVPA as the criterion measure, and raw object control skill scores and locomotor skill scores as independent variables.

## Chapter 4 Results

### Sample

Of the 106 participants who opted for the physical activity segment of the broader study, 58% (62 participants) satisfied the wear time criteria of 10 hours of recorded physical activity recorded on at least 4 days. The final sample comprised 37 boys and 25 girls with an average age of 5.7 years.

### Motor Skills

Both locomotor and object control skills were normally distributed, with no outliers. Mean percentage of correctly completed components was 54.1% for locomotor skills and 42.3% for object control skills (see Table 1). These data place locomotor skills in the 22<sup>nd</sup> percentile and object control skills in the 15<sup>th</sup> percentile compared with the TGMD-2 normative data (Ulrich, 2000). No overall effect was found for FMS and gender as suggested by a Wilks' Lambda ( $\lambda$ ) (Neal & King, 1969) of 0.929  $F(2, 58) = 2.21, p = .119$ .

### Physical Activity

On average, five days were valid for wear time and wear time for valid accelerometer files ranged between 10 and 15 hours. The majority (81%) of physical activity was of sedentary or light intensity (see Tables 2 and 3). Two hours of daily MVPA was recorded, with the majority (67%) of MVPA being in moderate rather than vigorous intensity. Daily, weekday only, and weekend day only physical activity and sedentary behaviour are reported in Table 4. Differences by gender were measured via MANCOVA for daily, weekday, and weekend physical activity in the following intensities: sedentary, light, moderate, vigorous, and MVPA. Again, there was no statistically significant overall effect for gender;  $\lambda = 0.829 F(3, 56) = 2.26, p = .091$ .

As there were no significant difference gender-based differences in physical activity or FMS, the data for boys and girls were combined in the correlation matrix and regression analyses examining the relationships between FMS and physical activity.

Table 1

*Descriptive Statistics of Gross Motor Skills as Measured by the TGMD-2 (Ulrich, 2000)*

Motor-Skill (range of scores)	All (n = 62)				Boys (n = 37)				Girls (n = 25)			
	Mean	Std. Dev	Min	Max	Mean	Std. Dev	Min	Max	Mean	Std. Dev	Min	Max
Locomotor Raw (0-48)	25.98	7.28	10.00	42.00	25.21	7.43	10.00	42.00	27.21	6.99	17.00	40.00
Locomotor Standard (1-20)	7.08	2.42	2.00	13.00	6.82	2.41	2.00	13.00	7.50	2.41	3.00	13.00
Locomotor Percentile (/100)	22.19	20.10	1.00	84.00	20.16	19.90	1.00	84.00	25.42	22.81	1.00	84.00
Object control Raw (0-48)	20.32	6.90	9.00	38.00	21.16	7.17	9.00	38.00	19.00	6.35	10.00	38.00
Object control Standard (1-20)	6.06	2.50	1.00	14.00	6.03	2.35	1.00	11.00	6.12	2.67	1.00	14.00
Object Percentile (/100)	15.29	18.43	1.00	91.00	14.95	16.59	1.00	63.00	15.83	21.40	1.00	91.00
Motor skill Quotient (46-160)	79.39	12.40	55.00	112.00	78.53	12.70	58.00	112.00	80.75	12.02	55.00	112.00
Percentile Ranking (/100)	14.27	17.75	1.00	79.00	13.58	17.99	1.00	79.00	15.37	17.68	1.00	79.00

Table 2

*Descriptive Statistics of Accelerometer Recorded Physical Activity Patterns in Minutes Per-Valid Day*

PA Intensity	All (n = 62)				Boys (n = 37)				Girls (n = 25)			
	Mean	Std. Dev	Min	Max	Mean	Std. Dev	Min	Max	Mean	Std. Dev	Min	Max
Sedentary	368.46	40.75	295.56	591.81	372.48	44.58	295.56	476.90	362.27	33.98	297.68	424.43
Light	216.79	28.88	96.71	333.75	212.60	30.92	96.70	262.66	223.26	24.67	184.37	279.45
Moderate	86.98	16.97	46.58	17.40	87.30	16.23	46.58	121.21	86.50	18.40	62.10	38.251
Vigorous	43.62	16.10	11.80	24.50	46.35	17.83	11.80	82.05	39.41	12.14	18.35	72.25
MVPA	131.74	28.67	65.55	210.50	134.86	28.36	65.55	184.54	126.92	29.06	80.45	210.50

Table 3

*Descriptive Statistics of Accelerometer Counts; Minutes Per-Valid Day*

Category-PA	All (n = 62)				Boys (n = 37)				Girls (n = 25)			
	Mean	Std.Dev	Min	Max	Mean	Std. Dev	Min	Max	Mean	Std. Dev	Min	Max
Sedentary	38692.55	112457.68	4309.40	519163.00	52756.06	137103.86	4309.40	519163.00	17011.31	52541.96	4810.00	263661.75
Light	133357.30	39433.80	95615.00	39842.00	137571.46	48321.39	95615.00	329842.00	126860.46	18145.47	104220.75	186976.00
Moderate	170761.10	32489.87	106247.20	268017.84	173240.18	30075.51	106247.20	238592.83	166939.06	36232.47	80585.00	260525.50
Vigorous	189780.18	106902.87	48104.80	789404.80	195976.63	127704.56	48101.80	789404.80	180227.31	64261.07	73060.20	326757.00
MVPA	337368.52	157428.11	5315.60	965325.60	337338.40	180902.02	5315.60	965325.60	337414.95	115889.20	7760.00	571013.00

Table 4

*Daily, Weekday Only, and Weekend Day Only Minutes of Physical Activity*

Physical Activity	Minutes per day		
	Daily	Weekday	Weekend
Sedentary	362.3 ± 34.0	364.9 ± 34.6	359.6 ± 50.5
Light	216.8 ± 28.9	216.6 ± 28.9	281.5 ± 206.9
Moderate	87.0 ± 17.0	88.4 ± 18.7	82.9 ± 25.1
Vigorous	43.6 ± 16.1	47.8 ± 27.9	38.8 ± 20.2
MVPA (4 METs)	131.7 ± 28.7	133.8 ± 32.0	121.6 ± 40.3

### Relationships between FMS and Physical Activity

The relationship between physical activity levels and motor skill proficiency was assessed via Pearson product correlations (see Table 5). Locomotor skill proficiency was significantly related to weekend light-intensity and moderate-intensity physical activity; accounting for 30.4% and 8.0% percent of the variance, respectively. Object control skills were significantly correlated with weekend moderate activity, daily and weekend vigorous activity, and daily and weekend MVPA. Object control skills accounted for 11.4% of weekend physical activity, 9.5% and 9.9% of the variance in daily and weekend vigorous activity, and 9.9% and 16.8% of variance in daily and weekend MVPA, respectively.

Regression analysis of total raw locomotor, total raw object control, and total motor skills (locomotor + object control), onto MVPA revealed that total motor skill was a better predictor ( $R^2 = 0.092$   $p = 0.018$ ) of MVPA than locomotor skill or object control separately. Independently object control was found to be a significant predictor ( $R^2 = .074$ ,  $p = 0.04$ ) of MVPA.

Table 5

*Correlation between Total Locomotor & Object Control Raw Scores and Recorded Physical Activity*

	Light Intensity			Moderate Intensity			Vigorous Intensity			MVPA Intensity		
	Daily	WD	WED	Daily	WD	WED	Daily	WD	WED	Daily	WD	WED
LM	.057	-.010	.552**	.138	.081	.282*	.227	.101	.161	.193	.106	.256
OC	.101	.051	.266	.225	.129	.338*	.320*	.113	.309*	.315*	.249	.410**

*Note.* \*Correlation is significant (2 tailed) at  $p < .05$  \*\*  $p < .01$ ; LM = Locomotor skills, OC = Object control skills, WD = weekday, WED = week end day

## Chapter 5 Discussion

The aim of this study was to describe the fundamental motor skill proficiency and physical activity levels of kindergarten children in School District 61, Victoria, British Columbia. In addition, the relationship between motor skill proficiency and physical activity was examined.

### Fundamental Motor Skills

Within the current sample of 62 kindergarten children, mastery of FMS as a percent of the individual components of each skill mastered was relatively low. The percent of the components of locomotor skills mastery ranged between 20%-88% with an overall average mastery level of 54.1%. The percent of the individual components of object control skill mastery ranged between 18%-80% with an overall average mastery level of 42.3% (see Table 1). Comparison of these data of FMS mastery to age specific normative data contained within the TGMD-2 examiner's manual (Ulrich, 2000) placed all motor skill levels of the current sample within the 22<sup>nd</sup> percentile for locomotor, and the 15<sup>th</sup> percentile, for object control. Further analysis on an individual basis of motor proficiency results reveals that 16% and 9% achieved the 50<sup>th</sup> percentile for object control, and locomotor respective skill sets. The levels of mastery within the current sample are similar to the levels within current literature, which reports early childhood FMS mastery to range between 20-75% (Hardy et al., 2010; Van Beurden et al., 2002).

The extant literature shows a consistent divide between genders in terms of motor skill proficiency. Van Beurden et al. (2002) reported the FMS proficiency of grade 3 and 4 children, with male children significantly outperforming females by 20% - 40%. Wrotniak et al. (2006) reported boys outperformed girls in motor tasks that involved strength; running, long jump, and throwing. Okely et al. (2001) have reported motor skill proficiency to have a greater effect on time in organized physical activity for girls during adolescence. Counter to the findings reported in the literature to date, the current sample of young children has shown no significant gender difference in FMS proficiency for either locomotor or object control skills. One plausible explanation for the lack of a FMS difference by gender may be the age of the children tested within this study. The children assessed by Van Beurden et al. and Wrotniak et al. were

between the ages of 8-10 years, and thus, would have had greater practice of each skill and therefore, more opportunity for practice and or refinement of FMS. The current study measured kindergarten children, which would have been early in motor development, and therefore in the initial process of FMS acquisition and refinement.

The lack of a gender difference in FMS suggests that FMS are more homogenous during early childhood. The gender differences reported to date have previously been attributed to socialization, more so than gender (Haywood & Getchell, 2010; Wrotniak et al., 2006). It is possible that socializing forces have not yet had a significant impact on the FMS of children in this study. But it is also possible that this group of children, whose parents opted for the accelerometry portion of the broader study, were somewhat different from their classmates who did not opt for this part of the study.

### **Physical Activity**

Canadian children are spending the majority of their time in sedentary and or light activity, with 93% of children and youth aged 6-19 years not achieving the current Canadian recommended daily accumulations of a minimum of 60-minutes of MVPA (Colley et al., 2011). Eighty-one percent of recorded activity in this study was in the combined light and sedentary intensities. Sedentary activity accounted for 51% of total average recorded time. MVPA accumulations show that 18.7% of total recorded time was within this intensity, with 64% in the moderate intensity range. These values equate to an average accumulation of daily activity of 6.2 hours of sedentary, 5.5 hours light-intensity, and 2.2 hours in MVPA. Of the accumulated MVPA, 40-minutes was of vigorous intensity.

Nationally, Colley et al. (2011) reported that one-quarter of Canadian children are meeting the minimal MVPA, with 97% of this activity being moderate in intensity, and 37% accumulated 20-minutes of vigorous intensities, one day a week, and 4% three days per week. The results of the current sample do not match those reported by Colley et al. The children in this study were far more active than the national sample; particularly the girls. Colley et al. reported that on average, 6 – 10 year old girls accumulated 47 minutes per day of MVPA and 6 – 10 year old boys accrued 69 minutes per day of MVPA. All of the children achieved 60-minutes or more of daily and weekday MVPA, and 82% of children achieved 60-minutes per day on the weekend. These results are even more striking since the Canadian Health Measures Survey uses a cut-off of 3 METs for MVPA (see Colley et al., 2011) and the present study uses 4 METs as recommended by Trost et al. (2010) for young children. Forty-four percent of the

children sampled accrued more than 60-minutes of vigorous activity on weekdays (see Table 2).

The physical activity findings in this study are indeed positive; however it should also be noted that children were sedentary for slightly more than six hours during accelerometer wear time. Sedentary behaviour is an independent predictor of adverse health outcomes such as increased BMI, and elevated blood pressure and blood cholesterol levels both during childhood and tracking into adulthood (Froberg & Andersen 2005; Hancox, et al., 2004). Physical activity and the benefits of increases in activity have shown to have a dose response to overall health, specifically in relation to MVPA and vigorous activity. The Canadian physical activity guidelines recommend that children engage in vigorous physical activity three days per week and Janssen and LeBlanc (2010) note that vigorous physical activity is an important threshold for many health benefits. The children in this study largely met the recommendation for MVPA by engaging in moderate-intensity physical activity as opposed to vigorous-intensity physical activity. This finding is consistent with national data (see Colley et al., 2011) and additional efforts to promote engagement in vigorous physical activities in a larger proportion of the children in kindergarten are warranted.

### **Relationship between FMS and Physical Activity**

The relationship between physical activity and FMS was investigated using bivariate correlations (see Table 5) and stepwise linear regression. Motor skill proficiency was related to participation and intensity of recorded activity; however the relationships varied based on the type of skill. Locomotor skill proficiency was significantly related to participation in weekend light- and moderate-intensity physical activity; accounting for 30.4% and 7.9% of the respective variance. Contrastingly, object control was significantly related with daily and weekend vigorous-intensity physical activity and MVPA, as well as weekend day moderate-intensity physical activity. Object control accounted for 11.4%, variance in weekend moderate activity, 10.2% and 9.5% of variance in daily and weekend vigorous activity, 9.9% and 16.8% of the variance in daily and weekend MVPA. These results suggest a different pattern of influence of locomotor and object control skills. If participation in physical activity is the medium through which children are developing their motor proficiency as suggested by Stodden et al. (2008); then children participation in more light-to-moderate physical activity on the weekends have higher levels of locomotor skill proficiency, whereas children participating in more moderate-to-vigorous physical activity have enhanced object control skills. The type of

activities participated in by the children was not examined in this study. Additional research to examine the nature of these moderate and vigorous physical activities is needed. It is possible that these activities directly promote the development of object control skills. For example, participation in soccer is likely to improve children's kicking skills.

Linear regression was also used to examine the extent to which motor skill level predicted MVPA. The results of the current study show that the combined effect of both locomotor and object control skills accounts for more variance in MVPA ( $R^2 = .092, p = 0.018$ ) than object control skills by themselves ( $R^2 = .074, p = 0.04$ ). This finding is counter to the reported relationship between FMS and physical activity to date, which has shown, object control skills, in the absence of locomotor skills having greater influence on physical activity (Barnett et al., 2009; Booth et al., 1999; Fisher et al., 2005; Hands, 2008). It is possible that the source/s of MVPA in the current study foster the development of both locomotor and object control skills. For example, along with the development of kicking skills, soccer would encourage children to run.

Stodden et al. (2008) have suggested FMS proficiency mediates participation in physical activity. According to their model, early proficiency in FMS is a driving force by which a child will be either positively or negatively predisposed toward participation in physical activity. Stodden et al. proposed high motor proficiency in early childhood cyclically fosters continual motor development, thereby influencing and creating opportunity for habitual participation in physical activity. In this model, the greater the FMS skill proficiency, the more physically active a child will be. Consequently, the greater amount of physical activity, the greater the advancements in neuromotor coordination and FMS competence. The integration and continual refinement of newly developed FMS will in turn lead to improved skill and adaptations of these skills into more complex game and sport (Stodden et al., 2008).

An intriguing aspect of the relationship between object control skills and moderate and vigorous physical activity is that the manipulation of objects in sports such as baseball, soccer, basketball are in and of themselves lower in intensity. The moderate to vigorous intensities in the aforementioned activities occurs when manipulative skills are combined with locomotor skills such as running. This may explain why the regression analysis in this study was stronger when locomotor skills were included. It also suggests that among older children and adolescents the relationship may be stronger as they are more likely to participate in games and sports involving both sets of skills. For older children, when locomotor skills are likely to be

proficient, object control may allow for greater opportunities to play, enjoy, and advance in these games. Increased participation and enjoyment of these games can positively and cyclically foster FMS skill development as suggested by Stodden et al. (2008).

### **Limitations**

There are several limitations related to the method of physical activity data collection, specifically:

- 1) The one time 7-day measurement duration of physical activity may not be a true reflection of activity patterns.
- 2) An accelerometer recording of physical activity was also only recorded on children whose parents had consented to the home-based portion of the study. This may limit this study in the following ways;
  - a. The novelty of being measured may in itself generate a desire by both the parents and the children to be more active. The parents were informed of the purpose of the accelerometer portion of the study, which may have unintentionally altered their children's activity levels during the measurement period.
  - b. The diversity of activity patterns measured may not be a true representation of children in School District 61. Opting for the study and the accelerometer portion of the study in particular, may have created an inherent bias. It is feasible that parents of children were either highly active or highly inactive, or with high or low levels of motor skill proficiency, may have been differentially attracted to participate.
- 3) Collection of data through the winter months may have added additional error to measured physical activity. Winter weather typically has a negative effect on participation in physical activity of young children (Temple, 2012).

### **Conclusion**

The findings of this study reveal that the kindergarten children engaged in MVPA at a rate equivalent to, or higher than, the minimum recommendations for Canadian children. However, motor skill proficiency was somewhat low. Both object control and locomotor skills were significantly related to the intensity of recorded activity. Current literature has consistently demonstrated that mastery of object control skills during childhood has a greater influence on continual participation in physical activity and sport. The findings of this study

show that the combined effect of both locomotor and object control skills predict MVPA to a greater degree than either locomotor or object control skills separately. Two likely explanations for the discrepancy between current literature and this study are the age of the children in this study and the concurrent cross-sectional measurement of motor skills and physical activity. It appears that both sets of skills are important for engaging in MVPA in this young group of children. However, it is also possible that higher levels of moderate-intensity physical activity facilitate skill development. It may be that object control skill proficiency is a more important predictor of physical activity in later childhood and adolescence, when these skills are more likely to be used in combination with locomotor skills, such as in advanced games and/or sport. Object control skills, such as throwing, kicking, striking, are stationary and therefore likely to produce only light-intensity physical activity. For example, catching and throwing are primarily stationary; however in the context of fielding a fly ball in baseball; the combination of running to the ball, catching, and throwing to the nearest base, may drastically increase the intensity of physical activity. In such game based contexts, locomotor skills must be sufficiently mastered. This interplay between MVPA and motor skill proficiency is evident in the predictability of MVPA being strongest when locomotor and object control skills were combined.

Low levels of FMS overall needs to be addressed. Although physical activity levels in this young group were good, the available literature indicates that as children age their perceptions of their competence will become increasingly important. The modest relationship between physical activity and FMS in this study suggests that FMS is currently influencing participation in physical activity; but this relationship may become stronger as the children age.

### **Future Research and Implications for Teachers**

#### **Future research.**

Future research should investigate the direction of the relationship between FMS and physical activity. The weight of evidence to date has not established whether greater FMS proficiency creates the opportunity for active pursuits, whether FMS proficiency is the result of greater participation in physical activity; or the extent to which both of these forces are at play. Future studies should manipulate FMS and physical activity experimentally to tease out the relative influence of these factors. Gaining a clear understanding of the causality of FMS development will elicit further understanding into the relationships between FMS and physical activity reported in this study and previous research.

**Implications for teachers.**

A focus on enhancing children's engagement in vigorous physical activity and the development of FMS for children in kindergarten is warranted. Although all of the children in this study met or exceeded the Canadian guidelines for physical activity, levels of vigorous physical activity were lower and little of this type of activity occurred during weekdays when the children were at school. Vigorous physical activity produces health benefits above and beyond moderate-intensity physical activity. For example, vigorous physical activities like jumping are important for bone health in early childhood (Specker and Binkley, 2003).

During preschool and early elementary years, gross motor capabilities are being refined. It is during these years the nervous system is initially capable of integrating the neuromuscular patterns required for skillful execution of motor skills. The span of development during elementary school years is very important for motor development. This study has shown that FMS, and physical activity participation habits are closely tied, and FMS is correlated with MVPA. Therefore, mastery of gross motor skills is necessary for progression into complex games and sport form. Furthermore, the results of this study indicate that for young children, the combined effect of locomotor and object control skills has the greatest influence on MVPA. In the early elementary years, teachers should help children develop both their locomotor and object control skills.

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## **Appendix A Parental Consent**

### **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 Dr.s Viviene 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 Viviene at 250-721-7846 or [vtemple@uvic.ca](mailto:vtemple@uvic.ca) or Rick at 250-721-8373 or [fbell@uvic.ca](mailto:fbell@uvic.ca).

#### **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 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 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.

#### **Participant Selection**

Your child is being asked to participate in this study because she/he is in Kindergarten 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, spatial awareness, 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 a picture-based questionnaire about their physical activity participation and how they feel about their motor skills; and 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 the 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 four 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 affect your child's physical education lessons. All children in the kindergarten 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. Rather than assuming your ongoing consent, we will seek you and your child's consent 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 classes. 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. However, the data we collect will be entered into the computer without names and all presentations will refer only to group 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 for the class as a whole.

**Disposal of Data**

The video data will be erased and surveys will be shredded five years after collection. The computer files (without names) will be kept in a secure database for 15 years. An important outcome of this project is to track the development of children's skills and physical activity longitudinally, therefore it is important to retain the Kindergarten data to compare with future data collection (i.e. grade 3 and 5).

### Contacts

Individuals that may be contacted regarding this study include Dr Vivienne Temple PH: 250-721-7846 or email: [vtemple@uvic.ca](mailto:vtemple@uvic.ca) or Dr Rick Bell PH: 250-721-8373 or email: [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)).

Your signature below indicates that you understand the above conditions of your child's participation in this study and that you have had the opportunity to have your questions answered by the researchers. We also ask that your child "signs" below to indicate that he/she is happy to be involved in the study.

---

*Child's Name*

---

*Child's Signature*

---

*Parent Name*

---

*Parent's Signature*

---

*Date*

***PLEASE COMPLETE THE INFORMATION ON THE BACK OF THIS PAGE AND  
RETURN IT TO SCHOOL IN THE ENVELOPE PROVIDED.***

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

To help us describe motor skills and physical activity participation more specifically we ask that you provide the following information about your child:

1. Age: \_\_\_\_\_ years \_\_\_\_\_ months

2. Gender:    Boy             Girl

3. Was your child born prematurely? Yes             No

If yes, how many weeks? \_\_\_\_\_

4. Does your child have a disability? Yes             No

If yes, please describe \_\_\_\_\_

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Your child may also choose to wear a motion sensor (accelerometer) for 7-days. The device is small like a pedometer and worn on an elastic belt. If your child would like to complete this part of the study please check the YES box below.



*Accelerometer*

My child will also participate in the YES   
accelerometer part of this study            NO

### 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 B1

## TGMD-2 Example Scoring Sheet

EXTRACT FROM the TGMD-2 (Ulrich, 2000)

<b>TGMD-2</b>		Test of Gross Motor Development-Second Edition		Profile/Examiner Record Form																																																																																	
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G. Notes and other considerations _____																																																																																					
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<b>Section VI. Subtest Performance Record</b>						
Preferred Hand: Right <input type="checkbox"/> Left <input type="checkbox"/> Not Established <input type="checkbox"/>						
Preferred Foot: Right <input type="checkbox"/> Left <input type="checkbox"/> Not Established <input type="checkbox"/>						
<b>Locomotor Subtest</b>						
Skill	Materials	Directions	Performance Criteria	Trial 1	Trial 2	Score
1. Run	60 feet of clear space and two cones	Place two cones 50 feet apart. Make sure there is at least 8 to 10 feet of space beyond the second cone for a safe stopping distance. Tell the child to run as fast as he or she can from one cone to the other when you say "Go." Repeat a second trial.	1. Arms move in opposition to legs, elbows bent 2. Brief period where both feet are off the ground 3. Narrow foot placement landing on heel or toe (i.e., not flat footed) 4. Nonsupport leg bent approximately 90 degrees (i.e., close to buttocks)			
<b>Skill Score</b>						
2. Gallop	25 feet of clear space, and tape or two cones	Mark off a distance of 25 feet with two cones or tape. Tell the child to gallop from one cone to the other. Repeat a second trial by galloping back to the original cone.	1. Arms bent and lifted to waist level at takeoff 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 3. Brief period when both feet are off the floor 4. Maintains a rhythmic pattern for four consecutive gallops			
<b>Skill Score</b>						
3. Hop	A minimum of 15 feet of clear space	Tell the child to hop three times on his or her preferred foot (established before testing) and then three times on the other foot. Repeat a second trial.	1. Nonsupport leg swings forward in pendular fashion to produce force 2. Foot of nonsupport leg remains behind body 3. Arms flexed and swing forward to produce force 4. Takes off and lands three consecutive times on preferred foot 5. Takes off and lands three consecutive times on nonpreferred foot			
<b>Skill Score</b>						
4. Leap	A minimum of 20 feet of clear space, a beanbag, and tape	Place a beanbag on the floor. Attach a piece of tape on the floor so it is parallel to and 10 feet away from the beanbag. Have the child stand on the tape and run up and leap over the beanbag. Repeat a second trial.	1. Take off on one foot and land on the opposite foot 2. A period where both feet are off the ground longer than running 3. Forward reach with the arm opposite the lead foot			
<b>Skill Score</b>						

## APPENDIX B2

### TGMD-2 Materials and Instructions Equipment

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

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

### Instructions

1. Children should wear rubber soled shoes or bare feet vs. socks.
2. Testing time takes 15-20 minutes for 1 child (can test 2 children at one time).
3. Complete the information on Profile/Examiner Record Form prior to starting.
4. Determine preferred hand and foot before starting.
5. Provide an accurate demonstration and verbal description of the skill to be performed.
6. Provide a practice trial and provide more clarification if necessary.
7. Administer 2 test trials and score each performance.
8. Score each behavioural component as follows:
  - 0 = if the child does not perform a behavioural component correctly.
  - 1 = if the child performs a behavioural component correctly.
  - It is not appropriate to score 0.5 to show that a child displays the criterion but is inconsistent.
9. After completing 2 trials, the score from each trial is added together and placed in the score box. A skill score is totaled from each test component (Appendix B-1).

Locomotor Subtest			
Skill	Materials	Directions	Performance Criteria
Run	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.	Arms move in opposition to legs, elbows bent. Brief period when both feet are off the ground. Narrow foot placement landing on heel or toe (not flat footed). Non-supporting leg bent approx. 90 degrees (close to buttocks).
Gallop	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.	Arms bent and lifted to waist level at take-off. 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. Brief period when both feet are off the floor. Maintains a rhythmic pattern for four consecutive gallops.
Hop	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.	Non-supported leg swings forward in a pendular fashion to produce force. Foot of non-support leg remains behind body. Arms flexed and swing forward to produce force. Takes off and lands 3 consecutive times on preferred foot. Takes off and lands 3 consecutive times on non-preferred foot.
Leap	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.	Take off on one foot and land on the opposite foot. A period where both feet are off the ground longer than running. Forward reach with the arm opposite the lead foot.
Horizontal Jump	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.	Preparatory movement includes flexion of both knees with arms extended behind body. Arms extended forcefully forward and upward reaching full extension above the head. Take off and land on both feet

			simultaneously. Arms are thrust downward during landing.
Slide	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.	Body turned sideways so shoulders are aligned with the lines on the floor. A step sideways with lead foot followed by a slide of the trailing foot to a point next to the lead foot. A minimum of 4 continuous step-slide cycles to the right. A minimum of 4 continuous step-slide cycles to the left.

<b>Object Control Subtest</b>			
<b>Skill</b>	<b>Materials</b>	<b>Directions</b>	<b>Performance Criteria</b>
Striking a stationary ball	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.	Dominant hand grips bat above non-dominant hand. Non-preferred side of body faces the imaginary tosser with feet parallel. Hip and shoulder rotation during swing. Transfer body weight to front foot. Bat contacts ball.
Stationary dribble	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.	Contacts ball with 1 hand at about belt level. Pushes ball with fingertips (not a slap). Ball contacts surface in front or to the side of the foot on the preferred side. Maintains control of ball for 4 consecutive bounces without having to move the feet to retrieve it.
Catch	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.	Preparation phase where hands are in front of the body and elbows are flexed. Arms extend while reaching for the ball as it arrives. Ball is caught by hands only.
Kick	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.	Rapid continuous approach to the ball. An elongated stride or leap immediately prior to ball contact. Non-kicking foot placed even with or slightly in back of the ball. Kicks ball with instep of preferred foot (shoelaces or toes).
Overhand throw	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	Windup is initiated with downward movement of hand/arm. Rotates hip and shoulders to a point where the non-throwing side faces the wall. Weight is transferred by stepping with the foot opposite the throwing hand.

Underhand roll	Tennis ball 2 cones tape 25ft space	<p>the wall. Repeat a 2<sup>nd</sup> trial.</p> <p>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.</p>	<p>Follow through beyond ball release diagonally across the body toward the non-preferred side.</p> <p>Preferred hand swings down and back, reaching behind the trunk while chest faces cones. Strides forward with foot opposite the preferred hand toward the cones. Bends knees to lower body. Releases ball close to the floor so ball does not bounce more than 4" high.</p>
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### Appendix B3

#### TGMD-2- Station Scripts

<i>Locomotor Script</i>	<i>Object Control Script</i>
<b>Run 50 feet</b>	<b>Strike (ball at belt level)</b>
<i>Run as fast as you can to the cone when I say go</i>	<i>Hit the ball hard</i>
<b>Gallop 25 feet</b>	<b>Dribble</b>
<i>Gallop to cone</i>	<i>Dribble four times without moving your feet, and then stop by catching the ball</i>
<b>Hop 3 times each foot</b>	<b>Catch 15 feet away.</b> Toss underhand
<i>Hop three times</i>	between shoulder and belt
<b>Leap bean bag 10 feet away</b>	<i>Catch the ball with both hands</i>
<b>Run to bean bag and leap over</b>	<b>Kick (mark 2 lines 10 feet apart)</b>
<b>Jump (mark start line)</b>	<i>Stand on the first line and run up and kick the ball hard</i>
<i>Jump as far as you can</i>	
<b>Slide 25 feet; slide to right and to left</b>	<b>Overhand throw (mark a line 20 feet from a wall; child faces wall)</b>
<i>Slide to the cone and back, stay facing the same way</i>	<i>Throw the ball hard at the wall</i>
	<b>Underhand roll (cones 4 feet apart; 20 feet away)</b>
	<i>Roll the ball hard so that it goes between the cones</i>

## **Appendix C-1**

### Note to Parents

To the parent of \_\_\_\_\_, today your child was fitted with an accelerometer motion sensor to be worn as part of the criteria to be a part of the home based portion of the motor skills project.

The accelerometer is a pedometer like device, which measures physical activity and is activated by motion. The motion sensor will provide us with an idea of the typical activity patterns of children in School District 61 Victoria BC. The motion sensor is safe and non-invasive, and is only attached via the elastic belt provided.

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. For ideal and accurate recordings, the elastic belt needs to be snugly fitted to waist, and is most accurate when worn on the hip, as close to the skin as possible. Should the elastic belt be uncomfortable for your child, it is acceptable to wear the device over top of light under clothing as well. The motion sensor is not waterproof and should be removed for swimming or bathing.

Attached to this letter is an activity log which we request a record of the times your child wears and removes the device. Should there be reasons for its removal, we would also request a short note as to the reasons for removal, such as swimming lessons etc.

Thank you for consenting to this portion of the motor skills and physical activity study. Should you have any questions please contact Ryan Cook by phone at \_\_\_\_\_, or by email at ryanc@uvic.ca

**Appendix C-2**

## Accelerometer Activity Log Sheet

Motion sensor activity log

*Name* \_\_\_\_\_ *School* \_\_\_\_\_

## Directions to parents

1. The accelerometer motion sensor should be worn underneath clothing, over top of lightweight under clothing if need be.
2. For accuracy of measurement, the device needs to be snugly fitted to the hip, as it measures motion and a loosely fitted belt may record non-active related motion.
3. The motion sensor is to be worn from wake up to bedtime, and should be removed only for events such as swimming and bathing, as the device is not waterproof.
4. On the reverse is an activity log, please record the times your child is fitted with the belt and the time the belt is removed. Should the belt be removed prior to bedtime please provide a short description of the reasons for its removal.
5. The motion sensor is very expensive and we would request that on the day of \_\_\_\_\_ your child wear it to school until a researcher collects it.

Thank you for your participation

Days							
Dates							
On time							
Off time							
Did weather change your Childs usual activity levels	yes						
	No						
Was the motion sensor removed prior to bedtime	yes						
	No						
If yes please provide a short description of reason for removal							
If yes please provide the time off and back on	Off ____:____ __						
	On ____:____ __						

Monitor # \_\_\_\_\_ - Initials: \_\_\_\_\_ -