Movement behaviours, body mass index, and demographics of toddlers and preschoolers attending Alberta child care centres

by

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Abstract

The overall objective of this thesis was to quantify levels of physical activity, sedentary behaviour and sleep (movement behaviours), and determine how they are related to body mass index (BMI) in toddlers and preschoolers, while considering the impact of demographic variables. A sample of toddlers (19 to 35 months old) and preschoolers (36 to 60 months old) who attended child care centres in Alberta Canada were used to address the overall objective, within two manuscripts.

The first manuscript describes objectively-measured physical activity and sedentary behaviour within child care centres, while examining differences between demographic groups (i.e., child sex, child age group, and parental immigration status). Children spent 7.0% of time engaged in moderate- to vigorous-intensity physical activity, and 61.5% of time engaged in sedentary behaviour. Short sedentary bouts (1-4 minutes) were more frequent than longer bouts (≥5 minutes). Additionally, preschoolers were found to be more active, less sedentary, and engage in less frequent sedentary bouts of longer duration (≥10 minutes) compared to toddlers.

The second manuscript examines the relationship between movement behaviours, within and outside of child care, with body mass index (BMI) z-scores; while testing if demographic variables moderated this relationship. A higher frequency of the shortest sedentary bouts (1-4 minutes) during child care was associated with a lower BMI z-score, after adjusting for demographic variables. No moderation effects were observed.

The findings within this thesis can help guide future research, and begin to inform future interventions, and public health initiatives. The limited physical activity levels, in particular moderate- to vigorous-intensity physical activity, and predominantly sedentary behaviour levels observed, indicate interventions/initiatives that promote healthy movement behaviours in this age

group may be needed. The negative relationship observed between frequency of short sedentary bouts and BMI z-scores indicate that breaking up sedentary behaviour into short sedentary bouts may be an important intervention target. Future longitudinal and experimental research is needed to confirm and build on this research in an effort to promote healthy growth and development in our youngest children.

Preface

The research conducted for this thesis forms part of the Supporting Active Living Behaviours in Alberta Child Care Settings study, a cross-Alberta research collaboration, led by Valerie Carson at the University of Alberta. Dawne Clark and Nancy Ogden from Mount Royal University facilitated data collection in Calgary, Alberta. Data collection in Edmonton was facilitated by myself and Valerie Carson. Chapter 3 of this thesis is published as: Kuzik, N. Clark, D., Ogden, N., Harber, V., Carson, V. (2015). "Physical activity and sedentary behaviour of toddlers and preschoolers in child care centres in Alberta, Canada", Canadian Journal of Public Health. Data analysis and manuscript composition was completed by myself. Valerie Carson assisted in manuscript composition and revisions, as well as accelerometer data reduction. All co-authors assisted with manuscript revisions. Chapter 4 of this thesis is in submission to the International Journal of Environmental Research and Public Health, under the working title of: Kuzik, N., Carson, V. "The relationship between movement behaviors and BMI in different settings among toddlers and preschoolers". Data analysis and manuscript composition was conducted by myself. Valerie Carson assisted with manuscript composition and performed accelerometer data reduction, as well as assisted in manuscript revisions.

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Chapter 1: Introduction

1.1 General Introduction

The early years (birth to five years of age) represents a time of critical development for children before they transition into the school environment (Irwin, Siddiqi, & Hertzman, 2007; Sallis, Prochaska, & Taylor, 2000). This period of life represents a key window of opportunity for the promotion of lifelong healthy movement behaviours: physical activity, sedentary behaviour and sleep (Goldfield, Harvey, Grattan, & Adamo, 2012; Reilly, 2008). The settings children of the early years spend their time in can influence their movement behaviours.

Children of the early years spend the vast majority of their time in home and child care settings (Gubbels, Van Kann, de Vries, Thijs, & Kremers, 2014). Factors within the home setting, where children of the early years spend most of their time, can have a major influence on movement behaviours (Beckwith & Parmelee, 1986; Sallis & Nader, 1998). A number of children are not under 24 hour parental care within the home. Therefore, factors within the child care setting can also influence movement behaviours (Bushnik, 2006). Lack of healthy movement behaviours in one or both these settings may contribute to overweight and obesity.

Childhood overweight and obesity has reached epidemic proportions, even in the early years (WHO, 2013). Childhood overweight and obesity has been linked to many short- and long-term negative health consequences (Reilly et al., 2003). Energy imbalance is thought to be a major contributor to the obesity epidemic (Ekelund, Hildebrand, & Collings, 2014). Therefore, the promotion of numerous modifiable behaviours, related to energy expenditure, in the early years can help to prevent childhood overweight and obesity.

Some important health behaviours to promote for overweight and obesity prevention, related to energy expenditure, are regular physical activity, minimal sedentary behaviour, and sufficient sleep. With the initiation of ambulation, children of the early years begin forming movement habits related to physical activity and sedentary behaviour (Goldfield, Harvey, Grattan, & Adamo, 2012; Reilly, 2008). Additionally, as infants (birth to 18 months) transition to toddlerhood (19 to 35 months) sleep habits begin to stabilize (Galland, Taylor, Elder, & Herbison, 2012). Movement behaviours are interdependent; therefore, when one increases or decreases, another movement behaviour must correspondingly decrease or increase. Emerging research in the early years, primarily in preschool children (aged 36 to 60 months), has observed low physical activity, inadequate sleep, and high sedentary behaviour; which may have major health implications (Iglowstein, Jenni, Molinari, & Largo, 2003; Matricciani, Olds, & Petkov, 2012; ParticipACTION, 2015). However, many gaps and limitations exist, especially in the Canadian literature in regards to physical activity, sedentary behaviours, and sleep in toddlers and preschoolers, and their associations with overweight and obesity. This thesis has specifically been designed to address a number of these gaps and limitations in order to begin to lay the groundwork for future intervention work.

1.2 Objectives

The overall objective of this thesis was to quantify levels of movement behaviours and determine how they are related to BMI z-scores in toddlers and preschoolers, while considering the influence of demographic variables. This thesis consists of two manuscripts with the same sample of toddlers and preschoolers aged 19 to 60 months who attended child care centres in Alberta, Canada.

The objectives of manuscript one were to: (1) describe objectively measured physical activity, sedentary time, and sedentary bouts during child care and (2) examine if levels of physical activity, sedentary time, and sedentary bouts during child care differed between child sex, child age, and parental immigration status groups.

The objectives of manuscript two were to: (3) describe objectively measured body mass index (BMI), (4) examine if levels of movement behaviours within and outside child care were associated with BMI, and (5) examine if the relationship between movement behaviours within and outside of child care and BMI were moderated by child sex, child age, and parental immigration status.

1.3 Definitions of Key Terms

Physical activity is any bodily movement produced by skeletal muscles that results in energy expenditure above the resting metabolic rate (Caspersen, Powell, & Christenson, 1985). Physical activity can be thought of in terms of frequency, intensity, time and type of activity (or FITT) (ACSM, 2013). Frequency consists of the amount of times one engages in physical activity, which could be looked at over a week, day, hour, minute, or another interval. Intensity refers to the work rate, effort level, or metabolic demand. Different intensities of physical activity are often defined based on metabolic equivalents (METs). One MET is equivalent to the resting metabolic rate in terms of oxygen consumption (3.5 mlxkg-1xmin-1), with more intense activities expressed as a multiple of this resting MET value (Burton & Edholm, 1955; LaGrange, 1890). Among children, light-intensity physical activity (LPA) is typically defined as 1.5 to <4 METs, moderate-intensity physical activity would be 4-6 METs, and vigorous-intensity physical activity would be >6 METs (Trost et al., 2011) . Often moderate- and vigorous-intensity physical activity are combined to create a moderate- to vigorous-intensity physical activity (MVPA) variable. Examples of LPA include standing, or walking slowly. Examples of MVPA include walking briskly, jogging, or running. Time, or duration, is the volume of activity. Lastly, type of activity refers to what is occurring while the activity is being completed; for example riding a bike, playing tag, or dancing.

Sedentary behaviour (from the Latin *sedere*, "to sit") refers to any waking activity characterized by an energy expenditure $\leq$ 1.5 metabolic equivalents in a sitting or reclining posture (SBRN, 2012). Complementing the physical activity FITT principle is the sedentary behaviour SITT principle, which stands for sedentary behaviour frequency, interruptions, time, and type (Tremblay, Colley, Saunders, Healy, & Owen, 2010). The frequency of sedentary bouts refers to the number of continuous intervals of sedentary behaviour that occur and sedentary behaviour interruptions are what separate the bouts. Time refers to the total duration spent sitting or lying. For example, if someone were to watch television for an hour and get up each time commercials played (every 13 minutes), this would produce approximately 4 sedentary bouts lasting 13 minutes each. The sedentary behaviour interruptions would be each time the person got up, and time would be the total duration of sitting (52 minutes=4 bouts×13 minutes). Type refers to the mode of sedentary behaviour. This can be broadly broken into screen based and non-screen based sedentary behaviour. Screen based sedentary behaviour could include computers, video games or television. Non-screen based sedentary behaviour could include being safely retrained in a high chair, stroller, car seat; or quietly sitting. It is important to note that total sedentary behaviour and bouts are often measured with motion sensors, such as accelerometers, which define sedentary behaviour by no/low movement but not necessarily by the posture of sitting/lying.

The state of sleep can be defined from a neurochemical, neuroelectrical, or subjective standpoint (Buysse, Reynolds Iii, Monk, Berman, & Kupfer, 1989). Sleep is subjectively experienced as a loss of conscious awareness (Brown, Basheer, McKenna, Strecker, & McCarley, 2012). The two main components of sleep are quality and quantity. Sleep quality in the early years it typically defined by sleep latency and night waking (Galland et al., 2012). Sleep quantity is often defined as the total amount of sleep in a 24-hour period, which can further be broke down into daytime and nighttime sleep (Galland et al., 2012). During a 24-hour day, children aged 0-5 years generally sleep in shorter daytime (i.e., napping) bouts and longer nighttime bouts.

The idea of movement behaviours considers movement on a continuum from no/low intensity (i.e., sleep/sedentary behaviour) to vigorous intensity (i.e., vigorous-intensity physical activity) (Carson, Faulkner, Sabiston, Tremblay, & Leatherdale, 2015). The conception of movement behaviours largely stems from the predominant research in moderate- to vigorous-intensity physical activity, while other movement behaviours which occur over the day were ignored (Chaput, Carson, Gray, & Tremblay, 2014). Considering MVPA accounts for <5% of the 24-hour day, this limits our understanding of how all movement behaviours impact health (Chaput et al., 2014). The distribution of movement behaviours over a 24-hour day is finite, so increasing/decreasing one movement behaviour leads to a subsequent decrease/increase in a different movement behaviour. For example, increasing sedentary behaviour by an hour in a day would require a decrease in sleep and/or physical activity to compensate.

Overweight or obesity refers to excessive fat/adipose tissue accumulation that presents a risk to health (WHO, 2013). Various tools and techniques exist to measure overweight and obesity status. One such measure is body mass index (BMI), which is a simple index of weight-for-height that is commonly used to classify underweight, normal weight, overweight and obesity in adults. It is defined as the weight in kilograms divided by the square of the height in metres (kg/m^2) (WHO, 2013). Growth in children is rapid but has phases that are age and sex dependent, so it is developmentally appropriate to use age- and sex-specific percentiles to define overweight and obesity.

The United Nations defines children as “a human being below the age of 18 years” (Unicef, 1989). Subcategories of children include: early childhood (prenatal to eight years old) (Irwin et al., 2007), the early years (0-5 years old) (Sallis et al., 2000), and school-aged children and adolescence (6–17 years) (Kail, 2012). The early years can be further divided in three main age groups: infants (birth-18months), toddlers (19-35 months), and preschoolers (36-60 months). This thesis focuses on toddlers and preschoolers who have begun ambulation (i.e., walking).

Child care centres in Alberta are licensed settings that seven or more children attend in order to receive non-parental care. Full time care refers to four or more hours per day (Government of Alberta, 2013a). While in child care, there is a maximum amount of children allowed in groups and also a ratio of staff members to children that must be adhered to (Table 1) (Government of Alberta, 2013a). However, when children are sleeping the ratios used can be halved (i.e., infants 12-18 months 1:8) (Government of Alberta, 2013a). Child care centres must also ensure outdoor play space is within walking distance and can accommodate at least 50% of child care capacity (Government of Alberta, 2013a). Additionally, within Alberta child care centres, an accreditation process is available. The accreditation process uses current research and leading practice to generate standards of excellence to provide high quality child care, in addition to the provincial licensing regulations. Comprehensive self-assessment and quality enhancement activities enable child care programs to achieve and maintain high quality of care for children in

Alberta (Government of Alberta, 2013b). As of 2011, 96% of licensed day cares and regulated day homes were either accredited or in the process of accreditation (Government of Alberta, 2011).

Table 1: Ratios and maximum group size

Age of Children	Staff to Children Ratio	Maximum Children in a Group
Infants ≤ 11 months	1:3	6
Infants 12-18 months	1:4	8
Toddlers 19-35 months	1:6	12
Preschoolers 36-53 months	1:8	16
Preschoolers ≥54 months	1:10	20

A determinant is a risk factor (or set of risk factors) that forms a causal relationship with behavioural or health indicators. In complex diseases/conditions with multifaceted etiologies, such as overweight and obesity, sets of determinants (e.g., sleep, sedentary behaviour, and physical activity) often act in concert in long-term and complicated pathways (Porta, 2014). This is not to be confused with correlates, which refers to the degree variables change together, or how much variables (two or more) are related (Porta, 2014). The major difference between the two is that determinants imply a causal relationship, whereas correlates do not.

A moderator is a variable that directly affects the strength and/or direction of the relationship between two variables. One common way to statistically test whether a variable is a moderator in a regression analysis is to introduce an interaction term. For example, to statistically test whether age moderated the relationship between physical activity and BMI, an interaction term (age multiplied by physical activity) could be added into a regression model. If statistically significant at an a priori level (e.g., p-value <0.05), stratified analyses based on age should be conducted when examining the relationship between physical activity and age.

Multilevel modeling has many different names, such as random-coefficient models, mixed-effect models, nested models, multilevel regression models, hierarchical linear models, and multilevel covariance structure models. A multi-level model is a statistical model that accounts for variance at more than one level. This allows for the correct analysis of hierarchical data (e.g., individual and area-level factors) or clustered data (e.g., children clustered in schools, repeated measures of the same children) (Heck et al., 2014). In this thesis, multi-level modeling is used to account for the clustering of children in child care centres. As a result, centre-to-centre variability can be separated from individual-to-individual variability of measurements.

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Chapter 2: Review of Literature

2.1 Early Childhood

Early childhood is seen as the most important developmental phase throughout the lifespan (Irwin, Siddiqi, & Hertzman, 2007). Early childhood consists of key transition phases such as prenatal development (fertilization to birth), the early years (0 to 5 years of age), and the commencement of formal schooling (5-6 years) (Sallis, Prochaska, & Taylor, 2000b). Growth during early childhood is marked by rapid physical, emotional, and cognitive development; which strongly influences lifelong well-being (Irwin et al., 2007). What happens to a child in early childhood shapes their lifelong developmental trajectory (Wadsworth, 1997). The early years, which includes infant (0 to 18 months), toddler (19-35 months) and preschool (36-60 months) age groups, are critical for the development of healthy movement behaviours (i.e., physical activity, sedentary behaviour, and sleep) that can determine both immediate and future health risk (Goldfield, Harvey, Grattan, & Adamo, 2012; Reilly, 2008). These behaviours are often influenced by the settings children spend their time in.

2.2 Settings

Behaviour settings include the physical situations in which behaviour takes place, and it has been argued that these situations can predict behaviour better than individual characteristics (Barker, 1968). This concept has been applied to physical activity and recently sedentary behaviour (Owen et al., 2011; Spence & Lee, 2003). For example, neighbourhood, recreation, transportation, workplace, school, and home environments are thought to be important behavioural settings for sedentary behaviour across the lifespan. A unique feature to children of the early years, is they are typically exposed to a limited number of settings, with the most common being the home and child care settings (Gubbels, Van Kann, de Vries, Thijs, & Kremers, 2014).

Children of the early years spend the majority of their time in the home setting; therefore, it is an important behavioural setting to consider when examining movement behaviours in this age group (Sallis & Nader, 1998). Parental influences are a key feature of the home setting, especially for children of the early years who have limited autonomy from their parents (Vaughn, Hales, & Ward, 2013). For example, one study found that higher parental support for physical activity within the home setting was associated with higher durations of moderate- to vigorous-intensity physical activity (Ostbye et al., 2013).

Though children spend the majority of time in the home setting, child care settings are an optimal setting for the promotion of healthy movement behaviours based on the number of reachable children. For instance, in 2011, 54% of children aged zero to four years were in non-parental care across Canada. This equates to approximately 70,000 children in Alberta Canada (Friendly, Halfon, Beach, & Forer, 2013). Across Canada, the majority of children are in child care for at least 30 hours/week (Sinha, 2014). Similar to Canada, many other developed countries have a high prevalence of child care attendance, such as Denmark (75%) (Kamper-Jørgensen, Wohlfahrt, Simonsen, & Benn, 2007), the United States (50%) (Hurwitz, Gunn, Pinsky, & Schonberger, 1991), and Australia (61%, 71% and 96.3% of 1, 2-3, and 4-5 year olds) ((ABS), 2011). Therefore, both home and child care settings are pivotal in promoting movement behaviours that optimize health and prevent adverse health consequences (e.g., obesity) in the early years.

2.3 Childhood Overweight and Obesity

2.3.1 Prevalence

Childhood overweight and obesity is considered a worldwide public health epidemic as rates have nearly doubled worldwide over the past 20 years (Ebbeling, Pawlak, & Ludwig, 2002). In Canada, childhood overweight and obesity more than doubled over the span of 25 years (Shields, 2006), and as of 2012, 31.5% of children aged 5 to 17 were considered overweight or obese (Roberts, Shields, de Groh, Aziz, & Gilbert, 2012). Body mass index (BMI) continues to shift in a skewed fashion, making the heaviest children heavier every year (Flegal & Troiano, 2000). Overweight and obesity status is now thought to begin in early childhood and track into adulthood (Wang & Lobstein, 2006). Forty million children of the early years are considered overweight worldwide (WHO, 2013). As of 2006, the most recent national estimates available, the prevalence of overweight and obesity among Canadian children aged 2-5 years were 15% and 6%, respectively, for a combined 21% (Shields, 2006). One study found that Canadian children attending child care (aged 1.5-4 years) have a higher risk (Odds ratio: 1.65, 95% CI: 1.13-2.41) of being overweight and obese (at ages 4-10 years) (Geoffroy et al., 2013). Therefore, the early years represent a key age group to target for overweight and obesity prevention, especially among children that attend child care centres.

2.3.2 Risk

Childhood overweight and obesity status is associated with many risks related to both short- and long-term physical and psycho-social health. In the short-term, the physical health risks include asthma, cardiovascular risk factors and chronic inflammation (Reilly et al., 2003). The psychological health risks include depression, low self-esteem (Reilly et al., 2003), and attention deficit/hyperactivity disorder (Agranat-Meged et al., 2005). In the long-term, childhood overweight and obesity is associated with adulthood type 2 diabetes, hypertension, coronary heart disease, stroke, forms of cancer, asthma, polycystic ovary syndrome symptoms, and premature mortality (Reilly & Kelly, 2011). Additionally, childhood obesity is associated with an increased risk of suicide in adolescence and adulthood (Heneghan, Heinberg, Windover, Rogula, & Schauer, 2012).

2.3.3 Determinants

In a recent review, Han, Lawlor, and Kimm (2010) produced an extensive list of determinants for childhood overweight and obesity, highlighting its complexity. This list consisted of genetics, epigenetics, disease, intrauterine exposure, birth weight, timing of weight gain, diet, energy expenditure, sleep, ethnicity, geographical location, physical/social environment and socioeconomic status. Arguably, one key cause of obesity is an imbalance between energy intake and energy expenditure. The most modifiable portion of energy expenditure is activity thermogenesis, which includes physical activity and sedentary behaviour (Ekelund, Hildebrand, & Collings, 2014). Furthermore, very recent research has emerged on the importance of entire movement spectrum in a 24 hour period, ranging from sleep and sedentary behaviour to vigorous-intensity physical activity, and the concurrent associations between movement behaviours and childhood overweight and obesity (Chaput, Carson, Gray, & Tremblay, 2014). Therefore, physical activity, sedentary behaviour and sleep are important modifiable determinants of adiposity to consider in the early years for overweight and obesity prevention.

For the purpose of this thesis a scoping review was performed to determine the consistency in the relationship between physical activity and adiposity, sedentary behaviour and adiposity, as well as sleep and adiposity in May/June, 2015. Medline via OVID was searched for relevant articles. Search terms for movement behaviours included the following and all derivatives: physical activity, sedentary behaviour, sleep, and nap. Search terms for adiposity included the following and all derivatives: obesity, overweight, adiposity, waist circumference, BMI, skinfold thickness, bio-electrical impedance, and DEXA. Age filters were applied in hopes of limiting search to only children of the early years. A total of 1415 studies were found in the initial search, of which 79 studies assessed the association between a movement behaviour and adiposity. Associations with four or more studies (Sallis, Prochaska, & Taylor, 2000a), were assessed for consistency by tallying the number of studies containing significant findings and in what direction. Consistency was defined as no association (0-33% of studies supporting association), inconsistent association (34-59% of studies supporting association), and consistent positive/negative association (60-100% of studies supporting association in positive/negative direction) (Sallis, Prochaska, & Taylor, 2000a). Consistency is one of Bradford Hill's criteria for causation used as a guide in epidemiological research for distinguishing between causal and non-causal relationships (Hill, 1965). If an association is repeatedly observed in different settings, at different times, and in different people, one should have more confidence in that effect (Hill, 1965). Though Hill has other criteria for causality, consistency it is the most common criteria assessed in scoping reviews, which are investigating movement behaviours in young people (Sallis, Prochaska, & Taylor, 2000a).

The relationship between physical activity and adiposity measures in children of the early years is gaining increasing attention. Based on the scoping review conducted for this thesis, a total of 42 studies (See Appendix 1) were identified in the review, including three studies with infants (0-18 months), five studies with toddlers (19-35 months), and 38 studies with preschoolers (36-60 months) (see Table 1). Since only three studies examined this relationship in infants, consistency was not assessed. A consistent negative association was found between physical activity and adiposity measures in toddlers, with 3 out of 5 studies showing a negative association. For preschoolers an inconsistent association was found with 2 out of 38 studies showing positive association, and 13 out of 38 studies showing a negative association.

Date of publications ranged from 1981-2014 and sample size ranged from 26 to 7805 Studies included were primarily from the United States (18/43), but also included the United Kingdom (8/43), other European countries (9/43), Asia (4/43), and Australia & New Zealand (4/43). No studies were found from Canada. Every study reviewed used an objective measure of overweight/obesity, and 33/43 used objective measures of physical activity. Of the 43 studies reviewed, infants and toddlers were underrepresented with only 3 and 5 studies each. Infants and toddlers are an important group to consider, based on their rapid development and habit formation. Additionally, though a number of studies showed consistent null findings in preschoolers, no studies were conducted in Canada. Therefore, additional research in Canada is needed in these age groups to draw more robust conclusions about this population. Future research using a settings-based approach may provide an increased understanding of this relationship in this age group.

Table 1: Association between physical activity and adiposity measurements

	Infants (0-18 months)	Toddlers (19-35 months)	Preschoolers (36-60 months)
# of Studies[a]	3	5	38
Positive association	0	0	2
Negative association	1	3	13
No association	2	2	23
Consistency[b]	n/a	-	0

n/a = not applicable; Note: Some studies were included in multiple age groups.

[a]**Number (#) of studies**: Includes studies published up to June, 2015.

[b]**Consistency of association**: 0 no association (0-33% studies supporting association); ? inconsistent association (34-59% studies supporting association); + consistent positive association; - consistent negative association (60-100% studies supporting association) (Sallis, Prochaska, & Taylor, 2000a). Note: consistency was based on statistical significance ($P \leq 0.05$) and was only assessed when there were ≥ 4 studies (Sallis et al., 2000a).

The relationship between sedentary behaviour and adiposity measures in early years children is also gaining attention. Based on the scoping review conducted for this thesis, a total of 30 studies could be found assessing this relationship (see Table 2). Consistency could not be assessed in infants and toddlers because only one study has been conducted in infants and only three studies in toddlers. An inconsistent association was observed in preschoolers, with 13 of 27 studies showing a positive association. Of note, no studies observed a positive association between sedentary behaviour and adiposity.

Date of publications ranged from 1994-2014 and sample size ranged from 30 to 9064. The United States (15/30) represented the most researched country, followed by the Australia & New Zealand (5/30), United Kingdom (3/30), other European countries (5/30), China (1/30), and Canada (1/30). Similar to physical activity, research in this area among Canadian populations is limited. Objective measurements were used to record overweight/obesity measurements in 27 out of 30 studies. Alternatively, subjective measurements of screen-time were used in 20 out of 30 studies. Therefore, even less is known regarding the relationship between objectively measured total sedentary behaviour and adiposity in this age group. Of these 30 studies, infants and toddlers were underrepresented with only one and three studies each. Infants and toddlers represent a period of rapid development and habit formation, so it is important to continue to add to the limited research. Similar to physical activity, preschoolers made up the majority of studies found but produced inconsistent findings. The use of objective measures as well as a setting based approach could shed new light on this relationship. Additionally, exploring how the accumulation of sedentary time (e.g., bouts) impacts adiposity in this age group could provide additional insight for future interventions.

Emerging research in school-age children indicates that the patterns of sedentary time or how sedentary time is accumulated may have important implications on overweight and obesity; independent of sedentary behaviour (Carson, Stone, & Faulkner, 2014; Saunders, Chaput, & Tremblay, 2014; Saunders et al., 2013). For instance, a negative relationship between short sedentary bouts (1-4 minutes) and BMI z-scores in 8-10 year olds , which indicates that breaking up sedentary time into short bouts is beneficial (Saunders et al., 2013). Likewise, among 11 year old children with lower levels of MVPA, a positive relationship between longer sedentary bouts (≥5 minutes) and BMI z-scores has been observed (Carson et al., 2014). This again adds evidence to the hypothesis that the sedentary time which is accumulated across the day, is best accumulated in short bouts. No study to date has examined these relationships in children of the early years. Conversely, patterns of physical activity may be of less importance. Unlike physical activity guidelines for adults, it is not necessary that children accumulate physical activity in bouts for health benefits (Tremblay et al., 2012a). All sporadic physical activity throughout the day is considered important for children (Tremblay et al., 2012a). For example, one study showed that bouts of activity and sporadic activity were of equal importance in determining the cardiometabolic risk of children aged 6-19 (Holman, Carson, & Janssen, 2011).

Table 2: Association between sedentary behaviour and adiposity measurements

	Infants	Toddlers	Preschoolers
# of Studies[a]	1	3	27
Positive association	0	2	13
Negative association	0	0	0
No association	1	1	14
Consistency[b]	n/a	n/a	?

n/a = not applicable; Note: Some studies were included in multiple age groups.

[a]**Number (#) of studies**: Includes studies published up to June, 2015.

[b]**Consistency of association**: 0 no association (0-33% studies supporting association); ? inconsistent association (34-59% studies supporting association); + consistent positive association; - consistent negative association (60-100% studies supporting association) (Sallis, Prochaska, & Taylor, 2000a). Note: consistency was based on statistical significance (P≤0.05) and was only assessed when there were ≥4 studies (Sallis et al., 2000a).

There is also a growing interest regarding the relationship between sleep duration and adiposity measures in early years children. According to the scoping review conducted for this thesis, a total of 22 studies could be found assessing this relationship (see Table 3). All age groups had a consistent negative association. More specifically, 4 out of 6 studies in infants, 6 out of 8 studies in toddlers, and 20 out of 22 studies in preschoolers reported negative associations. When assessing this association, some studies used total sleep time (daytime and nighttime sleep combined) and some reported nighttime and daytime sleep separately. A consistent negative association was found in total sleep time with 10 out of 12; whereas daytime sleep had a null association with 3 out of 4 studies across all age groups. Additionally, one study that did not test the association between daytime sleep and adiposity performed a moderation analysis and found daytime sleep did not moderate the relationship between nighttime sleep and adiposity (Miller et al., 2014).

Date of publications ranged from 2002-2015. The United States (10/22) represented the most researched country, followed by the Australia & New Zealand (4/22), Asia (3/22), the United Kingdom (2/22), other European countries (2/22), and Brazil (1/22). However, no Canadian studies could be found. Similar to both physical activity and sedentary behaviour, it is unclear if the relationship between sleep and adiposity is consistent in Canadian children. Objective measurements were used to record overweight/obesity measurements in 20 out of 22 studies. Alternatively, subjective measurements of sleep were used in 19 out of 22 studies. Though current research suggests a relatively consistent association between sleep and adiposity, less is known regarding the role of daytime sleep.

Table 3: Association between sleep and adiposity measurements

	Infants	Toddlers	Preschoolers
# of Studies[a]	6	8	22
Positive association	0	0	0
Negative association	4	6	20
No association	2	2	2
Consistency[c]	-	-	-

n/a = not applicable; Note: Some studies were included in multiple age groups.

[a]**Number (#) of studies**: Includes studies published up to June, 2015.

[b]**Consistency of association**: 0 no association (0-33% studies supporting association); ? inconsistent association (34-59% studies supporting association); + consistent positive association; - consistent negative association (60-100% studies supporting association) (Sallis, Prochaska, & Taylor, 2000a). Note: consistency was based on statistical significance (P≤0.05) and was only assessed when there were ≥4 studies (Sallis et al., 2000a).

The concurrent assessment of the relationship between physical activity, sedentary behaviour, and sleep (movement behaviours) and overweight and obesity, is a very recent research topic (Chaput, Carson, Gray, & Tremblay, 2014). To this end, limited studies can be found assessing the relationship between all movement behaviours and adiposity. From the scoping reviews reported, three studies were found that measured all movement behaviours (Carter et al., 2011; C. Magee et al., 2014; Tian et al., 2010). Consequently, consistency could not be assessed. Furthermore, preschoolers were the only included age-group. This further highlights the gap in this early years age group, including the important toddler age group, who are just consistently walking and forming movement behaviour habits (Goldfield, Harvey, Grattan, & Adamo, 2012; Reilly, 2008; Worobey, 2014). Two (Carter et al., 2011; Magee et al., 2014) of the 3 studies measured adiposity objectively. One study measured physical activity and sleep objectively (Carter et al., 2011), but all other movement behaviour measurements were subjective. Subjective measurements of movement behaviours are prone to biases (e.g., recall, social desirability); therefore, future research using objective measures is needed to address this limitation. Finally, given the three studies were conducted in Australia, New Zealand, and China;

future research is needed using samples in Canada, in order to draw conclusions in this population.

2.3.4 Measurement

Since obesity is defined as excess adipose tissue accumulation that presents a risk to health, body fatness is the ideal measure for determining obesity status (WHO, 2013). Measuring body fatness, or body composition, can be performed through dual energy X-ray absorptiometry, densitometry, bio-electrical impedance, peripheral quantitative computed tomography, and multicomponent models (Lohman, Hingle, & Going, 2013). However, these methods are often seen as impractical in population-based research (Reilly, 2010). Alternatively, skinfold measurements can be used to predict body composition in population based studies. However, these predictions have shown to lack accuracy and the equations used to predict body composition may not be valid in populations other than from which they were derived (Wells & Fewtrell, 2006).

As Reilly (2006) proposed, a less direct measure for classifying obesity that is a surrogate measure of fatness is needed for population-based research that can meet two essential criteria: the ability to identify the children with the highest proportions of adipose tissue (generally using well established reference data) and the ability to identify those with an increased risk of disease arising from their excess adiposity. Reilly (2006) has proposed two measurement options: waist circumference and BMI.

Waist circumference identifies children with the most abdominal adiposity. Percentile reference data is available in some developed countries. For example the United States has reference data for children and adolescents 2-18 years of age (Fernández, Redden, Pietrobelli, & Allison, 2004). Additionally, Canada has reference data for children 11-18 years (Katzmarzyk, 2004). Given reference data is not available for all children of the early years, other measurements such as body mass index may be more appropriate with samples that include children less than two years.

Body mass index (BMI) is a scale commonly used in adult populations with a BMI of 25-29 and 30 and above being classified as overweight and obese, respectively. However, the BMI of children fluctuate throughout their growth and development, making the application of adult classifications impractical. To correct this, the use of standard cut-points based on age and sex have been created for children, so that they may be compared to individuals with similar development.

Several national (e.g., Center for Disease Control, the USA) and international (i.e., World Health Organization (WHO) and the International Obesity Task Force (IOTF)) standard cut-points exist. Though debate exists over which cut-offs should be used, it is generally agreed the international standards proposed by the IOTF (Cole, Flegal, Nicholls, & Jackson, 2007) and WHO (WHO, 2006; de Onis et al., 2007) should be used for prevalence studies (Rolland-Cachera, 2011). Both the IOTF reference and the WHO standard were developed from international datasets.

The IOTF reference centile curves are used for children aged 2-18 years, and were developed with a database of over 190 000 girls and boys (birth-25 years old) from Brazil, Great Britain, Hong Kong, the Netherlands, and the USA (Cole et al., 2007). These centile curves define overweight and obesity in younger ages by backtracking from adult values corresponding to a BMI of 25 and 30 kg/m^2 while using a method to normalize skewed data (Cole, 1990).

The WHO standard is applicable to children 0-5 years of age with unimpeded development since the children sampled were from environments that did not constrain growth (e.g., ample food security, received vaccinations). Though sampling from ideal conditions limits global generalizability, it does create specificity when observing obesity, since obesity arises from unconstrained growth. The standard is based on two datasets totaling 7585 children from birth to 71 months of age in the countries of Brazil, Ghana, India, Norway, Oman, and the USA (WHO, 2006; de Onis, 2006) Additionally, growth references for school-aged children and adolescents (5-19 years) have been reconstructed in order to facilitate a smooth transition between the 0-5 years and 5-19 years WHO standards (de Onis et al., 2007).

Comparing the IOTF and WHO criteria on samples of preschool children under the age of 5 yields very different results, with the IOTF reference producing a higher prevalence of overweight and obesity compared to the WHO standards (Monasta, Lobstein, Cole, Vignerová, & Cattaneo, 2011). Since the WHO standard begins at birth, while the IOTF cut-offs begin at age 2, the WHO standard must be used when measuring children under the age of 2. Another benefit to the WHO standard is that a continuous BMI z-score or percentile can be generated, whereas the IOTF standard can only determine categorical weight status groups (i.e., underweight, normal weight, overweight, obese). Generating a BMI z-score or percentile is advantageous, as nearing a cut-off for overweight/obesity can be predictive of future health risk. For instance, 8-15 year olds in the 75-84th percentile of BMI (normal weight category) were at an increased risk (Odds ratio=3.6) of hypertension 8-12 years later (Field, Cook, & Gillman, 2005). Therefore, the WHO standard is most appropriate for determining specific z-score/percentile values in children of the early years.

2.4 Physical Activity

2.4.1 Prevalence

In 2012, Canada's first Physical Activity Guidelines for the Early Years were released (Tremblay et al., 2012a). These guidelines recommend that children 1-4 should accumulate 180 minutes of total physical activity a day while progressing to 60 minutes of energetic play (i.e., moderate- to vigorous-intensity physical activity; MVPA) by age 5 years. Similarly, Australia and the United Kingdom recommend 180 minutes of total daily physical activity; however, Australia recommends this for 1-5 year olds and the United Kingdom for 2-5 year olds (Start Active Stay Active, 2011; Australian Government, 2011). Furthermore, neither the Australian or United Kingdom guidelines have a specific recommendation for MVPA (Start Active Stay Active, 2011; Australian Government, 2011). It is not necessary for children to accumulate this time in bouts for healthy growth and development; rather, all physical activity accumulated throughout the day regardless of whether it is continuous or sporadic is important. In Canada, 70% of 3-4 year old children met the 180 minutes per day recommendation (ParticipACTION, 2015). However, only 11% of children met the 60 minutes per day of energetic play recommendation (Colley et al., 2013). Similar low levels have been reported in Australia, a comparable developed nation (Hinkley, Salmon, Okely, Crawford, & Hesketh, 2012).

The recommendations within the Canadian Physical Activity Guidelines for the early years apply to the total day and are not specific to the time spent in specific settings, such as child care. No Canadian physical activity recommendations exist for child care settings. However, a group in the United States has put forward the recommendations of 120 minutes of active playtime each day, teacher led physical activity ≥2 times per day, and outdoor active playtime ≥2 times per day (McWilliams et al., 2009). Conversely, since children spend varying amounts of time in child care, the Institute of Medicine recommends providing opportunities for physical activity for at least 15 minutes per hour while children are in child care (IOM, 2011).

Similar to findings for the total day, a review of physical activity in child care concluded that low levels of MVPA were prevalent in preschoolers around the world (i.e., Belgium, Sweden, the United States, and the United Kingdom) (Reilly, 2010). This review's conclusion was based on 12 included studies, 6 of which used accelerometers, which reported less than 60 minutes per 8 hour child care day of MVPA. One recent study in Canada also observed trends of low levels of accelerometer-derived physical activity in 31 preschool children (mean age = 4.10 years, SD=0.85), attending five different child care centres in London, Ontario. More specifically, children spent 1.54 (SD=1.41) minutes/hour engaged in MVPA (Vanderloo, Tucker, Johnson, & Holmes, 2013). Apart from this one small study, no other study has reported on the prevalence of physical activity in child care centres in Canada.

Among children not meeting recommended levels of physical activity, some demographic groups may be more likely to fall into this category. For example, two reviews (Hinkley, Salmon, Okely, Hesketh, & Crawford, 2012; Hinkley, Salmon, Okely, & Trost, 2010) found that preschooler boys were consistently more active than girls. Limited research has examined sex differences in physical activity among infants and toddlers. One study involving 347 Dutch 2 year old toddlers also found that boys were more physically active than girls (Wijtzes et al., 2013). Though current research suggests that sex differences in physical activity may begin at early age, additional research is needed to confirm this. Furthermore, additional research is needed to determine if other demographics groups are at increased risk. For instance, toddlers and preschoolers living in the United States (US) with immigrant parents have been shown to have less active play compared to children with parents born in the US (Cespedes et al., 2013). Furthermore, while guideline compliance and trends of low levels of physical activity have been previously described in preschoolers, it is unknown if these trends also exist in younger age groups. Therefore, a better understanding of demographic differences of physical activity can help determine whether targeted interventions are needed to ensure all children are participating in sufficient physical activity needed to obtain health benefits.

2.4.2 Risk

Physical inactivity has been proposed to be the largest public health crisis of the 21st century (Blair, 2009). The beginning of ambulation (i.e., walking) occurs in the early years, typically as a child transitions from infancy to toddlerhood (Worobey, 2014). Physical activity habits are formed during this period that have important implications for healthy growth and development (Hills, King, & Armstrong, 2007; Timmons et al., 2012). Furthermore, these habits accompany the child throughout their lifespan (Jones, Hinkley, Okely, & Salmon, 2013; Telama et al., 2005). One prominent focus of this thesis is on the risk of physical inactivity on overweight and obesity as described previously (Section 2.3.3). It is important to note that emerging research is showing increased or higher physical activity in the early years is beneficially associated with several physical and psycho-social health indicators. A systematic review that informed the physical activity guidelines for early years identified some preliminary evidence of the positive benefits of physical activity in this age group. In particular, physical activity was positively associated with motor skill and cognitive development, bone and skeletal health, and improved measures of adiposity indicators (Timmons et al., 2012).

Though research is emerging in the relationship between physical activity and health indicators, little is known about the potential moderators of this relationship. Research in older age groups have found demographic factors that moderate this relationship, including sex and age (Dyck et al., 2015; Trihn, Plotnikoff, Rhodes, North and Courneya, 2011). However, less is known about these moderating effects in the early years. One study by Niederer et al. (2012) found that age did not moderate the relationship between physical activity and BMI in a sample of Swiss 3-7 year olds. However, no other demographic moderators were explored. Determining if the relationship between physical activity and adiposity is moderated by demographic factors will enable interventions and health promotion initiatives to be effectively targeted. Given the limited evidence in this area, future research is needed to explore this relationship.

2.4.3 Measurement

Many methods and technologies exist to measure physical activity such as accelerometers, pedometers, direct observation and self- or proxy-report (Reilly et al., 2008; Sirard & Pate, 2001). The most convenient measure is self- or proxy-report, based on the low cost, non-invasive nature, ease of administration & interpretation, and lack of burden to the participant (Oliver, Schofield, & Kolt, 2007). However, since this measure is subjective in nature, it is prone to inaccuracies due to self- or proxy-report bias (Noland, Danner, DeWalt, McFadden, & Kotchen, 1990). This introduced bias manifests itself in questionnaires over-estimating physical activity when compared to objective measures (Adamo, Prince, Tricco, Connor-Gorber, & Tremblay, 2009.

The gold standard of objective measurements of physical activity in field settings is the accelerometer (Esliger, Copeland, Barnes, & Tremblay, 2005; Westerterp, 2009). An accelerometer is a tool that measures the acceleration of bodily movement, which is used to estimate the intensity, frequency and/or duration of physical activity (McClain & Tudor-Locke, 2009). Traditionally movement in the vertical plane (up and down) of the human body has been measured with the accelerometer, but newer accelerometers are composed of multiple sensors, which can measure accelerations in a combination of the vertical (up and down), sagittal (forward and backward), and/or frontal (side to side) axis's of motion (Chen & Bassett, 2005). The basic premise of an accelerometer is to record these accelerations. Accelerations are converted to an electric signal called a count, which is stored and recorded over a period of time called an epoch. Epochs can range from less than 1 second to 60 seconds. Determining when the individual was not wearing the accelerometer (non-wear time) and removing this data, so that it is not misinterpreted as sedentary time, occurs next. Then raw data counts per epoch are interpreted with a series of thresholds or cut-points, which group the counts into calibrated estimates of physical activity intensity, representative of particular energy expenditures. Further methods are applied throughout the data refining process in an attempt to most accurately estimate intensity, duration, and frequency of movement (McClain & Tudor-Locke, 2009). Accelerometry strikes an excellent balance between feasibility, and validity (Trost, 2007).

When using accelerometers to measure physical activity there are some key data collection and reduction procedures that need to be made, including accelerometer brand, epochs, non-wear time, and cut-points. Accelerometer brand and epochs can be seen as data collection decisions, whereas non-wear time and cut-points can be seen as data reduction decisions.

The first data collection choice is determining which accelerometer to use. Accelerometers predominantly seen in research consist of the ActiGraph [ActiGraph LLC, Pensacola, FL, USA] and Actical [Mini Mitter Co., Inc., Bend, OR, USA] brands. One review found 77% of accelerometers used from 2005-2010 were ActiGraphs (Cain, Sallis, Conway, Van Dyck, & Calhoon, 2013). However, in Canada Actical has been the accelerometer of choice for determining the national prevalence of physical activity and sedentary behaviour for the

Canadian Health Measures Survey (Colley et al., 2013). Acticals are a lightweight (0.5 ounces), small (1" square), water-proof, omnidirectional, brand of accelerometers. Actical accelerometers have been deemed reliable and valid in measuring preschoolers' physical activity and sedentary behavior (Cliff, Reilly, & Okely, 2009; Pate, O'Neill, & Mitchell, 2010). For example, Actical accelerometer counts have demonstrated high inter-instrument reliability coefficient (R=0.92) and Spearman correlation coefficient (r=0.89) with portable metabolic measures of oxygen consumption (Pfeiffer, Mciver, Dowda, Almeida, & Pate, 2006).

The advances in accelerometer brand choice technology have given the second decision for data collection, choosing a suitable epoch length, more options. Traditionally, the epoch length of 60 seconds dominated research because of the limited capacities of early accelerometers to record and store data (Ward, Evenson, Vaughn, Rodgers, & Troiano, 2005). With advances in technology shorter epochs are now feasible. As a result, researchers must decide on what epoch length to use when collecting accelerometer data. Shorter epochs are recommended for measuring physical activity in the early years due to the sporadic and intermittent nature of physical activity patterns (Ward et al., 2005). Using larger epochs could misclassify intensity of movements when averaged over a minute, since short bouts of high-intensity physical activity could be combined with bouts of low intensity activity (Cliff et al., 2009). For example, if a child stands up and runs for 10 seconds and sits down and colours for 50 seconds, this could be considered sedentary if averaged over a minute but vigorous and sedentary if averaged over 15 seconds. Recently, it has been shown that when comparing 15 second epochs to 30 second epochs, 15 second epochs captured more moderate-to-vigorous physical activity and sedentary time but less light and total physical activity (Colley, Harvey, Grattan, & Adamo, 2014). A 15 second epochs is now the most commonly used epoch length among children of the early years, primarily because this is the shortest epoch where validated cut-points exist (Cliff et al., 2009).

The first decision to make regarding data reduction is to determine criteria to exclude non-wear time. This is done by defining a consecutive amount of zero counts that seems implausible for a child to sit motionless. Non-wear time definitions have shown to impact sedentary behaviour measurements but have less impact on MVPA measurements (Winkler et al., 2012). One common definition of excluding non-wear time in the early years is to remove sequences of consecutive zero counts ≥ 20 minutes (Esliger et al., 2005).

The second data reduction decision is based on classifying counts into cut-points. Without interpretation of raw counts, the values measured with accelerometry are meaningless. This is because raw counts are unit-less and dimensionless (Chen & Bassett, 2005). In order to attach significance to the raw counts they must become a representation of intensity. Several validity studies have been conducted to determine activity intensities (e.g., light-intensity, moderate-intensity, vigorous-intensity), based on energy expenditure or direct observation (Cliff et al., 2009). The issue of deciding on a cut-point can be complicated because there are several cut-points available and there is not universal agreement on which ones to use. For Actical accelerometers, there are only two sets of cut-points that differentiate LPA from MVPA that have been validated in the preschooler age range, but none in the toddler age range (Adolph et al., 2012; Pfeiffer et al., 2006). The first is 750 cpm, which is proposed by Pfeiffer and colleagues (Pfeiffer et al., 2006). The second is 1,150 cpm, which is proposed by Adolph and colleagues (2012). The 1,150 cpm cut-point has shown significantly greater classification accuracy compared to other Actical accelerometer cut-points in preschoolers (Janssen et al.,

2015) and this is the cut-point used by Statistics Canada in the Canadian Health Measures Survey (Colley et al, 2013).

The accelerometer has a number of advantages as well as limitations. One advantage of the accelerometer is its reliability and accuracy over self/proxy-report and pedometers, and is relatively less burdensome and costly than methods such as direct observation (Trost, 2007). Another advantage accelerometer's have over other objective physical activity measurement estimates (e.g., pedometers) is that it can provide information of frequency, intensity and duration of physical activity. Lastly, accelerometers time-stamp their data, so what time of day activity has occurred can be known. This is helpful when examining physical activity in specific settings. However, accelerometers alone cannot provide context to the activity they are measuring, which is a key limitation. Additionally, accelerometers are not accurate at detecting all activities (e.g., bicycling and swimming), or non-ambulatory movements (e.g., sitting but lifting something). Furthermore, some issues arise in the validity of using accelerometers in the early years. For instance, infants do not begin to consistently walk until typically 18 months, instead using a mixture of crawling, creeping, and walking (Worobey, 2014). This complicates measurement, since an accelerometer was designed to capture ambulatory movement. This likely explains why no validated accelerometer protocol exists for infants. Consensus is also lacking for a standardized methodology in which accelerometer data is collected and reduced in all age groups, including early years children (Pate et al., 2013). Accelerometers also produce a large volume of data that requires someone to check, clean, classify, and summarize (Sallis, 2010). Lastly, accelerometers are relatively expensive and burdensome to participants compared to other physical activity measurement tools (Oliver et al., 2007).

2.5 Sedentary Behaviour

2.5.1 Prevalence

Along with the physical activity guidelines in March, 2012 the first Canadian Sedentary Behaviour Guidelines for the Early Years (Aged 0-4 years) was released (Tremblay et al., 2012b). The guidelines recommended that sedentary behaviour should be minimized. Specifically, it recommended limiting prolonged sitting to under an hour at a time, no screen time in children under 2 years, and under an hour/day screen time in children 2-4 years. This is in line with Australian guidelines (Australian Government, 2011); however the United Kingdom does not offer specific advice instead opting to broadly recommend limiting sedentary behaviour, especially in prolonged bouts (Start Active Stay Active, 2011). For screen time, only 18% of children aged 3-4 in Canada met recommendations in a national study (Colley et al., 2013). Furthermore, 32% of children younger than two years and 46% of children 2-4 met the recommendations of the guidelines in a sample of Ontario children (Carson, Tremblay, Spence, Timmons, & Janssen, 2013). Similar low levels of guideline adherence have been reported in Australia (Hinkley et al., 2012). No national sedentary behaviour guidelines exist within child care centres. Best-practice guidelines have been proposed by one groups in the United States which recommend children not be seated for more than 30 minutes at a time, and limiting the amount of screens available and watched (McWilliams et al., 2009).

Similar to when looking at data for the total day, emerging research suggests children may also engage in high levels of sedentary behaviour while in child care settings. One recent study in Canada observed high levels of sedentary behaviour in 31 preschool children (mean age= 4.10 years, SD=0.85), attending five different child care centres in London, Ontario, Canada (Vanderloo et al., 2013). Accelerometer measurements recorded children spending 40.64

(9.11) minutes/hour engaged in sedentary time (Vanderloo et al., 2013). Apart from this one small study, no other study has reported on the prevalence of sedentary behaviour in child care centres in Canada.

In line with physical activity, some demographic groups may be at increased risk of high sedentary behaviour. For instance, differences in sedentary behaviour may exist based on sex. Two reviews (Hinkley et al., 2012; Hinkley et al., 2010) found that in preschoolers girls tend to engage in more sedentary behaviour than boys. However, no sex-differences were observed for TV viewing. A more recent cross-sectional study of 331 children aged 3-5 attending preschools in the USA, found that girls were more sedentary than boys (Byun, Dowda, & Pate). Lastly, a study involving 347 Dutch 2 year old toddlers also found that boys were less sedentary than girls (Wijtzes et al., 2013). Though a trend for girls to be more sedentary than boys appears to be emerging, more research is needed to determine at what age this difference begins. Differences may also exist for first generation children whose parents have immigrated to a new country. For example, a study in toddlers and preschoolers showed that children living in the United States (US) with immigrant parents engaged in less screen time compared to children with parents born in the US (Cespedes et al., 2013). It is unknown if this is similar for Canadian immigrant families. Lastly, differences in sedentary time between toddlers and preschoolers are difficult to determine, based on the lack of information in the toddler age range. In order to effectively deliver interventions and public health initiatives to children of the early years it is important to determine if some demographic groups are more vulnerable and thus require more immediate resources. Furthermore, determining differences in age can help to determine what age is best to intervene. Further efforts to understand the differences in sedentary behaviour among children of the early years are needed.

2.5.2 Risk

Independent of physical activity, there is accumulating evidence that sedentary behaviour has important health implications (Tremblay et al., 2011). Decreasing sedentary behaviour can aid in lifelong healthy growth and development of early years children (Hills et al., 2007; LeBlanc et al., 2012). The formation of healthy sedentary behaviour habits can accompany the child throughout their lifespan (Jones et al., 2013). The risk of sedentary behaviour on overweight and obesity is a key focus in this thesis and has been described previously (Section 2.3.3). Aside from adiposity measures, the importance of reducing sedentary behaviour for physical and psycho-social health benefits is gaining attention. The association between sedentary behaviours and health indicators was explored in a systematic review that informed the early years guidelines (LeBlanc et al., 2012). Though evidence is still emerging, the review concluded that increased sedentary time in early years children was associated with unfavourable measures of adiposity, psychosocial health, and cognitive development (LeBlanc et al., 2012).

While research into the relationship between sedentary behaviour and health indicators is emerging, potential moderators of these relationships are still largely unknown. Though 30 studies examining the relationship between sedentary behaviour and obesity were found in a scoping review in section 2.3.3, none of the studies examined whether demographic factors moderated the relationship. If effective interventions and public health initiatives are to be created, it should be determined if demographic variables need additional consideration. Given the limited evidence in this area, future research is needed to explore this relationship.

2.5.3 Measurement

The measurement techniques for sedentary behaviour are very similar to the measurement techniques for physical activity as described in detail in section 2.4.3. Sedentary behaviour is often assessed via questionnaire. Typically questionnaires measure screen-based sedentary behaviour. This is reflected in Canadian Sedentary Behaviour Guidelines for the Early Years, where specific evidence-informed recommendations are only available for screen time. As mentioned (see 2.4.3) the use of subjective measures contain self- or proxy-report bias, which create measurement inaccuracies compared to objective measures.

Currently, there is limited ways to objectively measure screen time. Accelerometers are becoming more popular to objectively measure total sedentary behaviour, as well as bouts of sedentary behaviour. Two main cut-points are used in early years children to define sedentary behaviour using accelerometers. First, the Canadian Health Measure Survey uses a cut-point of 100 counts/minute to classify sedentary behaviour in early years children (Colley et al., 2013). Based on a validation study, the use of 100 counts/minute maximized sedentary and non-sedentary classification accuracy, compared to other cut-points in a sample of 6-12 year olds (Wong, Colley, Connor Gorber, & Tremblay, 2011). The second cut-point proposed by Adolph (2012), classifies sedentary behaviour as 25 counts/minute. This was based on validation using heart rate, in-room calorimetry, and direct observation in children aged 3-5 years (A. L. Adolph et al., 2012). One point of interest is that no cut-point has been validated in toddlers. Unlike physical activity, there is more widespread agreement on the use of the 100 counts/minute cut-point to define sedentary behaviour in all age groups. Sedentary bouts are measured by looking at the consecutive time spent sedentary, or consecutive time spent in particular bout lengths (e.g., 1-5 minute bouts, 6-10 minute bouts). This is an area gaining attention in school-age children (Valerie Carson et al., 2014; Saunders et al., 2013) and preschool children (Valerie Carson, Salmon, Crawford, Hinkley, & Hesketh, 2015), however no research currently exists looking at children under three years. Unique limitations exist with the accelerometer when measuring sedentary behaviour. First, an accelerometer is not sensitive enough to distinguish between postures (e.g., lying, standing, sitting). The definition for sedentary behaviour involves a sedentary posture (e.g., sitting, lying). So, misclassification of sedentary behaviour may occur when a child is in an active posture (e.g., standing) but motionless, instead of a sedentary posture (e.g., sitting) and motionless. The use of inclinometers, which are worn on the thigh, may provide better measures of posture change in order to more accurately distinguish between sedentary and non-sedentary time (Ridgers et al., 2012). However, young children often sit in postures that even the inclinometer cannot distinguish between sitting and standing (e.g., sitting on knees). Second, as briefly described in section 2.4.3, wear time definitions can greatly impact sedentary behaviour estimates. If a wear time definition is too liberal it can under-estimate sedentary behaviour, whereas if a wear time definition is too conservative it can over-estimate sedentary behaviour (Winkler et al., 2012).

2.6 Sleep

2.6.1 Prevalence

The pattern of sleep changes rapidly during infancy and begins stabilizing across childhood (Gruber et al., 2014). In Canada no guideline exists for sleep in children of the early years. However, the Canadian Sleep Society did release a position statement for pediatric sleep, which makes recommendations for children aged 1-2 years (12-14 hours), 2-3 years (12-14 hours), and 4-5 years (11-13 hours) (Gruber et al., 2014). Unfortunately, there is no published Canadian national data in early years children to compare this to.

Sleep duration among children of the early years can be broken into nighttime and daytime sleep. In children aged 1-2 years, the majority of sleep occurs during the night, and the remainder is supplemented by 1-2 daytime naps totaling 2.4-1.8 hours (Galland et al., 2012; Iglowstein, Jenni, Molinari, & Largo, 2003). Children aged 3-4 years continue to increase nighttime sleep while decreasing daytime sleep and obtain 1.7-1.5 hours of daytime sleep per day (Iglowstein et al., 2003). As children age, sleep becomes more consolidated into nighttime sleep. For example, around 18 months of age children typically go from two naps to one nap, while increasing nighttime sleep (Iglowstein et al., 2003). In fact, at three years of age 50% of children are still napping, with 35% continuing to nap until the ages of 4-5 years (Iglowstein et al., 2003). Most children at the age of five stop napping and consolidate sleep into one nighttime period (Weissbluth, 1995).

Some debate exists regarding whether total sleep duration has been decreasing over the years. Some have observed a reduction of sleep in young children between 1974 and 1986 (Iglowstein et al., 2003). A systematic review containing 690,747 children worldwide has also shown consistent and rapid decreases in sleep duration over the past century (Matricciani et al., 2012).

2.6.2 Risk

It is alarming if sleep is in fact on the decline because of the associated adverse health risks with curtailed sleep. Sleep is pivotal for a child's ability to cope with stress, regulate emotions, socialize and be productive (Gruber et al., 2014). Additionally, insufficient sleep can have negative impacts on daytime behaviour, cognitive development, and later in life academic performance (Curcio, Ferrara, & De Gennaro, 2006; Scher, 2005; Touchette et al., 2007). In addition to the association between insufficient sleep and obesity (described in section 2.3.3), sleep is also necessary for efficient immune responses, cardiovascular health and prevention of injuries (Knutson, Spiegel, Penev, & Van Cauter, 2007).

Though research in the relationship between sleep and health indicators is quite consistent, the role of demographic variables is unknown. Research into the moderating effects of demographic variables on the relationship between sleep and BMI in preschoolers and toddlers is lacking. In fact no studies could be found. A better understanding of demographic moderators could help create effective interventions and health promotions, which are effective across all demographic groups. If insufficient sleep has increased health risk in certain groups then tailored interventions may be optimal. Alternatively, if risk is similar across groups population health interventions and initiatives may be ideal. Given the limited evidence in this area, future research is needed to explore this relationship.

2.6.3 Measurement

Sleep can be measured in terms of quality or quantity. Quality of sleep includes measures of sleep latency, night wakings, and intensity of neuroelectrical and chemical signaling (Brown, Basheer, McKenna, Strecker, & McCarley, 2012). Sleep quality can be measured objectively by blood sampling, polysomnography, videosomnography (or other forms of direct observation) and accelerometry (Brown et al., 2012). Subjective measurements can assess sleep latency and night wakings in early years children by proxy report but they have been shown to lack accuracy (J. M. Henderson, K. G. France, J. L. Owens, & N. M. Blampied, 2010). When considering the burden/price of objective measurements and inaccuracy of subjective measurements, it is problematic to measure the sleep quality of early years children in population based studies.

Quantity of sleep can be measured objectively or subjectively. Objective measures of sleep are derived from polysomnography, videosomnography (or other forms of direct observation) and accelerometery (Galland et al., 2012). Polysomnography is considered the gold-standard for objectively measuring sleep (Van De Water, Holmes, & Hurley, 2011). However, polysomnography is burdensome due to high costs, expertise required for interpretation, and requiring the child to sleep in a laboratory (Iwasaki et al., 2010). Though polysomnography has limitations, it is often necessary to accurately detect sleep disorders/diseased states (Brown et al., 2012). However, less burdensome tools can be used to measure sleep quantity in population based research, and accelerometers are the recommended objective tool (Morgenthaler et al., 2007). This recommendation is based on accelerometers reasonable validity, reliability and feasibility (Morgenthaler et al., 2007; Sadeh, 2011).

An accelerometer measuring sleep differs from an accelerometer measuring physical activity or sedentary behaviour mainly due to placement. Sleep measuring accelerometers are traditionally placed on the wrist or ankle instead of the typical right hip placement for physical activity and sedentary behaviour (Cliff et al., 2009; Sadeh, 2011). Though some studies measuring physical activity and sedentary time have used the wrist placement, there is limited research on the validity/reliability on the wrist placement in early years children (Johansson, Ekelund, Nero, Marcus, & Hagströmer, 2015). However, recently an algorithm has been developed, which shows promise for valid nighttime sleep detection based on a waist-worn accelerometer (Barreira et al., 2015). Research is still needed to distinguish daytime sleep in accelerometer measurements.

Subjective measures of sleep include sleep diaries, questionnaires, or interviews; which in early years children is based on parental report (Galland et al., 2012). Measuring bedtime and wake time with log sheet or diaries have shown a high level of agreement (97%) when compared to videosomnography (Henderson, France, Owens, & Blampied, 2010). Proxy-report questionnaires for preschoolers have demonstrated significant and moderate correlation between accelerometers and diaries ($r= 0.59$; $p<0.001$) (Iwasaki et al., 2010). Therefore, the use of questionnaires is a valid measurement tool to assess sleep duration.

2.8 Conclusion

Children of the early years experience rapid growth and development that sets the stage for lifelong health and wellbeing. Therefore, they are an important age group to target to create healthy habits. Healthy habits related to overweight and obesity prevention are of particular interest, given the current childhood overweight and obesity epidemic. Some key modifiable determinants of overweight and obesity include movement behaviours (i.e., sleep, sedentary behaviour, and physical activity). The home and child care are key settings to understand these behaviours and their relationship with overweight and obesity. However, there are several gaps and limitations in the literature that need addressing. The following two manuscripts will address some of these gaps and limitations.

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Chapter 3

Physical activity and sedentary behaviour of toddlers and preschoolers in child care centres in Alberta, Canada

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3.1 Abstract

Objective: To describe duration of physical activity and duration and bouts of sedentary behaviour during child care in a sample of toddlers and preschoolers (19-60 months) from Alberta, Canada, and to examine if duration and bouts differed between age, sex, and parental immigration status groups.

Methods: One-hundred and fourteen children, aged 19-60 months from eight child care centres throughout Alberta participated. Data were collected at baseline of a study examining revised Alberta Child Care Accreditation Standards. Duration of physical activity (light (LPA), moderate-to-vigorous (MVPA)) as well as duration and bouts (1-4, 5-9, 10-14, and >15 minutes) of sedentary behaviour during child care were accelerometer-derived using 15-second epochs from October/November, 2013. Median [Interquartile ranges] and ANOVAs, accounting for the clustered nature of the data, were calculated.

Results: Minutes/hour spent in sedentary behaviour, LPA, and MVPA were 36.9 [32.9, 40.7], 18.4 [16.0, 20.9], and 4.2 [2.5, 5.6], respectively. Frequency/hour of sedentary bouts lasting 1-4, 5-9, 10-14 and ≥15 minutes were 6.7 [6.1, 7.6], 0.9 [0.6, 1.1], 0.4 [0.2, 0.5], and 0.3 [0.2, 0.4], respectively. Preschoolers participated in less sedentary behaviour and more LPA and MVPA, and had less sedentary bouts lasting 10-14 and ≥15 minutes compared to toddlers (P<0.05).

Conclusion: This is the first study in Canada study to report on the duration of physical activity and duration and bouts of sedentary behaviour among both toddlers and preschoolers attending child care centres. These findings suggest child care interventions are needed to increase MVPA and decrease total sedentary behaviour, while continuing to promote short sedentary bouts.

Key Words: Physical Activity; Child Care; Child, preschool

3.2 Introduction

Physical inactivity has been called the largest public health problem of the 21st century.[1] Emerging research indicates that sedentary behaviour may have important implications on health, independent of physical activity.[2] Low physical activity and high sedentary behaviour are associated with all-cause mortality, cardiovascular disease, type 2 diabetes, excess adiposity, and other cardiometabolic health risks.[3,4]

The early years (≤4 years of age, as defined by national guidelines)[5,6] provides a window of opportunity to establish healthy habits of regular physical activity and minimal sedentary behaviour for healthy growth and development.[7] For instance, regular physical activity is associated with enhanced motor skill and cognitive development, psychosocial health, bone and skeletal health, cardiometabolic health, and decreased adiposity in the early years.[3] Conversely, increased sedentary behaviour is associated with decreased psychosocial health, cognitive development and unfavourable adiposity in the early years.[4] Furthermore, the physical activity and sedentary behaviour patterns that are established in the early years have been shown to track moderately over time.[8] Taken together, these data suggest the possibility of an alarming future, given only 15% of Canadian children aged 3-4 years are meeting both the national physical activity and sedentary behaviour guidelines.[9]

An important setting for physical activity promotion and sedentary behaviour reduction in the early years are child care centres, given the reachability of children in these settings. For example, 54% of Canadian children, aged 0-5, are in non-parental care for an average of 29 hours/week.[10] In Alberta, Canada, this equates to almost 70,000 children in 2012.[11] Of interest, children attending child care in Canada have been found to be at increased risk of becoming overweight or obese compared to children under parental care.[12] This risk could be associated with the low physical activity and high sedentary behaviour commonly reported in child care centres in a number of developed countries (e.g., the United States, the United Kingdom, Belgium, and Sweden).[13]

There is currently little information on objectively measured physical activity and sedentary behaviour among preschool children (36-60 months of age) in Canadian child care settings. Vanderloo and colleagues measured 31 preschool children (mean age = 4.1 years, standard deviation (SD)=0.9), in five child care centres in London, Ontario, Canada.[14] They reported the children spent 1.5 (SD=1.4) minutes/hour engaged in moderate-to-vigorous physical activity (MVPA) and 40.6 (9.1) minutes/hour engaged in sedentary behaviour. However, in addition to the small sample size and limited geographical area observed, this study is also limited by the fact that children only wore the accelerometer for 1 day, which may not have captured habitual physical activity and sedentary behaviour.

Along with the limitations in the previous Canadian literature, there are several research gaps that need to be addressed. First, no study has examined objectively measured physical activity and sedentary behaviour among toddlers (19-35 months of age) within Canadian child care settings.[14] Internationally, evidence on the amount of objectively measured physical activity and sedentary behaviour toddlers participate in is also lacking.[15] Toddlers are an important population to study, in addition to preschool children, because this age group represents the beginning of ambulation.[15] Second, there is limited and conflicting evidence on the role of demographic factors (e.g., age, sex, parental immigration status) on physical activity and sedentary behaviour within child care centres. Further exploration of these demographic factors could be used for targeted interventions and initiatives to increase physical activity and decrease sedentary behaviour. Lastly, no study to date has reported how sedentary behaviour is accumulated during child care among toddlers or preschoolers (e.g., short sedentary bouts or longer sedentary bouts). Emerging research indicates that the patterns of sedentary behaviour may have important implications on health independent of total sedentary behaviour.[16]

A better understanding of physical activity and sedentary behaviour within child care settings among toddlers and preschoolers can help inform future initiatives and interventions that aim to promote regular physical activity and minimal sedentary behaviour in child care centres. Therefore, the purposes of this paper were to: 1) describe objectively measured physical activity, sedentary behaviour, and sedentary bouts during child care in a sample of toddlers and preschoolers aged 19-60 months from Alberta, Canada, and 2) examine whether duration and bouts differed between sex, age, and parental immigration status groups in this sample.

3.3 Methods

3.3.1 Participants

This study represents baseline data from the Supporting Active Living Behaviours in Alberta Child Care Settings study, which is examining the effects of revised Alberta Child Care Accreditation Standards. Child care centres in Alberta scheduled for initial accreditation during August to October, 2013 were eligible for the study. Out of the 12 centres that were eligible 8 (67%) agreed to participate. Seven centres were located in the cities of Edmonton (n=4) and Calgary (n=3), while one centre was located in a smaller city in Alberta.

All parents of children aged 19 to 60 months who attended the centre full time received a questionnaire package. Out of the 270 eligible children, 145 (54%) had a parent agree to their child's participation by returning a signed consent form and completed questionnaire. The questionnaire assessed demographics and children's physical activity and sedentary behaviour outside of child care. Four children were excluded because they were older than 60 months when their parents received the package, leaving a sample of 141 children. Data were collected between September and November, 2013. Ethics approval was obtained from the University of Alberta Health Research Ethics Board. Parents/guardians of all participating children provided written informed consent.

3.3.2 Physical Activity and Sedentary Behaviour

Accelerometers (Actical, Respironics, Bend, OR, USA), calibrated for this study, were fitted by research staff at the very beginning of the first data collection day on a belt positioned on the children's right hip. Children continuously wore the accelerometer either under or over light clothing while at the child care centre for five consecutive weekdays. Early childhood educators were asked to attach the accelerometer belts each morning when a participating child arrived and to remove the accelerometer belt at the end of each day before the child went home. Data were collected in 15 second epochs. Sequences of consecutive zero counts ≥20 minutes were deemed non-wear time and excluded from analyses.[17] Naps taken while wearing accelerometers were defined as non-wear time. Early childhood educators were given a log sheet to record each child's accelerometer on and off times, which was used to cross-reference non-wear time and to remove data points prior to the start time of the first data collection day. Consistent with previous studies in child care centres,[18,19] participants had to have ≥1 hour of wear time on ≥3 days to be considered valid and therefore included in the analyses.

Cut-points were defined based on national survey data from the Canadian Health Measures Survey[9] as follows: sedentary behaviour (<100 counts/minute; cpm or <25 counts/15 seconds), light-intensity physical activity (LPA; 100 to 1,149 cpm or 25 to <287.5 counts/15 seconds), and MVPA (≥1,150 cpm or ≥287.5 counts/15 seconds). All variables were checked for outliers (≥ ±3 SD) and one participant had their MVPA truncated to the nearest score below 3

SD. Sedentary behaviour was further classified into continuous bouts of 1-4, 5-9, 10-14, and ≥15 minutes. To account for variability in the duration each child spent at the child care centre, physical activity and sedentary behaviour variables were expressed as minutes/hour by dividing total minutes of physical activity and sedentary behaviour by total hours of wear time. All accelerometer data reduction was conducted and completed using SAS version 9.4 [SAS Institute Inc., Cary, NC].

3.3.3 Covariates

Sex (male or female), age (in months), and parental immigration status (born in Canada or not born in Canada) were assessed in the parental questionnaire.

3.3.4 Statistical Analysis

Data analyses were completed using SPSS version 21.0 [IBM Corp., Armonk, NY]. Descriptive statistics were calculated, including median and interquartile ranges (IQR). Chi-square tests examined if included and excluded (i.e., invalid wear-time and faulty accelerometers) participants differed between sex (male or female), age (toddler: 19-35 months or preschooler: 36-60 months), and parental immigration status (born in Canada or immigrated to Canada) groups. Analysis of variance models (ANOVAs) that took into account the clustered nature of the data were calculated to examine differences in sedentary behaviour, LPA, MVPA, and sedentary bouts between sex, age, and immigration status groups in three separate models. The assumption of normality for the ANOVAs was assessed by examining residuals. Sedentary bouts of 10-14 minute bouts, and ≥15 minute bouts were square root transformed to meet the assumption of normality for the ANOVA analyses. Statistical significance was set at $P<0.05$ for all analyses.

3.4 Results

Of the 141 children, valid accelerometer data were obtained for 114 children (19 excluded due to invalid wear-time, 8 excluded due to faulty monitors). On average, participants total wear time was 5.5 (1.6 SD) hours/day (See appendix 2 for more information). There were no significant differences in age, sex, and parent immigration status between the included and excluded participants. The average child age of the final sample was 38.0 months (12.4 SD), 47% were toddlers, 47% were females, and 29% had parents that immigrated to Canada.

The median minutes/hour spent in sedentary behaviour, LPA, and MVPA were 36.9 [IQR: 32.9, 40.7], 18.4 [16.0, 20.9], and 4.2 [2.5, 5.6], respectively (Table 1). The percentage of time spent in sedentary behaviour, LPA, and MVPA per hour was 61.5%, 30.6%, and 7.0%, respectively. Preschool aged children accumulated significantly less sedentary behaviour and significantly more LPA and MVPA than toddlers, but no other significant age or parental immigration status differences were observed for sedentary behaviour, LPA, or MVPA.

The median frequency/hour of sedentary bouts lasting 1-4, 5-9, 10-15 and >15 minutes was 6.7 [6.1, 7.6], 0.9 [0.6, 1.1], 0.4 [0.2, 0.5], and 0.3 [0.2, 0.4], respectively (Table 2). Therefore, over a 5.5 hour day (mean wear time) it could be approximated that this sample would accumulate 37 bouts of sedentary behaviour lasting 1-4 minutes, 5 bouts lasting 5-9 minutes, 2 bouts lasting 10-14 minutes and 2 bouts greater than 15 minutes. Compared to toddlers, preschool aged children had significantly less sedentary bouts per hour lasting 10-14 minutes and ≥15 minutes, but no other significant age, sex, or parent immigration status differences were observed for any of the sedentary bouts.

3.5 Discussion

This study described objectively measured physical activity, sedentary behaviour, and sedentary bouts and examined differences between child sex, child age, and parental immigration status groups in a sample of toddlers and preschoolers aged 19 to 60 months attending licensed child care programs in Alberta. Children spent approximately 60% of their time being sedentary and the majority of their time spent being physically active was of LPA. However, sedentary behaviour was primarily accumulated in 1-4 minute bouts, with almost no engagement in sedentary bouts longer than 15 minutes. Preschoolers participated in less sedentary behaviour, and more MVPA compared to toddlers. Preschoolers also had less 10-14 and ≥15 minute sedentary bouts compared to toddlers. To our knowledge this represents the youngest objectively measured sample of children in Canadian child care centres.

The finding that low MVPA and high sedentary behaviour were prevalent among preschoolers within child care centres in the present study is consistent with a previous review.[13] All six studies included in this review that used accelerometers had less than 60 minutes on average of MVPA during child care when extrapolated to a full child care day. Participants in the present study, who had an average 5.5 hour child care day, also had less than the 60 minutes on average.

Only one previous study has reported on objectively measured physical activity and sedentary behaviour among preschoolers in child care centres in Canada, drawing similar conclusions of low MVPA and high sedentary behaviour.[14] However, the current study overcame previous limitations by objectively measuring physical activity and sedentary behaviour for at least 3 days in a larger sample size across a broad geographical area. The use of different cut-points makes comparisons of the specific duration of physical activity and sedentary behaviour observed across studies challenging. Pate and colleagues recommended that consensus needs to be reached for a standardized methodology in which accelerometer data is collected and interpreted in this young population.[20] Therefore, the cut-points chosen for the present study are aligned with national data from the Canadian Health Measures Survey.[9] Furthermore, a recent study has shown that the ≥1,150 cpm is the most accurate Actical cut-point for classifying MVPA in young children.[21]

Currently, there are no Canadian guidelines for physical activity and sedentary behaviour within child care centres. However, there are Canadian Physical Activity and Sedentary Behaviour Guidelines for Children in the Early Years (aged 0-4 years) for the entire day.[5,6] For the physical activity guidelines it is recommended that children 1-4 years of age accumulate at least 180 minutes/day of total physical activity (LPA and MVPA) and progress to at least 60 minutes of energetic play per day (i.e., MVPA) by age 5 years to meet the guidelines for school-aged children and youth (5 to 17 years). In this sample, physical activity was predominantly accumulated in the LPA category. Limited evidence exists on the health benefits associated with different intensities of activity in children of the early years.[3] However, in school-aged children there is substantial evidence for the relationship between MVPA and health benefits, and these benefits have been observed to increase with intensity.[22,23] Thus future research is needed to explore the relationship between different intensities of physical activity and the health benefits for toddlers and preschoolers.

It is our understanding that this is the first study to measure and describe physical activity and sedentary behaviour among toddlers within child care centres internationally. Current evidence indicates that as school-age children become older they engage in more sedentary behaviour and less physical activity.[24] In this sample it was found that sedentary behaviour was lower and LPA and MVPA were higher in preschool age children compared to toddlers. Preschoolers could represent a peak in physical activity before dropping off when transitioning to school. Therefore, this age range may be an optimal point to intervene to positively reinforce these behavioural trajectories; however, longitudinal cohort studies using objective measures are needed to confirm this.[7] While no sex differences were observed in the present study, one previous study involving 3-5 year old children attending preschool in the United States observed boys engaging in more MVPA than girls but equivalent LPA and sedentary behaviour.[18] As a result further research is needed to determine when the well-known sex differences in MVPA among older children begin.[25] No study to our knowledge has examined the impact on immigration status on physical activity and sedentary behaviour during child care. While no differences were found in the present study, school-age children with immigrant parents have been shown to be at risk for physical inactivity and high sedentary behaviour as determined by questionnaires.[26] However, it cannot be determined if the difference in findings with the present study are the result of methodological or age group differences. Given the lack of evidence, further research around demographic differences in physical activity and sedentary behaviour during child care is needed to inform future interventions and initiatives aimed at promoting healthy active living behaviours in this environment for all children.

To our knowledge, no previous study has assessed or reported bouts of sedentary behaviour in toddlers and preschoolers. Similar to the children observed in the current study, school-aged children accumulate few longer sedentary bouts.[27] Longer sedentary bout lengths have been shown to be associated with increased BMI z-score, especially among children with lower MVPA.[27] Therefore, reinforcing the healthy habits of short sedentary bout length, such as the ones observed in this sample, with toddlers and preschoolers could be beneficial. However, the findings in the present study should be interpreted with caution, since accelerometers cannot capture posture changes, therefore some misclassification of sedentary bouts may exist when a child was in an upright posture (e.g., standing) but motionless, instead of a sedentary posture (e.g., sitting) and motionless. Future research examining sedentary patterns should use devices such as inclinometers[28] to minimize measurement error.

Overall, the findings of this study have important public health implications. More specifically, interventions and initiatives are needed to increase MVPA and to decrease total sedentary behaviour, while continuing to promote short bouts of sedentary behaviour, for toddlers and preschoolers within child care centres. Modest changes in physical activity and sedentary behaviour have been observed in previous child care interventions targeting various aspects of the childcare environment.[29] Staff training and behaviour as well as physical activity and sedentary behaviour policies might be promising strategies to explore in future research.[30] This study represents the baseline findings to such a policy level intervention. Future work will evaluate new accreditation standards that have recently been introduced in Alberta that target physical activity and sedentary behaviour. Additionally, future work is also needed to create Canadian guidelines for physical activity and sedentary behaviour that are specific to the child care setting as well as curriculum and training to support these guidelines.

A main strength of the study is the objective measure of physical activity and sedentary behaviour. In addition, participating child care centres represented multiple cities, which increase the generalizability of the findings. The study also addressed gaps in the literature by including the toddler age group and examining sedentary bouts. Though there were strengths, this study also has limitations. For example, while accelerometers have many advantages over proxy-report measures of physical activity and sedentary behaviour, as stated above, accelerometers cannot detect postural changes. This inability to detect postural changes may have resulted in some measurement error of sedentary behaviour and sedentary bouts. Additionally, the cut-points used in the current study were for 1-minute epochs and have been validated in preschoolers but not toddlers. Given the modest participation rate in the study, as well as the number of participants whose data was excluded from analyses, the possibility of selection bias cannot be eliminated. However, participation rates in the present study are similar or higher compared to other studies in this area.[14,18]

3.6 Conclusion

Children aged 19-60 months from licensed Alberta child care centres spent the majority of their time in child care engaging in sedentary behaviour and LPA. However, these children most frequently accumulated their sedentary behaviour in bouts lasting 1-4 minutes. These findings suggest interventions are needed to increase MVPA and decrease total sedentary behaviour within child care centres for toddlers and preschool children, while continuing to promote short sedentary bouts.

Table 1: Median [Interquartile range] minutes/hour of sedentary behaviour, LPA, and MVPA within child care, stratified by child sex, child age, and parental immigration status groups

	Total (n=114)	Sex (n=114)		Age (n=114)		Parent Immigration Status (n = 111)	
		Males (n=60)	Females (n=54)	Toddler (19-35 months) (n=54)	Preschooler (36-60 months) (n=60)	Born in Canada (n=79)	Immigrated to Canada (n=32)
Sedentary behaviour (min/hr)	36.9 [32.9, 40.7]	36.5 [32.8, 40.1]	37.8 [34.1, 41.4]	38.7[a] [35.6, 41.5]	36.2[a] [31.2, 39.1]	37.5 [34.2, 41.2]	35.9 [31.2, 40.1]
LPA (min/hr)	18.4 [16.0, 20.9]	18.7 [16.6, 21.6]	18.2 [16.0, 20.6]	17.5[a] [15.6, 20.0]	19.0[a] [16.7, 22.2]	18.3 [16.0, 20.8]	18.5 [16.5, 22.0]
MVPA (min/hr)	4.2 [2.5, 5.6]	4.1 [2.4, 5.6]	4.2 [2.5, 5.5]	3.1[a] [2.0, 4.9]	4.6[a] [3.2, 7.1]	3.5 [2.3, 5.3]	5.0 [4.1, 7.2]

LPA = light intensity physical activity; MVPA = moderate- to vigorous-intensity physical activity
[a] Significant age difference in sedentary behaviour, LPA, and MVPA
Min/hr = Minutes/hour

Table 2: Median [Interquartile range] frequency/hour of sedentary bouts within child care, stratified by child sex, child age and parental immigration status groups

	Total (n=114)	Sex (n=114)		Age (n=114)		Parental Immigration Status (n = 111)	
		Males (n=60)	Females (n=54)	Toddler (19-35 months) (n=54)	Preschooler (36-60 months) (n=60)	Born in Canada (n=79)	Immigrated to Canada (n=32)
1-4 (min/hr)	6.7 [6.1, 7.6]	6.5 [6.0, 7.1]	7.0 [6.2, 7.8]	6.3 [5.7, 7.4]	6.9 [6.2, 7.7]	6.6 [6.0, 7.6]	6.9 [6.3, 7.6]
5-9 (min/hr)	0.9 [0.6, 1.1]	0.9 [0.6, 1.1]	0.9 [0.6, 1.2]	0.9 [0.7, 1.1]	0.9 [0.6, 1.2]	0.9 [0.7, 1.2]	0.9 [0.6, 1.1]
10-14 (min/hr)	0.4 [0.2, 0.5]	0.4 [0.2, 0.5]	0.4 [0.2, 0.5]	0.4[a] [0.3, 0.5]	0.3[a] [0.2, 0.5]	0.4 [0.3, 0.5]	0.3 [0.2, 0.5]
≥15 (min/hr)	0.3 [0.2, 0.4]	0.3 [0.2, 0.4]	0.3 [0.2, 0.4]	0.4[a] [0.2, 0.5]	0.2[a] [0.1, 0.3]	0.3 [0.2, 0.4]	0.3 [0.2, 0.4]

[a] Significant age difference in 10-14 and ≥15 minute bouts
Min/hr = Minutes/hour

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Chapter 4

The relationship between movement behaviors and body mass index in different settings among toddlers and preschoolers

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4.1 Abstract

Purpose: The purpose of this study was to examine the relationship between movement behaviors (physical activity, sedentary behaviour and sleep) inside/outside child care, with body mass index (BMI) z-scores among a sample of toddlers and preschoolers; while also exploring potential moderating effects.

Methods: Children aged 19-60 months (n=84) from eight participating child care centers throughout Alberta, Canada participated. Movement behaviors inside child care were accelerometer-derived (i.e., sedentary time, light physical activity, moderate to vigorous physical activity (MVPA), and frequency of 1-4, 5-9, 10-14, and ≥15 minute sedentary bouts) and questionnaire-derived (i.e., daytime sleep). Movement behaviors outside of child care were questionnaire-derived (i.e., screen and non-screen sedentary behavior, MVPA, and nighttime sleep). Age- and sex-specific BMI z-scores were calculated. Multilevel linear regression models were conducted.

Results: Frequency of 1-4 minute sedentary bouts were associated with BMI z-scores (β= -0.04, 95% confidence interval: -0.06 to -0.02) after adjusting demographics. No other movement behaviors inside/outside of child care were associated with BMI z-scores. Demographic factors did not moderate the relationship between the movement behavior variables and BMI z-score.

Conclusions: Creating healthy movement behavior habits in the early years may be important for primary prevention of overweight/obesity. Frequent short sedentary bouts during child care seem particularly important. Future research is needed using large representative samples to confirm these findings.

Key Words: physical activity; sedentary behavior; sleep; body mass index; young children; child care.

4.2 Introduction

Movement can range from no/low-intensity during sleep/sedentary behavior, to high-intensity during vigorous physical activity. Consistent associations between movement behaviors (i.e., sleep, sedentary behavior, and physical activity) and adiposity measures have been reported in school-aged children and youth (aged 5-17 years) [1-3]. However, less is known regarding the associations between movement behaviors and adiposity measures in early years children (aged 0-5 years). Movement behavior habits formed in the early years have implications for future health [4]. Therefore, understanding the relationships between these behaviors and adiposity measures in this age group, could inform health promoting initiatives.

The limited studies that have examined the association between movement behaviours concurrently with adiposity in the early years have produced inconsistent findings. For example, one cross-sectional study involving 398 four year olds, a positive association between accelerometer-derived vigorous physical activity and adiposity measured with dual energy x-ray (DEXA) was reported [5]. However, accelerometer-derived low-to-moderate-intensity physical activity and sedentary behavior were not associated. Though parent-report sleep was assessed, it was only used as a covariate. Conversely, a longitudinal study looking at 244 children aged 3 to 7 years found an association between accelerometer-derived insufficient sleep and increased risk of being overweight, while accelerometer-derived total physical activity and parent reported TV viewing showed no associations [6].

Several gaps in the literature exist regarding the association between concurrent movement behaviors and adiposity in the early years. First, no study has observed these associations in different settings, such as inside and outside of child care. The importance of the home setting for children of the early years is well known [7-9]. Another important setting for early years children is child care. In Canada, 54% of children accumulate a large proportion (29 hours/week) of their movement behaviors inside child care centers [10]. Attending child care has been associated with an increased risk of overweight/obesity compared to parental care [11]. Thus, it is important to examine associations between movement behaviors and adiposity both inside and outside of child care. Second, there is limited research on the association between concurrent movement behaviors and adiposity in children <3 years, which makes it unclear whether there is an optimal age to intervene to prevent overweight and obesity. Finally, it is unknown whether specific demographic groups (e.g., girls, immigrant families) are at an increased risk and therefore should be specifically targeted for intervention.

The purpose of this study was to examine the associations between concurrent movement behaviors and BMI z-score in a sample of 19-60 month olds, inside and outside of child care centers; and to examine the moderation effects of age, sex, and parental immigration status.

4.3 Material and methods

4.3.1 Participants

The Supporting Active Living Behaviours in Alberta Child Care Settings study examined the effects of revised Child Care Accreditation Program Quality Standards in Alberta, Canada; as described in detail elsewhere [12]. Child care centers in Alberta scheduled for initial accreditation during August to October 2013 were eligible for the study. Out of the 12 eligible centers, eight (67%) agreed to participate. Seven centers were located in the cities of Edmonton (n=4) and Calgary (n=3), while one center was located in a smaller city in Alberta. The current study presents baseline data from this larger study.

Parents with a child aged 19 to 60 months who attended participating child care centers full-time were invited to participate. Out of the 270 eligible children, 145 (54%) had a parent return a signed consent form and questionnaire. Four children were excluded based on age restrictions, leaving 141 children. Data were collected between September to November 2013. The University of Alberta Health Research Ethics Board provided ethics approval for this project.

4.3.2 Adiposity Measure

Children's weight was measured to the nearest 0.1 kg using a digital scale and height was measured to the nearest 0.1 cm using a stadiometer. If a difference of >0.2 units were scored between the two measurements, a third measurement was performed and the average of the two closest measurements were used. BMI z-scores were calculated according to the World Health Organization's (WHO) criteria [13]. BMI z-scores from -1.99-1.99 are defined as normal, while ≥2 is considered an overweight weight status [13].

4.3.3 Movement Behaviors Inside Child Care

4.3.3.1 Physical Activity and Sedentary Behavior

Accelerometers (Actical, Respironics, Bend, OR, USA), calibrated for the study, were fitted over the right hip with a belt by research staff. After this initial fitting on the first morning of data collection, early childhood educators attached and removed the belts daily as children arrived and left the centers. Children continuously wore the accelerometer during five consecutive weekdays. Accelerometer data were collected in 15-second epochs [14]. Non-wear time was defined as sequences of consecutive zero counts ≥20 minutes and was excluded from analyses [15]. Early childhood educators filled out log-sheets indicating children's accelerometer on and off times. Log-sheets were used to cross-reference non-wear time and to remove data points prior to the start time of the first data collection day. Daytime sleep was assumed to be excluded with the non-wear time definition. This was confirmed by cross-referencing log-sheet data where daytime sleep was recorded. Since some centers did not record daytime sleep on the log-sheets, daytime sleep during child care was measured with parental questionnaires. This was based on the assumption that parents would know children's napping habits, through weekend observations. Consistent with previous studies inside child care centers [16, 17], participants with ≥1 hour of wear time on ≥3 days were considered to have valid data and therefore included in the analyses.

Based on national survey data from the Canadian Health Measures Survey [18] cut-points were defined as: sedentary behavior (<100 counts/minute; cpm or <25 counts/15 seconds), light-intensity physical activity (LPA; 100 to 1,149 cpm or 25 to <287.5 counts/15 seconds), and MVPA (≥1,150 cpm or ≥287.5 counts/15 seconds). This MVPA cut-point has significantly greater classification accuracy compared to other Actical accelerometer cut-points in this age group [19]. Sedentary behavior, LPA, and MVPA were expressed as hours/day. Frequency/day of sedentary bouts lasting 1-4, 5-9, 10-14, and ≥15 minutes were also calculated, while allowing for zero tolerance of interruption [20]. SAS version 9.4 [SAS Institute Inc., Cary, NC] was used for accelerometer data reduction.

4.3.3.2 Sleep

Daytime sleep during child care was determined by asking parents: "How long does your child usually nap during the day at the moment?" Responses for hours and minutes were used to calculate an hours/day variable.

4.3.4 Movement Behaviors Outside of Child Care

4.3.4.1 Physical Activity

MVPA was assessed by asking parents: "About how many hours a week does your child usually take part in physical activity (that makes him/her out of breath or warmer than usual) outside of child care while participating in…" both "…organized activities (e.g., swimming lessons, skating lessons, gymnastics)?" and "…non-organized activities (e.g., going for a walk, drop-in skating, playing at a splash pad or wading pool, bike or tricycle ride, playing at the park or in the yard)?" For both questions, a 5-point scale ranging from "never" to "7+ hours/week" was used. The mid-points of the responses in hours (i.e., 0, 1.0, 2.5, 5.0, and 7 hours) were calculated and the values for both questions were then summed and converted to an hours/day variable (Colley et al., 2013).

4.3.4.2 Sedentary Behavior

Screen based sedentary behavior was assessed by asking parents: "On average, how much time per day outside of child care does your child…" both "…watch television, videos or DVDs on a television, computer or portable device?" and "…play video/computer games on devices such as a learning laptop, leapfrog leapster, computer, laptop, tablet, cell phone, the internet, Playstation, XBOX?". Non-screen time sedentary behavior was assessed by asking parents: "On average, how much time per day outside of child care does your child spend…" both "…in a motor vehicle (e.g., car, LRT [light rail transit], bus)?" and "…being safely restrained in a high chair, stroller, etc. (do not include when they are in a motor vehicle)?" For all questions, a 7-point scale ranging from "none" to "3 hours or more" were used for weekdays and weekend days separately. The mid-points of the responses in minutes (i.e. 0, 7.5, 22.5, 45.0, 90.0, 150.0, and 180.0 minutes) were calculated and then converted to hours. Weighted means (weekday mean×5 + weekday mean×2 /7) were calculated to create hour/day variables for both screen time sedentary behavior and non-screen time sedentary behavior.

4.3.4.3 Sleep

Total nighttime sleep was assessed by asking parents: "How long does your child usually sleep per night at the moment?" Responses for hours and minutes were used to calculate an hours/day variable.

4.3.5 Covariates

Age (in months), sex (male or female), and parental immigration status (born in Canada or not born in Canada) were assessed in the parental questionnaire.

4.3.6 Statistical Analysis

SPSS version 22.0 [IBM Corp., Armonk, NY] was used to perform statistical analyses. Descriptive statistics were calculated including means, standard deviations, and percentages. Movement behavior variables deemed outlier's (≥ ±3 standard deviations) were truncated to the nearest non-outlier value (n=5). Cook's d values were calculated between each movement behavior variable and BMI z-score, and significant values (4/ (n-k-1) ≤ 0.041; where n=number of participants and k= number of factors) were removed (n =15) [21]. To address the study objectives, multilevel regression models were conducted examining the association between each movement behavior and BMI z-scores. First, models were created without adjustment, except in models with accelerometer-derived variables, which were adjusted for total accelerometer wear time. Next models were repeated, while adjusting for age, sex, and parental immigration status. In the final models, age, sex, and parental immigration moderating effects were tested by including interaction terms in the model. All multilevel regression models accounted for the data being clustered by child care center. Statistical significance was set at $P< 0.05$ for all analyses.

4.4 Results

Out of the 141 participants that agreed to participate, 84 children had complete data for BMI z-scores, accelerometers, and parental questionnaires and acceptable values for cook's D. Age, sex, parental immigration status, and BMI z-scores did not significantly differ between included and excluded participants. Participant characteristics of the 84 children are located in Table 1. Children in the final sample were on average 37.8 (standard deviation (SD) = 12.4) months of age, 47.6% were female, and 31.0% had a parent that immigrated to Canada. One (1.2%) child had a BMI z-score which was considered overweight, while all others were in the normal weight category. Inside child care, children's average total accelerometer wear time was 5.7 (SD=1.4) hours/day, which was predominantly spent sedentary (3.4 hours/day sedentary / 5.7 hours total wear time = 59.6% of time). Furthermore, sedentary time was most frequently accumulated in 1-4 minute bouts (39.5 bouts/day / 48.1 total bouts/day = 82.1% of bouts). Children accumulated 1.2 (SD = 0.9) hours/day of daytime sleep and 10.3 (SD = 0.9) hours/day of nighttime sleep. During waking hours, screen time was the most prevalent movement behavior outside of child care accounting for 1.3 (SD = 0.9) hours/day. The guideline adherence of these movement behaviours is discussed in Appendix 3.

Results for the multilevel regression models are presented in Table 2. Frequency/day of sedentary bouts lasting 1-4 minutes was the only movement behavior significantly associated with BMI z-score (Unstandardized regression coefficient (β) = -0.04; 95% confidence interval (95% CI): -0.06, -0.02) in model 1. After controlling for age, sex, and parental immigration in model 2, frequency per day of sedentary bouts lasting 1-4 minutes (β = -0.04; 95% CI: -0.06, -0.02) remained significant. No significant age, sex, and parental immigrations interactions were observed for any of the movement variables.

4.5 Discussion

This study examined the associations between movement behaviors and BMI z-scores among 19-60 month olds inside and outside of child care, and the potential moderating effects of age, sex, and parental immigration status. Sedentary bouts lasting 1-4 minutes during child care was the only movement behavior independently associated with BMI z-score. Demographic factors did not moderate the relationship between the movement behavior variables and BMI z-score.

To our knowledge, this is the first study to look at the relationship between sedentary bouts and a health indicator in toddlers and preschoolers. Findings are consistent with two studies in school-age children [22, 23]. There are several potential explanations for the inverse relationship between short sedentary bouts and BMI z-scores. First, alternating between sedentary and non-sedentary postures requires energy expenditure [24]. The energy expended from repetitive postural transitions may be protective against BMI z-score increases. Second, an important aspect of a healthy physiological system is the ability to adapt to unpredictable stresses and stimuli [25]. The sporadic movement profile associated with frequently changing postures would present unpredictable stimuli and stress to the physiological system, which could protect against BMI z-score increases. Conversely, long bouts of sedentary behavior may not offer ideal stimulation for adaptation. Lastly, given the current evidence is cross-sectional and temporality is unknown, it is possible that children with higher BMI z-scores are more likely to engage in longer sedentary bouts [22]. Longitudinal and experimental studies are needed to further explore the relationship between sedentary bouts and BMI z-scores both inside and outside of child care in this age group.

The findings suggest that for every additional sedentary bout lasting 1-4 minutes inside child care there was a 0.04 SD lowering in BMI z-score. Though this finding is statistically significant, it may not have large clinical significance. According to Field, Cook and Gillman [26], 8-15 year olds in the 50-74th percentile of BMI (equivalent to 0.0 to 0.6 BMI z-scores) are associated with a higher risk of becoming overweight 8-12 years later. In the present sample, it would theoretically require 25.8 additional 1-4 minute sedentary bouts to decrease from the 74th percentile to the 49th percentile; thus, reducing future overweight risk. However, the majority of bouts, on average, were already of short duration. It is important to note that more frequent breaks in sedentary time; thus, shorter sedentary bouts, have shown clinically significant health benefits in adults [27-29]. Therefore, creating habits of short sedentary bouts in young children may contribute to positive health later in life.

No other movement behaviors were associated with BMI z-scores in the present study. Previous systematic reviews that synthesized evidence on physical activity, sedentary behavior and adiposity measures in the early years also reported some null associations [30, 31]. In contrast, relatively consistent associations between insufficient sleep and higher adiposity measures in this age group were reported in a systematic review [1]. One potential reason no associations were observed between most movement behaviors and BMI z-score in this sample, is that prevalence of overweight and obesity in children increases with age. For instance, in the United States the prevalence of children in the 95th percentile for BMI during 2011-2012 was significantly higher when comparing 2-5 year olds (8.4%) and 6-11 year olds (17.7%) [32]. Consequently, it may take time for the exposure of unhealthy movement behaviors to accumulate and manifest in overweight/obesity risk. Therefore, cross-sectional associations with movement behaviors in the early years may be limited in their ability to determine associations with overweight and obesity. Perhaps more importantly, the early years represents a window of opportunity for movement behavior habit formation. Creating habits of healthy movement behavior in this age group could deter adiposity over-accumulation and prevent future overweight and obesity status [4, 33]. Additionally, although efforts were made to study a diverse sample, the current sample was relatively healthy compared to national data, which indicates 21% of 2-5 year olds are overweight or obese [34]. However, it should be noted that previous national data is based on International Obesity Task Force criteria, which produces higher rates of overweight/obesity status compared to the WHO criteria used in this study [35]. Future longitudinal studies with large representative samples that included toddlers are needed to examine changes in movement behaviors and adiposity measures over time.

To our knowledge this is the first study to explore the moderating effects of demographic variables on the relationship between movement behaviors and BMI z-scores. No evidence of moderation was found; thus, the relationship between movement behaviors and BMI z-scores may be similar across age, sex, and parental immigration status within this age group. In an older sample (3-7 years old), Niederer et al. [36] also found that age did not moderate the relationship between physical activity and BMI, but no other demographic moderators were explored. Given the limited evidence in this area, future research is needed to confirm the present findings to understand whether targeted interventions are needed.

There were several limitations within this study, first of which included the use of subjective measures of movement behaviors outside of child care. As a result, sedentary bouts outside of child care could not be calculated. Furthermore, the use of parental questionnaires to estimate daytime sleep inside child care may have resulted in measurement error. Though, 24 hour accelerometer wear protocols are more frequently being used, currently there is not an algorithm to determine daytime sleep from accelerometer data in this age group without an adequate log-sheet [37]. Secondly, a small sample size, modest participation rates, and excluded participants, could have introduced selection bias and reduced the generalizability of the findings. However, included and excluded participants did not differ on BMI z-scores, age, sex, and parental immigration status. Lastly, while the accelerometer cut-points were the same as cut-points used in a Canadian national survey [18], they were intended for 1-minute epochs and have been validated in preschoolers [38] but not toddlers. This study also had several strengths, such as collecting data from three geographic regions in Alberta, Canada, inclusion of toddlers, and assessing moderation of demographic variables. Additionally, objectively measured physical activity and sedentary behavior used recommended accelerometer data management protocols [18-20].

4.6 Conclusion

A small negative association between frequency of sedentary bouts lasting 1-4 minutes and BMI z-scores were observed in this sample. No other movement behaviors inside or outside of child care were associated with BMI z-scores. These findings suggest that establishing healthy habits around movement behaviors during this period of life may be important in the primary prevention of overweight and obesity. Given this was a small and relatively healthy sample, future research is needed using large representative samples to confirm these findings.

4.7 Acknowledgements

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Table 1. Participant Characteristics

Variables	Total (n=84)
Adiposity Measure	
BMI z-score	0.5 (0.7)
Movement Behaviors Inside Child Care	
Total accelerometer wear time (hours/day)	5.7 (1.4)
LPA (hours/day)	1.8 (0.6)
MVPA (hours/day)	0.5 (0.3)
Sedentary time (hours/day)	3.4 (0.8)
Frequency/day of sedentary bouts lasting	
1-4 minutes	39.5 (12.9)
5-9 minutes	5.0 (2.1)
10-14 minutes	2.0 (0.8)
≥ 15 minutes	1.6 (0.8)
Daytime Sleep (hours/day)	1.2 (0.9)
Movement Behaviors Outside of Child Care	
MVPA (hours/day)	0.6 (0.3)
Screen time (hours/day)	1.3 (0.9)
Non-screen time (hours/day)	1.0 (0.6)
Nighttime sleep (hours/day)	10.3 (0.9)
Covariates	
Age (months)	37.8 (12.4)
Sex	
Female	47.6%
Male	52.4%
Parental Immigration Status	
Born in Canada	69.0%
Immigrated to Canada	31.0%

Values represent mean (standard deviation) for continuous variables and percentage for categorical variables; BMI= body mass index; LPA= light physical activity; MVPA= moderate-to-vigorous physical activity.

Table 2. Associations between movement behaviors and BMI z-scores inside and outside of child care

	Model 1	Model 2
	β (95% CI)	**β (95% CI)**
Movement Behaviors Inside Child Care		
Physical Activity		
LPA (hours/day)	0.09 (-0.37, 0.55)	0.16 (-0.31, 0.63)
MVPA (hours/day)	-0.01 (-0.60, 0.59)	0.28 (-0.37, 0.93)
Sedentary Behavior		
Sedentary time (hours/day)	-0.04 (-0.36, 0.28)	-0.17 (-0.51, 0.17)
Frequency/day of sedentary bouts lasting		
1-4 minutes	**-0.04 (-0.06, -0.02)***	**-0.04 (-0.06, -0.02)***
5-9 minutes	0.01 (-0.07, 0.09)	0.01 (-0.07, 0.09)
10-14 minutes	0.10 (-0.08, 0.28)	0.05 (-0.14, 0.24)
≥ 15 minutes	0.11 (-0.08, 0.30)	0.04 (-0.18, 0.25)
Sleep		
Daytime sleep (hours/day)	0.09 (-0.06, 0.25)	-0.05 (-0.30, 0.20)
Movement Behaviors Outside of Child Care		
Physical Activity		
MVPA (hours/day)	0.08 (-0.36, 0.52)	0.08 (-0.38, 0.54)
Sedentary Behavior		
Screen time (hours/day)	-0.14 (-0.32, 0.03)	-0.12 (-0.29, 0.06)
Non-screen time (hours/day)	0.01 (-0.23, 0.26)	-0.10 (-0.36, 0.17)
Sleep		
Nighttime sleep (hours/day)	0.07 (-0.09, 0.22)	0.03 (-0.13, 0.20)

β (95% CI) = unstandardized regression coefficient (95% confidence interval); LPA= light physical activity; MVPA= moderate-vigorous physical activity; Model 1= accelerometer variables controlled for total wear time; Model 2=model 1 and variables controlled for age, sex, and parental immigration status; *= p≤0.05

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Chapter 5: General Discussion and Conclusions

5.1 Overview

This thesis involved a sample of toddlers and preschoolers within child care centres in Alberta, Canada. Two main objectives were explored in two manuscripts. The first main objective, within manuscript one, was to describe objectively-measured physical activity and sedentary behaviour within child care centres. The second main objective, within paper two was to examine the relationship between physical activity, sedentary behaviour and sleep (movement behaviours), within and outside of child care, and BMI z-scores. Furthermore, the role of demographic variables (i.e., child sex, child age and parental immigration status) were explored in both manuscripts. Through these manuscripts several key findings were observed.

5.2 Summary of key findings

A key finding of manuscript one is children, on average, spent 61.5% of time sedentary and spent 7.0% of time engaged in moderate-to vigorous-intensity physical activity (MVPA). Additionally, sedentary time most frequently occurred in short bouts lasting 1-4 minutes, as compared to longer bouts lasting 5-9, 10-14, and ≥15 minutes. Significant age differences were also observed with preschoolers participating in more MVPA, and light-intensity physical activity and less sedentary behaviour compared to toddlers. Preschoolers also had a higher frequency of longer sedentary bouts (10-14 and ≥15 minute bouts/hour) compared to toddlers.

A key finding of manuscript two is more frequent sedentary bouts lasting 1-4 minutes were associated with lower BMI z-scores, while adjusting for age, sex, and parental immigration status. However, no other movement behaviours were significantly associated with BMI z-scores in this sample. Additionally no demographic variables moderated the relationship between movement behaviours and BMI z-score.

5.3 Implications of key findings

The key findings of this thesis have both public health and future research implications. The findings suggest that on average this sample of toddlers and preschoolers, who attended child care full time, do not meet the recommendations within the Canadian Physical Activity Guidelines for the Early Years while in care. More specifically, the total physical activity accumulated within child care was 124.3 minutes/day (sum of 18.4 minutes/hour light-intensity physical activity (LPA) and 4.2 minutes/hour moderate- to vigorous-intensity physical activity (MVPA) multiplied by 5.5 hours/day accelerometer wear time). Considering parents believe that children obtain adequate daily physical activity in child care, the 124.3 minutes/day falls short of the 180 minutes/day Canadian recommendations (Irwin, He, Bouck, Tucker, & Pollett, 2005). Parental report within manuscript two reported the average duration of physical activity accumulated outside of childcare was 36 minutes/day of MVPA. Though this estimate may not include LPA, parental report measures of physical activity are typically higher then objective measures (Adamo, Prince, Tricco, Connor-Gorber, & Tremblay, 2009). Combined, this suggests that across the total day, this sample on average may have been falling short of the recommended minimum 180 minutes/day total and 60 minutes/day energetic play (Tremblay et al., 2012a). In fact, when the accelerometer-derived and questionnaire-derived physical activity variables were combined, only 38.1% of the sample met the minimum 180 minutes/day total physical activity guideline (See Appendix 3). Furthermore, when the accelerometer-derived and questionnaire-derived MVPA variables were combined, only 48.8% of the sample met the minimum energetic play guideline (See Appendix 3). Canadian national estimates indicate that 11% of 3-4 year olds are obtaining at least 180 minutes of total physical activity, with at least 60 minutes of energetic play (Colley et al., 2013). Unfortunately, this study did not ascertain child care status, and recommended future research should determine the influence child care status has on physical activity (Colley et al., 2013). Combined these findings are concerning from a public health standpoint as children of the early years may not developing optimally. Future research is needed to determine national prevalence rates for children under 3 years and whether prevalence rates differ according to child care status.

Similar to the physical activity findings and consistent with national estimates of 3-4 year olds (Colley et al., 2013), on average this sample exceeded the screen time recommendations within the Canadian Sedentary Behaviour Guidelines for the Early Years. In particular, within the second manuscript parental report estimated that 0% of the sample under the age of two no screen time (See Appendix 3). Furthermore, within the second manuscript parental report estimated that 44% of the sample aged 2-4 years had over 1 hour of screen time a day (See Appendix 3). Exceeding screen time recommendations could present a risk to optimal health and development. No bench mark currently exists for the maximum amount of total sedentary behaviours in a day for optimal growth and development in any age group. That is why understanding the association between sedentary behaviour and health indicators was highlighted as an area requiring further research (Tremblay et al., 2012b). Manuscript two added to this body of research by examining sedentary behaviour and BMI z-scores. Since this is only one health indicator, future research is also needed in social and cognitive health indicators, which may present themselves before physical outcomes.

Considering national estimates of early years children's sleep duration could not be found, it is difficult to compare results in this thesis. However, based on the Canadian Sleep Society recommendations some comparisons can be made (Gruber et al., 2014). In particular, according to parental report within manuscript two 69% of children aged 1-2 years, and 50% of children aged 2-3 years, slept for at least 12 hours/day (See Appendix 3). Additionally, only 40% of children aged 4-5 slept for at least 11 hours/day (See Appendix 3). However, these are just recommendations and no formal Canadian guidelines exist yet.

This sample had a low rate of guideline adherence for physical activity and sedentary behaviour, however the toddler sub-sample was even less active, more sedentary, and also had more longer sedentary bouts during child care. This is novel in that no known studies have compared toddlers and preschoolers levels of physical activity and levels and bouts of sedentary behaviour. Differences between toddlers and preschoolers may be driven by development (Hesketh, Crawford, Abbott, Campbell, & Salmon, 2014; Ridgway et al., 2009). For instance, age-adjusted positive associations have been found between motor skills (a measure of motor development) in and physical activity in children 4-6 years of age (Burgi et al., 2011). Future longitudinal work is needed to understand physical activity and sedentary behaviour trajectories in the early years, and the role that motor development plays in this relationship.

The finding that the frequency of short sedentary bouts had an inverse relationship with BMI z-scores, is consistent with literature in school-aged children (Carson, Stone, & Faulkner, 2014; Saunders et al., 2013). Conversely, no other movement behaviours were associated with BMI z-score in manuscript two. This is in line with the scoping review (section 2.3.3) that found sedentary behaviour and physical activity had mainly limited and indeterminate associations with adiposity. However, this is inconsistent with the scoping review on sleep. Unlike the majority of studies reviewed, manuscript two examined the impact of day and night sleep on adiposity separately. As a result comparisons are difficult to make. The combined findings suggest that the early years could be an optimal age group for overweight and obesity interventions. Interventions at this age could be ideal because the accumulation of unhealthy movement behaviours may not have manifested themselves into negative health, and creating healthy habits could prevent these manifestations from occurring. Modest changes in physical activity and sedentary behaviour have been observed in home and child care interventions (Mehtälä, Sääkslahti, Inkinen, & Poskiparta, 2014; O'Dwyer, Fairclough, Knowles, & Stratton, 2012). Within child care possible intervention targets could include policies and staff training incorporating physical activity and sedentary behaviour (Ward, Vaughn, McWilliams, & Hales, 2009). Within the home setting interventions could target parental behaviours while minimizing time based barriers (Knowlden & Sharma, 2012). Interventions targeting both home and school settings have been proposed for effective behaviour change in school-age children (Van Sluijs, McMinn, & Griffin, 2007). Future research should explore whether targeting both child care and home settings is also an effective strategy for behavioural change.

5.4 Overall strengths of the thesis

Overall this thesis has three main strengths. First, participants included in the manuscripts of this thesis were recruited from several locations across Alberta. This overcomes limitations of previous Canadian studies in this area that recruited from small local samples. Though this sample cannot be considered representative of the Alberta population, the generalizability of the findings are increased over previous work. Second, the inclusion of both toddlers and preschoolers within the manuscripts of this thesis addressed major gaps in the literature. For instance, manuscript one represents the first study to describe objectively-measured physical activity and sedentary behaviour in toddlers and preschoolers attending child care. Finally, the inclusion of sedentary bout measurements is a key strength. Sedentary bouts are gaining attention for their important health implications independent of total sedentary behaviour in adults and school-age children, but research into toddlers and preschoolers is very limited.

5.5 Overall limitations of the thesis

Though this thesis had several strengths, it is not without limitations. Overall, this thesis had four main limitations. First, these manuscripts are cross-sectional in nature and therefore cannot draw causal conclusions. However, the findings lay the foundation for future longitudinal and experimental work. Second, within the centres sampled, there was a modest participation rate and the sample size was relatively small; so the probability of selection bias is inflated. Nevertheless, the present study has are similar or higher participation rates compared to other studies in this area (Pate, Pfeiffer, Trost, Ziegler, & Dowda, 2004; Vanderloo et al., 2014). Third, the use of subjective measures of physical activity and sedentary behaviour outside of child care and subjective measures of sleep both within and outside child care was a limitation. Subjective measures are more prone to biases (e.g., recall, social desirability bias) compared to objective measurements. This thesis used data from a larger study, which assessed the effect of accreditation within child care on the physical activity and sedentary behaviour of children. The best measures available within the larger study were used. Though, it would have been ideal to have full-day objective measures, this protocol presents new challenges in determining when participants, with varying schedules were within and outside of the child care setting each day. Lastly, the cut-points used with the objective measurements were intended for use with 1 minute epochs and have not been validated in toddlers. Cut-points used in accelerometer research are criterion validated in alignment with direct observation or energy expenditure. Not having a cut-point validated for toddlers means reports of their levels of sedentary behaviour and physical activity could be incorrect. Currently, validated cut-points for toddlers exist for Actigraph brand accelerometers. In the absence of future work to develop Actical cut-points for toddlers, Actigraph monitors may be a better option when measuring physical activity and sedentary among children in the early years in the future.

5.6 Summary of MSc Research Experience

In preparation and production of this thesis, valuable research experience was gained. Prior to collecting data, experience was gained in managing child care centre directors/educators concerns, recruiting parents/guardians of potential participants, and coordinating data collection. Through data collection, experience was gained in managing research participants in a unique age category (i.e., toddlers and preschoolers), performing anthropometric measurements, initializing accelerometers, fitting accelerometers, and explaining accelerometer and log sheet instructions to child care educators/directors. When processing the collected data, experience was gained in data entry and data analysis; including advanced statistical techniques such as multi-level modeling. Finally, when data analysis was complete experience was gained in interpreting the results, disseminating study results (i.e., posters and presentations), manuscript creation, and manuscript revision based on feedback. To date, manuscript one has been accepted for publication and manuscript two is currently awaiting submission. Additionally, two posters have been presented at two international conferences.

5.7 Conclusions

Physical inactivity, increased sedentary behaviour, insufficient sleep and elevated BMI in children have serious public health implications (Chen et al., 2008; LeBlanc et al., 2012; Timmons et al., 2012). Despite these implications, the prevalence of all four are high in the Canadian population. Though parental perceptions (Bentley et al., 2012) and historical beliefs (Ross & Pate, 1987) have assumed that children of the early years are sufficiently active, this thesis contributes to the growing evidence that challenges this assumption (Cardon, Van

Cauwenberghe, & De Bourdeaudhuij, 2011; Tucker, 2008). The early years (birth to 5 years) has been proposed as a critical time to intervene, to positively influence movement behaviours (Goldfield et al., 2012) and subsequent health indicators, such as obesity. More than half of Canadian children under the age of five attend non-parental childcare, making it an excellent environment to target health behaviours in a large proportion of children in the early years. Given the importance of parental influences in the home setting, understanding movement behaviours in both home and child care settings are important. Unfortunately, there is a lack of data on movement behaviours and their associative health implications in the early years in these settings that could guide interventions. The findings of this thesis provided some preliminary groundwork in this area. For instance, the high levels of sedentary behaviour and low levels of physical activity, in particular MVPA, suggest that interventions are needed to positively influence movement behaviours in this age group. Additionally, it was shown that the frequency of short sedentary bouts was inversely associated with BMI z-scores. Finally, it was shown that differences exist in the physical activity and sedentary behaviour patterns between toddlers and preschoolers. Interventions in this age group promoting regular physical activity, sufficient sleep, short sedentary bouts, and minimizing sedentary behaviour, could be effective in creating lifelong healthy habits.

5.8 References

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Appendix 1: Scoping review

Table 1: Scoping review-Physical activity and adiposity associations

Author	Year	Sample Size	Country	Age Group (association)	Movement Behaviour Measurement	Adiposity Measurement
Al-Hazzaa & Al-Rasheedi	2007	224	Saudi Arabia	Preschooler (-)	Pedometer	BMI , skinfold
Annesi, Smith, & Tennant	2013	885	United States of America	Preschooler (0)	Accelerometer	BMI
Atkin & Davies	2000	77	United Kingdom	Toddler (-), and preschooler (0)	Doubly labeled water	Doubly labeled water
Burgi et al.	2011	217	Switzerland	Preschooler (0)	Accelerometer	BIA
Carter, Taylor, Williams, & Taylor	2011	244	New Zealand	Preschooler (-)	Accelerometer	DEXA & BMI
Collings et al.	2013	398	United Kingdom	Preschooler (0)	Accelerometer	DEXA
De Coen, De Bourdeaudhuij, Verbestel, Maes, & Vereecken	2014	568	Belgium	Preschooler (-)	Questionnaire	BMI
Eriksson, Henriksson, Lof, Hannestad, & Forsum	2012	45	Sweden	Toddler (-)	Doubly labeled water	Densitometry
Espana-Romero, Mitchell, Dowda, O'Neill, & Pate	2013	357	United States of America	Preschooler (-)	Accelerometer	BMI and waist circumference
Finn, Johannsen, & Specker	2002	214	United States of America	Preschooler (-)	Accelerometer	BMI
Firrincieli et al.	2005	54	United States of America	Preschooler (-)	Accelerometer	BMI
Jackson, Djafarian, Stewart, &	2009	89	United Kingdom	Toddler (-), and preschooler	Accelerometer	DEXA

Speakman				(-)		
Jackson et al.	2003	60	United Kingdom	Preschooler (+)	Accelerometer	BMI
Jago, Baranowski, Baranowski, Thompson, & Greaves	2005	133	United States of America	Preschooler (0)	Direct observation	BMI
Rachel A. Jones, Okely, Gregory, & Cliff	2009	97	Australia	Preschooler (-)	Accelerometer	BMI
R. A. Jones et al.	2011	140	Australia	Preschooler (-)	Accelerometer	BMI
Kelly et al.	2006	339	United Kingdom	Preschooler (-)	Accelerometer	BMI
Klesges, Klesges, Eck, & Shelton	1995	146	United States of America	preschooler (0)	Questionnaire	BMI
Ku, Shapiro, Crawford, & Huenemann	1981	170	United States of America	Infant (0)	Questionnaire	Skinfolds
Kuhl et al.	2014	30	United States of America	Preschooler (-)	Accelerometer	BMI
Li, O'Connor, Buckley, & Specker	1995	31	United States of America	Infant (0)	Direct observation	DEXA
Magee, Caputi, & Iverson	2014	2984	Australia	Preschooler (-)	questionnaire	BMI
Mendoza, McLeod, Chen, Nicklas, & Baranowski	2014	96	United States of America	Preschooler (0)	Accelerometer	BMI
Metallinos-Katsaras, Freedson, Fulton, & Sherry	2007	56	United States of America	Toddler (0), and preschooler (0)	Accelerometer	BMI
Metcalf et al.	2009	213	United Kingdom	Preschooler (-)	Accelerometer	DEXA
Mo-suwan, Pongprapai, Junjana, & Puetpaiboon	1998	103	Thailand	Preschooler (-)	Accelerometer	BMI & skinfolds

Moore et al.	2003	97	United States of America	Preschooler (0)	Accelerometer	BMI & skinfolds
Moore, Nguyen, Rothman, Cupples, & Ellison	1995	292	United States of America	Preschooler (0)	Aerobic activity intervention	BMI & skin folds
Nicaise, Kahan, & Sallis	2011	204	United States of America	Preschooler (0)	Direct observation	BMI
Niederer et al.	2012	613	Switzerland	Preschooler (0)	Accelerometer	BMI
Pate, McIver, Dowda, Brown, & Addy	2008	493	United States of America	Preschooler (0)	Direct observation	BMI
Reilly et al.	2006	545	United Kingdom	Preschooler (-)	Accelerometer	BMI
Salbe et al.	2002	138	United States of America	Preschooler (-)	Doubly labeled water	Doubly labeled water
Specker & Binkley	2003	178	United States of America	Preschooler (-)	Accelerometer	DEXA
Tanaka & Tanaka	2013	425	Japan	Preschooler (-)	Accelerometer	BMI
Tian et al.	2010	1236	China	Preschooler (-)	Questionnaire	BMI
Trost, Sirard, Dowda, Pfeiffer, & Pate	2003	245	United States of America	Preschooler (0)	Direct observation and Accelerometer	BMI
Vale, Santos, Silva, Soares-Miranda, & Mota	2011	59	Portugal	Preschooler (-)	Accelerometer	BMI
van Stralen et al.	2012	6472	European collaboration	Preschooler (-)	Questionnaire	BMI
Veldhuis et al.	2012	7505	Netherlands	Preschooler (-)	Questionnaire	BMI
Vorwerg, Petroff, Kiess, & Bluher	2013	119	Germany	Preschooler (-)	Accelerometer	BMI
Wells & Ritz	2001	26	United	Infant (-)	Doubly labeled	Doubly

			Kingdom		water	labeled water
Wijtzes et al.	2013	347	Netherland s	Toddler (0)	Accelerometer	BMI (self-report)

BMI= body mass index, DEXA= dual-energy X-ray absorptiometry

Table 2: Scoping review-Sedentary behaviour and adiposity associations

Author	Year	Sample Size	Country	Age Group (association)	Movement Behaviour Measurement	Adiposity Measurement
Anderson & Whitaker	2010	8550	United States of America	Preschooler (+)	Questionnaire	BMI
Byun, Liu, & Pate	2013	418	United States of America	Preschooler (0)	Accelerometer	BMI
Carter et al.	2011	244	New Zealand	Preschooler (0)	Accelerometer	DEXA & BMI
Collings et al.	2013	398	United Kingdom	Preschooler (0)	Accelerometer	DEXA
Cox et al.	2012	135	Australia	Preschooler (+)	Diary	BMI (self-report)
De Coen et al.	2014	568	Belgium	Preschooler (+)	Questionnaire	BMI
Dennison, Russo, Burdick, & Jenkins	2004	77	United States of America	Preschooler (0)	Questionnaire	BMI
DuRant, Baranowski, Johnson, & Thompson	1994	191	United States of America	Preschooler (0)	Direct observation	BMI
Espana-Romero et al.	2013	357	United States of America	Preschooler (0)	Accelerometer	BMI and waist circumference
Fuller-Tyszkiewicz, Skouteris, Hardy, & Halse	2012	9064	Australia	Preschooler (+)	Questionnaire	BMI
Hancox & Poulton	2006	1037	New Zealand	Preschooler (+)	Questionnaire	BMI
Jackson et al.	2009	89	United Kingdom	Preschooler (+)	Questionnaire	DEXA
Jago et al.	2005	133	United	Preschooler	Direct	BMI

			States of America	(+)	observation	
Kuhl et al.	2014	30	United States of America	Preschooler (0)	Questionnaire	BMI
LaRowe et al.	2010	135	United States of America	Preschooler (+)	Accelerometer	BMI
Lumeng, Rahnama, Appugliese, Kaciroti, & Bradley	2006	1016	United States of America	toddler (0)	Questionnaire	BMI
Magee et al.	2014	2984	Australia	Preschooler (+)	Questionnaire	BMI
Mendoza et al.	2014	96	United States of America	Preschooler (0)	Diary	BMI
Pagani, Fitzpatrick, Barnett, & Dubow	2010	1314	Canada	Toddler (+)	Questionnaire	BMI
Proctor et al.	2003	106	United States of America	Preschooler (+)	Questionnaire	BMI & skin folds
Reilly et al.	2004	150	United Kingdom	Toddler (+)	Accelerometer	BMI
Salbe et al.	2002	138	United States of America	Preschooler (0)	Questionnaire	Doubly labeled water
Suglia, Duarte, Chambers, & Boynton-Jarrett	2013	1589	United States of America	Preschooler (0)	Questionnaire	BMI
Taverno Ross, Dowda, Saunders, & Pate	2013	339	United States of America	Preschooler (0)	Questionnaire	BMI
Tian et al.	2010	1236	China	Preschooler (+)	Questionnaire	BMI
Vale et al.	2011	59	Portugal	Preschooler (0)	Accelerometer	BMI
van Stralen et al.	2012	6472	European collaboration	Preschooler (+)	Questionnaire	BMI

Veldhuis et al.	2012	7505	Netherland	Preschooler (+)	Questionnaire	BMI
Vorwerg et al.	2013	119	Germany	Preschooler (0)	Accelerometer	BMI
Zimmerman & Bell	2010	1118	United States of America	Infant (0), and Preschooler (0)	Diary	BMI (self-report)

BMI= body mass index, DEXA= dual-energy X-ray absorptiometry

Table 3: Scoping review-Sleep and adiposity associations

Author	Year	Sample Size	Country	Age Group (association)	Movement Behaviour Measurement	Adiposity Measurement
Agras, Hammer, McNicholas, & Kraemer	2004	150	United States of America	Infant (-), toddler (-), and preschooler (-)	Questionnaire	BMI
Anderson & Whitaker	2010	8550	United States of America	Preschooler (-)	Questionnaire	BMI
Bell & Zimmerman	2010	1930	United States of America	Infant (-), toddler (-), and preschooler (-)	Log sheet	BMI
Bonuck, Chervin, & Howe	2015	1899	United Kingdom	Preschooler (-)	Questionnaire	BMI
Carter et al.	2011	244	New Zealand	Preschooler (-)	Accelerometer	DEXA & BMI
Clifford et al.	2012	41	United States of America	Preschooler (-)	Diary	BMI
Dev et al.	2013	329	United States of America	Toddler (-), and preschooler (-)	Questionnaire	BMI
Diethelm, Bolzenius, Cheng, Remer, & Buyken	2011	481	Germany	Toddler (-), and preschooler (-)	Questionnaire	BMI & skinfold
Hiscock,	2011	9070	Australia	Infant (0),	Diary	BMI

Scalzo, Canterford, & Wake				toddler (0), and preschooler (0)		
Jiang et al.	2009	1311	China	Preschooler (-)	Questionnaire	BMI
Klingenberg et al.	2013	311	Denmark	Infant (0), toddler (0), and preschooler (0)	Questionnaire, then accelerometer	BMI & skinfold
Louzada, Rauber, Campagnolo, & Vitolo	2012	348	Brazil	Preschooler (-)	Direct observation	BMI, waist circumference and skinfold
Magee et al.	2014	2984	Australia	Preschooler (-)	Questionnaire	BMI
Magee, Caputi, & Iverson	2013	1079	Australia	Preschooler (-)	Questionnaire	BMI
Miller et al.	2014	366	United States of America	Preschooler (-)	Questionnaire	BMI
Moraleda-Cibrian & O'Brien	2014	306	United States of America	Preschooler (-)	PSG	BMI
Reilly et al.	2005	909	United Kingdom	Preschooler (-)	Questionnaire	BMI
Sekine et al.	2002	8941	Japan	Preschooler (-)	Questionnaire	BMI
Suglia et al.	2013	1589	United States of America	Preschooler (-)	Questionnaire	BMI
Taveras, Gillman, Pena, Redline, & Rifas-Shiman	2014	1046	United States of America	Infant (-), toddler (-), and preschooler (-)	Questionnaire	BMI, DEXA, waist circumference and hip circumference
Taveras, Rifas-Shiman, Oken, Gunderson, & Gillman	2008	915	United States of America	Infant (-), toddler (-), and preschooler (-)	Questionnaire	BMI & skinfold
Tian et al.	2010	1236	China	Preschooler (-)	Questionnaire	BMI

BMI= body mass index, DEXA= dual-energy X-ray absorptiometry, PSG=Polysomnography

Appendix 2: Valid days and hours/day of accelerometer data

Table 1: Valid days of accelerometer data

	Number of valid days of accelerometer wear			
Valid Days	>3	3	4	5
Manuscript 1 (n=133)	19	18	26	70
Manuscript 2 (n=103)	19	10	21	53

Values represent number of participants equaling each valid day category. Valid days were considered having more than 3 days with at least 1 hour in each day.

Table 2: Valid hours/day of accelerometer data

	Number of valid hours/day of accelerometer wear								
Valid Hours	1	2	3	4	5	6	7	8	9
Manuscript 1 (n=114)	1	3	12	14	22	32	17	12	1
Manuscript 2 (n=84)	0	2	4	10	17	29	11	10	1

Values represent number of participants equaling each valid hour/day category. Valid days were considered having more than 3 days with at least 1 hour in each day.

Appendix 3: Guideline adherence

Table 1: Movement behaviour guideline adherence

Guideline	Meeting guideline	Not meeting guideline
180 minutes of total physical activity/day	38.1%	61.9%
60 minutes of energetic play/day	48.8%	51.2%
Children under 2 years, should not accumulate screen time	0.0%	100.0%
Children 2-4 years, should limit screen time to >1 hour	44.0%	56.0%
Children 1-2 years achieve 12-14 hours sleep	69.2%	30.8%
Children 2-3 years achieve 12-14 hours sleep	50.0%	50.0%
Children 4-5 years achieve 11-13 hours sleep	40.0%	60.0%

Values represent percentage of participants meeting specific guidelines. qualing each valid hour/day category. Valid days were considered having more than 3 days with at least 1 hour in each day.

Appendix 4: Parent/guardian questionnaire

ID # ______________

UNIVERSITY OF ALBERTA

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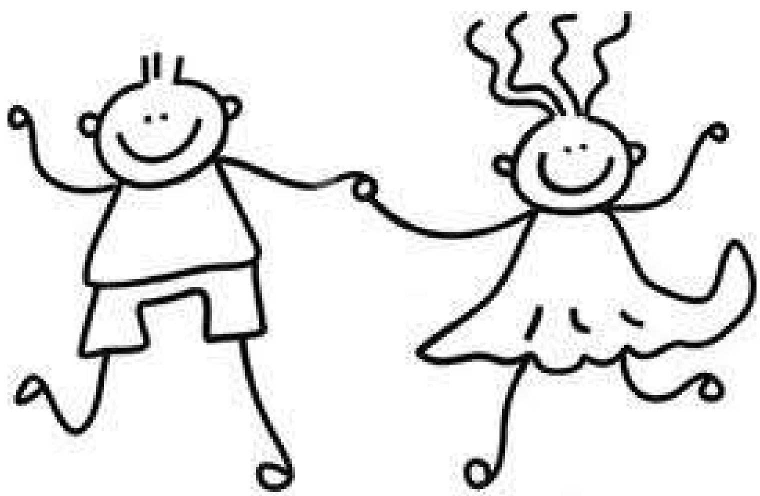
PARENT/GUARDIAN QUESTIONNAIRE

Supporting Healthy Active Living Behaviours in Alberta Child Care Settings



Instructions: **This survey is for parents/guardians who have a child aged 19 months to 5 years**. Please take your time and read each question carefully. Choose the answer that best describes you and your child by placing an (✔) in the box provided or writing in the space provided. If there is a question that you do not want to answer, you do not have to. **Your responses will be kept confidential.**

If you have more than one child in this age range at this child care centre, please answer the questions based on the child with the birth date closest to January 1st. In the case of twins, please answer the survey based on the first born (i.e., oldest twin).

Part A: Demographic Characteristics of Your Child

1. Is your child male or female? ☐ Male ☐ Female

2. What is your child's birth date? ___ ___/ ___ ____/ ___ ___ ___ ___
D D M M Y Y Y Y

Part B: Your Child's Activities

3. On average, how much time **per day outside of childcare** does your child watch television, videos, or DVDs **on** a television, computer, or portable device?

Weekdays (per day)	Weekend (per day)
☐ None	☐ None
☐ Less than 15 minutes	☐ Less than 15 minutes
☐ 15 minutes to less than 30 minutes	☐ 15 minutes to less than 30 minutes
☐ 30 minutes to less than 1 hour	☐ 30 minutes to less than 1 hour
☐ 1 hour to less than 2 hours	☐ 1 hour to less than 2 hours
☐ 2 hours to less than 3 hours	☐ 2 hours to less than 3 hours
☐ 3 hours or more	☐ 3 hours or more

4. On average, how much time **per day outside of childcare** does your child play video/computer games **on** devices such as a learning laptop, leapfrog leapster, computer, laptop, tablet, cell phone, the internet, Playstation, XBOX?

Weekdays (per day)	Weekend (per day)
☐ None	☐ None
☐ Less than 15 minutes	☐ Less than 15 minutes
☐ 15 minutes to less than 30 minutes	☐ 15 minutes to less than 30 minutes
☐ 30 minutes to less than 1 hour	☐ 30 minutes to less than 1 hour
☐ 1 hour to less than 2 hours	☐ 1 hour to less than 2 hours
☐ 2 hours to less than 3 hours	☐ 2 hours to less than 3 hours
☐ 3 hours or more	☐ 3 hours or more

5. On average, how much time **per day outside of childcare** does your child spend in a motor vehicle (e.g., car, LRT, bus)?

Weekdays (per day)	Weekend (per day)
☐ None	☐ None
☐ Less than 15 minutes	☐ Less than 15 minutes
☐ 15 minutes to less than 30 minutes	☐ 15 minutes to less than 30 minutes
☐ 30 minutes to less than 1 hour	☐ 30 minutes to less than 1 hour
☐ 1 hour to less than 2 hours	☐ 1 hour to less than 2 hours
☐ 2 hours to less than 3 hours	☐ 2 hours to less than 3 hours
☐ 3 hours or more	☐ 3 hours or more

6. On average, how much time **per day outside of childcare** does your child spend being safely restrained in a high chair, stroller, etc. (do not include when they are in a motor vehicle)?

Weekdays (per day)	Weekend (per day)
☐ None	☐ None
☐ Less than 15 minutes	☐ Less than 15 minutes
☐ 15 minutes to less than 30 minutes	☐ 15 minutes to less than 30 minutes
☐ 30 minutes to less than 1 hour	☐ 30 minutes to less than 1 hour
☐ 1 hour to less than 2 hours	☐ 1 hour to less than 2 hours
☐ 2 hours to less than 3 hours	☐ 2 hours to less than 3 hours
☐ 3 hours or more	☐ 3 hours or more

7. How long does your child usually sleep **per night** at the moment? _______ Hours **AND** _______ Minutes

8. How long does your child usually nap **during the day** at the moment? _______ Hours **AND** _______ Minutes

9. About how many hours a week does your child **usually** take part in physical activity (that makes him/her out of breath or warmer than usual) **outside of child care** while participating in **organized activities** (e.g., swimming lessons, skating lessons, gymnastics)?
    ☐ Never ☐ Less than 2 hours per week ☐ 2-3 hours per week ☐ 4-6 hours per week ☐ 7+ hours per week

10. About how many hours a week does your child **usually** take part in physical activity (that makes him/her out of breath or warmer than usual) **outside of childcare** while participating in **non-organized** activities (e.g., going for a walk, drop-in skating, playing at a splash pad or wading pool, bike or tricycle ride, playing at the park or in the yard)?
    ☐ Never ☐ Less than 2 hours per week ☐ 2-3 hours per week ☐ 4-6 hours per week ☐ 7+ hours per week

Part C: Your Thoughts on your Child's Activities

11. In a **typical** week how often do you limit/restrict the amount of time your child spends…

	Never					**to**		**Daily**
	0	1	2	3	4	5	6	7
watching TV/videos/DVDs or using video/computer games (e.g., iPad or cell phone)	☐	☐	☐	☐	☐	☐	☐	☐
sitting for prolonged periods during waking hours (e.g., quiet indoor activities, restrained in a stroller)	☐	☐	☐	☐	☐	☐	☐	☐

12. If I limit my child's screen time (TV/computer/video games) activities…

	No chance			**to**			**Certain to happen**	
	0	1	2	3	4	5	6	7
it will be more difficult to get household chores done	☐	☐	☐	☐	☐	☐	☐	☐
they will miss out on a good learning tool	☐	☐	☐	☐	☐	☐	☐	☐
it will disrupt family practices and routines	☐	☐	☐	☐	☐	☐	☐	☐
my child will be unhappy	☐	☐	☐	☐	☐	☐	☐	☐
it will improve my child's health	☐	☐	☐	☐	☐	☐	☐	☐
It will improve my child's mood or behaviour	☐	☐	☐	☐	☐	☐	☐	☐
It will improve my child's social skills	☐	☐	☐	☐	☐	☐	☐	☐

13. If you really wanted to, how confident are you in limiting your child's screen time (TV/computer/video games) activities even if…

	Not confident			**to**		**Completely Confident**		
	0	1	2	3	4	5	6	7
you have household chores to do (e.g. cooking)	☐	☐	☐	☐	☐	☐	☐	☐
the weather outside is poor (e.g. cold or rainy)	☐	☐	☐	☐	☐	☐	☐	☐
your child really wants to participate in these activities	☐	☐	☐	☐	☐	☐	☐	☐

14. In a **typical** week, how often do you support your child's physical activities or active play by…

	Never			to				Daily
	0	1	2	3	4	5	6	7
encouraging your child to do physical activities or active play	☐	☐	☐	☐	☐	☐	☐	☐
doing physical activities or active play with your child	☐	☐	☐	☐	☐	☐	☐	☐
taking your child to a place (e.g., park, pool) where they can do physical activities or active play	☐	☐	☐	☐	☐	☐	☐	☐
watching your child participate in physical activities or active play	☐	☐	☐	☐	☐	☐	☐	☐
telling your child that being physically active is good for their health	☐	☐	☐	☐	☐	☐	☐	☐

15. If I support my child in more physical activity and active play…

	No chance			to		Certain to happen		
	0	1	2	3	4	5	6	7
it will improve my child's health and fitness	☐	☐	☐	☐	☐	☐	☐	☐
It will improve my child's mood or behaviour	☐	☐	☐	☐	☐	☐	☐	☐
It will improve my child's social skills	☐	☐	☐	☐	☐	☐	☐	☐
It will strengthen my relationship with my child	☐	☐	☐	☐	☐	☐	☐	☐
it will be more difficult to get household chores done	☐	☐	☐	☐	☐	☐	☐	☐
It will be fun and enjoyable	☐	☐	☐	☐	☐	☐	☐	☐
It will be too costly	☐	☐	☐	☐	☐	☐	☐	☐
It will make me tired	☐	☐	☐	☐	☐	☐	☐	☐

16. If you really wanted to, how confident are you that you can support your child in physical activity or active play even if…

	Not confident			to		Completely Confident		
	0	1	2	3	4	5	6	7
the child's preferred activity is expensive	☐	☐	☐	☐	☐	☐	☐	☐
you have a lot of housework	☐	☐	☐	☐	☐	☐	☐	☐
you are tired	☐	☐	☐	☐	☐	☐	☐	☐
your child is not interested	☐	☐	☐	☐	☐	☐	☐	☐
there is a lack of places/areas to play	☐	☐	☐	☐	☐	☐	☐	☐
the weather outside is poor	☐	☐	☐	☐	☐	☐	☐	☐
there are no other children to play with	☐	☐	☐	☐	☐	☐	☐	☐

<u>Part D: Your Information</u>

17. What is the highest grade or level of education you have completed?

- ☐ (Grades 1-8)
- ☐ Grade 9-12)
- ☐ Community/Technical College
- ☐ University (i.e., Undergraduate, teacher's college)
- ☐ Graduate University (i.e., master's, doctorate, medicine, dentistry, etc.)

18. Where you born in Canada? ☐ Yes ☐ No

19. **If No**, what year did you first come to Canada to live? ____________

Future Research

We hope to conduct similar research to this in the future, examining children's active living behaviours.

Would you be willing to be contacted in the future about research?

☐ Yes ☐ No

If **Yes**, please provide your contact details below. Only the research team will have access to this information:

My name: ____

My address: _____________

____

Unit/House number Street name

____ ___________

City Postcode

My phone numbers:

Home: _________________________

Business: _________________________

Mobile: _________________________

My Email (please write clearly):

____

Name of a close friend or relative (in the event you move and cannot be contacted):

Name: ________________________________

Address: ____

Phone: _______________________________

Email: ________________________________

Relationship to you: ________________________

Please return both the consent form and survey to the child care staff at your child's centre.

Appendix 5: Information letter

UNIVERSITY OF ALBERTA INFORMATION LETTER MOUNT ROYAL UNIVERSITY 1910

Supporting Healthy Active Living Behaviours in Alberta Child Care Settings

Principal Investigator: Dr. Valerie Carson, W1-34 Van Vliet Centre, University of Alberta, Edmonton, AB, T6G 2H9
Co-Investigator: Dr. Dawne Clark, 4825 Mount Royal Gate S.W., Mount Royal University, Calgary, AB T3E 6K6
Co-Investigator: Ms. Elaine Danelesko, 4825 Mount Royal Gate S.W., Mount Royal University, Calgary, AB T3E 6K6
Co-Investigator: Dr. Vicki Harber, E-424 Van Vliet Centre, University of Alberta, Edmonton, AB, T6G 2H9

Dear Parent/Guardian,

This research is being led by Dr. Valerie Carson from the University of Alberta in collaboration with Dr. Vicki Harber from the University of Alberta and Dr. Dawne Clark and Ms. Elaine Danelesko from Mount Royal University. We are asking for you and your child to participate in this important new research study.

What is this study about? The purpose of this study is to evaluate new accreditation standards being implemented by the Alberta government in child care settings. These new standards have been created to ensure that children are obtaining regular opportunities to be active while in child care. This is critical for healthy growth and development. This study will help determine how well the new standards are working.

What will participation entail? 1) You will be asked to **complete and return** the consent form and a short questionnaire, included with this letter, to the early child care educator at your child's centre. 2) Your child will be asked to wear a physical activity monitor **while in child care** for five consecutive days <u>before</u> and five consecutive days <u>after</u> the new standards are implemented. The physical activity monitor is called an accelerometer. It is safe, small (1" square), and light weight (0.5 ounces). It is safely worn on a comfortable adjustable elastic belt around the waist over or under clothing and will not impact day-to-day activities. After being trained by study personnel, the early child care educators will put this monitor on your child in the morning when your child arrives and will take it off before your child goes home for the five consecutive measurement days. 3) After the new standards are implemented we will ask you to complete the same short questionnaire.

Is my participation voluntary? Yes. You and your child are under no obligation to participate in this study. You should not feel obliged to answer any survey questions you do not wish to. Even if you agree to participate, you and your child may withdraw from the study **at any time** without any penalty and you can ask to have any collected data withdrawn and not included in the study. If your child does not want to wear the monitor at any time, it will be removed immediately and the child will not have to participate further in the study.

Are there any benefits or risks by participating? You or your child will not directly benefit from participating in the study. However, we hope the study will help us better understand how to support healthy active living behaviours in child care settings. This can benefit the healthy growth and development of many children. There are no known physical, psychological, economic, or social risks associated with the study.

What will happen to the information collected? All data collected will be kept confidential. Only the research team will have access to it. The study data will be kept in a secure place for a minimum of seven years. If the data is to be used for other studies, ethics approval will be obtained. The data may also be published in professional journals or presented at scientific conferences, but any such presentations will be of general findings and will never breach individual confidentiality. Should you be interested, you are entitled to a copy of the findings.

What if I have questions or concerns? If you have any questions or concerns regarding this study, please contact the principal investigator, Dr. Valerie Carson (780-492-1004 or vlcarson@ualberta.ca). The plan for this study has been reviewed for its adherence to ethical guidelines by a Research Ethics Board at the University of Alberta. For questions regarding participant rights and ethical conduct of research, contact the Research Ethics Office (780-492-2615).

Would you like to participate? **If you and your child would like to participate please <u>complete and return the consent form and short questionnaire</u> included in this package to the child care educators at your child's centre.**

UNIVERSITY OF ALBERTA CONSENT FORM MOUNT ROYAL UNIVERSITY

Supporting Healthy Active Living Behaviours in Alberta Child Care Settings

1. I have read the letter of information and have had any questions answered to my satisfaction.
2. I understand that my child and I will be participating in the study called "Supporting Healthy Active Living Behaviours in Alberta Child Care Settings". I understand that this means I will complete a brief questionnaire now and after the new accreditation standards are implemented. Also, my child will wear a physical activity monitor while in child care at two time points for five consecutive days.
3. I understand participation is voluntary and I may withdraw at any time. I understand that every effort will be made to maintain the confidentiality of the data now and in the future.
4. I am aware that if I have any questions, concerns, or complaints, I may contact the principal investigator, Dr. Valerie Carson (780-492-1004 or vlcarson@ualberta.ca) or the Research Ethics Office (780-492-2615).

I have read the above statements and freely consent for my child and I to participate in this research:

____________________________ ____________________________

Name of child Date of Birth (MM/DD/YYYY)

____________________ ____________________ ____________________

Name of Parent/Guardian Signature of Parent/Guardian Today's Date (MM/DD/YYYY)

If you and your child would like to participate please <u>complete and return this consent form and short questionnaire</u> included in this package to the child care educators at your child's centre. <u>You can keep the cover and information letter for your records.</u>