Longitudinal and cross-sectional associations between physical activity, screen time, and fitness in a sample of young children from Edmonton, Canada

by

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Abstract

Background: High fitness is associated with several positive health outcomes; however, fitness of Canadian children has declined over the past two decades. Correlates of fitness in children under 10 years of age are relatively unexplored, and few studies involving young children have looked at this relationship over time. Understanding these potential associations at young ages and over time is necessary to better understand how to increase fitness levels in children. The purpose of this thesis is to: (1) describe the fitness level of a large group of Canadian children; (2) examine the cross-sectional associations between physical activity (PA), screen time (ST), and fitness; (3) examine the longitudinal associations between PA, ST, and fitness; and (4) explore PA and ST tracking over three years.

Methods: Findings are based on 649 participants (4.5 ± 0.5 years at baseline; 52.4% female) from Edmonton, Canada who participated in the Spatial Health Assessment of Physical Environments (SHAPEs) baseline study (2005-2007) and the SHAPEs of Things to Come three-year follow-up (2008-2011) study. Parent-reported questionnaires measured PA and ST in hours/week at both time points. At follow-up, PA was also objectively measured using pedometers. Fitness was measured using the Canadian PA, Fitness and Lifestyle Approach manual at follow-up only. Vertical jump, sit-and-reach, waist circumference, grip strength, and predicted VO_2 max were expressed as z-scores. Total fitness-complete (complete results for vertical jump, sit-and-reach, waist circumference, grip strength, and predicted VO_2 max) and fitness-partial (complete results for at least three of the measures included in fitness-complete) were averaged and expressed as z-scores. Due to non-normal distributions, push-ups and partial curl-ups were categorized into high (“gold-standard” for the Canada Fitness Award) and low groups. Linear or logistic regression was used to examine the cross-sectional and longitudinal associations, and models adjusted for follow-up age, sex, household income, and body mass index. Sex-interactions were explored. Spearman correlations were used to examine PA and ST tracking.

Results: Children's mean fitness scores were 39.4 ± 2.3 $ml\cdot(kg\cdot min)^{-1}$ for predicted VO_2max, 30.8 ± 6.1 kg for grip strength, 20.4 ± 5.1 cm for vertical jump, 28.1 ± 6.6 cm for sit-and-reach, and 59.8 ± 6.0 cm for waist circumference. For push-ups and partial curl-ups, 20.5% and 7.9% of participants were categorized into the high fitness group, respectively.

Cross-sectionally, some positive associations were observed between objective PA and fitness (fitness-complete: β=0.009, 95% CI: 0.001, 0.017; fitness-partial: β=0.006, 95% CI: 0.000, 0.011; vertical jump: β=0.043, 95% CI: 0.008, 0.078; boys VO_2 max: β=0.084, 95% CI: 0.012, 0.157 and; being in the high push-up group: OR=1.156 95%CI: 1.054, 1.267) and between subjective PA and fitness (fitness-partial: β=0.025, 95% CI: 0.007, 0.042; vertical jump: β=0.011, 95% CI: 0.000, 0.022; boys VO_2 max: β=0.040, 95% CI: 0.018, 0.063 and; boys grip strength: β=0.025, 95% CI: 0.011, 0.040). Negative associations were observed between fitness and ST for boys grip strength only (β=-0.016, 95% CI: -0.028, -0.004).

Longitudinally, no significant associations between baseline PA and follow-up fitness scores were observed but two positive associations approached significance (p=0.05; fitness-complete: β=0.007, 95% CI: 0.000, 0.014; VO_2 max, β=0.014, 95% CI: 0.000, 0.027). Only two significant negative associations were observed between baseline ST and follow-up fitness (fitness complete: β=-0.009, 95% CI: -0.016, -0.002; grip strength: β=-0.010, 95% CI: -0.019, -0.001). Physical activity displayed moderate (r_s=0.30), and ST displayed large (r_s=0.53) tracking coefficients over three years. No sex-interactions were observed.

Conclusions: This thesis adds valuable knowledge to the fitness literature by providing evidence on an important, yet understudied, group of children. For PA, significant or borderline significant associations were observed with overall fitness in both analyses. For ST, cross-sectional and longitudinal associations were observed with one musculoskeletal fitness score (grip strength) and longitudinal associations were observed with overall fitness. Overall, these findings suggest that targeting PA and ST may be important for overall fitness, especially because these behaviours track over time. Given the paucity of evidence in this age group and the small effects observed, additional research is needed to confirm these findings and determine the best ways to intervene.

Preface

The research conducted for this thesis is part of the Spatial Health Assessment of Physical Environments (SHAPEs) baseline study and the SHAPEs of Things to Come longitudinal follow-up study, led by Dr. John C. Spence at the University of Alberta. The University of Alberta's Ethics Board (HREB) approved both studies. Research students and staff of Dr. Spence collected data used in this thesis. Jodie Stearns assisted with managing the dataset. With the assistance of Dr. Valerie Carson, Morgan Potter led the development of the research questions, literature review, data analysis, results interpretation, and the writing of manuscripts 1 and 2. All co-authors assisted in the revisions of each manuscript. Manuscript 1 (Chapter 3) is formatted according to the Journal of Applied Physiology, Nutrition, and Metabolism (APNM), where it will be submitted for publication. Manuscript 2 (Chapter 4) is formatted according to the Journal of Physical Activity and Health (JPAH), where it will be submitted for publication.

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Chapter 1: Introduction

1.1 General Introduction

At a national level, the fitness of Canadian children has only been examined twice in the past few decades, in 1981 with the Canadian Fitness Survey (1983) and most recently in 2007 to 2009 as part of the Canadian Health Measures Survey (Tremblay et al., 2010). When comparing the fitness of Canadian children from these studies, research indicates that fitness levels have declined significantly, regardless of age or sex of the child (Tremblay et al., 2010). This phenomenon has also been observed worldwide (Tomkinson, Leger, Olds, & Cazorla, 2003).

As the fitness of Canadian children declines, children are more likely to adopt the risk factors for chronic disease and the poor health implications that are associated with low musculoskeletal fitness and low cardiovascular fitness (Grontved et al., 2013; Ortega et al., 2008; Garcia-Artero et al., 2007). Reversing this trend and improving children's fitness levels would likely provide children with positive health outcomes, such as less abdominal obesity, improved bone health, and reduced stress, anxiety, and depression (Ortega et al., 2008; Janssen and Leblanc, 2010). In order to appropriately target health initiatives and interventions, it is important to determine the critical age in which correlates of fitness significantly impact children's fitness.

This thesis explores both physical activity (PA) and screen time (ST) as correlates of fitness in children. Manuscript 1 (Chapter 3) examines the cross-sectional associations at the follow-up time point, and manuscript 2 (Chapter 4) examines the longitudinal associations between baseline measures and the three-year follow-up time point measures. Data from the Spatial Health Assessment of Physical Environments (SHAPEs) baseline study and the SHAPEs of Things to Come longitudinal follow-up study were used in both manuscripts comprised in this thesis. Included in the introduction is a brief history of the nation-wide fitness testing in Canadian children.

1.2 Objectives

The overall objectives of this thesis were to explore the relationship between PA, ST, and fitness in a large sample of children at two time points, both cross-sectionnally and longitudinally.

The objectives of manuscript 1 were to: (1) describe fitness levels in a sample of 6- to 10-year-old children; (2) examine the cross-sectional association between PA, ST, and fitness; and (3) examine if sex moderates the association between PA, ST, and fitness at the follow-up time point.

The objectives of manuscript 2 were to: (1) examine the longitudinal associations between baseline PA, baseline ST, and fitness at follow-up; (2) explore PA and ST tracking from baseline to the three-year follow-up; and (3) examine if sex moderates the associations between PA, ST, and fitness longitudinally.

1.3 Definitions of Key Terms

Physical activity (PA) is defined as any motion caused by a skeletal muscle that increases energy expenditure (Caspersen, Powell, & Christenson, 1985). Physical activity is often described using a set of four FITT principles: frequency, intensity, time, and type (Barisic, Leatherdale, & Kreiger, 2011). The intensity component of the FITT principle can be broken down in light-intensity PA and moderate-to-vigorous PA (MVPA), where MVPA in children is greater than or equal to four metabolic equivalents (METs; Trost, Loprinzi, Moore, & Pfeiffer, 2011). This is the intensity level that children aged 5 to 17 years should be accumulating in order to fulfill national PA guidelines (Canadian Society for Exercise Physiology, 2016); whereas, PA at any intensity is encouraged for early years children aged 1 to 4 years (Canadian Society for Exercise Physiology, 2014). The remaining FITT principles refer to the frequency of the PA bouts, time spent in these bouts, and type of PA involved (e.g., running, walking, or resistance training; Barisic, Leatherdale, & Kreiger, 2011).

Sedentary behaviour is defined as any waking activity in a seated or reclined position that has an energy expenditure less than or equal to 1.5 metabolic equivalents (Sedentary Behaviour Research Network, 2012). Examples of sedentary behavior include computer use, playing video games, television viewing (TV), reading, or passive transport. Computer, video games, and TV are collectively termed "screen time" (ST) and are a common type of sedentary behaviour in children. (Sedentary Behaviour Research Network, 2012; Must & Tybor, 2005). Screen time is the measure of sedentary behaviour used in this thesis.

Physical fitness often refers to the capacity to perform activities, and reflects the status of musculoskeletal or cardiovascular functioning (Ortega, Ruiz, Castillo, & Sjostrom, 2008). In this thesis, physical fitness refers to the children's ability to performing a series of fitness tests (muscular strength, muscular endurance, cardiovascular fitness, flexibility and body composition) described in the Canadian Physical Activity, Fitness & Lifestyle Approach manual (Canadian Society for Exercise Physiology, 2003).

Children are classified as individuals 4 to 11 years of age and youth are classified as individuals 12 to 17 years of age, inclusively, as defined by the Center for Disease Control and Prevention (2015). This thesis focuses on children ages 4 to 10 years old.

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Chapter 2: Review of Literature

2.1 Fitness of Canadian Children

2.1.1 History

In 1966, Manitoba became the first province in Canada to adopt the Centennial Athletic Awards (Province of Manitoba, 1966). These awards were sponsored by the Centennial Commission in Ottawa and aimed to encourage and promote athleticism. Children and youth aged 6 to 18 years were to complete three mandatory fitness tasks (one-minute speed sit-ups, 300 yard run, and standing broad jump), and one of three additional fitness tasks (swimming, skating, or a long distance run; Province of Manitoba, 1966). Children were given gold, silver, bronze, or red crests according to their age and athletic ability (Province of Manitoba, 1966). This program ran for one year and reports reveal that sorting, packaging, and shipping the crests to schools was tedious and time consuming (Government of Newfoundland and Labrador, 1967).

Building on the Centennial program, the Canada Fitness Award (CFA) program was created. It was developed by Sport and Recreation Canada in 1970 as a motivator for children to achieve higher levels of fitness and increase awareness of sport and recreation (Canada Fitness Award Manual, 1986). Similar to the Centennial program, the CFA was facilitated in schools and students revived a coloured crest corresponding to their fitness level. In the first 13 years of the CFA program, 16 million children participated and 10 million had fitness scores high enough to receive a coloured crest (Canada Fitness Award Manual, 1986). Fitness norms were based on results from the Canadian Association for Health, Physical Education and Recreation (CAHPER) Fitness Performance test done in 1965 (Canada Fitness Award Manual, 1986). The CFA originally consisted of six tests: 50 yard run, 300 yard run, flexed arm hang, speed sit-ups, shuttle run and standing long jump (Till, 2010). After a study done by CAPHER in 1979, revisions were made to the fitness tests (Quinney, Watkinson, Massicotte, Conger, & Gauthier, 1981), and the fitness standards were adjusted to include pre-determined percentages based on a child's age and sex (Canada Fitness Award Manual, 1986). The revised CFA replaced the arm hang with push-ups, replaced the speed sit-ups with partial curl-ups, and replaced the 300 yard run with an endurance run of either 800m, 1600m, or 2400m, depending on the child's age (Canada Fitness Award Manual, 1986). If a child received an "excellence" level on all six fitness tests they were awarded a red crest. If they received a gold level or higher on five components, a silver level or higher on four components, or a bronze level or higher on four components they were given a gold, silver, or bronze crest, respectively (Canada Fitness Award Manual, 1986). The CFA was a memorable component of mandatory physical education class of school-aged children until 1992 when the program ended. Since then, there has been no nation-wide fitness testing done in Canadian schools to the scale of the CFA.

Outside of the school environment, a comprehensive look at the physical fitness of Canadians was measured in 1981 (Canada Fitness Survey, 1983), and again in 1988 (Stephens & Craig, 1990) that included children, youth, and adults. Nationally, the fitness of Canadian Children and youth was not measured again until 2007-2009 through Statistics Canada Canadian Health Measures Survey (CHMS; Tremblay et al., 2010).

2.1.2 Prevalence

Canada Fitness Survey was the first nation-wide attempt to report the fitness of Canadian citizens, providing baseline fitness information on people ages 7 to 69 years of age (Canada's Fitness, 1982). The survey included fitness tests and a questionnaire; however, children 7 to 9 years old only participated in the fitness tests and did not complete the questionnaire. The published results from the cardiovascular fitness tests grouped all children 14 years of age and under in one group, and reported the 82% of 7- to 14-year-olds met the recommended cardiovascular fitness levels (Canada's Fitness, 1982). Preliminary findings from this survey highlight that declines in muscular endurance start after adolescence, and declines in cardiovascular fitness and flexibility can begin even earlier (Canada's Fitness, 1982), suggesting the importance of maintaining children's fitness levels from a young age. While this survey provided valuable fitness information on fitness of Canadian citizens, it did not provide fitness information on children under 7 years of age.

Two decades later the CHMS repeated several of the measures used in the Canada Fitness Survey on a large population of 6- to 79-year-olds representing 97% of the Canadian population (Tremblay et al., 2010). Published data from the first cycle of the CHMS in children was sub-categorized into age ranges: 6 to 10, 11 to 14, and 15 to 19 years (Tremblay et al., 2010). This study found that flexibility and muscular strength scores of children were lower, and measures of obesity were greater for boys and girls when compared to the 1981 data (Tremblay et al, 2010). The CHMS mean values for 6- to 10-year-olds in the sit-and-reach flexibility test were 24cm and 29cm and the mean values for grip strength were 25kg and 23 kg, for boys and girls, respectively (Tremblay et al., 2010). Cardiovascular fitness and muscular endurance were not measured in 6- or 7-year-olds, but the partial curl-up measure for muscular endurance for 8- to 10-year-olds in the CHMS stated that 11% of boys and 13% of girls were able to complete the maximal number of repetitions (25 repetitions; Tremblay et al., 2010). Also in the CHMS, the mean predicted VO_2 max for 8- to 10-year-olds were reported as 56.3 $ml\cdot(kg\cdot min)^{-1}$ in boys and 50.7 $ml\cdot(kg\cdot min)^{-1}$ in girls (Tremblay et al, 2010). Overall, boys scored higher on muscular strength, muscular endurance, and cardiovascular fitness than girls of the same age; whereas, girls scored higher on the sit-and-reach flexibility test (Tremblay et al., 2010).

2.1.3 Health Implications

Higher levels of physical fitness have known health benefits in children and youth (Janssen, 2007). For instance, cardiovascular fitness has been associated with fewer cardiovascular disease risk factors, regardless of age, sex, or country (Anderson et al., 2007). There are also association between musculoskeletal fitness and health (Smith et al., 2014). Muscular fitness in youth has favourable associations with self-esteem, bone health, central adiposity, and metabolic risk factors (Smith et al., 2014). In fact, it is recommended that children take part in activities that strengthen muscle and bone two to three days per week (CSEP, 2014b; Janssen & Leblanc, 2010). Low levels of overall fitness may also lead to more chronic disease development in children and higher associated health care costs in the future (Tremblay et al., 2010). Given the associations between children's fitness and their health, it is important to understand the factors that are associated with increased fitness.

2.1.4 Predictors

Physical fitness is determined in part by non-modifiable factors, such as genetics and lower birth weight (Froberg, 2014). In fact, low birth weight alone has been associated with reduced muscular endurance, cardiovascular endurance, and muscular strength (Froberg, 2014; van Deutekom, Chinapaw, Vrijkotte, & Gemke, 2015). Physical fitness is also influenced by modifiable factors (Ortega, Ruiz, Castillo, & Sjostrom, 2008). Two modifiable factors that may be of particular importance are PA and sedentary behaviour. For example, increasing physical activity (PA) can increase a person's energy expenditure, which in turn can cause changes to physiological variables leading to positive fitness changes (Blair, Cheng, & Holder, 2001). Also, it is likely that the time children spend sedentary or engaging in screen time (ST) activities takes away from time that could be spent moving (i.e. light PA; Saunders et al., 2016).

One systematic review by Janssen and LeBlanc investigated PA, fitness and health in children and youth 5 to 17 years of age (2010). This review concluded that PA's in this age group should include both cardiovascular and musculoskeletal (muscle and bone) strengthening 3 days per week (Janssen & LeBlanc, 2010). However, this review used child and youth fitness as proxy measure for PA, rather than including the studies that investigated the associations between PA and fitness to draw conclusions (Janssen & LeBlanc, 2010). It is important to note that physical fitness and PA are separate entities, as described in the definition section.

A recent review looked at the associations between objective PA and fitness in children and youth 5 to 17 years, with fitness as the outcome variable (Poitras et al., 2016). This review included 38 studies, where 29 were observational studies and nine experimental studies. Eighteen out of the 29 observational studies examined PA cross-sectionally using both pedometers (n=4) and accelerometers (n=14), and all had positive associations between a cardiovascular fitness measure and total PA (Poitras et al., 2016). However, the nine experimental studies found mixed results between PA and cardiovascular fitness (Poitras et al., 2016). In terms of musculoskeletal fitness, 10 observational studies in the Poitras et al. (2016) review explored the association between PA and muscular strength, and results were mixed. Of all the articles included in the review, only six studies looked at this association between PA and fitness in young children (≤8 years of age), and none of those six included measures of muscular strength or muscular endurance (Poitras et al., 2016). Furthermore, only three studies included Canadian samples. While there is some supporting evidence in older children, information on the relationship between children's PA and fitness is lacking, especially in relation to musculoskeletal fitness and in samples of young Canadian children. Furthermore, the longitudinal associations between PA and fitness are unclear.

When looking at the associations between PA and fitness in children, it is important to understand whether differences exist between boys and girls. Although hormonal differences are not present between pre-pubescent boys and girls (Forest, 1981), other characteristics, such as fat mass, can differ slightly between sexes in young children (Kirchengast, 2010), which can have an influence on fitness (Aires et al., 2009). Furthermore, on average, boys take more daily steps than girls (CANPLAY, 2014), and boys tend to score higher on grip strength and predicted VO_2 max measures than girls (Tremblay et al., 2010). Conversely girls tend to have higher flexibility scores (Tremblay et al., 2010). Even though the maturational hormone differences between young girls and boys might be minimal, the possibility of sex as a moderator of PA and fitness association should be explored.

In regards to sedentary behaviour, a systematic review by Tremblay et al. included 15 studies looking at the associations between sedentary behaviour and fitness, in which 12 were cross-sectional, two were longitudinal, and one was an intervention study (2011). Findings from eight cross sectional studies and one longitudinal study suggested that engaging in more than 2 hours of ST per day is associated with decreased overall fitness, decreased cardiovascular capacity, lower cardiorespiratory fitness, and decreased musculoskeletal fitness (Tremblay et al., 2010). Of these studies, only one included data of children under 8 years old. Majority of studies focused on youth over 12 years of age (Tremblay et al., 2011). Further, only two of these studies were conducted in Canada (Tremblay et al., 2011).

Recently, an additional review was published capturing the associations between sedentary behaviour and various health indicators in the last five years, and included fitness as an health outcome (Carson et al., 2016). This review included 21 studies with an outcome measure of fitness, three of which were longitudinal studies and 18 were cross-sectional studies. Fifteen of the studies examined ST and fitness specifically. However, only two of them included children with a mean age less than eight years (Ciesla et al. 2014; Drenowatz et al. 2014). Overall, findings from this review indicated that higher amounts of ST were associated with lower fitness in both study designs (Carson et al., 2016). Understanding if theses associations are present in younger ages can fill an existing gap in the literature while building upon current research in the area.

Similar to the reported sex-differences mentioned above with PA, research has observed sex-differences in ST, where boys engage in more daily ST, especially videogames, compared to girls (Public Health Ontario, 2015). Combining this with the known sex-differences in fitness scores of young children (Tremblay et al., 2010), it is important to examine whether sex moderates the relationship between ST and fitness in children.

2.1.5 Measurement

The body of literature on health related fitness measures in children and youth is growing, but research is limited by inconsistent measures between studies and lack of reliable and valid measures (Niederer et al., 2013). Also, there is limited current reference data on child and youth muscular fitness tests that can be used to identify fitness levels (Castro-Pinero et al., 2009). Below are some common fitness measures that have been used for child and youth fitness testing in research, both in Canada and internationally.

There are many measures of cardiovascular fitness, and three common, but not exclusive, methods used in research are: the shuttle run, the step test, and a long distance run. The shuttle run used in the CFA program was performed at a distance of 10 meters (Canada Fitness Award Manual, 1986). However, a shuttle run can also be done at a distance of 20 meters and is sometimes termed the “beep test” (Garcia & Zakrajsek, 2000). The 20 meter shuttle run involves continuous running between two markers placed 20 meters apart (Garcia & Zakrajsek, 2000). In this cardiovascular test, running cadence is signaled using a recorded disc that “beeps” when the participants have to run back to the other marker (Heroux et al., 2013). Each minute into the shuttle run test the time between the beep-sound decreases, which increases the speed that the participants have to run. The test is stopped when the participant fails to reach the end marker in time for two consecutive ends. The level the participant was able to reach successfully is recorded and equations are used to predict their VO_2max. This field test is widely used with children, but requires a large space to be done safely and effectively (Garcia & Zakrajsek, 2000).

The long distance run was introduced during the revision of the CFA, as it originally did not contain an endurance component (Canada Fitness Award Manual, 1986). The standards in this manual reflect the times in minutes and seconds a child needs to complete the distance run in on order to receive an excellence, gold, silver, or bronze award. For example, a 16-year-old boy would have to run 2400 meters in 10:08 minutes in order to receive an excellence rating. For a 16-year-old girl, the time would be 12:38 to receive the excellence rating (Canada Fitness Award Manual, 1986). Similar to the shuttle run, a large space is needed to administer a long distance run test.

Step tests require less physical space than a running field test, and can be simple to administer. In Canada, the Canadian PA, Fitness & Lifestyle Approach (CPAFLA) is commonly used tool that is standardized by the Canadian Society for Exercise Physiology and used nationwide (2003). This protocol includes clear instruction for muscular strength and endurance, aerobic capacity, and flexibility. Results from each category are given a value that corresponds to a health benefit rating. The cardiovascular test used in the CPAFLA is the modified Canadian Aerobic Fitness Test (mCAFT), where participants step up and down to a set cadence as instructed by an audiotape or disc (CPAFLA, 2003). While these tests are relatively easy to administer, the standard protocols have not been validated for children less than 15 years of age. A criticism of the step tests, especially in younger participants, is they require coordination to maintain the stepping pattern to the appropriate cadence (Tremblay et al., 2010). Strengths of the mCAFT include the submaximal nature of the test and that the test can be performed in small spaces, such as a classroom or an office.

The field tests that are used to test muscular fitness in children and youth differ with available fitness testing measurement tools and protocols. Two common measures for measuring lower body explosive strength in children and youth are a standing broad jump and a vertical jump. The standing broad jump has participants stand at a marked line on the floor and jump as far forward as possible. The horizontal distance jumped is recorded. In a vertical jump, participants stand beside a wall and jump upwards, reaching up the wall with an outstretched arm and touching the wall at the apex of their jump. The participants standing reach is subtracted from their jumping reach and they are given a score of vertical jump height.

Upper body strength and endurance in children and youth have also been measured using different methods. For example, two common measures sometimes used for muscular strength are a grip-strength test and a bent-arm hang test. For the grip-strength test, individuals squeeze a handheld dynamometer which produces an output value in kilograms. This is done on each hand, and the combined value is recorded as a measure of upper body strength (CSEP, 2003). The grip-strength test has been considered a reliable tool for measuring muscular strength in children (Artero et al, 2011), and can be used to measure grip strength in children as young as three years old (Sanchez-Delgado et al., 2015). Another measure, the bent-arm hang, requires less specialized equipment, and was originally used in the initial Canada Fitness Awards (Canada

Fitness Award Manual, 1986). This test has participants maintain a bent arm position while hanging from a bar. Grasping the bar with palms forward and keeping their chin above the bar, the total time is recorded until the participant breaks form or quits (Castro-Pinero et al., 2009a). Upper body muscular endurance is typically measured through the use of a push up test (Castro-Pinero et al., 2009a). However, the protocols differ between methods. For example, The Fitnessgram push-up test has all participants perform push-ups pivoting from the toes at a set cadence of 20 push-ups per minute, where a total number of repetitions until failure are recorded (2013). This differs from the CPAFLA protocol where males complete the test pivoting from the toes, and females perform push-ups pivoting from the knees, while keeping a consistent cadence set by the participant (CSEP, 2003).

Abdominal endurance is commonly measured using a variation of a sit-up or abdominal crunch. Generally, participants lay supine on the ground with their knees bent (Castro-Pinero et al., 2009a). Some protocols require the participant to complete as many repetitions as possible in a given time (e.g., 30 seconds), either with ankles bound to the ground or not (Castro-Pinero et al., 2009a). Other protocols, such as the Fitnessgram (2013) and CPAFLA use a slower, more controlled abdominal endurance approach where participants have to perform curl-ups to a set cadence, up to a maximum number of repetitions. The maximum number is 75 in the Fitnessgram protocol and 25 in the CPAFLA protocol (Fitnessgram, 2013; CSEP, 2003).

Hamstring and lower back flexibility is typically measured using a sit-and-reach test, or a leg raise test (Castro-Pinero, et al., 2009b). In a passive straight leg raise test, a person lays supine on the ground while another person, the tester, passively moves their straight leg up-wards, decreasing the angle between the spine and the femur. The tester measures the angle at the point where tightness is felt, where smaller angles reflect greater hamstring and lower back flexibility (Castro-Pinero, et al., 2009b). This test requires a skilled and trained person to facilitate testing, but is considered a good measure of hamstring and lower back flexibility (Castro-Pinero, et al., 2009b). An alternate flexibility test used in children and adults is a sit-and-reach test. During this test, a person sits on the ground with their legs extended straight in front of them and feet against a measuring device. They are instructed to lean forward as far as possible with arms outstretched, pausing at the end of the stretch. The distance of forward reach is measured, and a larger distance reflects greater hamstring and lower back flexibility (Castro-Pinero, et al., 2009b). The sit-and-reach test is easy and quick to administer, and has a test-restest reliability of 0.88 in children 11 to 16 years of age (Jones, Stratton, Reilly, & Unnithan, 2002).

2.2 Physical Activity in Children

2.2.1 Prevalence

The Canadian PA Guidelines recommend that 4-year-old children should accumulate 180 minutes of PA at any intensity throughout the day (Canadian Society for Exercise Physiology, 2014a) and work towards 60 minutes of energetic play (i.e., moderate- to vigorous-intensity PA (MVPA)). For children 5 to 11 years old, it is recommended that they participate in a minimum of 60 minutes of daily MVPA (Canadian Society for Exercise Physiology, 2016). While research suggests that approximately three quarters of children participate in PA a few days per week, many children do not meet the national guidelines (The Well-being of Canada's Young Children, 2011). More specifically, only 14% of Canadian children aged 5 to 11 years are meeting the 60-minute recommendation according to objectively measured data from the Canadian Health Measures Survey (ParticipACTION Report Card, 2016). Of children 3 to 4 years of age, 84% met the recommended guideline of 180 minutes of total PA (Colley et al., 2013). However, only 11% of children are participating in 180 minutes of total PA and 60 minutes of MVPA (Colley et al., 2011). Furthermore, girls are less likely to participate in PA than boys the same age (The Well-being of Canada's Young Children, 2011).

Research has also examined PA tracking over time. For example, a recent review that looked at PA tracking from early childhood (< 5 years) to middle-childhood (6 to 11 years), reported the median PA tracking as moderate with a tracking coefficient of 0.36 (Jones, Hinkley, Okely, & Salmon, 2013). It is important to consider how behaviours track, especially when determining the best ages to target for interventions. Considering that PA behaviours track moderately overtime, and currently a low percentage of children in Canada meet national guidelines, improvements are needed to positively impact the health of Canadian children.

2.2.2 Health Implications

As described in the predictors of fitness section, there is some evidence to indicate that higher PA may be associated with improved cardiovascular endurance and muscular strength (The Well-being of Canada's Young Children, 2011). In addition to fitness, there are many other health benefits of PA. For instance, a review by Janssen & LeBlanc (2011) that informed the Canadian PA Guidelines for Children and Youth reported that participating in 60 minutes or more of MVPA is associated with the greatest health benefits. These benefits include controlled blood pressure, reduced risk of metabolic syndrome, reduced overweight and obesity, improved bone mineral density and reduced depression (Poitras, et al., 2016; Janssen & LeBlanc, 2010). In early years children 0 to 4 years old, higher levels of PA are associated with bone health, motor skill development, psychosocial health, cognitive development, and cardiometabolic health (Timmons et al., 2012).

Also, understanding the impact of PA on health of children and youth under 18 years is important because of its known association with obesity in childhood and the likelihood of it leading to obesity in adolescence and adulthood (Yang, Telama, Viikari, & Raitakari, 2006; Tammelin, Laitinen, & Nayha, 2004). One study reported that 33% of preschool aged children were obese and half of these children would remain obese into their adult years (Plourde, 2006). Similarly, another study tracked PA and weight status over 21 years (from age 9 to adulthood); concluding that persistent PA lowers the risk of abdominal obesity in women (Yang, Telama, Viikari, & Raitakari, 2006). Both studies suggest that childhood behavior, healthy or unhealthy, may track into adulthood.

2.2.3 Measurement

There are several different methods for measuring children's PA. Direct calorimetry measures energy expenditure and is considered the gold standard for measuring PA (Sirard & Pate, 2001). However, this method is invasive, costly, and would not be appropriate for measuring typical PA patterns in children (Schoeller & Webb, 1984), especially in large population-based samples. The next best approach for measuring PA in children and youth is to objectively measure their movement through the use of a pedometer or an accelerometer. A pedometer is normally worn on clothing at the hip joint and counts the number of steps taken. The daily number of steps are recorded and the child is considered sufficiently active if they accumulate 12,000 steps/day and 15, 000 steps/day for girls and boys, respectively (Tudor-Locke et al., 2004). Rather than counting steps, an accelerometer can detect movement in different planes of motion. An accelerometer is typically worn at the hip and researchers must use specialized computer software and validated cut-points to determine time spent in different PA intensities (Sirard & Pate, 2001). While both the pedometer and accelerometer are commonly used, they are expensive to purchase, especially the accelerometer, and need to be worn for multiple days for accurate results (Herrmann, Barreira, Kang, & Ainsworth, 2014).

Another common method for measuring PA data is through the use of a questionnaire. When children are young, proxy-reports are used and parents, guardians, or other caregivers complete the questions on the child's behalf. Proxy-reports have been found to provide reliable information on the type, frequency, and duration of PA among children 12 years old and younger (Telford, Salmon, Jolley, & Crawford, 2004). Using the proxy-report in these ages is also beneficial because it reduces recall errors that may be present due to cognitive limitations of the children (Sirard & Pate, 2001). However, using a proxy-questionnaire also has limitations. For instance, the proxy is responsible for remembering and accurately recording the amount of PA a child participates in even if they are not with the child the entire day due to school or childcare, which can introduce biases, such as recall bias. Furthermore, social desirability bias can be introduced if the proxy feels social pressure to answer in a certain way. Even with these limitations, questionnaires are an acceptable and affordable option when there are limited resources and large sample sizes.

2.3 Screen Time in Children

2.3.1 Prevalence

In children, a common type of sedentary behaviour is ST (Must & Tybor, 2005). National sedentary behaviour guidelines state that early years children 2 to 4 years of age should limit ST to one hour or less each day (Canadian Society for Exercise Physiology, 2014b), and children between the ages of 5 and 17 years should limit ST to two hours or less each day (Canadian Society for Exercise Physiology, 2016). Research in a national sample of grade 6 to 10 students indicated that only approximately 20% of participants were meeting the two hours per day guideline for ST (Mark, Boyce, & Janssen, 2006). This value is similar to another nationally representative sample where only 24% of children aged 5 to 11 years met the recommended guideline of less than two hours of ST each day (ParticipACTION Report Card, 2016). Furthermore, children aged 5 to 17 years spent on average 8.5 waking hours per day sedentary (ParticipACTION Report Card, 2016). For early years children, only 18% of Canadian 3- to 4-year-olds met the recommendations of less than one hour of ST activities each day (Colley, et al., 2013).

Similar to PA, research has also examined ST tracking over time. Jones and others (Jones, Hinkley, Okely, & Salmon, 2013) conducted a review and observed that sedentary behaviours tracked largely from early childhood (<5 years) to middle-childhood (6 to 11 years) with a median tracking coefficient of 0.52. With majority of young Canadian children not meeting recommended ST guidelines and the tendency for ST levels to track over time, it is important to consider targeting this behaviour at a young age to establish healthy habits that could be carried over into later childhood.

2.3.2 Health Implications

As described in the predictors of fitness section, there is some evidence that higher sedentary behaviour is associated with lower fitness in children and youth. In addition to associations with fitness, higher ST among early years children, and children and youth aged 0 to 4 and 5 to 17 years have been found to be associated with several other negative health indicators (Carson et al., 2016; LeBlanc et al., 2012; Tremblay et al., 2011). Specifically with children aged 0 to 4 years, higher ST is associated with poorer adiposity, psychosocial health scores, and cognitive development (LeBlanc et al., 2012). Similarly, more than two hours of ST, primarily TV, among children and youth aged 5 to 17 years is associated with poor body composition, self-esteem, cardiovascular fitness and academic achievement (Tremblay et al., 2011). Furthermore, recently published literature suggests that increased sedentary behaviours may contribute to the increased levels of cardiovascular disease risk factors in children, such as abdominal obesity, hypertension, disturbed glucose and insulin metabolism (Froberg, 2014), and low bone mineral density in 6- to 12-years-olds (Sioen et al., 2015).

2.3.3 Measurement

Children's ST is typically measured using self- or proxy-report questionnaires or log books (Carson, Rosu, & Janssen, 2014; Yang, Telama, Viikari, & Raitakari, 2006). For example, to determine how much television a child watches, the proxy-report might ask the parent to report what time the child started and stopped watching a television program in a log book. Alternatively, the parent or guardian might be asked to recall and record the amount of television viewing time from the previous week in a questionnaire. The current limitation of the self- and proxy-report measures of ST is the lack of valid and reliable tools (Bryant, Lucove, Evenson, & Marshall, 2006).

Similar to PA, total daily sedentary behaviour can be objectively measured using an accelerometer. The accelerometer data can be used to determine periods in time where no or minimal movement occurred (Lubans et al., 2011). The time spent in minimal movement during the day is summed to create a daily time spent in sedentary behaviour variable. Similar to measuring PA with accelerometers, research suggests that individuals wear the accelerometers 10 to 12 hours a day for 3 to 4 days to achieve an accurate representation of sedentary behaviour (Herrmann, Barreira, Kang, & Ainsworth, 2014). However, it is not possible to specifically measure ST with accelerometers alone, therefore; combining accelerometer data with a subjective measure is recommended (Lubans et al., 2011).

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Chapter 3: Manuscript 1

Associations between physical activity, screen time, and fitness among 6- to 10-year-old children living in Edmonton, Canada

This manuscript will be submitted to Applied Physiology, Nutrition, and Metabolism and is presented according to the journal requirements.

3.1 Abstract

The objectives of this study were to describe fitness levels, examine associations between physical activity (PA), screen time (ST), and fitness, and examine sex moderating effects in a sample of children. Participants were 649 children (7.8 ± 0.6 years; 52.4% female) from Edmonton, Canada. Hours/week of PA and ST were parental-reported. Physical activity was also objectively measured with pedometers and expressed as 1000 steps/day. Fitness components (i.e., vertical jump, sit-and-reach, waist circumference, grip strength, predicted maximal oxygen consumption (VO_2 max), push-ups, partial curl-ups, overall fitness) were measured according to the Canadian PA, Fitness and Lifestyle Approach protocols and expressed as z-scores or low/high fitness. Positive associations were observed between PA and overall fitness for both the complete (subjective: β=0.009, 95% CI: 0.001, 0.017) and partial ($\geq$3 available fitness measures; subjective: β=0.006, 95% CI: 0.000, 0.011; objective: β=0.025, 95% CI: 0.007, 0.042) fitness scores. Subjective (β=0.011, 95% CI: 0.000, 0.022) and objective (β=0.043, 95% CI: 0.008, 0.078) PA were positively associated with vertical jump. Children with higher objective PA were more likely to be in the high push-ups group (OR=1.156, 95% CI: 1.054, 1.267). Physical activity was positively associated with predicted VO_2 max (subjective: β=0.040, 95% CI: 0.018, 0.063; objective: β=0.084, 95% CI: 0.012, 0.157) and grip strength (subjective: β=0.025, 95% CI: 0.011, 0.040) in boys only. Screen time was negatively associated with grip strength (β=-0.016, 95% CI: -0.028, -0.004) in boys only. Physical activity was associated with several components of fitness, especially in boys. However, few associations were observed between ST and fitness. Promoting regular PA in young children may address declining fitness levels.

3.2 Introduction

Low musculoskeletal and cardiovascular fitness in children are associated with risk factors for chronic diseases (Grontved et al., 2013; Ortega et al., 2008; Garcia-Artero et al., 2007). Conversely, improved or higher levels of fitness are associated with reduced blood pressure, less abdominal obesity, improved bone mineral density, and reduced depression, anxiety, and stress (Ortega et al., 2008; Tremblay et al., 2010; Janssen and Leblanc, 2010). Despite the clear health benefits, fitness levels have decreased significantly in children since the 1980s (Tremblay et al., 2010). Consequently, it is important to understand the factors that predict fitness, especially in children, to reverse these trends.

Some research in children suggests that fitness is determined in part by non-modifiable factors, such as genetics (Guth & Ross, 2013; Chiu et al., 2011) and low birth weight (van Deutekom et al., 2015). Physical fitness may also be influenced by modifiable factors such as, PA and sedentary behaviour (Santos et al., 2015). More specifically, it is possible that increasing energy output through PA can create notable changes in physiological variables, such as blood lipid, blood pressure, or body composition changes that can in turn impact physical fitness levels (Blair, Cheng, & Holder, 2001). This is important considering the dose-response for various health outcomes and physical fitness in adults is steep (Blair, Cheng, & Holder, 2001). It is likely that the reverse could present with increased ST, as increased time in sedentary behaviour generally reduces energy output.

The PA of children and youth has been a key public health focus over the past two decades (Tremblay et al., 2010; ParticipACTION, 2016), and many interventions have been developed and implemented to target these behaviours in multiple settings (Showell et al., 2013; Harris et al., 2009). However, research indicates that children's PA remains extremely low

(Colley et al., 2011; Tremblay et al., 2010; Shields, 2006). Currently only 14% of Canadian children aged 5 to 11 years are meeting the recommended PA guidelines (ParticipACTION, 2016). Similar to PA, only 24% of children aged 5 to 11 years meet the ST recommendations (ParticipACTION, 2016) within the sedentary behaviour guidelines for Canadian children (Canadian Society for Exercise Physiology, 2016). Current low levels of PA and high levels of ST may partially explain the declining fitness levels and consequential health impacts.

To date, fitness levels and factors affecting fitness in children less than 10 years of age such as PA and sedentary behaviour have been relatively unexplored (Smith et al., 2014). Furthermore, the role of sex in these relationships is unclear. Since children naturally experience an increase in strength until puberty, and girls' fitness tends to plateau where boys' fitness tends to increase after pubertal changes (Beunen & Thomis, 2000; Gallahue & Ozman, 2006), it is necessary to explore sex as a moderator of the relationship between PA or ST and fitness in children. Therefore, the objectives of this paper are to: (1) describe fitness levels in a sample of 6- to 10-year-olds from Edmonton, Canada; (2) examine the associations between PA, ST, and fitness; and (3) examine if sex moderates the associations between PA, ST, and fitness.

3.3 Methods

3.3.1 Participants

Participants for this cross-sectional study were a part of the Spatial Health Assessment of Physical Environments (SHAPEs) baseline study and the SHAPEs of Things to Come longitudinal follow-up study. During the baseline phase (2005-2007), children aged 4 to 6 years and their parents were recruited from Capital Health Centers when the children received their preschool immunizations. Though preschool immunization is not mandatory in the province of Alberta, prior research indicated that 74% of children in the Edmonton region were given the immunization for Diphtheria, Tetanus, Pertussis and Polio (DTap-IPV) before entering grade one in 2004 (Edwards et al. 2008). The percentage of early years children immunized for DTap-IPV in 2014 stayed relatively consistent at 76% (Government of Alberta, 2015). This suggests that most children access these health centers before entering grade one, making the centers an appropriate place to access a large proportion of children from the Edmonton health region.

A total of 2,114 children participated in the baseline study. Of these, 1,337 (63%) agreed to be re-contacted for future research. Once contacted, 649 children aged 6 to 10 years participated in the follow-up data collection. This study is based on the follow-up data collection only. The University of Alberta's Ethics Board (HREB) approved this study and all parents provided written and informed consent.

3.3.2 Procedures

Children whose parents agreed to be contacted regarding the follow-up study during the baseline data collection were contacted by telephone. If the parents remained interested in participating they were sent an information form, consent form, and a short questionnaire. All fitness testing was done at the University of Alberta campus. Once at the facility, the consent form and brief questionnaire were collected from the parent. The procedures were then explained to both the parent and child, and the child performed the physical fitness assessment. At the end of the session, children were provided a pedometer to take home. They were asked to wear the pedometer for four consecutive days, including at least one weekend day, and parents recorded the total number of steps at the end of each day in a logbook. Participating families received a small thank-you gift valued at approximately $20 per family. Full procedures are included in Appendix A. The information form, questionnaires, and logbook are included in Appendices B, C, D, E, & F.

3.3.3 Measures

3.3.3.1 Exposure Variables

A modified version of the Children's Leisure Activities Study Survey (CLASS; Telford et al., 2004) was used to collect parent-reported PA of the child (subjective PA). Specifically, they reported on nine PA's that the child usually participates in during the current season: swimming (lessons and for fun), soccer, ballet/dance, gymnastics, skating, hockey, bike riding, gym activities, and active play (including at a playground). A tenth space was provided for inclusion of a PA that was not listed in the first nine options. Parents recorded frequency (how many times) and duration (average minutes each time) for each activity done on a weekday (Monday - Friday) and weekend (Saturday - Sunday). Total hours per week of subjective PA were calculated by summing weekday and weekend minutes and dividing by 60. Physical activity values greater than 42 hours per week were defined as outliers and truncated to 42 hours (n=6). Previous work has shown substantial to almost perfect 2-week test-retest reliability (62%-94% agreement) for the CLASS when estimating PA for children ages 5 to 6 years (Telford et al., 2004).

Physical activity was also measured objectively using a StepsCount SC-T2 [Steps Count, Deep River, ON, CA] pedometer. Parents and children were instructed to have the child put on the pedometer as soon as they awoke in the morning. Once the pedometer was in place and positioned above the right hip, participants were to walk 20 steps and check that the pedometer recorded between 19 and 21 steps, inclusively. If this did not happen, participants were instructed to re-position the pedometer and try again. Pedometers were not to be worn while swimming or bathing. Participants removed the pedometer before going to bed and parents recorded the number of steps taken during the day in the activity log. Participants with at least three days of complete pedometer data were included. Average steps per day (objective PA) were calculated by averaging across valid days, and was expressed as 1000 steps/day (steps per day divided by 1000). Pedometers have shown acceptable reliability (r = 0.79) for measuring PA in elementary school children (mean age = 9.3 years) when worn for at least three days (Ling & King, 2015).

Screen time was assessed through parent-proxy report of usual participation in three ST activities: TV/videos, play station/Nintendo/x-box/ game-boy, and computer/internet/computer games. An additional space was provided for the inclusion of a ST activity that was not mentioned previously. Parents recorded the total amount of time their child participated in these activities in a typical week and in a typical weekend. Average hours per week of ST were calculated by summing weekday and weekend day minutes and dividing by 60. Outlying ST values greater than 42 hours per week were truncated to 42 hours of weekly ST (n=6). While no reliability information is available for this ST proxy report, it has been used in previously published work (Carson, Spence, Cutumisu, & Cargill, 2010).

3.3.3.2 Outcome Variables

The Canadian PA, Fitness & Lifestyle Approach (CPAFLA) Manual and fitness testing protocol was used to assess physical fitness (CSEP, 2003). At the time of data collection, this was the current protocol in place with the Canadian Society for Exercise Physiology (CSEP). At least one of the research assistants was recognized as Certified Personal Trainer through programs offered by CSEP. The battery of fitness tests measured anthropometry (waist circumference), cardiorespiratory fitness (step test), musculoskeletal fitness (grip strength, push-ups, partial curls-ups, vertical jump), and flexibility (sit-and-reach test). The data record sheet for the fitness component is located in Appendix G. A Physical Activity Readiness Questionnaire (PAR-Q; CSEP, 2014a; Appendix H) was completed by parents prior to children participating in the physical fitness tests. Also, participants were pre-screened using a heart rate measure. Resting heart rate less than 100 beats per minute was used as the pre-screening cut off. If heart rate exceeded 100 beats per minute, participants were instructed to wait seated for five minutes before being re-tested. Only participants who meet the resting heart rate requirements on the first or second measures were allowed to proceed with the fitness testing.

Anthropometric measure: Waist circumference was the anthropometric measure used. A non-stretch tape measure was used to assess waist girth to the nearest 0.1 cm at the top border of the iliac crest. Each participant's waist circumference was measured twice, and if the two measures differed by more than 0.5 cm a third measure was taken. The final waist circumference value consists of an average of the two or three trials.

Cardiovascular Fitness: Cardiovascular fitness was measured using the modified Canadian Aerobic Fitness Test (mCAFT). The mCAFT protocol involves stepping up and down two stairs to a set cadence. The cadence is played through an audio recording that increases in intensity as participant's progress through the stages. Boys started the step test at stage four and girls started at a stage three. Participants progressed through the stages until they reached 85% of their predicted heart rate max (220-age; CSEP, 2003). Post exercise heart rate was measured 2, 3 and 4 minutes after completion of the exercise. Predicted maximal aerobic power (VO_2 max) was calculated for participants who reached 85% of their age-predicted maximal heart rate using the Weller Equation (Weller et al., 1995). This equation is typically used to predict VO_2 max in adults, but has been used previously with children (Tremblay et al., 2010).

Musculoskeletal Fitness: Musculoskeletal fitness was measured using grip strength, push-ups, partial curl-ups, and vertical jump. Grip strength was used to measure overall muscular strength using a dynamometer. The participants were asked to stand upright with their arms slightly raised to the sides and alternate squeezing the dynamometer in each hand twice, resting between each try. The output for each hand was recorded to the nearest 1.0 kilograms by the examiner. The highest outputs for each hand were summed to create a grip strength score.

Push-ups measured upper body muscular endurance. Boys completed push-ups pivoting from the toes and girls pivoting from the knees. Participants were instructed to lay prone on a mat with their hands underneath their shoulders and palms on the ground. Pivoting from either the toes or knees, participants completed push-ups until failure. The participants had to fully straighten their arms at the top of the push-up and lower their body until their chin was near the mat, without their stomach touching the mat. If any push-ups were done improperly, the examiner would verbally correct the participants form. If done incorrectly a second time the child was told to stop the test. Incorrect repetitions did not count. The number of correct completed push-ups before failure was recorded.

Partial curl-ups tested abdominal endurance. Participants were instructed to lay supine on a mat with their knees bent at ninety degrees and their arms resting palms down beside their body. Participants were to slide their hands forward on the mat 10 centimeters, as marked with tape, and move back to resting position. This was done to a set cadence of 50 beats per minute. The number of partial curls-ups done in one minute was recorded (maximum of 25 repetitions).

Vertical jump was used to measure lower body power. To record standing reaching height, participants stood perpendicular to a wall with their feet flat on the floor and one arm extended up the wall. Next, the participant stood slightly away from the wall (with hands on the hips, elbow should almost be able to touch the wall). With no pre-jump, the participant was instructed to bend their knees, pause briefly, and jump as high as they could, touching the wall at the peak jump height. Peak jump height was tested three times, with a rest period of 15 seconds between each attempt. The standing reaching height was subtracted from the best jump height and recorded as vertical jump height to the nearest 0.5 cm.

Flexibility: The sit-and-reach test was used to measure hamstring and lower back flexibility. Before beginning this test, participants were instructed to stretch each leg twice for 20 seconds using the modified hurdler stretch. A Flexometer was set up against a wall and participants were instructed to take off their shoes, sit on the floor with legs fully extended, and press their feet against the base of the Flexometer. With arms fully extended, hands over lapped with palms down, participants gently pushed the sliding marker forward as far as possible and paused for 2 seconds. This was done twice and the maximum reach between the two trials was recoded to the nearest 0.5 cm.

Vertical jump, waist circumference, sit-and-reach, predicted VO_2 max and grip strength were expressed as sex-specific z-scores specific to this sample. The values for the push-up and partial curl-up test were not normally distributed and did not improve with transformation; therefore, participants were categorized into “high” and “low” fitness using the age and sex specific standards outlined for gold in the Canada Fitness Award Manual (1986). For example, a 10 year old boy would meet the gold standard if they completed at least 20 push-ups or 30 partial curl-ups, whereas a 10 year old girl would meet the gold standard if they completed at least 19 push-ups or 28 partial curl-ups (Canada Fitness Award Manual, 1986).

Overall fitness: Predicted VO_2 max, grip strength, vertical jump, waist circumference, and sit-and-reach z-scores were used to create two total fitness scores. “Fitness-complete” reflects the mean of the five fitness z-scores (predicted VO_2 max, grip strength, vertical jump, waist circumference and sit-and-reach) for participants that have complete data for all five tests.

"Fitness-partial" reflects the mean of the fitness z-scores for participants who have complete data on at least three of the five fitness tests.

3.3.4 Covariates

Covariates included age (years), sex (girls, boys), household income, and body mass index (BMI) based on previous research in older children (Teran-Garcia, Rankinen, & Bouchard, 2008; Cleland, Ball, Magnussen, Dwyer, & Venn, 2009). Household income was parent-reported. The question included six response options ranging from <$20, 000 to >$100, 000 of annual income. For BMI, height was measured to the nearest 1.0 mm using a stadiometer and weight was measured to the nearest 0.1kg using a calibrated scale. BMI was expressed using the World Health Organizations age and sex specific z-scores for children (de Onis et al., 2007).

3.3.5 Statistical Analysis

All data analyses were conducted using IBM SPSS Statistics 23.0 software [IBM Corp., Armonk, NY]. To address objective 1, the means and standard deviations were calculated for the raw predicted VO_2 max, grip strength, vertical jump, sit-and-reach, and waist circumference values. Frequencies were calculated for the percentage of participants in the "high" and "low" fitness categories for both the push-up and partial curl-up fitness tests according to the Canada Fitness Award "gold standard" (Canada Fitness Award Manual, 1986). To address objective 2, linear regression analyses were used to examine the association between ST, subjective PA, and objective PA with predicted VO_2 max, grip strength, vertical jump, sit-and-reach, waist circumference, fitness-complete, and fitness-partial. Logistic regressions were used to examine associations between ST, subjective PA, and objective PA with partial curl-ups and push-ups. For all regression models, with the exception of waist circumference, model 1 controlled for age, sex and household income, and model 2 controlled for age, sex, household income and BMI.

Due to the high correlation between BMI and waist circumference, BMI was not adjusted for in the models that included waist circumference. To address objective 3, a moderation analysis was conducted for each association by including a sex × PA or sex × ST interaction term in the model. When statistically significant interaction terms were observed, sex-stratified analyses were conducted. Statistical significance was set at $p<0.05$.

3.4 Results

To maximize the data collected, those participants with complete data for each association examined were included in the analysis, resulting in a different total number of participants for each analysis. The amount of missingness was highest in the cardiovascular fitness test (56%) and second highest for the objective PA measure (30%). All other PA, ST, and fitness measures had <5% of missing values. The high number of missingness (n=350) in the cardiovascular fitness test was due to participants not reaching 85% of their predicted max heart rate, which is necessary for accurate predictions of VO_2 max in the CPAFLA protocol (2003). Reasons for not meeting the recommended heart rate ceiling included the children's inability to maintain a set cadence or their choosing to stop the test early. For the objective PA measure, high missingness (n=193) was due to participants not returning the logbook or not wearing the step counter for a total of three days.

Participant information, including fitness is presented in Table 1. The mean age of participants was 7.8 ± 0.6 years, and approximately half (52.4%) of participants were female. Total mean and standard deviation of PA was 12.6 ± 7.4 weekly hours when measured with a proxy-report, and 8645 ± 2759 daily steps when measured with a pedometer. Average weekly hours of ST was 13.9 ± 8.1. The mean scores for the fitness variables tested in the total sample were: 39.4 ± 2.3 $ml\cdot(kg\cdot min^{-1})$ for predicted VO_2 max, 30.8 ± 6.1 kg for grip strength, 20.4 ± 5.1

cm for vertical jump, 28.1 ± 6.6 cm for sit-and-reach, and 59.8 ± 6.0 cm for waist circumference. Only 20.5% and 7.9% of participants scored in the high push-ups and high partial curl-ups groups, respectively.

Results for the linear regression models are presented in Tables 2 and 3. In the fully adjusted models (model 2), positive associations were observed between subjective PA and overall fitness for both the complete (β=0.009, 95% CI: 0.001, 0.017) and the partial (β=0.006, 95% CI: 0.000, 0.011) fitness scores. Objective PA was also positively associated with the fitness-partial (β=0.025, 95%CI: 0.007, 0.042). There was a trend for a negative association between ST and the fitness-partial score (p=0.057; β=-0.005, 95% CI:-0.010, 0.000). No significant associations were observed between objective PA or ST and the fitness-complete score.

For individual fitness measures in the fully adjusted models, subjective and objective PA were positively associated with vertical jump height (β=0.011, 95% CI: 0.000, 0.022 and β=0.043, 95% CI: 0.008, 0.078, respectively). No significant associations were observed for sit-and-reach or waist circumference.

Grip strength and predicted VO_2 max were moderated by sex; therefore, linear regressions for both of these fitness measures were stratified by sex (Table 3). In the fully adjusted model, subjective PA was positively associated with predicted VO_2 max (β=0.040, 95% CI: 0.018, 0.063) and grip strength (β=0.025, 95% CI: 0.011, 0.040) score in boys only. Similarly, boy's objective PA was positively associated with predicted VO_2 max (β=0.084, 95%CI: 0.012, 0.157). A negative association with ST and grip strength (β=-0.016, 95% CI: -0.028, -0.004) was also observed in boys only. No significant associations were observed for PA or ST with predicted VO_2 max or grip strength in girls (Table 3).

Results for the logistic regression are presented in Table 4. In the fully adjusted model, children with higher objective PA were more likely to be in the high push-up group (OR=1.156 95% CI: 1.054, 1.267). No significant associations were observed between subjective PA or ST and push-ups or partial curl-ups.

3.5 Discussion

This study examined associations between PA, ST and various fitness measures in a sample of children aged 6 to 10 years. Both objective and subjective PA measures were positively associated with overall fitness, vertical jump, and predicted VO_2 max (boys only). Subjective PA was also positively associated with grip strength (boys only), and objective PA was associated with increased likelihood of scoring "high" on the push-up test. Few associations were observed between ST and fitness, apart from grip strength in boys, where negative associations were observed. It is important to note that the size of effects for all associations were small.

For the most part, fitness testing protocol in the present study matches those used in a nationally representative sample of Canadian children and youth in 2007-2009 (Tremblay et al., 2010). Compared to the 6- to10-year old children in Tremblay et al. (2010), the participants in our study had higher grip strength and sit-and-reach scores, and lower predicted VO_2 max scores. For example, fitness in the Tremblay et al paper was expressed for both boys and girls, respectively: grip strength (25kg and 23kg), sit-and-reach (24cm and 29cm), and VO_2 max (56.3 $ml{\cdot}(kg{\cdot}min^{-1})$ and 50.7 $ml{\cdot}(kg{\cdot}min^{-1})$; 2016). In our sample, the mean fitness scores for both boys and girls, respectively were: grip strength (32kg and 30kg), sit-and-reach (26cm and 31cm), and VO_2 max (40.53 $ml{\cdot}(kg{\cdot}min^{-1})$ and 38.6 $ml{\cdot}(kg{\cdot}min^{-1})$). Differences in demographic factors between samples may explain some of the differences in fitness between samples. For instance, higher socioeconomic status has been found to be associated with higher fitness scores (Cleland et al., 2009), and the Edmonton region sample had a higher median income than reported in the 2006 census data (Statistics Canada, 2010). While the socioeconomic differences may explain the higher sit-and-reach and grip strength scores in the present sample compared to the national sample, it does not explain the opposite finding for VO_2 max scores. In addition to socioeconomic differences, the national sample reported slightly higher BMI scores compared to the Edmonton region sample and only included predicted VO_2 max scores for 8- to 10-year-olds. Since the Weller equation (Weller, 1995) used to calculate predicted VO_2 max includes both age and weight (i.e., predicted VO_2 max $= 32 + 16($$O_2$ cost of stepping in L/min) – 0.17(weight in kg) – 0.24(age in years)), one would expect that lower age and weight values would result in a higher average VO_2 max score when compared to the national sample. However, it is unclear why this was not found in the present study.

The association between objective PA and fitness in children 5 to 17 years of age across 38 studies has recently been summarized in a systematic review on PA and health indicators (Poitras et al., 2016). Eighteen out of 29 observational studies, which were all cross-sectional, looked at total PA using both pedometers (n=4) and accelerometers (n=14) and all had associations between a cardiovascular fitness measure and total PA (Poitras et al., 2016). However, cardiovascular fitness findings in the nine included experimental studies were mixed (Poitras et al., 2016). In the present study, a significant association was observed between objective total PA and cardiovascular fitness in boys only, suggesting that sex may be an important effect modifier to include when examining this relationship in future research.

Ten observational studies in the Poitras et al. (2016) review examined the association between PA and muscular strength, and the results were mixed. Similarly in the present study, some significant associations were observed between objective PA and vertical jump, push-ups and fitness-partial scores but not for grip strength, sit and reach, or predicted VO_2 max, but overall results were mixed. Of the 38 included studies in the Poitras et al. review, only six had a mean age similar to our study (≤8 years of age) and none of those included measures of muscular strength or muscular endurance. Therefore, including both cardiovascular and muscular fitness in the present sample of 6- to 10-year-olds provides novel insight into the similarities and differences between objectively measured PA and fitness in young children, compared to the associations seen in their older counterparts.

While both capture PA, subjective measures and objective measures can potentially capture different types of movements or activities (i.e., upper body movements or water activities). Additionally, it is likely that the subjective measures in the present study captured time spent in organized activities that could be of higher intensity. Conversely, the objective step count measure would have captured all activity performed throughout the day, including lower intensity activities. These differences between measures could potentially explain the different associations observed between objective and subjective PA and fitness in the analysis. Specifically, subjective PA in the present study was positively associated with grip strength (in boys only) and vertical jump, which indicates that the types of activities captured by the PA questionnaire may be positively associated with muscular strength in young children. Upper and lower body strength (push-up test and vertical jump test, respectively) were also associated with the objective PA measures. Therefore, both measures of PA were able to capture the importance of PA on children's upper and lower body muscular fitness in this sample of children.

In addition to PA, the present study also examined ST as a correlate of fitness in children. Currently, two systematic reviews have looked at the relationship between sedentary behaviour and various health indicators, including fitness, in children and youth. A 2011 review (Tremblay et al., 2011) included 15 studies that assessed fitness as a health indicator. More than two hours of ST per day was associated with lower predicted VO_2 max, cardiovascular fitness, or muscular strength in 10 of the 15 studies (Tremblay et al., 2011). However, only four of these studies assessed muscular strength or endurance, and only one study had a mean age younger than 8 years of age (Tremblay et al., 2011). A five year update to the Tremblay et al. (2011) review that included 21 new studies found similar findings for total ST and TV viewing (Carson et al., 2016) However, computer and video game usage alone was not associated with any physical health indicators, such as fitness or body composition. Of the 15 studies that specifically examined the association between ST and fitness, only two had a sample with a mean age of less than 8 years (Ciesla et al., 2014; Drenowatz et al., 2014). The age differences could potentially explain inconsistent findings between the school-aged children reviews and the present study. It is possible that the effect of ST on fitness in young children may not present as strongly as it does with adolescents, and more time is needed before the amount of ST young children engage in has an effect on health-related fitness measures. However, given most of the observational evidence is based on cross-sectional data, future research using a longitudinal design is needed to better understand the relationships between ST and fitness over time, especially with a baseline sample of younger children.

In line with systematic review evidence (Poitras et al., 2016), our findings suggest promoting regular PA in young children may help to address the declining fitness levels in children and youth. Because few studies have examined the relationship between PA, ST, and fitness in children under 10 years of age, future research is needed to confirm findings from the present study. For instance, understanding the age at which PA and ST begin to influence children's fitness is crucial for determining the optimal time to intervene on the downward trend in fitness. One potential reason explaining why limited fitness data are available in young children could be because of the paucity of fitness measures validated for this age group. Future research that provides standardized measures of physical fitness in young children will allow for better comparisons between studies.

The main strengths of this study are the young age of the participants, the relatively large sample size of Canadian children, and the inclusion of muscular strength and endurance in the analyses. However, this study is not without limitations. Though the prediction of child VO_2 max is consistent with previous research (Tremblay et al., 2010), the equation has not been validated in children; therefore, the cardiovascular fitness results should be interpreted with caution. Additionally, the psychometric properties of the ST questionnaire are unknown; therefore, information bias may have been present. Furthermore, the cross-sectional design prevents us from making causal claims about the findings. Finally, the behaviour measures did not assess the entire movement behaviour pattern throughout the children's day, including sedentary time, light PA and moderate-to-vigorous PA. It is possible that the intensity of PA may be more strongly associated with fitness than duration, which was not captured by our objective pedometer measure (Blair, Cheng, & Holder, 2001).

3.6 Conclusion

PA of young children in Edmonton was associated with overall fitness and some individual components of cardiovascular and muscular fitness. However, in contrast to studies in older children, the associations between ST and fitness measures were primarily null in this age group. Young children may be at an optimal age to target PA and ST behaviours to reverse the current declining fitness trends, but future research using longitudinal study designs is needed to confirm these observations.

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Table 1. Participant information and descriptive statistics of a sample of Edmonton children.

Variables	Girls	Boys	Total
Gender (%)			
Male	-	-	47.6
Female	-	-	52.4
			N=649
Age (years)	7.8(±0.6)	7.8(±0.6)	7.8(±0.6)
BMI (%)			
Non-overweight	78.6	77.6	78.1
Overweight/Obese	21.8	22.4	21.9
			n=628
Household Income (%)			
<$20,000	1.3	2.1	1.7
$20-39,999	1.3	2.1	1.7
$40-59,999	7.9	5	6.5
$60-79,999	12.7	9.6	11.2
$80-99,999	19	22.5	20.6
>$100, 000	57.9	58.6	58.2
			n= 596
Physical Activity (hours/week)	12.6(±7.6)	12.6(±7.0)	12.6(±7.4)
			n=631
Physical Activity (steps/day)	8171.7(2641.2)	9185.1(2796.1)	8645.1(±2758.5)
			n=456
Screen Time (hours/week)	12.4(±7.2)	15.6(±8.7)	13.9(±8.1)
			n=630
Fitness Scores			
VO_2 max (ml·(kg·min)$^{-1}$; n=285)	38.6(±2.1)	40.5(±2.1)	39.4(±2.3)
Grip strength (kg; n=639)	29.7(±5.6)	32.1(±6.3)	30.8(±6.1)
Vertical Jump (cm; n=641)	20.1(±5.0)	20.7(±5.1)	20.4(±5.1)
Sit-and-Reach (cm; n=641)	30.7±6.3)	26.4(±6.2)	28.7(±6.6)
Waist Circumference (cm; n=642)	60.0(±6.2)	60.0(±6.2)	59.8(±6.0)
Push-ups (%; n=639)			
High	28.7	11.5	20.5
Low	71.3	88.5	79.5
Partial Curl-ups (%; n=636)			
High	6.9	8.9	7.9
Low	93.1	91.1	92.1

Note: Data presented as mean (± standard deviation) or as percentage (%).

Table 2. Associations between vertical jump, sit-and-reach, waist circumference, and fitness scores (complete and partial) with objective physical activity (steps/day/1000), subjective physical activity (hours/week) and screen time (hours/week) in children.

	Vertical jump	Sit-and-reach	Waist circumference	Fitness-complete	Fitness-partial
	β (95% CI)	β (95% CI)	β (95% CI)	β (95% CI)	β (95% CI)
Objective PA					
Model 1	0.045(0.010, 0.079)*	0.001(-0.034, 0.036)	-0.019(-0.054, 0.016)	-0.006(-0.035, 0.023)	0.014(-0.007, 0.034)
Model 2	0.043(0.008, 0.078)*	0.001(-0.034, 0.037)	N/A	0.005(-0.021, 0.030)	0.025(0.007, 0.042)*
N	455	455	456	200	456
Subjective PA					
Model 1	0.011(0.000, 0.022)*	0.000(-0.011, 0.011)	-0.001(-0.082, 0.060)	0.009(0.000, 0.018)†	0.006(0.000, 0.012)†
Model 2	0.011(0.000, 0.022)*	0.000(-0.011, 0.011)	N/A	0.009(0.001, 0.017)*	0.006(0.000, 0.011)*
N	624	624	625	271	625
Subjective ST					
Model 1	-0.004(-0.014, 0.006)	-0.005(-0.015, 0.005)	0.007(-0.004, 0.017)	-0.005(-0.013, 0.004)	-0.003(-0.009, 0.003)
Model 2	-0.003(-0.014, 0.007)	-0.005(-0.015, 0.005)	N/A	-0.007(-0.014, 0.001)	-0.005(-0.010, 0.000)†
N	641	641	642	283	642

Note: Fitness-complete includes participants with complete data for vertical jump, sit-and-reach, VO_2 max, grip strength, and waist circumference. Fitness-partial includes participants with complete data for at least three components of fitness-complete. Model 1 is adjusted for age, sex, and household income. Model 2 is adjusted for age, sex, household income and BMI.

* significant at $p < 0.05$

† significant at $p < 0.07$

Table 3. Sex specific grip strength and predicted VO_2 max scores and objective (steps/day/1000) and subjective (hours/week) physical activity and screen time (hours/week).

	VO_2 max (boys) β (95% CI)	Grip strength (boys) β (95% CI)	VO_2 max (girls) β (95% CI)	Grip strength (girls) β (95% CI)
Objective PA				
Model 1	0.065(-0.016, 0.147)	0.022(-0.028, 0.072)	0.015(-0.053, 0.083)	0.023(-0.025, 0.071)
Model 2	0.084(0.012, 0.157)*	0.039(-0.006, 0.084)	0.028(-0.036, 0.092)	0.035(-0.010, 0.080)
N	78	221	124	242
Subjective PA				
Model 1	0.040(0.015, 0.066)*	0.025(0.009, 0.041)*	0.010(-0.010, 0.031)	0.003(-0.011, 0.017)
Model 2	0.040(0.018, 0.063)*	0.025(, 0.011, 0.040)*	0.010(-0.009, 0.030)	0.003(-0.010, 0.016)
N	115	294	158	328
Subjective ST				
Model 1	0.002(-0.020, 0.024)	-0.016(-0.029, -0.002)*	-0.002(-0.025, 0.021)	0.000(-0.015, 0.016)
Model 2	0.001(-0.018, 0.021)	-0.016(-0.028, -0.004)*	-0.007(-0.029, 0.014)	-0.004(-0.019, 0.010)
N	120	303	165	336

Note: Model 1 is adjusted for age and household income. Model 2 is adjusted for age, household income and BMI.
* significant at $p < 0.05$

Table 4. Objective (steps/day/1000) and subjective (hours/week) physical activity, screen time (hours/week) and predicting a high push-up or partial curl-up score (gold-standard score with the Canada Fitness Award).

	Push-up OR (95% CI)	Partial curl-up OR (95% CI)
Objective PA		
Model 1	1.165(1.064, 10227)*	0.863(0.735, 1.012) †
Model 2	1.156(1.054, 1.267)*	0.860(0.735, 1.010) †
N	420	420
Subjective PA		
Model 1	1.017(0.989, 1.045)	1.029(0.990, 1.070)
Model 2	1.019(0.992, 1.048)	1.029(0.988, 1.070)
N	578	575
Subjective ST		
Model 1	1.006(0.979, 1.033)	1.020(0.984, 1.058)
Model 2	1.006(0.979, 1.034)	1.020(0.984, 1.058)
N	593	590

Note: Model 1 is adjusted for age, sex and household income. Model 2 is adjusted for age, sex, household income and BMI.
* significant at $p < 0.05$; † significant at $p < 0.07$.

Chapter 4: Manuscript 2

Behaviour tracking and three-year longitudinal associations between physical activity, screen time, and fitness among children living in Edmonton, Canada

This manuscript will be submitted to Journal of Physical Activity and Health and is presented according to the journal requirements.

4.1 Abstract

Background: Understanding the correlates of children's fitness as children develop is needed. The objectives of this study were to: (1) examine the longitudinal associations between physical activity (PA), screen time (ST), and fitness; (2) determine if sex moderates associations; and (3) track PA and ST over three years.

Methods: Findings are based on 649 children (baseline: 4.5 ± 0.5 years; follow-up: 7.8 ± 0.6 years) from Edmonton, Canada. Parental-reported hour/week of PA and ST were measured at baseline and at a three-year follow up. Fitness (vertical jump, sit-and-reach, waist circumference, grip strength, predicted VO_2 max, push-ups, and partial curl-ups) was measured using established protocols at follow-up. Sex-specific z-scores or low/high fitness groups were calculated. Linear or logistic multiple regression models and spearman correlations were conducted.

Results: Baseline ST was negatively associated with follow-up grip strength (β=-0.010, 95% CI: -0.019, -0.001) and follow-up overall fitness (β=-0.009, 95% CI: -0.016, -0.002). Associations between baseline PA and follow-up VO_2 max (β=0.014, 95% CI: 0.000, 0.027) and overall fitness (β=0.007, 95% CI: 0.000, 0.014) approached significance (p=0.05). No sex-interactions were observed. Moderate and large tracking were observed for PA (r_s=0.30) and ST (r_s=0.53), respectively.

Conclusions: PA and ST may be important modifiable correlates of overall fitness in young children.

4.2 Introduction

Improved or high levels of physical fitness in children have been associated with a wealth of positive outcomes. For example, high or improved cardiovascular and muscular fitness are associated with lower total and central adiposity and a lower cardiovascular disease risk factor score (Smith et al., 2014; Ortega et al., 2008). Cardiovascular fitness is also associated with reduced depression, anxiety, and stress; whereas, muscular fitness is associated with better bone health (Smith et al., 2014; Ortega et al., 2008; Janssen & Leblanc, 2010). Despite these known health implications, children's fitness levels have declined significantly over the past two decades in Canada and internationally (Tremblay et al., 2010; Tomkinson, Leger, Olds, & Cazorla, 2003). For example, in 2007-2009, a typical 12-year-old boy's grip strength score was 5 kg less than the score of a typical boy the same age in 1981 (Tremblay et al., 2010). This same trend occurred in girls (Tremblay et al., 2010). Understanding why fitness levels are declining in children is critical for informing future interventions.

Evidence suggests that PA and sedentary behaviour, in particular ST, are important correlates of fitness in children and youth (Poitras et al., 2016; Carson et al. 2016). However, much of the evidence examining the association between PA, ST, and fitness in children and youth are cross-sectional in nature, limiting the ability to make conclusions about causality (Poitras et al., 2016; Carson et al., 2016). For instance, a recent systematic review on PA and health indicators in this age group (Poitras et al., 2016) only found one longitudinal study that included fitness (Carson et al., 2014). This study examined different PA intensities in relation to cardiovascular fitness, and concluded that there was a positive dose-response trend for vigorous PA at baseline and cardiovascular fitness two years later (Carson et al., 2014). Similarly, recent reviews on sedentary behaviour and health indicators in children and youth (Tremblay et al., 2011; Carson et al., 2016) found only three longitudinal studies that included fitness (Aires et al., 2010; Aggio et al., 2012; Mitchell et al., 2012). Screen time was associated with low cardiorespiratory fitness in all three of these studies (Carson et al., 2016). However, only one of the longitudinal studies in either the PA or sedentary behaviour review examined musculoskeletal fitness (Aires et al., 2011).

Another gap in the current literature regarding the relationship between PA, ST, and fitness is few studies have focused on younger children under the age of 10. For instance, of the four longitudinal studies included in the Carson et al. (2016) and Poitras et al. (2016) reviews, the mean ages of the children ranged from 10 to 12.2 years at baseline. Understanding the longitudinal relationship between PA, ST, and fitness of younger children will help determine the critical age to intervene to improve the health of children. Additionally, longitudinal evidence can provide insight on how these behaviours track over time. When examining these associations it is important to explore potential sex-interactions, as research suggests that the association between PA and health outcomes may differ for boys and girls aged 5 to 17 years (Janssen & LeBlanc, 2010). Therefore, the objectives of this paper were to: (1) examine the longitudinal associations between PA, ST, and fitness; (2) examine if sex moderates the longitudinal associations between PA, ST, and fitness; and (3) track PA and ST over a three-year period in a sample of young children.

4.3 Methods

4.3.1 Participants

Participants were part of the Spatial Health Assessment of Physical Environments (SHAPEs) and the SHAPEs of Things to Come longitudinal follow-up study. Children aged 4 to 5 years and their parents were recruited while visiting a Capital Health Center in Edmonton, Alberta, Canada for a preschool immunization appointment in 2005-2007. Though not mandatory in the province of Alberta, 74% of children in the Edmonton health region received an immunization for Diphtheria, Tetanus, Pertussis and Polio (DTap-IPV) before entering grade one in 2004 (Edwards et al., 2008). Therefore, these centers provided access to a large representative sample of children from this region. Of the 2,114 children who participated in the baseline study, 1,337 (63%) agreed to be contacted regarding future research. A total of 649 (49%) children 6 to 10 years participated in the follow-up data collection three years later. Children who participated in the follow-up study had lower baseline BMI z-scores (mean difference = 0.15) and lower baseline parent reported ST (mean difference = 48 minutes/week) compared to children lost to follow-up. Furthermore, a higher percentage of girls (52.5% versus 46.5%) participated in the follow-up study compared to those children who did not participate. However, parent-reported baseline PA was not significantly different between children included in the follow-up study and those lost to follow-up. The University of Alberta's Ethics Board (HREB) approved this study and all parents provided written informed consent at both time points. Children also provided informed verbal assent prior to fitness testing at follow-up.

4.3.2 Procedures

Families who scheduled immunizations through participating Capital Health Centers were contacted about the SHAPEs study. Those interested in the study were mailed an information letter, a consent form, and a brief questionnaire to bring to the child's appointment. Extra copies of these forms were kept at the health centers. After receiving completed forms and questionnaires, families indicated if they were willing to be contacted in the future about a follow-up study. Approximately three years later, attempts were made to contact all those families by telephone. If contact was made and families were still interested, an information letter, consent form, and questionnaire were mailed to families and an appointment was scheduled for fitness testing at the University of Alberta. During that visit all completed materials were collected and children completed the fitness components. Participating families received small tokens of appreciation valued at approximately $20 per family. A complete data collection protocol is in Appendix A. The information form and questionnaires are located in Appendices B, D, & F.

4.3.3 Measures

4.3.3.1 Exposure Variables

Physical activity was assessed through a modified version of the Children's Leisure Activities Study Survey (CLASS) questionnaire (Telford et al., 2004). There were nine questions on specific activities including, swimming (lessons and for fun), soccer, ballet/dance, gymnastics, skating, hockey, bike riding, gym activities, and active play (including at a playground). An open-ended item also allowed parents to record any other PA that was not listed. Parents reported both frequency and duration for each PA item for both weekdays and weekend days. The product of the minutes and frequency were summed across the activities and divided by 60 to create a total hours per week of PA variable. Values > 42 hours per week were considered as outliers and truncated to 42 hours (n=6). Previous research has reported substantial to almost perfect agreement (62% - 94%) for 2-week test-retest reliability of the CLASS questionnaire in a sample of children aged 5 to 6 years (Telford et al., 2004).

Parents responded to three questions on different types of ST, including TV/video, play station/Nintendo/x-box/ game boy, and computer/internet/computer games. An open-ended question was also included to record any other type of ST that was not listed. The total amount of time spent in each activity on a typical weekday and weekend day was reported. Weekday and weekend minutes of ST were summed and converted into hours per week by dividing by 60. Values > 42 hours per week were considered outliers and truncated to 42 hours (n=6). No psychometric properties are available for these questions. This measure has been in a previously published study (Carson, Spence, Cutumisu, & Cargill, 2010).

4.3.3.2 Outcome Variables

The Canadian Physical Activity, Fitness & Lifestyle Approach (CPAFLA; 2003) manual and fitness testing protocol was used to assess physical fitness at follow-up. At least one research assistant facilitating data collection was certified as a Personal Trainer through the Canadian Society for Exercise Physiology (CSEP). The battery of fitness tests measured anthropometry (waist circumference), cardiovascular fitness (step test), musculoskeletal fitness (grip strength, push-ups, partial curls-ups, vertical jump), and flexibility (sit-and-reach test), and all fitness test results were recorded (Appendix G). All participants were cleared for fitness testing by the Physical Activity Readiness Questionnaire (PAR-Q; Canadian Society for Exercise Physiology 2014; Appendix H). Before beginning the fitness testing, participants' resting heart rate had to be less than 100 beats per minute in order to proceed. If this was not met, participants were instructed to wait seated for five minutes before being re-tested. Participants who met the resting heart rate on the first or second measure were allowed to continue with testing.

Waist circumference was the anthropometry measure used. The circumference at the top border of the participant's iliac crest was measured twice to the nearest 0.1cm using a non-stretch measuring tape. If the initial two measures differed by 0.5 cm a third measure was taken. The final waist circumference value was an average of the two or three measures.

Cardiovascular fitness was measured using the modified Canadian Aerobic Fitness Test (mCAFT). This is a multi-stage step test where participants are encouraged to continue until they reach 85% of their predicted heart rate max (220-age; CPAFLA 2003). Predicted maximal aerobic power (VO_2 max) was calculated for participants who reached 85% of their age-predicted maximal heart rate using the Weller Equation (Weller et al., 1995). This equation typically predicts VO_2 max in adults, but has been used to predict children's VO_2 max in previous research (Tremblay et al., 2010).

Musculoskeletal fitness was measured using grip strength, vertical jump, push-up, and partial curl-up tests. The grip strength value was calculated by combining the top right and left hand scores of two trials, rounded to the nearest 1.0 kg. The vertical jump value was calculated by subtracting participants' standing reach height from the highest of three jump attempts, rounded to the nearest 0.5 cm. The push-up value was the number of push-ups until failure. For this test, boys pivoted from their toes and girls pivoted from their knees. The partial curl-up value was the number of completed partial curl-ups up to a maximum of 25. Partial curl-ups were done to a set cadence of 50 beats per minute.

The sit-and-reach test was used to measure hamstring and lower back flexibility. The values reflect the farthest forward reach of two trails to the nearest 0.5 cm.

Vertical jump, waist circumference, sit-and-reach, predicted VO_2 max, and grip strength were expressed as sample- and sex-specific z-scores. Since the push-up and partial curl-up scores had highly skewed distributions that were not improved by transformations they were categorized into high or low scores, determined by the age and sex specific "gold-standard" performance standards of the Canada Fitness Award (Canada Fitness Award Manual, 1986).

Two total fitness scores were created by averaging the z-score values. “Fitness-complete” represents the mean of the five fitness z-scores (predicted VO_2 max, grip strength, vertical jump, waist circumference and sit-and-reach) for participants who had complete data for all five fitness tests. “Fitness-partial” represents the mean of the fitness z-scores for participants who had complete data on at least three of the five fitness tests.

4.3.4 Covariates

Covariates included follow-up age (years), sex (girls, boys), household income, and body mass index (BMI). These covariates were selected based on previous research examining the association between PA, ST, and fitness (Teran-Garcia, Rankinen, & Bouchard, 2008; Cleland, Ball, Magnussen, Dwyer, & Venn, 2009). Age, sex, and household income were measured in the follow-up parental questionnaire. Six possible household income response categories ranged from <$20, 000 to >$100, 000. BMI was measured using height (to the nearest 1.0 mm) and weight (to the nearest 0.1 kg), and transformed using the World Health Organizations age and sex specific z-scores for children (de Onis et al., 2007).

4.3.5 Statistical Analysis

IBM SPSS Statistics 23.0 software [IBM Corp., Armonk, NY] was used for all data analyses. To address objective 1, separate linear regression models were conducted to examine the relationship between PA and ST at baseline with the predicted VO_2 max, grip strength, vertical jump, sit-and-reach, waist circumference, fitness-complete, and fitness-partial scores at the three-year follow-up. Separate logistic regression models were conducted to examine the relationship between PA and ST at baseline with push-up and partial curl-up scores at the three-year follow-up. Logistic regression models predicted the high push-up and the high partial curl-up groups, with the low groups being the referent category. Age, sex and household income were adjusted for in model 1 for all analyses. Age, sex, household income, and BMI were adjusted for in model 2 for all regression analyses, with the exception of the waist circumference models. Body mass index was not adjusted for in waist circumference models due to the high correlation between the two variables. To address objective 2, a sex × PA or sex × ST interaction term was included in each model to examine the moderating effect of sex. Finally, to address objective 3, PA and ST values were ranked at baseline and follow-up and spearman rank order correlations were conducted to assess PA and ST tracking. Correlation coefficients were defined as small (0.10 - 0.29), moderate (0.30-0.49), and large (≥ 0.50) based on previous research (Jones, Hinkley, Okely. & Salmon, 2013; Biddle, Pearson, Ross, & Braithwaite, 2010). Statistical significance was set at $p<0.05$.

4.4 Results

Participant information is presented in Table 1. It is important to note that all participants with complete data for each association were included in the analysis to maximize the data collected. The mean ages at baseline and follow-up were 4.5 ± 0.5 and 7.8 ± 0.6 years, respectively. Average PA was 12.0 ± 8.2 hours per week at baseline and 12.6 ± 7.4 hours per week at follow-up. Baseline ST was 13.4 ± 8.1 hours per week and follow-up ST was 13.9 ± 8.1 hours per week.

Results from the linear regressions are presented in Table 2. Baseline ST was negatively associated with follow-up grip strength ($\beta=-0.010$, 95% CI: -0.019, -0.001) and follow-up overall fitness (fitness-complete; $\beta=-0.009$, 95% CI: -0.016, -0.002) in model 2. The associations between baseline PA and follow-up predicted VO_2 max ($\beta=0.014$, 95% CI: 0.000, 0.027), and overall fitness (fitness-complete; $\beta=0.007$, 95% CI: 0.000, 0.014) approached significance ($p=0.05$). No other significant associations were observed between ST, PA, and fitness. Additionally, no significant sex-interactions were observed. The logistic regression results are presented in Table 3. No significant associations were present between baseline PA or ST and follow-up push-up or partial curl-up tests. Furthermore, no sex interactions were observed. Three-year tracking of PA and ST is presented in Table 4. The Spearman correlations indicated moderate tracking for PA (r_s=0.30, p=0.01) and large tracking for ST (r_s=0.53, p=0.01) over the three-year period.

4.5 Discussion

The first two objectives of this study were to examine the three-year longitudinal associations between PA, ST, and fitness and potential sex moderating effects in a sample of young Canadian children. Baseline ST was only significantly associated with overall fitness scores (fitness-complete) and grip strength three years later. Similar findings were observed for PA in regards to total fitness and VO_2 max; however, associations were borderline non-significant. Overall, small effect sizes were observed. Additionally, no sex-interactions were observed. A third objective of this study was to determine if baseline ST and PA behaviours tracked over three years in this sample. A moderate tracking coefficient was observed for PA and a large tracking coefficient was observed for ST over this time period.

Recent reviews (Tremblay et al., 2011; Carson et al., 2016) on sedentary behaviour and health indicators in children identified three longitudinal studies that examined the relationship between ST and fitness (musculoskeletal or cardiovascular; Aires et al., 2010; Aggio et al., 2012; Mitchell et al., 2012). While those three studies found significant associations between ST and cardiovascular fitness, ST did not predict cardiovascular fitness in the present study. Only one of the three studies also included a muscular fitness component (i.e., curl-ups, push-ups) and a total fitness component (Aires et al., 2010), and unlike the associations between muscular fitness (grip strength) and ST in the present study, Aires and others did not find any significant associations.

One of the major differences between the previous longitudinal studies and the current study is the age of participants; where previous studies report a mean baseline age of 11.5 years and older (Aires et al., 2010; Aggio et al., 2012; Mitchell et al., 2012), and the current study has an average baseline age of 4.5 years. It is possible that the relationship between ST and cardiovascular fitness in young children presents differently than seen in later childhood. The different measures used to predict cardiorespiratory fitness between the present study and previous ones may also explain the differences in findings. More specifically, the previous studies all used a maximal 20-meter shuttle run test. Nevertheless, ST was predicted some fitness measures (i.e., grip strength and overall fitness) in this sample, suggesting that even at this young age ST may have important implications on fitness, in particular overall fitness. Given that so few studies have examined these relationships, especially in this young age group, future research is needed to confirm these findings.

No significant associations were observed between baseline PA and follow-up fitness in the present study; however, associations with overall fitness and predicted VO_2 max approached significance (p=0.05). A recent review only identified one study that longitudinally examined association between PA and fitness in children (Carson et al., 2014). This study objectively measured PA using accelerometers and assessed cardiorespiratory fitness, assessed via a shuttle run, as an outcome measure in children (mean age: 12.2 years). Findings indicate that light and moderate PA were not associated with fitness, but baseline vigorous PA had a positive dose-response association with cardiorespiratory fitness two years later (Carson et al., 2014). The parental-report measure of PA in our study did not capture the intensity of PA; rather the frequency and duration. It is possible that the intensity of PA may be a stronger predictor of fitness (Carson et al., 2014) than the duration or frequency. Different findings between studies could also be due to the different measures of cardiorespiratory fitness and PA, or the different sample ages. Given the lack of longitudinal evidence across children and youth age groups, more research is needed to clarify this association.

Pre-pubescent sex difference between boys' and girls' fitness (Flanagan et al., 2015), PA (Metcalf et al., 2015), and ST (Public Health Ontario, 2015) have been reported previously; however, sex did not significantly modify the association between baseline PA, baseline ST, and fitness at follow-up in the present study. No study to our knowledge has examined these sex-interactions in this age group. However, similar findings of no sex-interactions were observed for a sample of adolescents aged 12.5 to 17.5 years when examining the association between PA and fitness (Jimenez-Pavon et al., 2015). Therefore, based on current evidence, longitudinal associations between PA, ST, and fitness appear consistent across boys and girls.

The moderate tracking of PA and large tracking of ST observed in the present study over three years is consistent with previous research (Jones, Hinkley, Okely, & Salmon, 2013). A recent review synthesized studies examining the tracking of PA and ST during the transition period of early-childhood (< 5 years) to middle-childhood (6 to 11 years; Jones, Hinkley, Okely, & Salmon, 2013). Similar to the present study, the median tracking coefficient observed across studies was r_s=0.36 (moderate tracking) for PA and r_s=0.52 (large tracking) for ST (Jones, Hinkley, Okely, & Salmon, 2013). Furthermore, PA in childhood has also shown to track moderately into adulthood (Telama et al., 2005). Combined these findings support the importance of promoting healthy PA and ST behaviours in young children to set good habits for later childhood and even adulthood. This is especially important for ST, where tracking coefficients were larger than PA.

This study is not without limitations. Though the formula to predict VO_2 max has been used in previous studies with children (Tremblay et al., 2010), it has not been validated in children; therefore, results should be interpreted with caution. Additionally, a large portion of participants did not reach the target heart rate zone during the cardiovascular fitness test primarily due to children's inability to maintain a set cadence or children choosing to stop the test early. As a result this outcome had a smaller sample compared to other fitness measures. Also, fitness was measured at follow-up only; therefore the influence of children's fitness levels at baseline on these relationships could not be examined. Furthermore, subjective measures of PA and ST were used, potentially resulting in a measurement error. Additionally, the ST measure has no known psychometric properties. However, both the ST and PA measured in this sample had similar tracking coefficients in total sample as the review by Jones and colleagues, suggesting that the ST and PA questionnaires may have similar psychometric properties to those used in previous research (2013). Lastly, the baseline SHAPEs study was not originally set up as a cohort study; therefore, not everyone at baseline agreed to participate in future research and contact was not maintained with participants between measurement periods to minimize loss to follow-up. Consequently, the loss to follow-up from the original SHAPEs study was large (68%), and significant baseline differences in BMI and ST were observed between those that participated at follow-up and those that did not. Strengths of this study include the three-year longitudinal design, the relatively large sample size, the young age of the participants, and the inclusion of cardiovascular, musculoskeletal, and flexibility fitness tests.

4.6 Conclusion

Unfortunately, the fitness levels of children are declining (Tremblay et al., 2010; Tomkinson, Leger, Olds, & Cazorla, 2003) and it is necessary to reverse this trend given the known health benefits associated with improved fitness in children (Ortega et al., 2008). The amount of time 4- to 5-year-old children spent in ST and PA appeared to be important for overall fitness three years later; however, this relationship was less clear with PA and overall associations were small. Though few associations were seen with individual fitness measures, overall fitness may be a more important fitness measure because of the associated health benefits across the different components of fitness. Since childhood ST and PA values track to later in life, future public health initiatives should consider more targeted approaches to increase PA and decrease ST in young children to instil healthy behavioural patterns from a young age. Doing so may positively impact children's overall fitness.

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Table 1 Descriptive statistics at baseline and three-year follow-up

	baseline	follow-up
Age (years; M (SD))	4.5(±0.5)	7.8(±0.6)
	N=649	N=649
Gender (%)		
Male	47.6	47.6
Female	52.4	52.4
	N=649	N=649
BMI (%)		
Non-overweight	78.2	78.1
Overweight/obese	21.8	21.9
	n=639	n=628
Household Income (%)		
<$20,000	-	1.7
$20-39,999	-	1.7
$40-59,999	-	6.5
$60-79,999	-	11.2
$80-99,999	-	20.6
>$100, 000	-	58.2
		n= 596
Physical Activity (hours/week)	12.0(±8.2)	12.6(±7.4)
	n=641	n=631
Screen Time (hours/week)	13.4(±8.1)	13.9(±8.1)
	n=644	n=630
Fitness Scores (M (SD))		
VO_2 max ($ml \cdot (kg \cdot min)^{-1}$; n=285)	-	39.4(±2.3)
Grip strength (kg; n=639)	-	30.8(±6.1)
Vertical Jump (cm; n=641)	-	20.4(±5.1)
Sit and Reach (cm; n=641)	-	28.7(±6.6)
Waist Circumference (cm; n=642)	-	59.8(±6.0)
Push-ups (%; n=639)		
High	-	20.5
Low	-	79.5
Partial Curl-ups (%; n=636)		
High	-	7.9
Low	-	92.1

Note. Fitness and household income were collected at follow-up only. BMI = body mass index

Table 2 Longitudinal association between follow up VO$_2$ max, grip strength, vertical jump, sit and reach, waist circumference, and fitness scores (complete and partial) and baseline physical activity (hours/week) and baseline screen time (hours/week).

	VO$_2$ max	Grip strength	Vertical jump	Sit and reach	Waist circumference	Fitness-complete	Fitness-partial
	β (95% CI)	**β (95% CI)**	**β (95% CI)**	**β (95% CI)**	**β (95% CI)**	**β (95% CI)**	**β (95% CI)**
Physical Activity							
Model 1	0.014(-0.001, 0.029)ᵻ	0.005(-0.005, 0.015)	0.003(-0.007, 0.013)	0.004(-0.006, 0.014)	0.004(-0.006, 0.014)	0.008(-0.001, 0.016)	0.004(-0.002, 0.010)
Model 2	0.014(0.000, 0.027)ᵻ	0.004(-0.004, 0.013)	0.003(-0.007, 0.013)	0.004(-0.081, 0.080)	N/A	0.007(0.000, 0.014)ᵻ	0.003(-0.002, 0.008)
n	281	633	635	635	636	280	636
Screen Time							
Model 1	-0.003(-0.018, 0.012)	-0.004(-0.013, 0.006)	0.000(-0.010, 0.010)	0.000(-0.010, 0.010)	0.007(-0.003, 0.018)	-0.004(-0.013, 0.004)	0.002(-0.004, 0.007)
Model 2	-0.009(-0.023, 0.005)	-0.010(-0.019, -0.001)*	0.001(-0.009, 0.011)	0.000(-0.010, 0.010)	N/A	-0.009(-0.016, -0.002)*	-0.003(-0.008, 0.002)
n	283	637	638	638	639	281	639

Note. Fitness-complete includes participants with complete data for vertical jump, sit and reach, VO$_2$ max, grip strength, and waist circumference. Fitness-partial includes participants with complete data for at least 3 components of Fitness-complete. Model 1 is adjusted for follow-up age, sex, and household income. Model 2 is adjusted for follow-up age, sex, household income and BMI *p < 0.05 and ᵻp < 0.07 level. BMI = body mass index. Fitness variables are represented as sex-specific z-scores.

Table 3 Longitudinal associations between high push-up or partial curl-up score at follow-up (Gold-standard score of the Canada Fitness Award) and baseline physical activity (hours/week) and screen time (hours/week).

	Push-up
	OR (95% CI)
Physical Activity	
Model 1	1.008(0.982, 1.035)
Model 2	1.009(0.983, 1.036)
n	571
Screen Time	
Model 1	1.004(0.979, 01.030)
Model 2	1.006(0.980, 1.033)
n	573

Note. Model 1 is adjusted for age, sex and household income. Model 2 is adjusted for age, sex, household income and BMI. BMI = body mass index. Referent categories are the low push-up and low partial curl-up groups.

Table 4 Tracking of total physical activity (hours/week) and screen time (hours/week) in children over three years.

	Change	Spearman	Strength
Physical Activity	0.68 ± 9.46	0.30	moderate
Screen Time	0.51 ± 8.01	0.53	large

Note. Change is measured by subtracting the baseline score (hours/week) from the follow-up score (hours/week).

Change (mean ± SD), p=0.01

Chapter 5: General Discussion and Conclusions

5.1 Overview

This thesis focused on physical activity (PA), screen time (ST), and cardiovascular, musculoskeletal, and flexibility fitness outcomes in young children in two analyses using data from the SHAPEs and SHAPEs of Things to Come studies. Three main objectives were addressed in each manuscript. In manuscript 1, the objectives were to (1) describe fitness levels in a sample of 6- to 10-year-old children; (2) examine the cross-sectional association between PA, ST, and fitness; and (3) examine if sex moderates the association between PA, ST, and fitness at the follow-up time point. In manuscript 2, the objectives were to (1) examine the longitudinal associations between baseline PA, baseline ST, and fitness at follow-up; (2) explore PA and ST tracking from baseline to the three-year follow-up; and (3) examine if sex moderates the associations between PA, ST, and fitness longitudinally.

5.2 Summary of key findings

This thesis provides evidence of the associations between PA, ST, and some fitness measures in an understudied group of young children. The key findings across both manuscripts are the associations between PA and ST with overall fitness scores. As improved overall fitness in this age group is necessary for maximal health benefits because an overall fitness score encompasses multiple components of fitness and their respective health benefits. Therefore, the measure of overall fitness might be more important than individual measures. Physical activity had significant and borderline non-significant associations with overall fitness in both the cross-sectional and the longitudinal analyses. Screen time was associated with overall fitness longitudinally. Together, findings suggest that PA and ST may be important target behaviours for improving overall fitness in this age group; however, it should be noted that the size of effects observed in both studies were small.

5.3 Implications of key findings

These findings have implications on future research and public health interventions and initiatives. Though manuscripts 1 and 2 provide some preliminary evidence of associations between PA, ST, and fitness in young children, future research is needed to confirm and build upon these findings. More specifically, future research should examine the role PA intensity plays in improving fitness, and whether different types and durations of sedentary behaviours (e.g., television viewing versus playing computer games) have different impacts on fitness. Finally, the development and use of fitness measures that are valid and reliable in young children could help advance the knowledge base in this area.

Currently, PA recommendations encourage MVPA for optimum health benefits for children (Janssen & LeBlanc, 2010; CSEP 2016). Research is beginning to explore the benefits of different PA intensities in association with improved fitness, typically measured with accelerometers (Poitras et al., 2016). For example, a Canadian study observed positive associations between accelerometer-measured baseline vigorous PA and predicted VO_2 max scores two years later in 12 year old children, but this association was not present with moderate or light PA (Carson et al, 2014). Additionally, intervention studies have had mixed results when increasing MVPA in aims to improve children's fitness (Poitras et al., 2016). Perhaps the distinction between moderate PA and vigorous PA has important implications in the PA and fitness associations in children. Unfortunately, the measures of PA used in this thesis did not allow for an examination of intensity. Furthermore, of the interventions studies mentioned in a recent review (Poitras et al., 2016), the majority used cardiovascular fitness as the sole fitness outcome measure, and only one study included a muscular strength and a flexibility component (Verstaete et al., 2007). Future research that explores different intensities, in particular vigorous PA, across cardiovascular, muscular strength, and flexibility fitness measures is needed to further understand the relationship between PA and fitness in children.

The intensity principle for PA research does not apply to ST research; however, future ST research should consider classifying ST into different types and exploring those associations with cardiovascular, muscular strength, and flexibility fitness measures in children. Interestingly, a recent review found ST and TV to be harmful to nearly all aspects of health; whereas time spent playing computer/video games were not associated with any indicators of physical health, including fitness (Carson et al., 2016). Since then, one study has specifically explored the association between different types of ST with muscular strength in children (Edelson, Mathias, Fulgoni, & Karagounis, 2016). This research observed that television viewing was significantly and negatively associated with all measures of strength, where computer and video game use was only significantly and negatively associated with one measure of strength in 6- to 15-year-old children (Edelson, Mathias, Fulgoni, & Karagounis, 2016). The authors speculate that this finding may be due to the differences in posture and muscular tension when a child is passively watching a screen versus when the child is physically engaged in a screen activity (Edelson, Mathias, Fulgoni, & Karagounis, 2016). Though the SHAPEs studies collected information on different types of ST, it was beyond the scope of this thesis to examine them. Understanding if the type of ST has different impacts on fitness could help inform future interventions aimed at improving fitness through targeting specific types of ST for reduction.

In order to improve our understanding of PA, ST, and fitness associations among young children in future research, standard fitness measures that are valid and reliable in this age group need to be determined. Currently, the lack of valid and reliable fitness measures for young children makes comparisons between studies challenging. Along with valid and reliable measures, fitness tests need to be feasible for different facilities to carry-out and feasible for young children to perform successfully. The FITNESSGRAM test battery is an example of a valid and reliable measure for youth widely used in the U.S.; however, this battery was not designed for children younger than third grade (Morrow, Martin, & Jackson, 2016). Currently, a test battery is being developed to address this gap in the literature in children 3 to 5 years of age (Cadenas-Sanchez et al., in press). The proposed PREFIT test battery includes a 20m shuttle run, 4 x 10m agility shuttle run, and grip strength protocol that is both feasible and reliable in this age group; however, the standing long jump test proposed by PREFIT requires further adjustments before being used in this age group (Cadenas-Sanchez et al., in press). This work begins to address this major limitation in the literature and, if successful, can potentially lead to advancements in fitness research in young children, in particular those aged 3 to 5 years.

Despite the need for future research, findings from this thesis do have important implications on public health interventions and initiatives. Fitness has been well established as a strong indicator of health in adults, delaying all-cause mortality and lowering rates of cardiovascular disease (Blair et al., 1989). More recently in children, cardiovascular and musculoskeletal benefits have also been associated with lower risk factors for cardiovascular disease (Ortega, Ruiz, Castillo, & Sjostrom, 2008). Considering both PA and ST may be important modifiable correlates of overall fitness in young children, healthy movement behaviour practices in this age group should be promoted. Developing these healthy practices in young children is particularly important because PA and ST track from early childhood onward (Yang, Telama, Viikari, & Raitakari, 2006; Biddle, Pearson, Ross, & Braithwaite, 2010; Jones, Hinkley, Okely, & Salmon, 2013). Furthermore, regular PA and low amounts of ST are associated with a wide range of health benefits (Janssen & LeBlanc, 2010; Smith et al., 2014; Tremblay et al., 2011).

5.4 Overall strengths of the thesis

This thesis has some key strengths. First, it includes a relatively large sample of young children addressing a gap in the current literature. Similarly, the longitudinal analyses included in manuscript 2 addressed another important gap in the literature. Lastly, both manuscripts included musculoskeletal fitness, cardiovascular fitness, and flexibility fitness measures as well as a combined overall fitness score.

5.5 Overall limitations of the thesis

This thesis is not without limitations. First, although the fitness measures used in this thesis have been used with children previously (Tremblay et al., 2010), the test battery was not designed for people under 15 years of age. This may have contributed to the large amount of children who did not complete the cardiovascular fitness measures, reducing the sample size for some analyses. This work is also limited by the subjective measure of PA and ST in the longitudinal analyses (manuscript 2); though a pedometer measure was included as a PA measure in manuscript 1. Subjective measures could have resulted in a measurement error, and potentially contribute to the small effect sizes observed. Lastly, the loss to follow-up from the original SHAPEs study was large (68%), which could have resulted in selection bias. However, selection bias likely had a larger impact on the descriptive results and less of an impact on the associations between PA, ST, and fitness.

5.6 Summary of MSc Research Experience

Valuable research experience was gained throughout the MSc program in preparing manuscript 1 (chapter 3) and manuscript 2 (chapter 4), and by working as a research assistant on other projects in the Behavioural Epidemiology Laboratory. In terms of the manuscripts, experience was gained working with a large dataset, analyzing data, interpreting results, and writing and editing each manuscript. Focus was placed on reviewing past and current fitness testing measures used with children and exploring how to best use the fitness data collected within the SHAPEs study to accurately represent the fitness of this sample. Two posters were presented at the International Society for Behavioural Nutrition and Physical Activity conference in June, 2016. Additionally, both manuscripts are being prepared for submission to peer-reviewed journals.

Outside of the thesis work, experience was gained as a recruitment coordinator and sole data collector for a large cohort study (COMPASS) in Alberta. This role involved coordinating participation and data collection with administrators at the school division and school level, managing and conducting data collection, tracking school participation, progress, and communication, and facilitating knowledge translation. Finally, additional experience was gained recruiting families for another cohort study (PREPS) within the Behavioral Epidemiology Laboratory.

5.7 Conclusions

As the fitness levels of children in Canada decline (Tremblay et al., 2010), the proportion of children who are able to benefit from the health-related benefits that are associated with fitness also declines (Ortega, Ruiz, Castillo, & Sjostrom, 2008; Adegboye et al., 2011). Historically, less focus is being placed on physical fitness in Canadian schools, as the last nationwide fitness initiative ended in 1992. In addition, few children are meeting the recommended PA and ST provided by national guidelines designed specifically to optimize health outcomes, including fitness (ParticipACTION, 2016). This thesis explored PA and ST as correlates of fitness, and overall findings suggest that PA and ST may be important modifiable correlates to consider when addressing overall fitness in this young age group. This is further supported by the fact that PA and ST appear to track from early childhood to later childhood (Biddle, Pearson, Ross, & Braithwaite, 2010; Jones, Hinkley, Okely, & Salmon, 2013), where consistent associations with fitness have been observed (Carson et al., 2016; Poitras et al., 2016). Therefore, moving forward future research should build on these findings to help inform public health interventions that aim to instill healthy PA and ST habits in young children with an over-arching goal of obtaining the health benefits associated with high overall fitness.

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Appendix A: Data Collection Protocol

Data Collection Protocol

August 2008

Consent, Par-Q, Resting Heart Rate

★*Equipment Set Up:*

- *Consent Forms &Par-Q's*
- *Heart Rate Monitor & Stethoscope*
- *Stop Watch*
- *Data Recording Sheet*

1. Consent

- Ensure consent forms are filled out by caregiver prior to beginning.
- Be prepared to answer questions the caregiver may have regarding the fitness testing.

2. Par-Q

- Ensure Par-Q has been filled out by the caregiver on behalf of the child.
- Review the Par-Q:
  - If all 7 answers are ☑ **NO**, then proceed with testing
  - If any of the answers are ☑ **YES,** then refer to flow chart ***(Figure 1)***

3. Child Information

- Correctly fill out Child ID, testing date, tester(s)
  - Date will be recorded as **dd-MON-yyyy**: *ie.* ***18-AUG-2008.***

4. Resting Heart Rate

- If proceeding with testing, assist the child in correctly placing the heart rate monitor:
  - Choose the best sized chest strap & attach strap around the child's waist. Tighten as appropriate
  - Demonstrate where the strap should be placed, under the shirt (point to base of sternum) ***(Figure 2)***
  - Wet the monitor just prior to positioning
  - Have child face wall & slide the strap into place
  - Turn on watch transceiver & check to see if monitor is in correct place
    - *If assistance is needed to tighten strap or re-adjust positioning, ask permission to help. If child seems reluctant, ask caregiver to assist*
  - If heart rate monitor does not record after adjustments, please remove and take heart rate manually with a stethoscope (resting = 15 sec)
- Once the heart rate monitor is positioned, the child should sit still for 5 minutes. Start timer. During this time, the tester should make the child feel at ease through general conversation.

- At 5 minutes, record resting heart rate on Data Recording Sheet.
    - *Have child keep heart rate monitor on until all fitness is completed*

Height, Weight, Waist Circumference

★*Equipment Set Up:*

- *Electronic Scale*
- *Stadiometer (**★note: should be against a wall)***
- *Gulick Tape Measure*
- *Data Recording Sheet*

1. Height

- Have child remove shoes.
- Position child:
    - Stand tall
    - Spine in line with stadiometer, hands at side
    - Feet together, heels touching back surface of stadiometer
    - Chin positioned so top of head is parallel to floor
    - Instruct child to take a breathe in & position set square
- Measure height on inhalation.
    - Have child bend knees & step away (remind to exhale)
    - Read & record the measure immediately to **nearest 0.1cm**
- Repeat measure a 2nd time.
    - If **> 0.5cm**, take a 3rd measure. Average the 2 closest measures.

2. Weight

- Have child continue with shoes off & remove any bulky clothing. Light gym wear is preferred (shorts & t-shirt).
- Ensure scale is on & reads “0”.
- Weigh child:
    - Have child stand very still in centre of scale until value is stable
    - Read & record the measure immediately to **nearest 0.1kg**
- Repeat measure a 2nd time.
    - Have child step off & then back on to scale. Measure.
    - If **> 0.2 kg**, take a 3rd measure. Average the 2 closest measures.

3. Waist Circumference

- Explain to child you need to place a marking on them ("tattoo"). If child is wearing tighter pants, ask them to loosen / lower then pants below the hip bones.
    - *Tighter waistbands will increase the measurement site.*
- Iliac Crest Site
    - On the right side of child, palpate the top of the iliac crest along the midaxillary line. ***(see Figure 3)*** Make a horizontal mark at site
    - Have the child hold on to the end of the tape measure & "spin in a circle". This will wrap the tape measure around the child unobtrusively
    - Position tape measure at measurement site. Ensure tape is horizontal
    - Child stand tall, looks forward, arms relaxed at side
    - Ensure proper tension in tape measure. Read measure at end of an exhalation. Record immediately to **nearest 0.1cm**
    - Repeat measure a 2nd time
        - If **> 0.5cm**, take a 3rd measure. Average the 2 closest
- Narrowest Site
    - Have the child hold on to the end of the tape measure & "spin in a circle". This will wrap the tape measure around the child unobtrusively
    - Position tape measure at the narrowest site between the bottom of the ribcage & top of the iliac crest. ***(see Figure 4)*** Ensure tape is horizontal
    - Child stand tall, looks forward, arms relaxed at side
    - Ensure proper tension in tape measure. Read measure at end of an exhalation. Record immediately to **nearest 0.1cm**
    - Repeat measure a 2nd time
        - If **> 0.5cm**, take a 3rd measure. Average the 2 closest

Tips:

- *Bow clips may be helpful to keep the t-shirt out of the measurement site*
- *Ensure arms are relaxed & child is looking ahead*
- *Feel free to make general conversation to keep child at ease*
- *Always ask for permission prior to marking or adjusting*

Muscular Strength & Flexibility

★*Equipment Set Up:*

- *Hand Grip Dynamometer*
- *Mat, Counter & Metronome*
- *Masking Tape & Ruler*
- *Sit & Reach Device*
- *Data Recording Sheet*

1. Grip Strength

- Instruct child to put shoes back on.
- Have child compare hand size with tester & set appropriate grip for child.
        - *2nd joint of fingers can wrap around the handle*
- Set to "0".
- Instruct child:
    - Stand tall, holding dynamometer in RIGHT hand
    - Squeeze the handle as hard as possible while exhaling
    - Avoid touching the side of the body
- Record score immediately to nearest 1.0 kg.
- Re-set to "0" & test left hand.
- Repeat measure a 2nd time for each hand.
- Select highest score for each hand. Combine two highest scores.

2. Partial Curl Ups

- Shoes remain on.
- Position child on mat:
    - Knees bent to 90°
    - Fingers in line with tape marker closest to head
    - Explain to child to curl up to touch the 2nd piece of tape (10 cm away) & return to start position = 1 repetition
    - Turn on metronome (50 bpm) & instruct child to stay with the tempo
        - Up for beat, Down for beat (rate of 25 / min)
        - Allow child one practice, provide feedback
- Ensure counter reads "000".
- Begin test. Count "1" for every full repetition. Test ends when child:
    - Cannot keep with cadence
    - Cannot maintain technique over 2 repetitions (2 warnings)
    - Experiences undue discomfort

- Record measure immediately.
-

3. Push Ups

- Shoes remain on.
- Position child on mat:
  - GIRLS:
    - Lie on stomach, legs together, feet stay on mat
    - Hands point forward under shoulders
    - Push up from mat, arms fully extended, while remaining on knees
    - Upper body remains straight
    - Return to start (chin touches mat)
      - *Stomach nor thighs should touch the mat*
  - BOYS:
    - Lie on stomach, legs together, feet stay on mat
    - Hands point forward under shoulders
    - Push up from mat, arms fully extended, while remaining on toes
    - Upper body remains straight
    - Return to start (chin touches mat)
      - *Stomach nor thighs should touch the mat*
- Ensure counter reads “000”.
- Begin test. Count “1” for every full repetition. Test ends when child:
  - Cannot maintain technique over 2 repetitions (2 warnings)
  - Experiences undue discomfort
- Record measure immediately.

4. Vertical Jump

- Shoes remain on
- Child positioned near wall, dominant side closest to wall.
    - *Ask child what hand is used for writing*
  - Place a rolled piece of tape on longest finger
- Start position:
  - Knees bent, arms at side, shoulder close to wall
  - Cue child to use arms & jump as high as possible
  - Touch wall at top of jump, leaving tape
  - Allow one practice
- Begin test. Test 3 jumps. Highest jump will be counted as best.
  - After the three jumps, identify the highest marker
  - Place tape on child’s finger, again, and have child stand directly under highest marker, reach up as high as possible with feet still on the ground while looking forward & place marker
  - Record each jumping height.
  - Record standing height.
  - Measure distance between standing height & highest jumping height to **nearest 0.5 cm**

- Record measure immediately. Highest jump is best score.
-

5. Sit & Reach

- Shoes are removed.
- Demonstrate appropriate stretches & have child perform them. ***(Figure 5)***
- Start position:
    - Aligned toes to markers for left & right foot
    - Middle fingers glued together, on top of ruler
    - Tester positions to side of child, one hand resting on knees to prevent knee bent
    - Child exhales and reaches as far along the ruler as possible & holds for 2 seconds
    - Score is read at the **nearest 0.5 cm**
- Two trials. Record measures immediately. Highest score is best score.

Aerobic Fitness

★*Equipment Set Up:*

- *Heart Rate Monitor /or Stethoscope*
- *CD Player & mCAFT Step Test CD*
- *Step (2 x 20.3 cm height)*
- *Stopwatch*
- *Data Recording Sheet*

1. mCAFT Step Test

- Instruct child to put shoes back on & that heart rate monitor is still reading.
- Demonstrate, then have child practice stepping sequence.
  - Clap hands & call out “UP–2–3, DOWN–2–3” *or* “STEP, STEP, UP, STEP, STEP, DOWN”.
    - *It may help to step with child, at onset, to get coordination.*
- Determine starting stage:
  - **BOYS = Stage 4** **GIRLS = Stage 3**
- Review instructions:
  - Each time, child will step for 3 minutes, keeping with the music.
  - When the music stops, the child will stand still.
  - The tester will tell child when to start the next turn & when the turns are over.
- Testing:
  - Pre-determine the ceiling post-exercise heart rate cut off for child ***(Figure 6)***
    - = 85% of predicted maximum heart rate **= (220 – age) x 0.85**
  - Begin with the appropriate stage (see above).
  - Have the child start that stage. Encourage tempo through clapping, calling out beats &/or walking alongside.
    - *Throughout stage, ensure safety and correct child to ensure proper rhythm, upright posture, entire foot placement on step, and full knee extension on top step.*
  - Immediately after the music stops (end of stage), check child’s heart rate. If using manual read, listen with stethoscope & “START/STOP” with cue on CD. Refer to ***Figure 6*** for conversions. If using heart rate monitor, read on the word “START” on CD.
    - If < calculate heart rate cut-off, proceed to next stage when cued by CD.
    - If = or > than calculated heart rate cut-off, the test is complete.
  - Record heart rate for EACH stage. Record what stage was the last stage completed.
  - Immediately following last stage, start stopwatch and:
    - Have child walk around for 2 minutes, then sit still for 3 minutes.
    - Record heart rate at 2 min, 3 min & 4 min
- Post-testing:

- Ensure child is fully recovered before they leave.
- Retrieve heart rate monitor.
- Thank child & parent. Provide child with “loot bag”.

Post-Testing Procedures

1. Equipment Clean Up

- Following each test, the following equipment needs to be cleaned thoroughly with a disinfectant:
  - Stethoscope
  - Weigh Scale Platform
  - Stadiometer Head Rest
  - Tape Measure
  - Hand Grip Dynamometer
  - Mats
- Heart rate monitors need to be washed with antibacterial soap & left to dry.
- All equipment should be returned to the assigned storage container.

2. Equipment Log Book

- Broken / unusable equipment should be placed aside, marked as REPAIR & not used until it has been fixed or replaced.
- Document all equipment issues in the equipment log book.
- Do not use equipment that is in need or repair.
- Ensure the research coordinator is aware of issues immediately.

3. Data Recording Sheets

- Following each test, ensure the data recording sheet is completed thoroughly:
  - Date of test
  - Child ID
  - Tester ID
  - All raw data & calculated data
  - All relevant notes or comments
- Any missing data should be noted as to circumstances.
- Data recording sheet should be returned with Par-Q to the research binder. The research coordinator and GRAs will ensure data is entered & calculations are made.

Figure 1

PAR-Q Flow Sheet

1. Exclusion Criteria:

- If tester is a CSEP – CPT or lesser certified,
    - an affirmative "☑ " was made to ANY PAR-Q questions 1, 2, 3, 4, 5, 6 or 7
        - **Do not** test mCAFT
        - **Use discretion** for MSK
        - Note rationale on PAR-Q and initial.
        - Note rationale on testing sheet and initial.
- If tester is a CSEP – CEP
    - an affirmative "☑ " was made to PAR-Q questions 4, 5 or 7
        - Query family further & CEP may clear for mCAFT &/or MKS at discretion
    - an affirmative "☑ " was made to PAR-Q questions 1 or 6
        - Query family further & CEP may clear for mCAFT &/or MKS at discretion
    - an affirmative "☑ " was made to PAR-Q questions 2 or 3
        - Seek medical clearance and **do not** test mCAFT
        - **Use discretion** for MSK
    - Note rationale on PAR-Q and initial.
    - Note rationale on testing sheet and initial.

- Mentally and physically impaired individuals that are unable to perform a given task
    - Every effort should be made to be inclusive of individuals with disabilities provided that all safety precautions are taken.
    - Note any exceptions of testing that was omitted & provide rationale.

- Children who have the following should seek medical clearance before fitness testing:
    - have difficulty breathing at rest.
    - appear ill or complains of fever.
    - have a persistent cough.
    - have lower extremity swelling.

Figure 2

Heart Rate Monitor Placement

- ★ Ensure the monitor (chest strap) is slightly wet on the side that will make contact with the chest. The water will help in picking up the signal.
- ★ The centre of the monitor should be directly over the sternum, just above the xyphoid process. Have the child hold it there while tightening the side straps. The strap should be snug enough that is won't slip out of place.
  - o A knot may need to be tied if strap is too big
- ★ Within a minute, the receiver (watch strap) should pick up the heart rate & display as beats per minute. If not, gently tap the receiver to the monitor to activate the signaling.
- ★ Some models will have other functions including time, ability to downloa. Please consult the manufacturer model for more detailed instructions relevant to the model.
- ★ If heart rate is not recording on watch, reposition & re-wetting. If there is still no heart rate, please switch to use of a stethoscope.
  - o **Resting HR = 15 sec count** ***(multiply x 4 for bpm)***
  - o **Activity HR = 10 sec count** ***(multiply x 6 for bpm)***

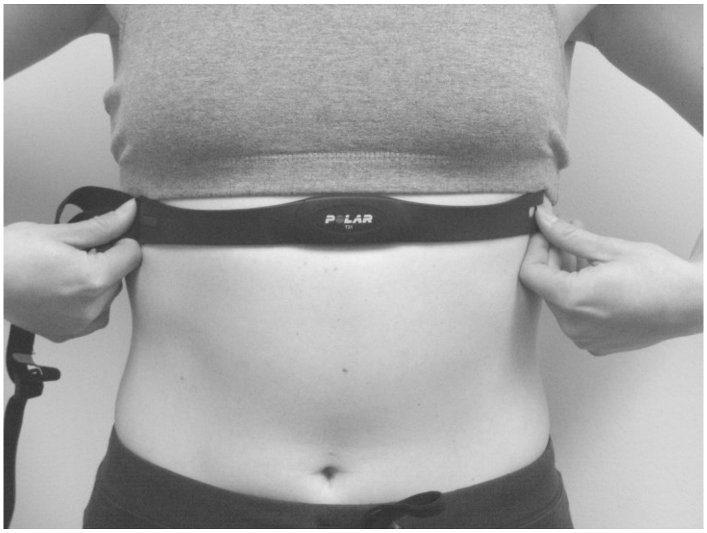


Figure 3

Iliac Crest Landmark

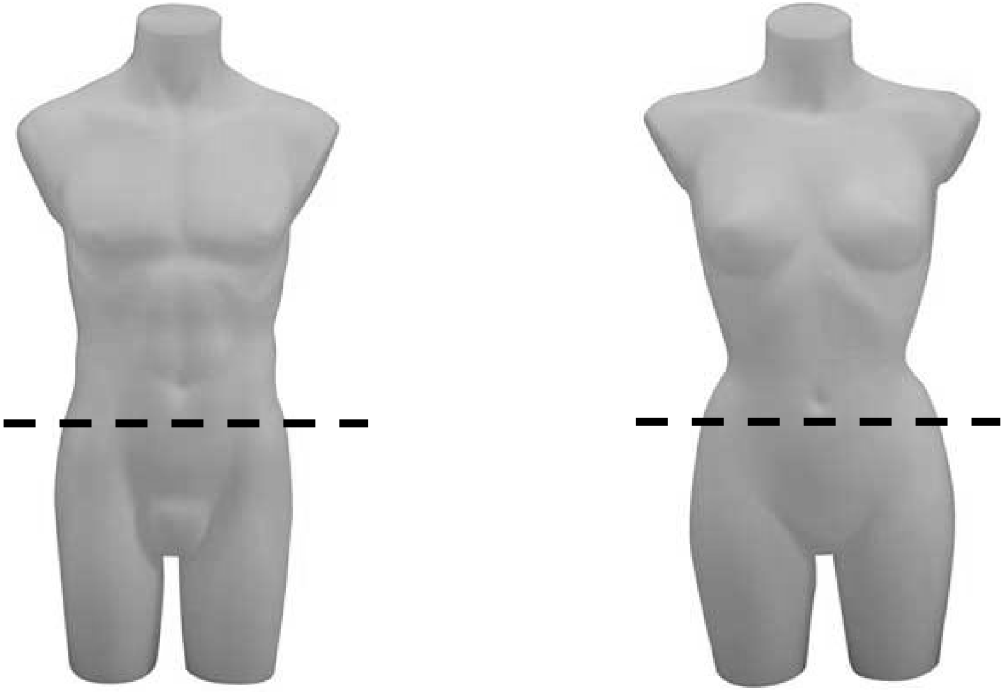


Figure 4

Narrowest Waist Landmark

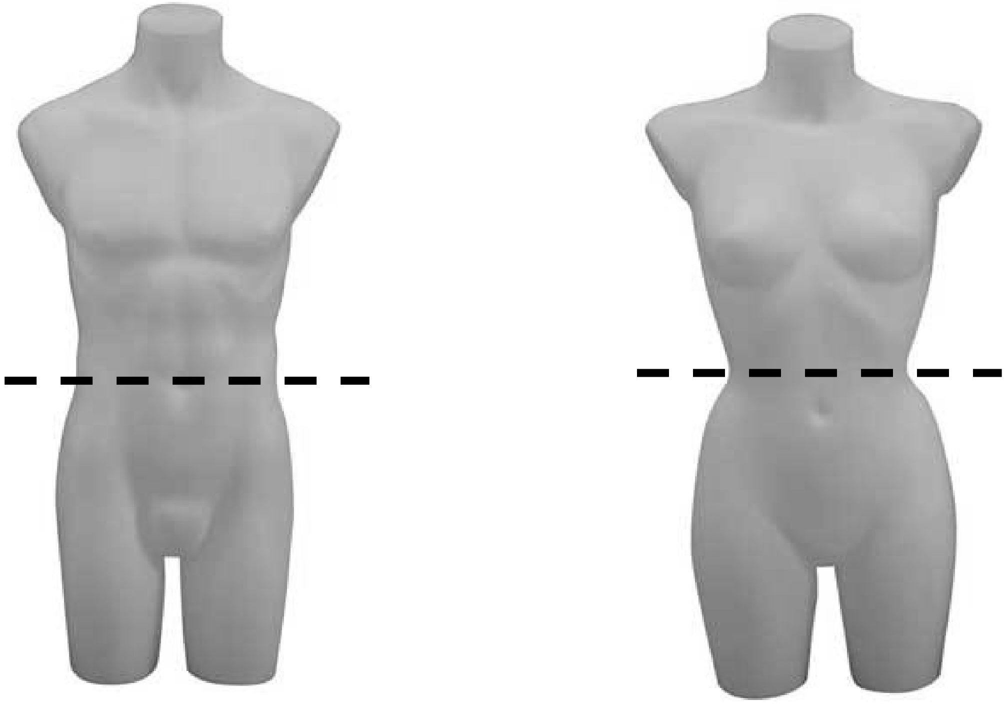
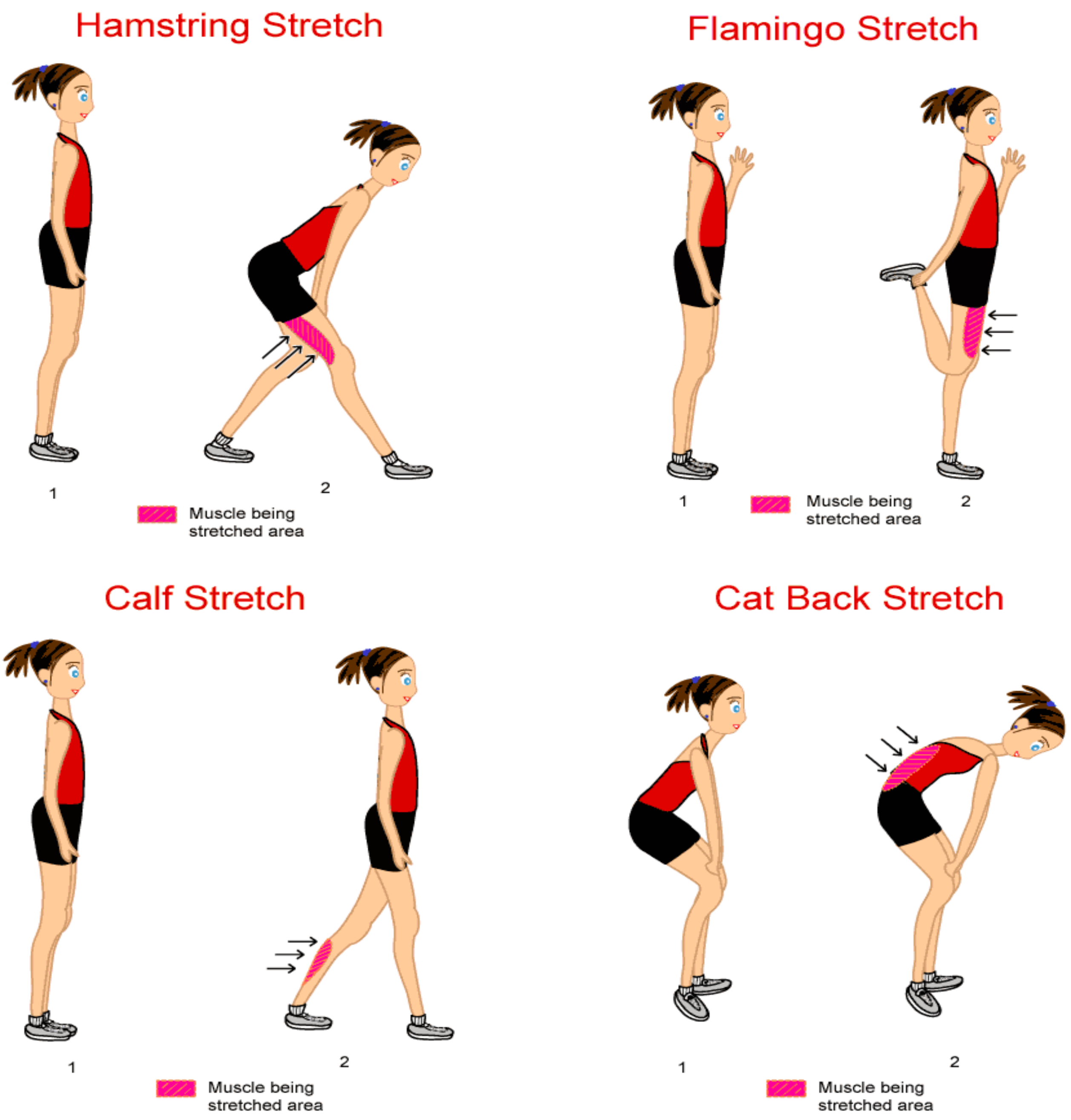


Figure 5

Stretches before Sit & Reach



Ceiling Post-Exercise Heart Rate Cut-Off

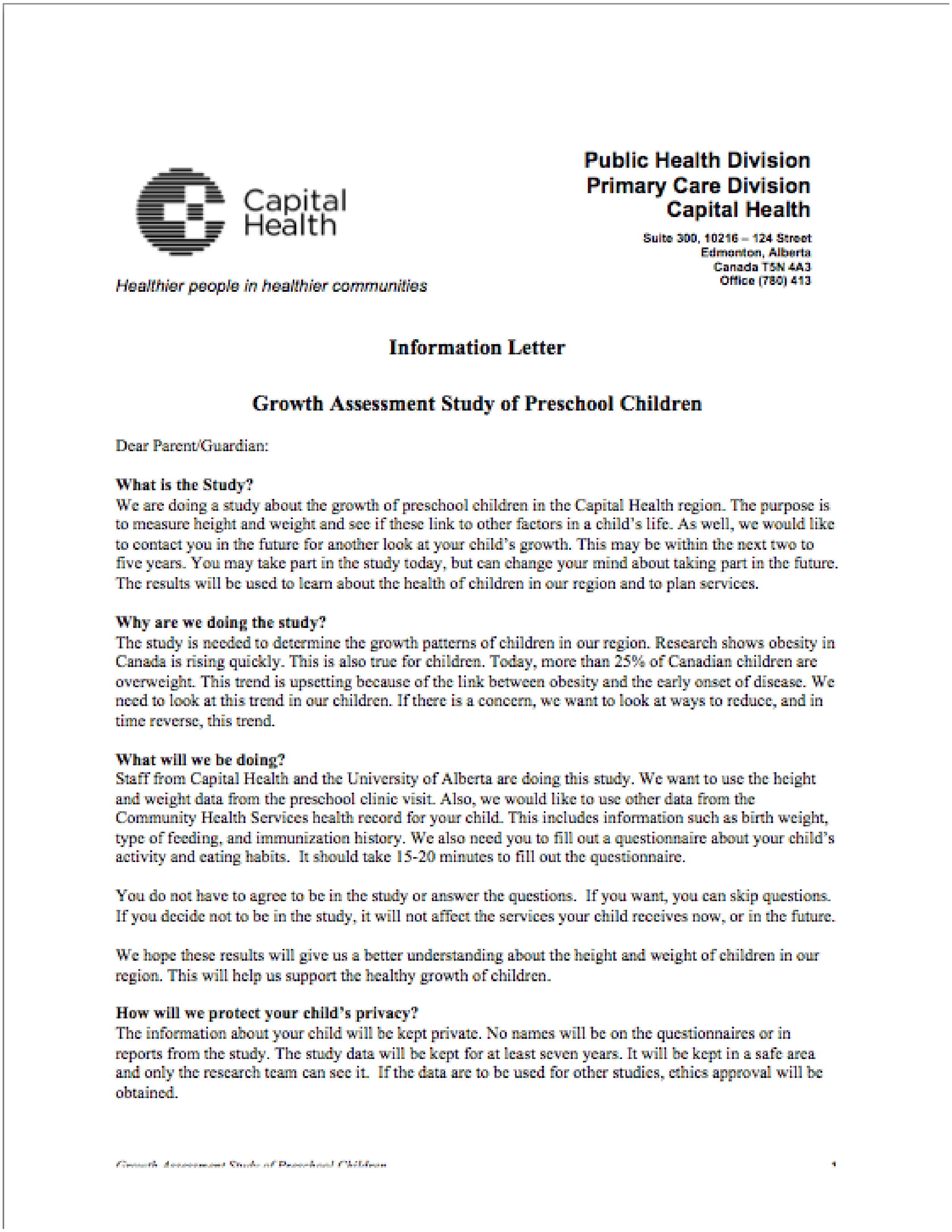
(220 – Age) x 0.85

Age (years)	Heart Rate Cut-Off (bpm)
5	183
6	182
7	181
8	180
9	179
10	178
11	178
12	177
13	176

10 sec Exercising Heart Rate Conversion

10 sec count (# beats)	Heart Rate (bpm)	10 sec count (# beats)	Heart Rate (bpm)
10	60	23	138
11	66	24	144
12	72	25	150
13	78	26	156
14	84	27	162
15	90	28	168
16	96	29	174
17	102	30	180
18	108	31	186
19	114	32	192
20	120	33	198
21	126	34	204
22	132	35	210

Appendix B: Information Letter and Consent Form (Baseline)



Capital Health

Healthier people in healthier communities

Public Health Division
Primary Care Division
Capital Health

Suite 300, 10216 – 124 Street
Edmonton, Alberta
Canada T5N 4A3
Office (780) 413

Information Letter

Growth Assessment Study of Preschool Children

Dear Parent/Guardian:

What is the Study?
We are doing a study about the growth of preschool children in the Capital Health region. The purpose is to measure height and weight and see if these link to other factors in a child's life. As well, we would like to contact you in the future for another look at your child's growth. This may be within the next two to five years. You may take part in the study today, but can change your mind about taking part in the future. The results will be used to learn about the health of children in our region and to plan services.

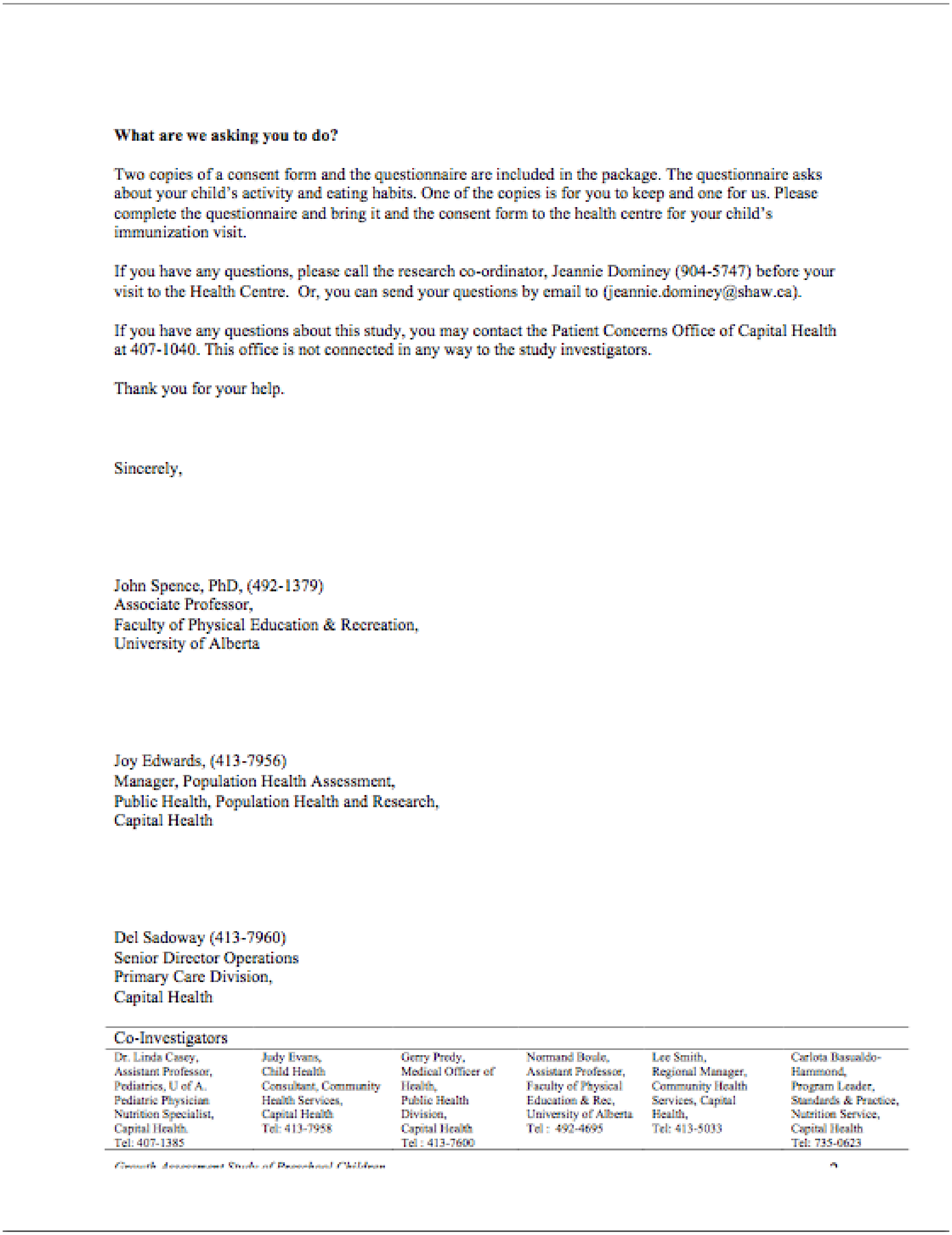
Why are we doing the study?
The study is needed to determine the growth patterns of children in our region. Research shows obesity in Canada is rising quickly. This is also true for children. Today, more than 25% of Canadian children are overweight. This trend is upsetting because of the link between obesity and the early onset of disease. We need to look at this trend in our children. If there is a concern, we want to look at ways to reduce, and in time reverse, this trend.

What will we be doing?
Staff from Capital Health and the University of Alberta are doing this study. We want to use the height and weight data from the preschool clinic visit. Also, we would like to use other data from the Community Health Services health record for your child. This includes information such as birth weight, type of feeding, and immunization history. We also need you to fill out a questionnaire about your child's activity and eating habits. It should take 15-20 minutes to fill out the questionnaire.

You do not have to agree to be in the study or answer the questions. If you want, you can skip questions. If you decide not to be in the study, it will not affect the services your child receives now, or in the future.

We hope these results will give us a better understanding about the height and weight of children in our region. This will help us support the healthy growth of children.

How will we protect your child's privacy?
The information about your child will be kept private. No names will be on the questionnaires or in reports from the study. The study data will be kept for at least seven years. It will be kept in a safe area and only the research team can see it. If the data are to be used for other studies, ethics approval will be obtained.



What are we asking you to do?

Two copies of a consent form and the questionnaire are included in the package. The questionnaire asks about your child's activity and eating habits. One of the copies is for you to keep and one for us. Please complete the questionnaire and bring it and the consent form to the health centre for your child's immunization visit.

If you have any questions, please call the research co-ordinator, Jeannie Dominey (904-5747) before your visit to the Health Centre. Or, you can send your questions by email to (jeannie.dominey@shaw.ca).

If you have any questions about this study, you may contact the Patient Concerns Office of Capital Health at 407-1040. This office is not connected in any way to the study investigators.

Thank you for your help.

Sincerely,

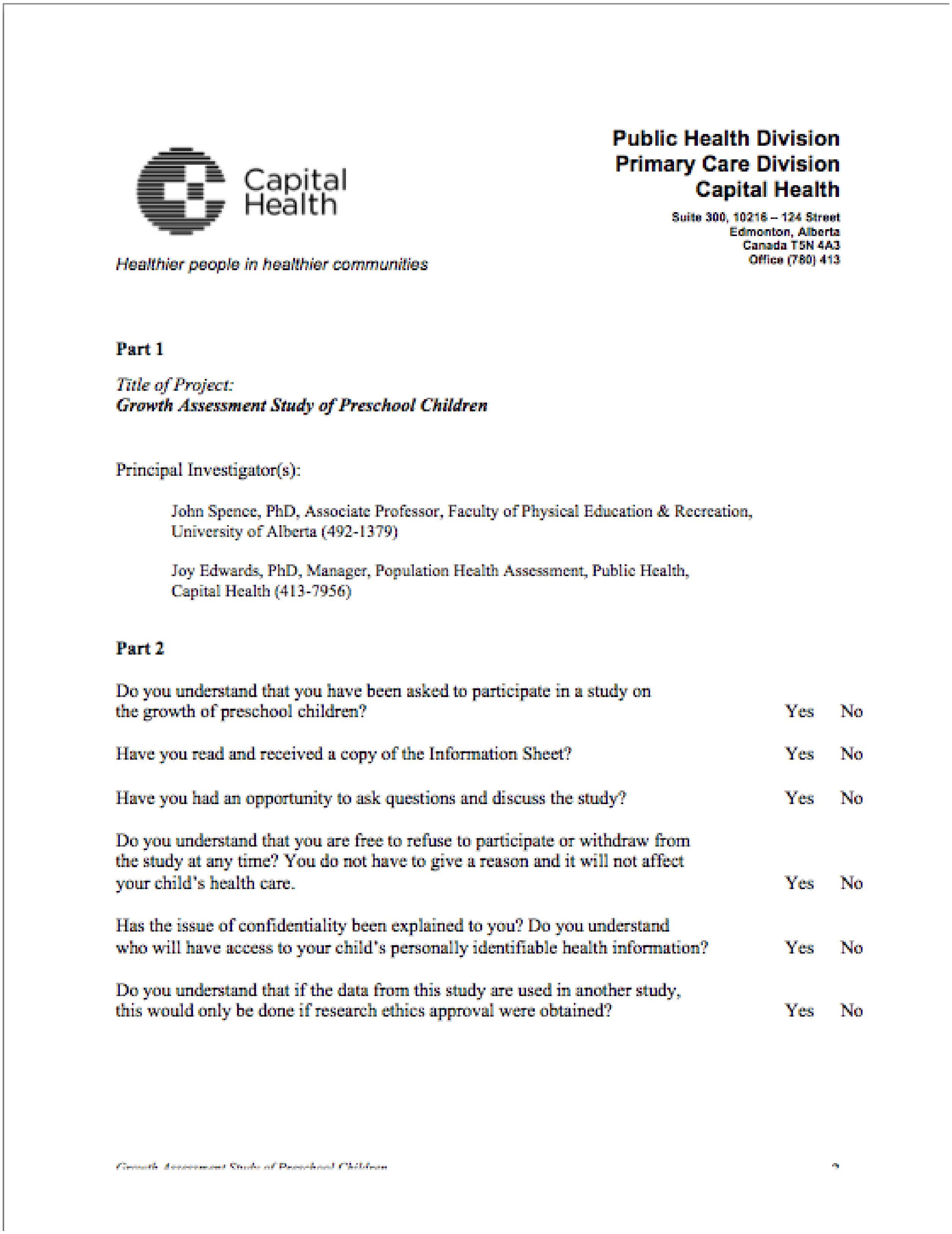
John Spence, PhD, (492-1379)
Associate Professor,
Faculty of Physical Education & Recreation,
University of Alberta

Joy Edwards, (413-7956)
Manager, Population Health Assessment,
Public Health, Population Health and Research,
Capital Health

Del Sadoway (413-7960)
Senior Director Operations
Primary Care Division,
Capital Health

Co-Investigators

Dr. Linda Casey, Assistant Professor, Pediatrics, U of A. Pediatric Physician Nutrition Specialist, Capital Health. Tel: 407-1385	Judy Evans, Child Health Consultant, Community Health Services, Capital Health Tel: 413-7958	Gerry Predy, Medical Officer of Health, Public Health Division, Capital Health Tel : 413-7600	Normand Boule, Assistant Professor, Faculty of Physical Education & Rec, University of Alberta Tel : 492-4695	Lee Smith, Regional Manager, Community Health Services, Capital Health, Tel: 413-5033	Carlota Basualdo- Hammond, Program Leader, Standards & Practice, Nutrition Service, Capital Health Tel: 735-0623



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Public Health Division
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Capital Health
Suite 300, 10216 – 124 Street
Edmonton, Alberta
Canada T5N 4A3
Office (780) 413

Part 1

Title of Project:
Growth Assessment Study of Preschool Children

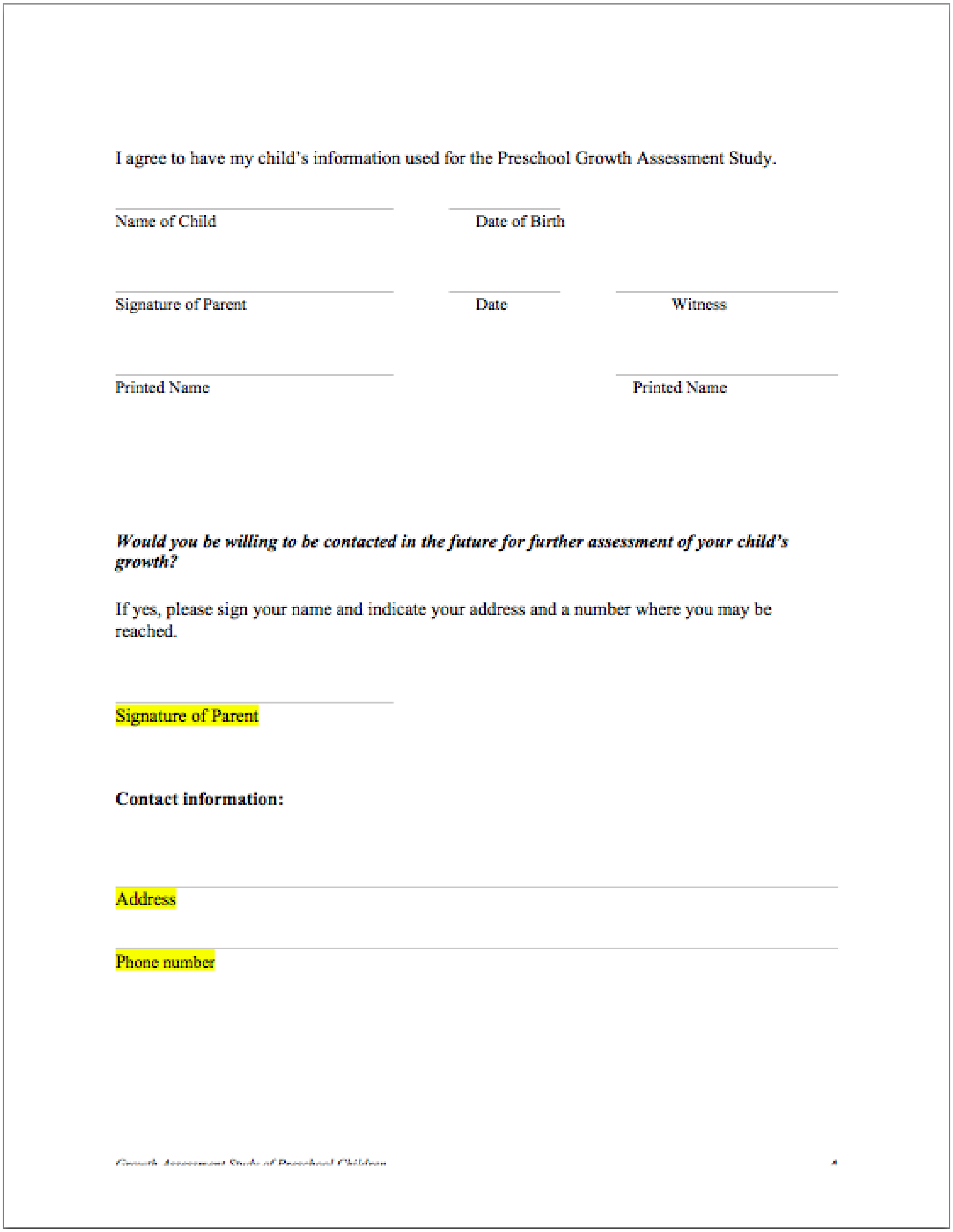
Principal Investigator(s):

John Spence, PhD, Associate Professor, Faculty of Physical Education & Recreation, University of Alberta (492-1379)

Joy Edwards, PhD, Manager, Population Health Assessment, Public Health, Capital Health (413-7956)

Part 2

Do you understand that you have been asked to participate in a study on the growth of preschool children?	Yes	No
Have you read and received a copy of the Information Sheet?	Yes	No
Have you had an opportunity to ask questions and discuss the study?	Yes	No
Do you understand that you are free to refuse to participate or withdraw from the study at any time? You do not have to give a reason and it will not affect your child's health care.	Yes	No
Has the issue of confidentiality been explained to you? Do you understand who will have access to your child's personally identifiable health information?	Yes	No
Do you understand that if the data from this study are used in another study, this would only be done if research ethics approval were obtained?	Yes	No



I agree to have my child's information used for the Preschool Growth Assessment Study.

Name of Child
Date of Birth

Signature of Parent
Date
Witness

Printed Name
Printed Name

Would you be willing to be contacted in the future for further assessment of your child's growth?

If yes, please sign your name and indicate your address and a number where you may be reached.

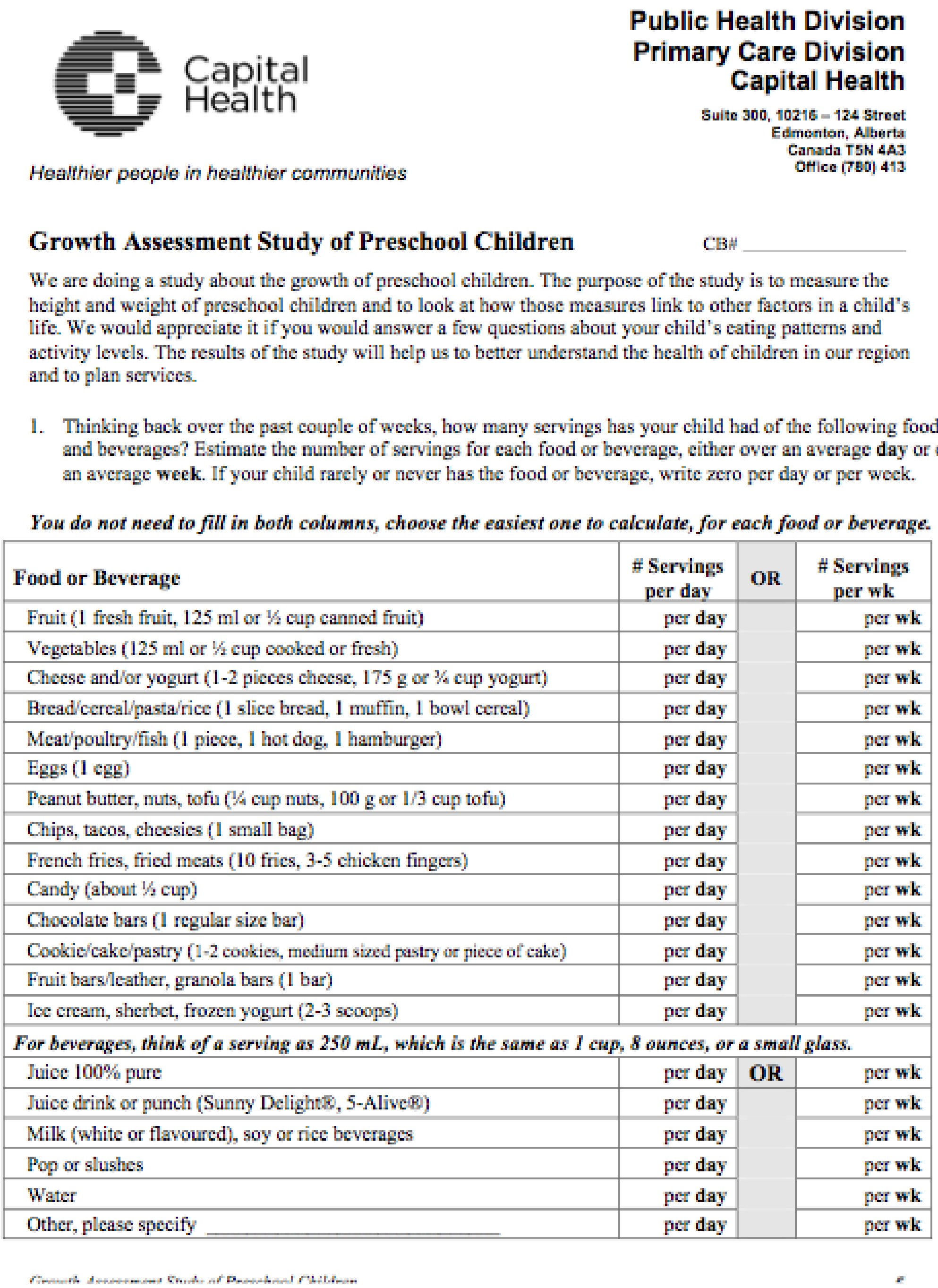
Signature of Parent

Contact information:

Address

Phone number

Appendix C: Child Questionnaire (Baseline)



Capital Health

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Public Health Division
Primary Care Division
Capital Health

Suite 300, 10216 – 124 Street
Edmonton, Alberta
Canada T5N 4A3
Office (780) 413

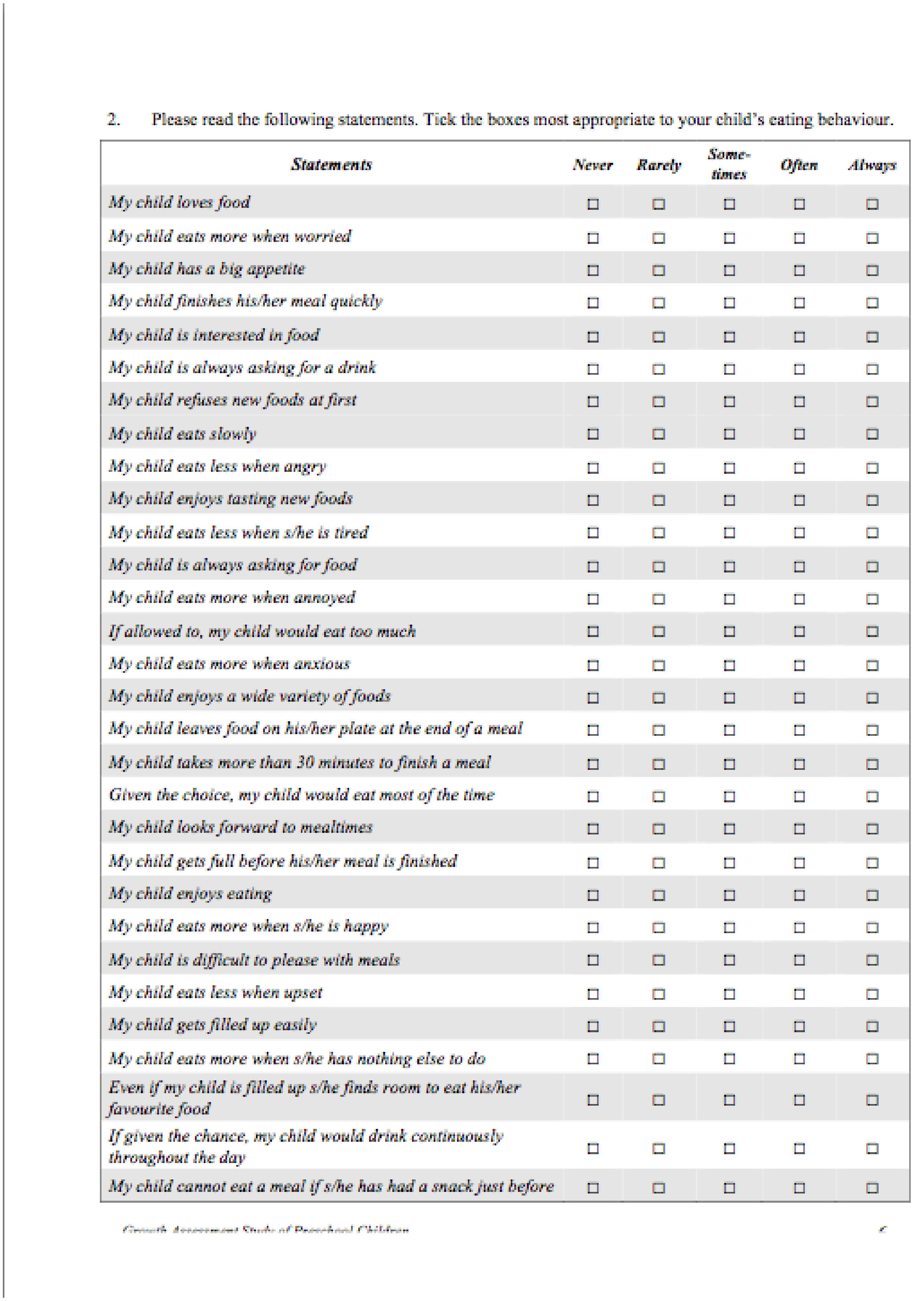
Growth Assessment Study of Preschool Children CB# ______________

We are doing a study about the growth of preschool children. The purpose of the study is to measure the height and weight of preschool children and to look at how those measures link to other factors in a child's life. We would appreciate it if you would answer a few questions about your child's eating patterns and activity levels. The results of the study will help us to better understand the health of children in our region and to plan services.

1. Thinking back over the past couple of weeks, how many servings has your child had of the following foods and beverages? Estimate the number of servings for each food or beverage, either over an average **day** or over an average **week**. If your child rarely or never has the food or beverage, write zero per day or per week.

You do not need to fill in both columns, choose the easiest one to calculate, for each food or beverage.

Food or Beverage	**# Servings per day**	**OR**	**# Servings per wk**
Fruit (1 fresh fruit, 125 ml or ½ cup canned fruit)	per day		per wk
Vegetables (125 ml or ½ cup cooked or fresh)	per day		per wk
Cheese and/or yogurt (1-2 pieces cheese, 175 g or ¾ cup yogurt)	per day		per wk
Bread/cereal/pasta/rice (1 slice bread, 1 muffin, 1 bowl cereal)	per day		per wk
Meat/poultry/fish (1 piece, 1 hot dog, 1 hamburger)	per day		per wk
Eggs (1 egg)	per day		per wk
Peanut butter, nuts, tofu (¼ cup nuts, 100 g or 1/3 cup tofu)	per day		per wk
Chips, tacos, cheesies (1 small bag)	per day		per wk
French fries, fried meats (10 fries, 3-5 chicken fingers)	per day		per wk
Candy (about ½ cup)	per day		per wk
Chocolate bars (1 regular size bar)	per day		per wk
Cookie/cake/pastry (1-2 cookies, medium sized pastry or piece of cake)	per day		per wk
Fruit bars/leather, granola bars (1 bar)	per day		per wk
Ice cream, sherbet, frozen yogurt (2-3 scoops)	per day		per wk
For beverages, think of a serving as 250 mL, which is the same as 1 cup, 8 ounces, or a small glass.			
Juice 100% pure	per day	**OR**	per wk
Juice drink or punch (Sunny Delight®, 5-Alive®)	per day		per wk
Milk (white or flavoured), soy or rice beverages	per day		per wk
Pop or slushes	per day		per wk
Water	per day		per wk
Other, please specify ______________________	per day		per wk



2. Please read the following statements. Tick the boxes most appropriate to your child's eating behaviour.

Statements	***Never***	***Rarely***	***Some-times***	***Often***	***Always***
My child loves food	☐	☐	☐	☐	☐
My child eats more when worried	☐	☐	☐	☐	☐
My child has a big appetite	☐	☐	☐	☐	☐
My child finishes his/her meal quickly	☐	☐	☐	☐	☐
My child is interested in food	☐	☐	☐	☐	☐
My child is always asking for a drink	☐	☐	☐	☐	☐
My child refuses new foods at first	☐	☐	☐	☐	☐
My child eats slowly	☐	☐	☐	☐	☐
My child eats less when angry	☐	☐	☐	☐	☐
My child enjoys tasting new foods	☐	☐	☐	☐	☐
My child eats less when s/he is tired	☐	☐	☐	☐	☐
My child is always asking for food	☐	☐	☐	☐	☐
My child eats more when annoyed	☐	☐	☐	☐	☐
If allowed to, my child would eat too much	☐	☐	☐	☐	☐
My child eats more when anxious	☐	☐	☐	☐	☐
My child enjoys a wide variety of foods	☐	☐	☐	☐	☐
My child leaves food on his/her plate at the end of a meal	☐	☐	☐	☐	☐
My child takes more than 30 minutes to finish a meal	☐	☐	☐	☐	☐
Given the choice, my child would eat most of the time	☐	☐	☐	☐	☐
My child looks forward to mealtimes	☐	☐	☐	☐	☐
My child gets full before his/her meal is finished	☐	☐	☐	☐	☐
My child enjoys eating	☐	☐	☐	☐	☐
My child eats more when s/he is happy	☐	☐	☐	☐	☐
My child is difficult to please with meals	☐	☐	☐	☐	☐
My child eats less when upset	☐	☐	☐	☐	☐
My child gets filled up easily	☐	☐	☐	☐	☐
My child eats more when s/he has nothing else to do	☐	☐	☐	☐	☐
Even if my child is filled up s/he finds room to eat his/her favourite food	☐	☐	☐	☐	☐
If given the chance, my child would drink continuously throughout the day	☐	☐	☐	☐	☐
My child cannot eat a meal if s/he has had a snack just before	☐	☐	☐	☐	☐

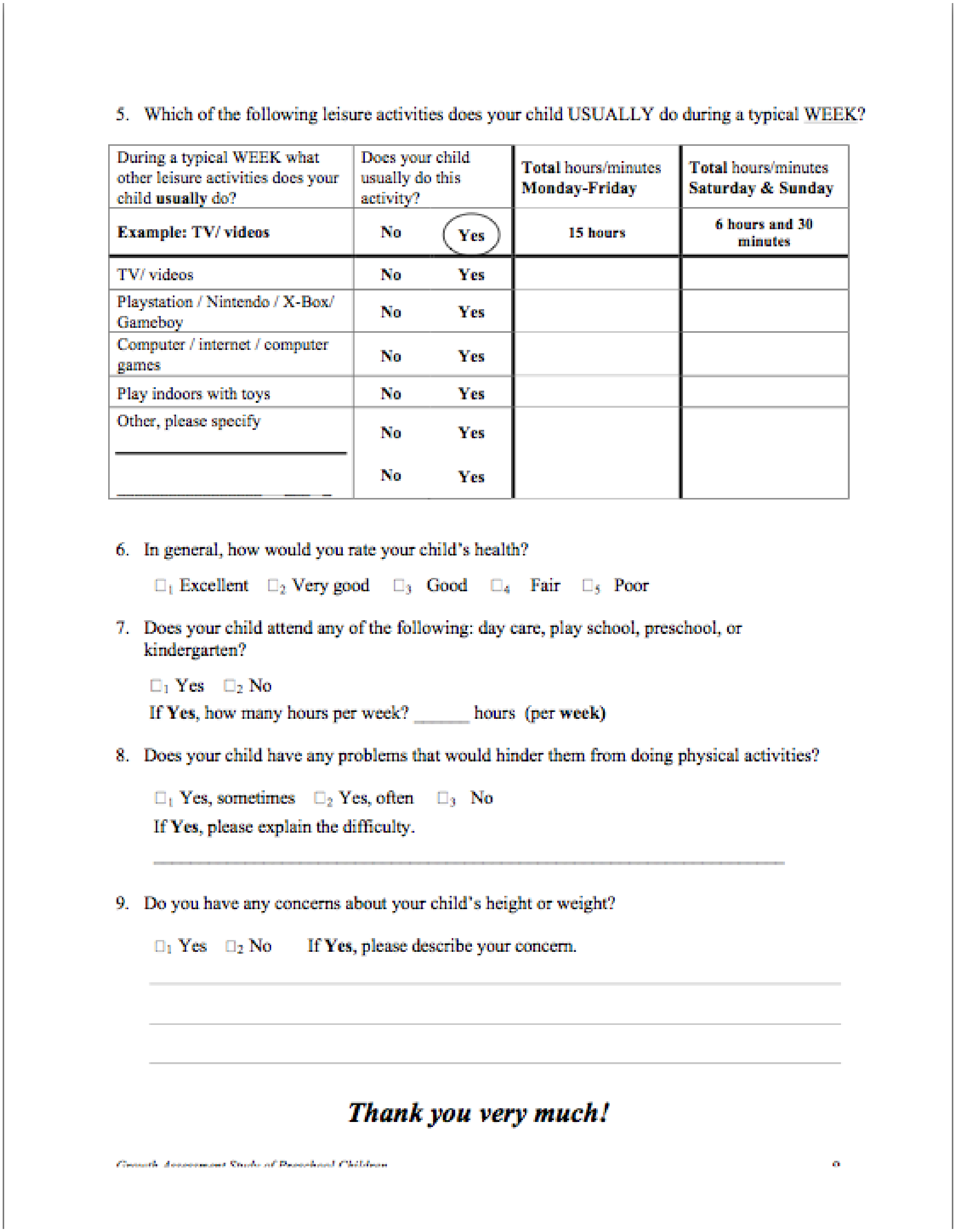
Statements	***Never***	***Rarely***	***Some-times***	***Often***	***Always***
If given the chance, my child would always be having a drink	☐	☐	☐	☐	☐
My child is interested in tasting food s/he hasn't tasted before	☐	☐	☐	☐	☐
My child decides that s/he doesn't like a food, even without tasting it	☐	☐	☐	☐	☐
If given the chance, my child would always have food in his/her mouth	☐	☐	☐	☐	☐
My child eats more and more slowly during the course of a meal	☐	☐	☐	☐	☐

3. How many times does your family sit together for a meal during a typical WEEK?

_______ times per week

4. Which of the following physical activities does your child USUALLY do during a typical WEEK?

During a typical WEEK what activities does your child **usually** do?	Does your child usually do this activity?	**Monday - Friday**		**Saturday & Sunday**	
		How many times **Monday to Friday?**	Total hours/minutes **Monday to Friday?**	How many times – **Saturday & Sunday?**	Total hours/minutes **Saturday & Sunday?**
Example: Bike riding	**No [✓ Yes]**	**2**	**40 minutes**	**1**	**15 minutes**
Swimming – lessons and for fun	**No Yes**				
Soccer	**No Yes**				
Ballet/Dance	**No Yes**				
Gymnastics	**No Yes**				
Skating	**No Yes**				
Hockey	**No Yes**				
Bike riding	**No Yes**				
Gym activities	**No Yes**				
Active play – including at a playground	**No Yes**				
Other, please specify ____________________	**No Yes**				
____________________	**No Yes**				



5. Which of the following leisure activities does your child USUALLY do during a typical WEEK?

During a typical WEEK what other leisure activities does your child **usually** do?	Does your child usually do this activity?	**Total** hours/minutes **Monday-Friday**	**Total** hours/minutes **Saturday & Sunday**
Example: TV/ videos	**No** [✓ **Yes**]	**15 hours**	**6 hours and 30 minutes**
TV/ videos	**No Yes**		
Playstation / Nintendo / X-Box/ Gameboy	**No Yes**		
Computer / internet / computer games	**No Yes**		
Play indoors with toys	**No Yes**		
Other, please specify ____________	**No Yes**		
____________	**No Yes**		

6. In general, how would you rate your child's health?

☐$_1$ Excellent ☐$_2$ Very good ☐$_3$ Good ☐$_4$ Fair ☐$_5$ Poor

7. Does your child attend any of the following: day care, play school, preschool, or kindergarten?

☐$_1$ Yes ☐$_2$ No

If **Yes**, how many hours per week? ______ hours (per **week**)

8. Does your child have any problems that would hinder them from doing physical activities?

☐$_1$ Yes, sometimes ☐$_2$ Yes, often ☐$_3$ No

If **Yes**, please explain the difficulty.

____

9. Do you have any concerns about your child's height or weight?

☐$_1$ Yes ☐$_2$ No If **Yes**, please describe your concern.

____

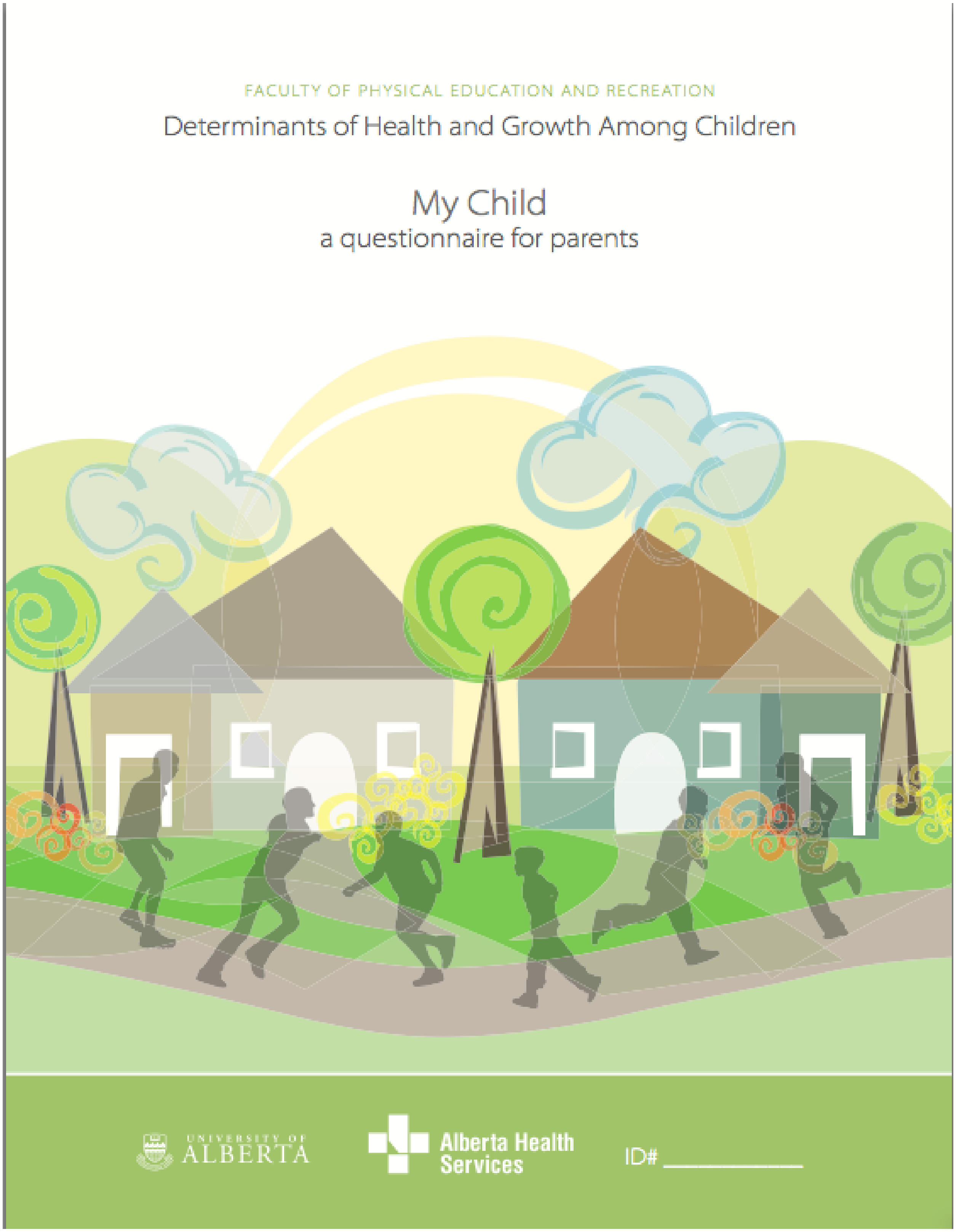
____

____

Thank you very much!

Growth Assessment Study of Preschool Children 9

Appendix D: My Child Questionnaire (Follow-up)



FACULTY OF PHYSICAL EDUCATION AND RECREATION

Determinants of Health and Growth Among Children

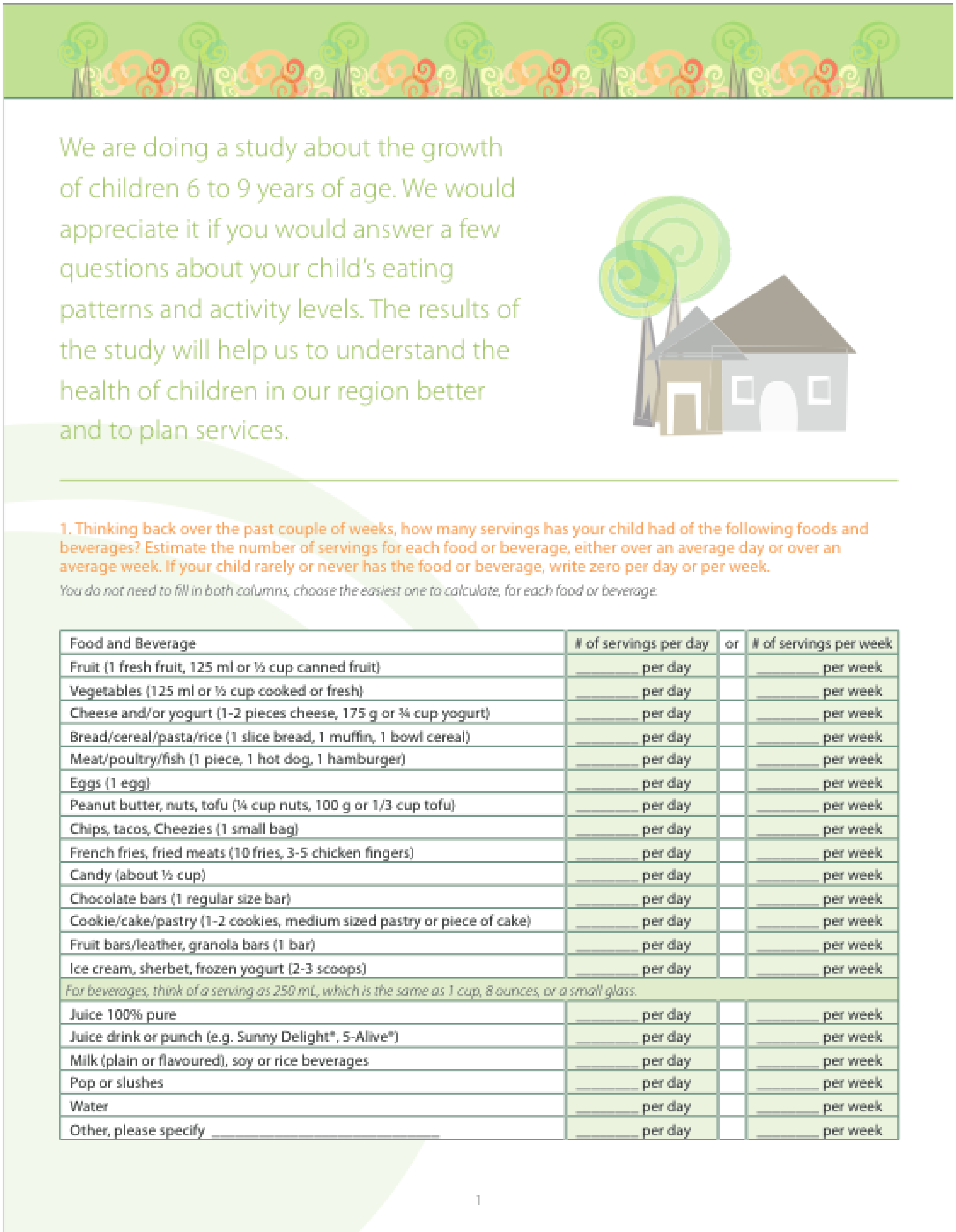
My Child

a questionnaire for parents

UNIVERSITY OF ALBERTA

Alberta Health Services

ID# ___________

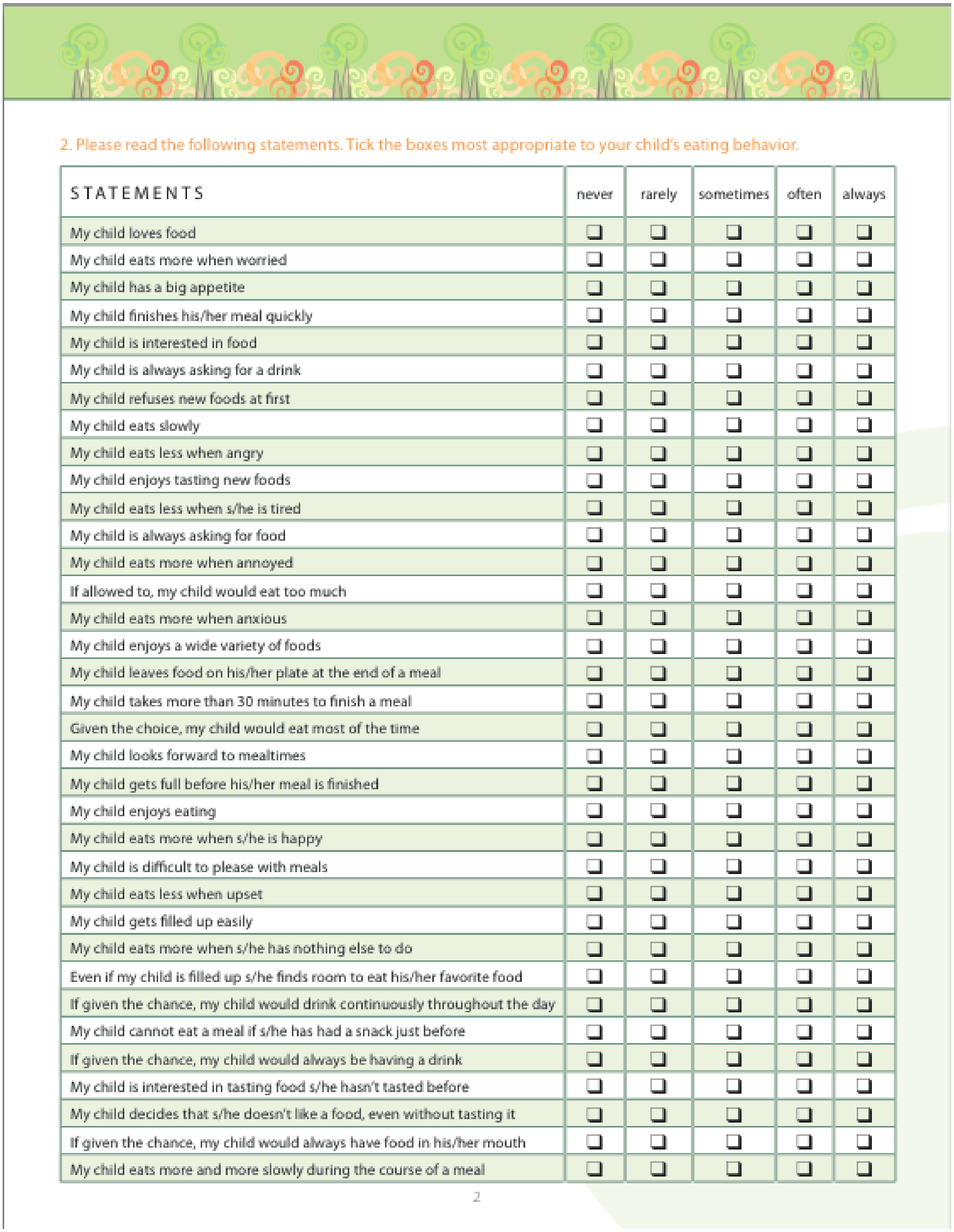


We are doing a study about the growth of children 6 to 9 years of age. We would appreciate it if you would answer a few questions about your child's eating patterns and activity levels. The results of the study will help us to understand the health of children in our region better and to plan services.

1. Thinking back over the past couple of weeks, how many servings has your child had of the following foods and beverages? Estimate the number of servings for each food or beverage, either over an average day or over an average week. If your child rarely or never has the food or beverage, write zero per day or per week.

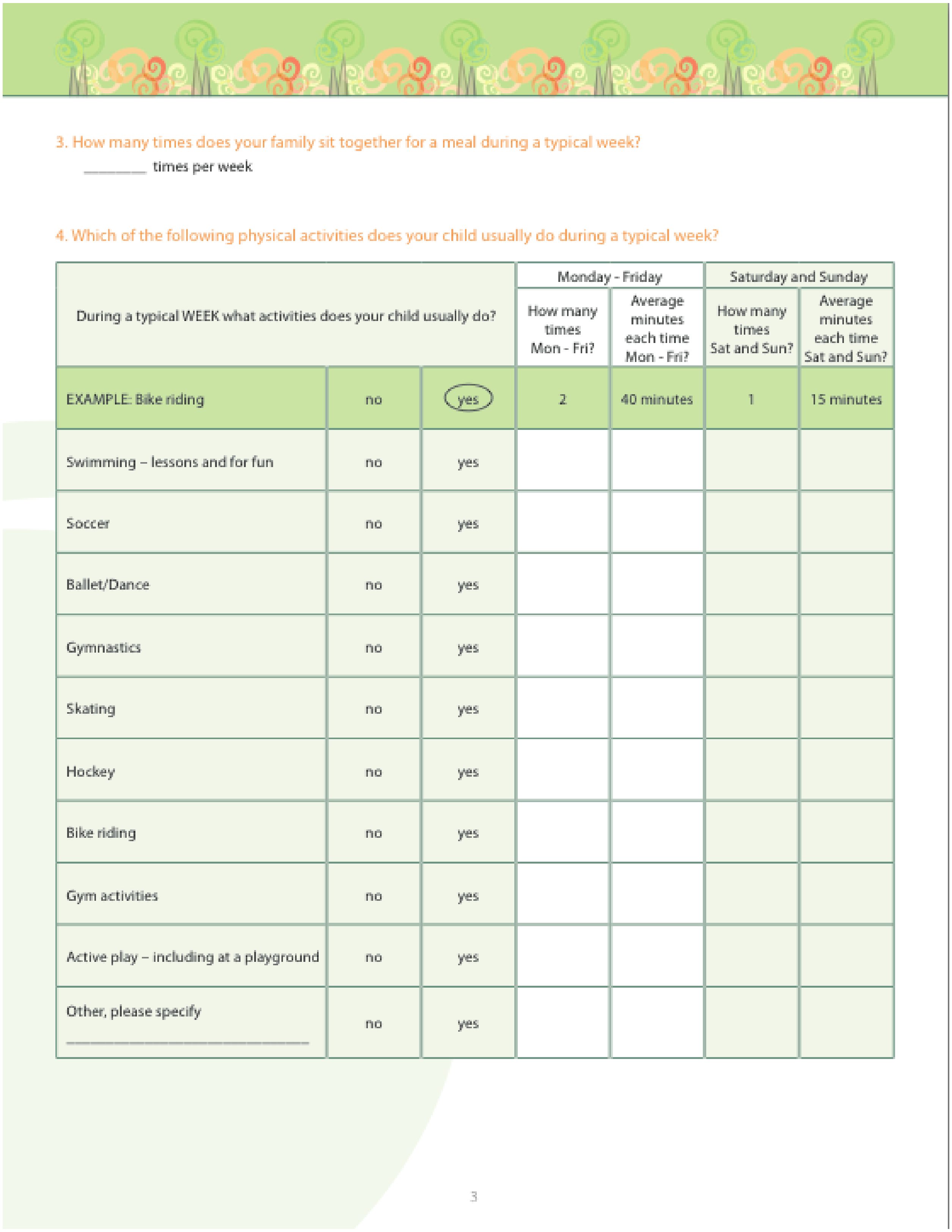
You do not need to fill in both columns, choose the easiest one to calculate, for each food or beverage.

Food and Beverage	# of servings per day	or	# of servings per week
Fruit (1 fresh fruit, 125 ml or ½ cup canned fruit)	________ per day		________ per week
Vegetables (125 ml or ½ cup cooked or fresh)	________ per day		________ per week
Cheese and/or yogurt (1-2 pieces cheese, 175 g or ¾ cup yogurt)	________ per day		________ per week
Bread/cereal/pasta/rice (1 slice bread, 1 muffin, 1 bowl cereal)	________ per day		________ per week
Meat/poultry/fish (1 piece, 1 hot dog, 1 hamburger)	________ per day		________ per week
Eggs (1 egg)	________ per day		________ per week
Peanut butter, nuts, tofu (¼ cup nuts, 100 g or 1/3 cup tofu)	________ per day		________ per week
Chips, tacos, Cheezies (1 small bag)	________ per day		________ per week
French fries, fried meats (10 fries, 3-5 chicken fingers)	________ per day		________ per week
Candy (about ½ cup)	________ per day		________ per week
Chocolate bars (1 regular size bar)	________ per day		________ per week
Cookie/cake/pastry (1-2 cookies, medium sized pastry or piece of cake)	________ per day		________ per week
Fruit bars/leather, granola bars (1 bar)	________ per day		________ per week
Ice cream, sherbet, frozen yogurt (2-3 scoops)	________ per day		________ per week
For beverages, think of a serving as 250 mL, which is the same as 1 cup, 8 ounces, or a small glass.			
Juice 100% pure	________ per day		________ per week
Juice drink or punch (e.g. Sunny Delight®, 5-Alive®)	________ per day		________ per week
Milk (plain or flavoured), soy or rice beverages	________ per day		________ per week
Pop or slushes	________ per day		________ per week
Water	________ per day		________ per week
Other, please specify ______________________________	________ per day		________ per week



2. Please read the following statements. Tick the boxes most appropriate to your child's eating behavior.

STATEMENTS	never	rarely	sometimes	often	always
My child loves food	☐	☐	☐	☐	☐
My child eats more when worried	☐	☐	☐	☐	☐
My child has a big appetite	☐	☐	☐	☐	☐
My child finishes his/her meal quickly	☐	☐	☐	☐	☐
My child is interested in food	☐	☐	☐	☐	☐
My child is always asking for a drink	☐	☐	☐	☐	☐
My child refuses new foods at first	☐	☐	☐	☐	☐
My child eats slowly	☐	☐	☐	☐	☐
My child eats less when angry	☐	☐	☐	☐	☐
My child enjoys tasting new foods	☐	☐	☐	☐	☐
My child eats less when s/he is tired	☐	☐	☐	☐	☐
My child is always asking for food	☐	☐	☐	☐	☐
My child eats more when annoyed	☐	☐	☐	☐	☐
If allowed to, my child would eat too much	☐	☐	☐	☐	☐
My child eats more when anxious	☐	☐	☐	☐	☐
My child enjoys a wide variety of foods	☐	☐	☐	☐	☐
My child leaves food on his/her plate at the end of a meal	☐	☐	☐	☐	☐
My child takes more than 30 minutes to finish a meal	☐	☐	☐	☐	☐
Given the choice, my child would eat most of the time	☐	☐	☐	☐	☐
My child looks forward to mealtimes	☐	☐	☐	☐	☐
My child gets full before his/her meal is finished	☐	☐	☐	☐	☐
My child enjoys eating	☐	☐	☐	☐	☐
My child eats more when s/he is happy	☐	☐	☐	☐	☐
My child is difficult to please with meals	☐	☐	☐	☐	☐
My child eats less when upset	☐	☐	☐	☐	☐
My child gets filled up easily	☐	☐	☐	☐	☐
My child eats more when s/he has nothing else to do	☐	☐	☐	☐	☐
Even if my child is filled up s/he finds room to eat his/her favorite food	☐	☐	☐	☐	☐
If given the chance, my child would drink continuously throughout the day	☐	☐	☐	☐	☐
My child cannot eat a meal if s/he has had a snack just before	☐	☐	☐	☐	☐
If given the chance, my child would always be having a drink	☐	☐	☐	☐	☐
My child is interested in tasting food s/he hasn't tasted before	☐	☐	☐	☐	☐
My child decides that s/he doesn't like a food, even without tasting it	☐	☐	☐	☐	☐
If given the chance, my child would always have food in his/her mouth	☐	☐	☐	☐	☐
My child eats more and more slowly during the course of a meal	☐	☐	☐	☐	☐



3. How many times does your family sit together for a meal during a typical week?

_______ times per week

4. Which of the following physical activities does your child usually do during a typical week?

During a typical WEEK what activities does your child usually do?			Monday - Friday		Saturday and Sunday	
			How many times Mon - Fri?	Average minutes each time Mon - Fri?	How many times Sat and Sun?	Average minutes each time Sat and Sun?
EXAMPLE: Bike riding	no	[✓ yes]	2	40 minutes	1	15 minutes
Swimming – lessons and for fun	no	yes				
Soccer	no	yes				
Ballet/Dance	no	yes				
Gymnastics	no	yes				
Skating	no	yes				
Hockey	no	yes				
Bike riding	no	yes				
Gym activities	no	yes				
Active play – including at a playground	no	yes				
Other, please specify ____________________	no	yes				

5. Which of the following leisure activities does your child USUALLY do during a typical WEEK?

During a typical WEEK what activities does your child usually do?			Total hours/minutes Monday-Friday	Total hours/minutes Saturday and Sunday
Example: TV / videos	no	[✓ yes]	15 hours	6 hours and 30 minutes
TV / videos	no	yes		
Play station / Nintendo / X-Box / Game boy	no	yes		
Computer / internet / computer games	no	yes		
Play indoors with toys	no	yes		
Other, please specify ______________________________	no	yes		

6. At what time does your child usually go to sleep during:

	1	2	3	4	5	6
	before 7pm	7-7:30pm	7:30-8pm	8-8:30pm	8:30-9pm	after 9pm
The week	☐	☐	☐	☐	☐	☐
The weekend	☐	☐	☐	☐	☐	☐

7. At what time does your child usually wake up during:

	1	2	3	4	5	6
	before 7am	7-7:30am	7:30-8am	8-8:30am	8:30-9am	after 9am
The week	☐	☐	☐	☐	☐	☐
The weekend	☐	☐	☐	☐	☐	☐

8. In general, how would you rate your child's health?

☐ Excellent ☐ Very Good ☐ Good ☐ Fair ☐ Poor

9. Does your child have any problems that would hinder them from doing physical activities?

☐ Yes, sometimes ☐ Yes, often ☐ No

If Yes, please explain the difficulty ____

____

10. Do you have any concerns about your child's height or weight?

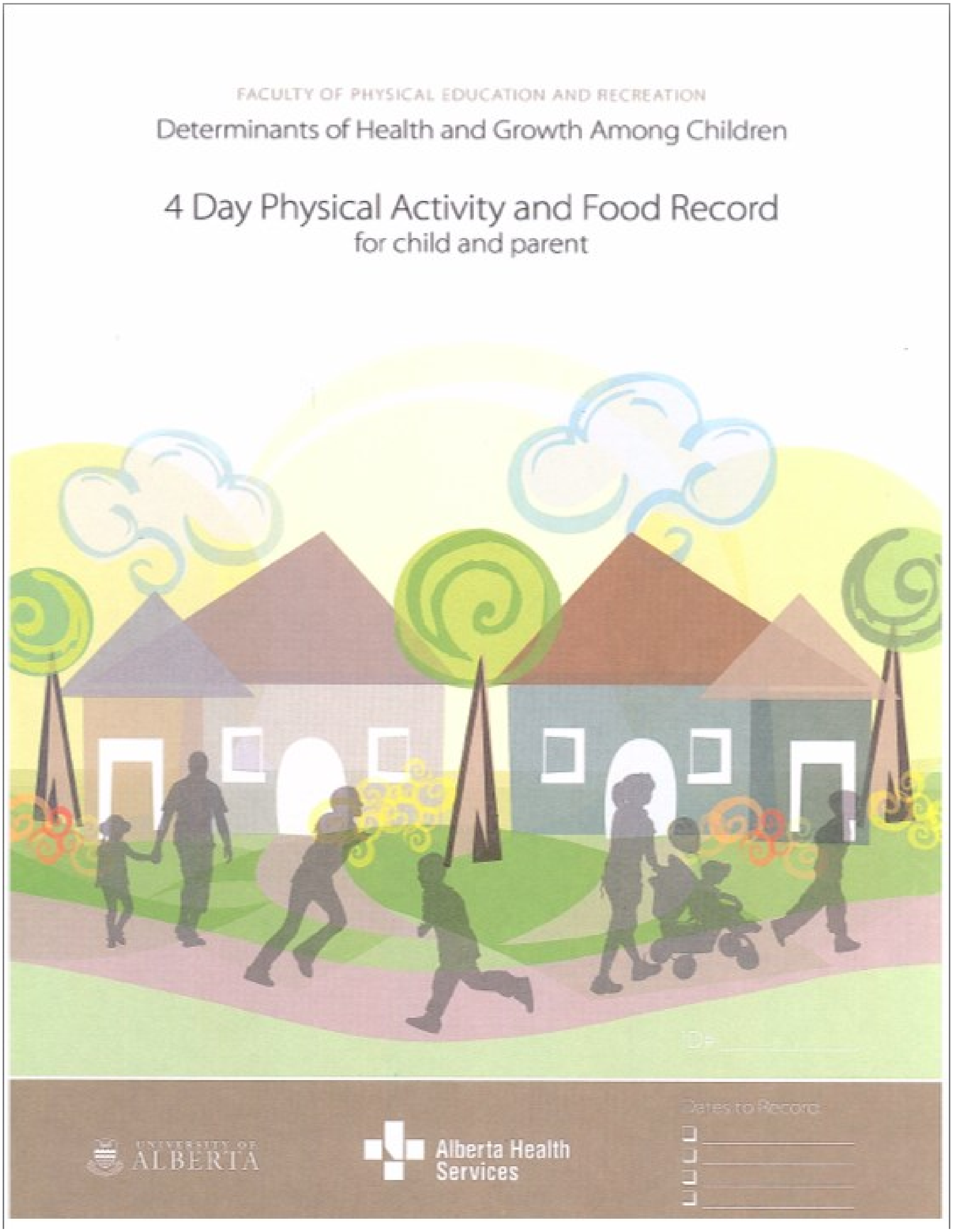
☐ Yes ☐ No

If Yes, please describe your concern ____

____

Thank you very much!

Appendix E: 4 Day Physical Activity and Food Record (Follow-up)



FACULTY OF PHYSICAL EDUCATION AND RECREATION

Determinants of Health and Growth Among Children

4 Day Physical Activity and Food Record

for child and parent

ID#__________

Dates to Record:

☐ __________

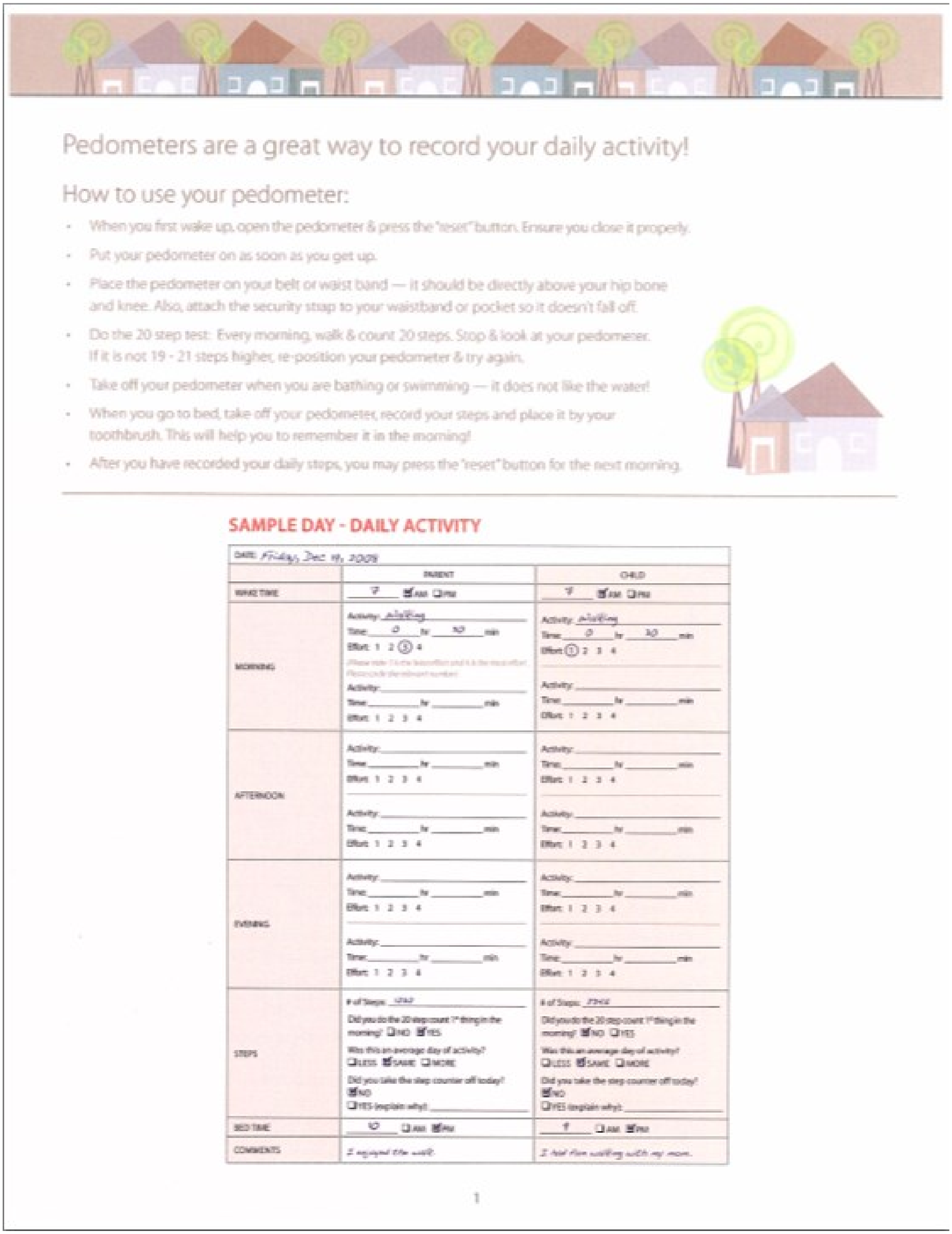
☐ __________

☐ __________

☐ __________

UNIVERSITY OF ALBERTA

Alberta Health Services



Pedometers are a great way to record your daily activity!

How to use your pedometer:

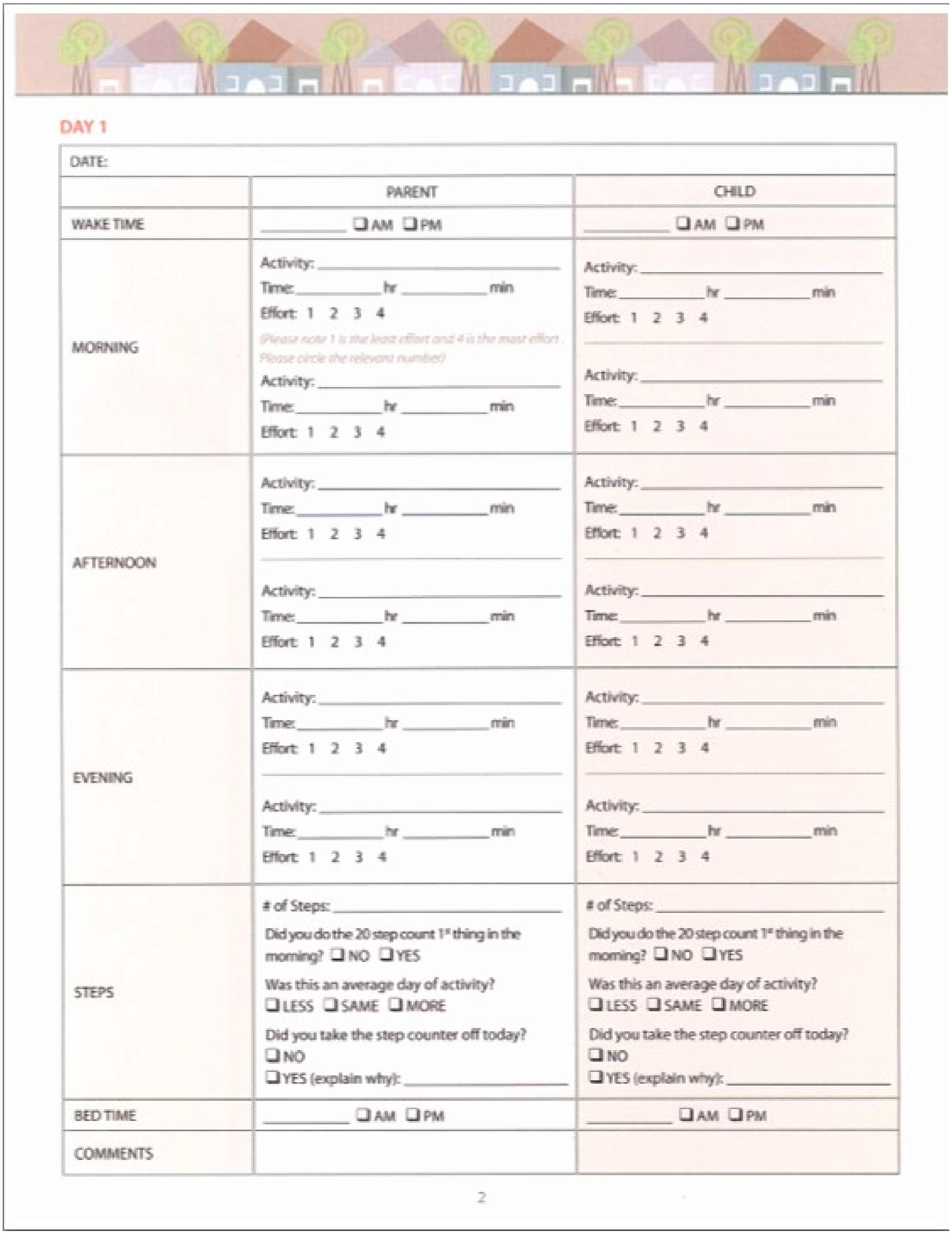
- When you first wake up, open the pedometer & press the "reset" button. Ensure you close it properly.
- Put your pedometer on as soon as you get up.
- Place the pedometer on your belt or waist band — it should be directly above your hip bone and knee. Also, attach the security strap to your waistband or pocket so it doesn't fall off.
- Do the 20 step test: Every morning, walk & count 20 steps. Stop & look at your pedometer. If it is not 19 - 21 steps higher, re-position your pedometer & try again.
- Take off your pedometer when you are bathing or swimming — it does not like the water!
- When you go to bed, take off your pedometer, record your steps and place it by your toothbrush. This will help you to remember it in the morning!
- After you have recorded your daily steps, you may press the "reset" button for the next morning.

SAMPLE DAY - DAILY ACTIVITY

DATE: Friday, Dec 19, 2009

	PARENT	CHILD
WAKE TIME	7 ☑ AM ☐ PM	7 ☑ AM ☐ PM
MORNING	Activity: walking Time: 0 hr 30 min Effort: 1 2 [✓ 3] 4 (Please note: 1 is the least effort and 4 is the most effort. Please circle the relevant number) Activity: Time: hr min Effort: 1 2 3 4	Activity: walking Time: 0 hr 30 min Effort: [✓ 1] 2 3 4 Activity: Time: hr min Effort: 1 2 3 4
AFTERNOON	Activity: Time: hr min Effort: 1 2 3 4 Activity: Time: hr min Effort: 1 2 3 4	Activity: Time: hr min Effort: 1 2 3 4 Activity: Time: hr min Effort: 1 2 3 4
EVENING	Activity: Time: hr min Effort: 1 2 3 4 Activity: Time: hr min Effort: 1 2 3 4	Activity: Time: hr min Effort: 1 2 3 4 Activity: Time: hr min Effort: 1 2 3 4
STEPS	# of Steps: [illegible] Did you do the 20 step count 1st thing in the morning? ☐ NO ☑ YES Was this an average day of activity? ☐ LESS ☑ SAME ☐ MORE Did you take the step counter off today? ☑ NO ☐ YES (explain why):	# of Steps: [illegible] Did you do the 20 step count 1st thing in the morning? ☑ NO ☐ YES Was this an average day of activity? ☐ LESS ☑ SAME ☐ MORE Did you take the step counter off today? ☑ NO ☐ YES (explain why):
BED TIME	10 ☐ AM ☑ PM	9 ☐ AM ☑ PM
COMMENTS	I enjoyed the walk.	I had fun walking with my mom.

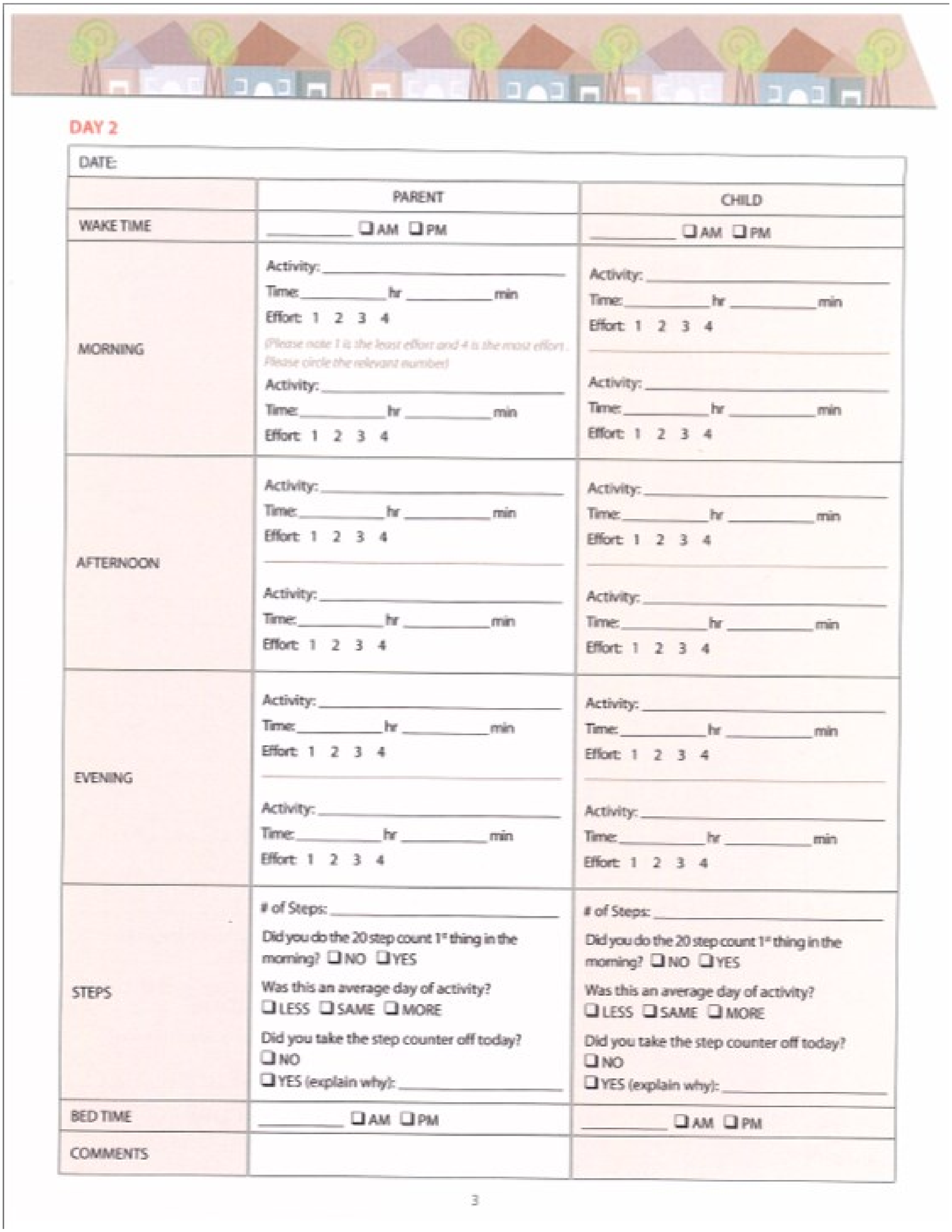
1



DAY 1

DATE:		
	PARENT	CHILD
WAKE TIME	________ ☐ AM ☐ PM	________ ☐ AM ☐ PM
MORNING	Activity: ________ Time: ________ hr ________ min Effort: 1 2 3 4 (Please note 1 is the least effort and 4 is the most effort . Please circle the relevant number) Activity: ________ Time: ________ hr ________ min Effort: 1 2 3 4	Activity: ________ Time: ________ hr ________ min Effort: 1 2 3 4 Activity: ________ Time: ________ hr ________ min Effort: 1 2 3 4
AFTERNOON	Activity: ________ Time: ________ hr ________ min Effort: 1 2 3 4 Activity: ________ Time: ________ hr ________ min Effort: 1 2 3 4	Activity: ________ Time: ________ hr ________ min Effort: 1 2 3 4 Activity: ________ Time: ________ hr ________ min Effort: 1 2 3 4
EVENING	Activity: ________ Time: ________ hr ________ min Effort: 1 2 3 4 Activity: ________ Time: ________ hr ________ min Effort: 1 2 3 4	Activity: ________ Time: ________ hr ________ min Effort: 1 2 3 4 Activity: ________ Time: ________ hr ________ min Effort: 1 2 3 4
STEPS	# of Steps: ________ Did you do the 20 step count 1st thing in the morning? ☐ NO ☐ YES Was this an average day of activity? ☐ LESS ☐ SAME ☐ MORE Did you take the step counter off today? ☐ NO ☐ YES (explain why): ________	# of Steps: ________ Did you do the 20 step count 1st thing in the morning? ☐ NO ☐ YES Was this an average day of activity? ☐ LESS ☐ SAME ☐ MORE Did you take the step counter off today? ☐ NO ☐ YES (explain why): ________
BED TIME	________ ☐ AM ☐ PM	________ ☐ AM ☐ PM
COMMENTS		

2

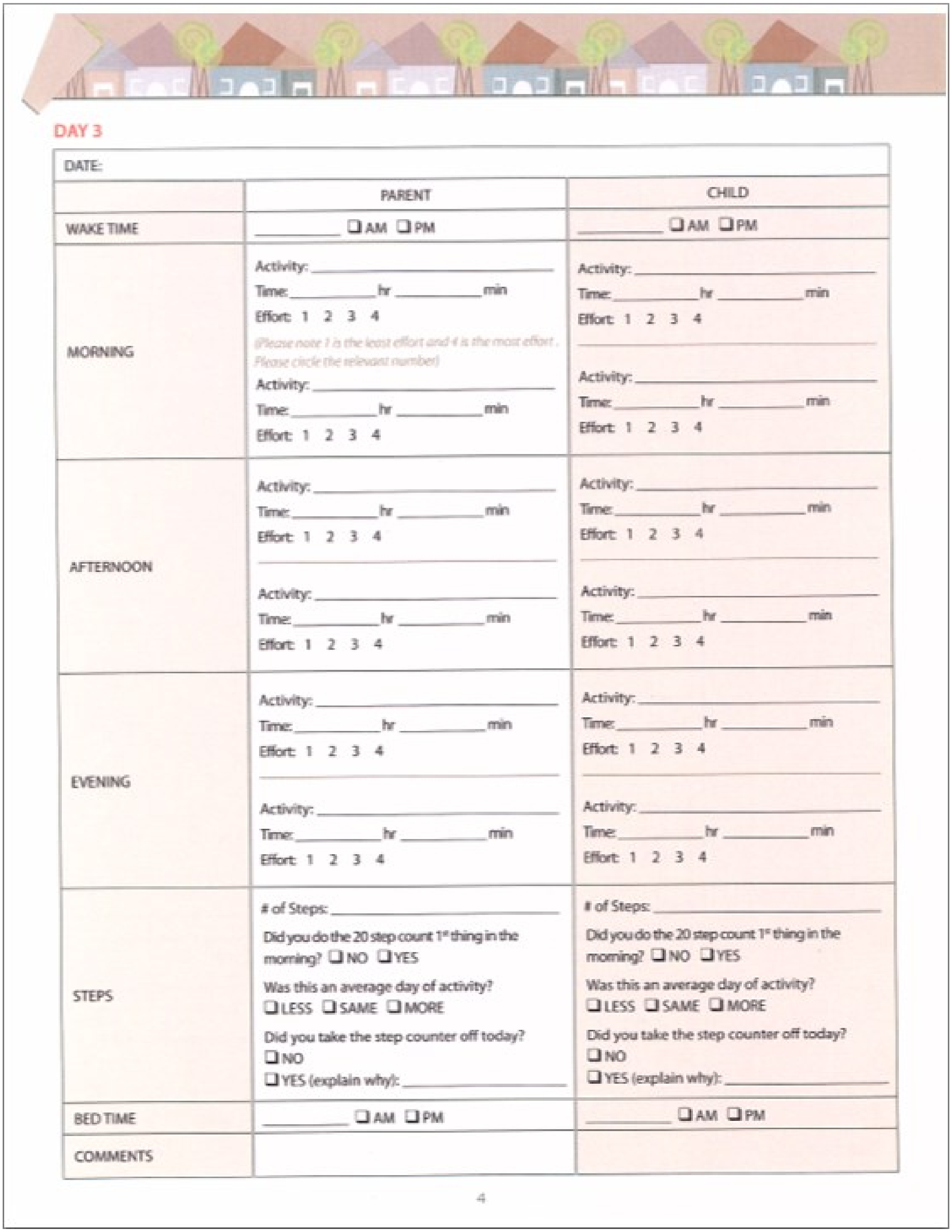


DAY 2

DATE:

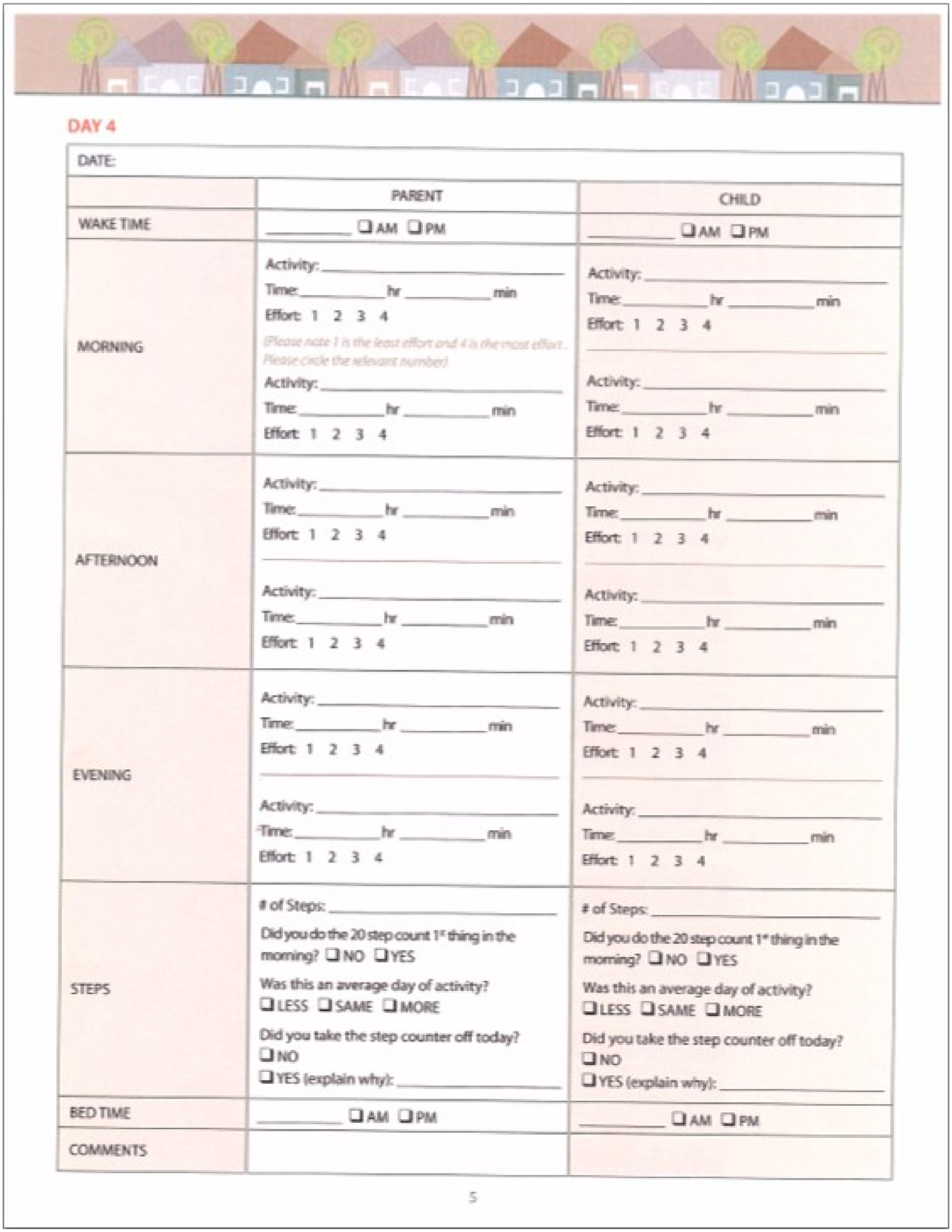
	PARENT	CHILD
WAKE TIME	____ ☐ AM ☐ PM	____ ☐ AM ☐ PM
MORNING	Activity: ____ Time: ____ hr ____ min Effort: 1 2 3 4 *(Please note 1 is the least effort and 4 is the most effort. Please circle the relevant number)* Activity: ____ Time: ____ hr ____ min Effort: 1 2 3 4	Activity: ____ Time: ____ hr ____ min Effort: 1 2 3 4 Activity: ____ Time: ____ hr ____ min Effort: 1 2 3 4
AFTERNOON	Activity: ____ Time: ____ hr ____ min Effort: 1 2 3 4 Activity: ____ Time: ____ hr ____ min Effort: 1 2 3 4	Activity: ____ Time: ____ hr ____ min Effort: 1 2 3 4 Activity: ____ Time: ____ hr ____ min Effort: 1 2 3 4
EVENING	Activity: ____ Time: ____ hr ____ min Effort: 1 2 3 4 Activity: ____ Time: ____ hr ____ min Effort: 1 2 3 4	Activity: ____ Time: ____ hr ____ min Effort: 1 2 3 4 Activity: ____ Time: ____ hr ____ min Effort: 1 2 3 4
STEPS	# of Steps: ____ Did you do the 20 step count 1st thing in the morning? ☐ NO ☐ YES Was this an average day of activity? ☐ LESS ☐ SAME ☐ MORE Did you take the step counter off today? ☐ NO ☐ YES (explain why): ____	# of Steps: ____ Did you do the 20 step count 1st thing in the morning? ☐ NO ☐ YES Was this an average day of activity? ☐ LESS ☐ SAME ☐ MORE Did you take the step counter off today? ☐ NO ☐ YES (explain why): ____
BED TIME	____ ☐ AM ☐ PM	____ ☐ AM ☐ PM
COMMENTS		

3



DAY 3

DATE:		
	PARENT	CHILD
WAKE TIME	________ ☐ AM ☐ PM	________ ☐ AM ☐ PM
MORNING	Activity: ________ Time: ________ hr ________ min Effort: 1 2 3 4 *(Please note 1 is the least effort and 4 is the most effort. Please circle the relevant number)* Activity: ________ Time: ________ hr ________ min Effort: 1 2 3 4	Activity: ________ Time: ________ hr ________ min Effort: 1 2 3 4 Activity: ________ Time: ________ hr ________ min Effort: 1 2 3 4
AFTERNOON	Activity: ________ Time: ________ hr ________ min Effort: 1 2 3 4 Activity: ________ Time: ________ hr ________ min Effort: 1 2 3 4	Activity: ________ Time: ________ hr ________ min Effort: 1 2 3 4 Activity: ________ Time: ________ hr ________ min Effort: 1 2 3 4
EVENING	Activity: ________ Time: ________ hr ________ min Effort: 1 2 3 4 Activity: ________ Time: ________ hr ________ min Effort: 1 2 3 4	Activity: ________ Time: ________ hr ________ min Effort: 1 2 3 4 Activity: ________ Time: ________ hr ________ min Effort: 1 2 3 4
STEPS	# of Steps: ________ Did you do the 20 step count 1st thing in the morning? ☐ NO ☐ YES Was this an average day of activity? ☐ LESS ☐ SAME ☐ MORE Did you take the step counter off today? ☐ NO ☐ YES (explain why): ________	# of Steps: ________ Did you do the 20 step count 1st thing in the morning? ☐ NO ☐ YES Was this an average day of activity? ☐ LESS ☐ SAME ☐ MORE Did you take the step counter off today? ☐ NO ☐ YES (explain why): ________
BED TIME	________ ☐ AM ☐ PM	________ ☐ AM ☐ PM
COMMENTS		

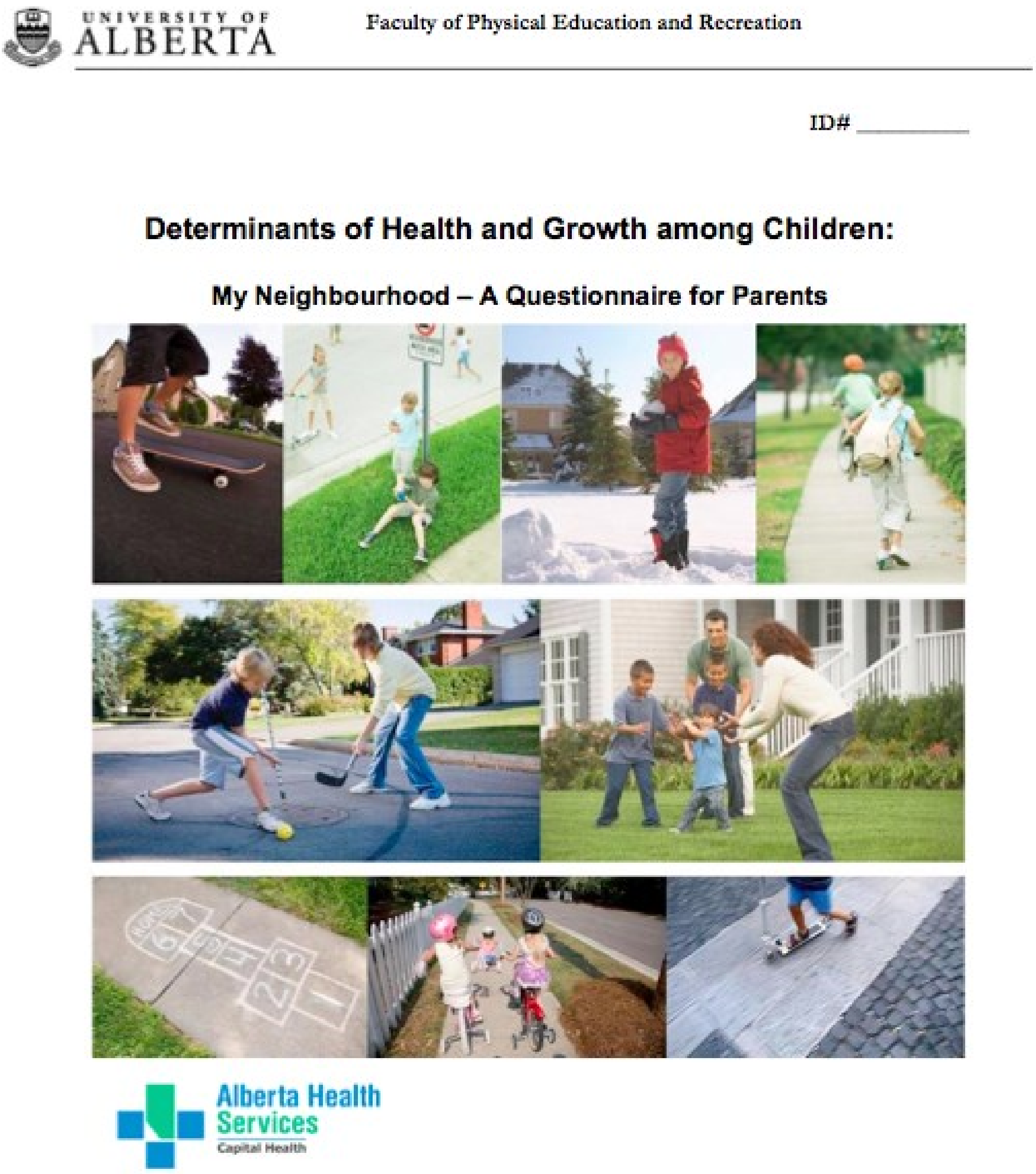


DAY 4

DATE:		
	PARENT	CHILD
WAKE TIME	________ ☐ AM ☐ PM	________ ☐ AM ☐ PM
MORNING	Activity: ________ Time: ________ hr ________ min Effort: 1 2 3 4 (Please note 1 is the least effort and 4 is the most effort. Please circle the relevant number) Activity: ________ Time: ________ hr ________ min Effort: 1 2 3 4	Activity: ________ Time: ________ hr ________ min Effort: 1 2 3 4 Activity: ________ Time: ________ hr ________ min Effort: 1 2 3 4
AFTERNOON	Activity: ________ Time: ________ hr ________ min Effort: 1 2 3 4 Activity: ________ Time: ________ hr ________ min Effort: 1 2 3 4	Activity: ________ Time: ________ hr ________ min Effort: 1 2 3 4 Activity: ________ Time: ________ hr ________ min Effort: 1 2 3 4
EVENING	Activity: ________ Time: ________ hr ________ min Effort: 1 2 3 4 Activity: ________ Time: ________ hr ________ min Effort: 1 2 3 4	Activity: ________ Time: ________ hr ________ min Effort: 1 2 3 4 Activity: ________ Time: ________ hr ________ min Effort: 1 2 3 4
STEPS	# of Steps: ________ Did you do the 20 step count 1st thing in the morning? ☐ NO ☐ YES Was this an average day of activity? ☐ LESS ☐ SAME ☐ MORE Did you take the step counter off today? ☐ NO ☐ YES (explain why): ________	# of Steps: ________ Did you do the 20 step count 1st thing in the morning? ☐ NO ☐ YES Was this an average day of activity? ☐ LESS ☐ SAME ☐ MORE Did you take the step counter off today? ☐ NO ☐ YES (explain why): ________
BED TIME	________ ☐ AM ☐ PM	________ ☐ AM ☐ PM
COMMENTS		

5

Appendix F: My Neighborhood – A Questionnaire for Parents (Follow-up)



UNIVERSITY OF ALBERTA

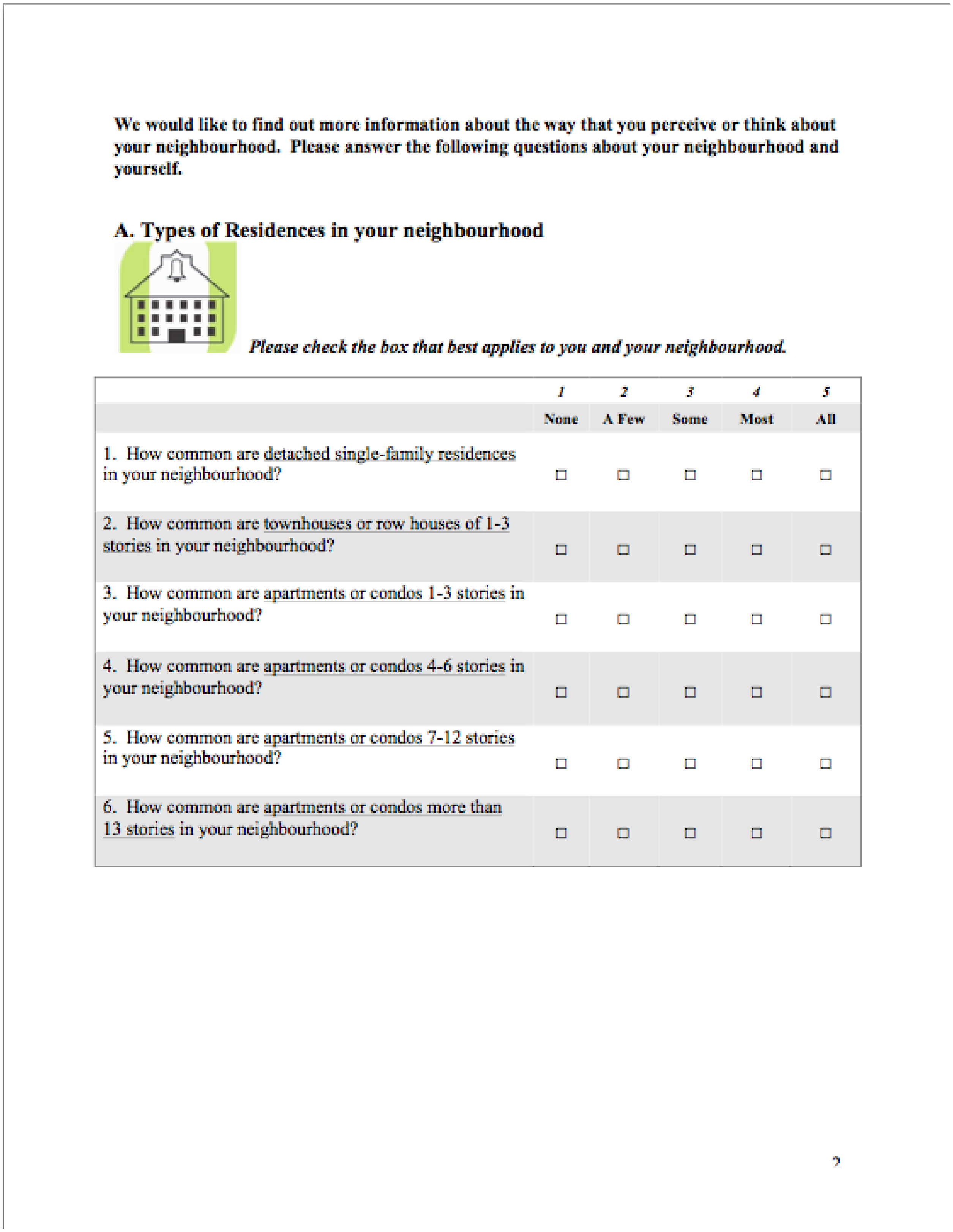
Faculty of Physical Education and Recreation

ID# __________

Determinants of Health and Growth among Children:

My Neighbourhood – A Questionnaire for Parents

Alberta Health Services
Capital Health



We would like to find out more information about the way that you perceive or think about your neighbourhood. Please answer the following questions about your neighbourhood and yourself.

A. Types of Residences in your neighbourhood

Please check the box that best applies to you and your neighbourhood.

	1 **None**	*2* **A Few**	*3* **Some**	*4* **Most**	*5* **All**
1. How common are detached single-family residences in your neighbourhood?	☐	☐	☐	☐	☐
2. How common are townhouses or row houses of 1-3 stories in your neighbourhood?	☐	☐	☐	☐	☐
3. How common are apartments or condos 1-3 stories in your neighbourhood?	☐	☐	☐	☐	☐
4. How common are apartments or condos 4-6 stories in your neighbourhood?	☐	☐	☐	☐	☐
5. How common are apartments or condos 7-12 stories in your neighbourhood?	☐	☐	☐	☐	☐
6. How common are apartments or condos more than 13 stories in your neighbourhood?	☐	☐	☐	☐	☐

B. Stores, facilities, and other things in your neighbourhood

About how long would it take to get from your home to the nearest businesses or facilities (e.g., schools) listed below if you walked to them? Please put only one check mark (√) for each business or facility.

Statements	**1**	**2**	**3**	**4**	**5**	**6**
	1-5 min	**6-10min**	**11-20min**	**20-30min**	**30+min**	**Don't know**
1. Example: shoe repair shop	☐	☐	☑	☐	☐	☐

Statements	**1**	**2**	**3**	**4**	**5**	**6**
	1-5 min	**6-10min**	**11-20min**	**20-30min**	**30+min**	**Don't know**
1. convenience or small grocery store	☐	☐	☐	☐	☐	☐
2.supermarket	☐	☐	☐	☐	☐	☐
3. hardware store	☐	☐	☐	☐	☐	☐
4. fruit and vegetable market	☐	☐	☐	☐	☐	☐
5. laundry/dry cleaners	☐	☐	☐	☐	☐	☐
6. clothing store	☐	☐	☐	☐	☐	☐
7. post office	☐	☐	☐	☐	☐	☐
8. library	☐	☐	☐	☐	☐	☐
9. elementary school	☐	☐	☐	☐	☐	☐
10. other schools	☐	☐	☐	☐	☐	☐

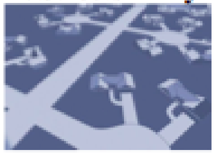
Statements	1	2	3	4	5	6
11. bookstore	☐	☐	☐	☐	☐	☐
12. fast-food restaurant	☐	☐	☐	☐	☐	☐
13. coffee place	☐	☐	☐	☐	☐	☐
14. bank/credit union	☐	☐	☐	☐	☐	☐
15. non fast-food restaurant	☐	☐	☐	☐	☐	☐
16. video store	☐	☐	☐	☐	☐	☐
17 pharmacy/drug store	☐	☐	☐	☐	☐	☐
18. salon/barber shop	☐	☐	☐	☐	☐	☐
19. bus or LRT train	☐	☐	☐	☐	☐	☐
20. park	☐	☐	☐	☐	☐	☐
21. recreation centre	☐	☐	☐	☐	☐	☐
22. gym/fitness facility	☐	☐	☐	☐	☐	☐
23. your job/school Check here__ if not applicable (Applies to 23 only)	☐	☐	☐	☐	☐	☐

C. Access to services

Please put a check mark on the answer that best applies to you and your neighbourhood. The terms local and within walking distance mean within a 10-15 minute walk from your home.

Statements	**1**	**2**	**3**	**4**
	Strongly disagree	**Somewhat disagree**	**Somewhat agree**	**Strongly agree**
1. Stores are within easy walking distance of my home.	☐	☐	☐	☐
2. Parking is difficult in shopping areas.	☐	☐	☐	☐
3. There are many places to go within walking distance of my home.	☐	☐	☐	☐
4. A transit stop (bus, train) is within walking distance from my home.	☐	☐	☐	☐
5. The streets in my neighbourhood are hilly, making my neighbourhood difficult to walk in.	☐	☐	☐	☐
6. There are major barriers to walking in my local area that make it hard to get from place to place (for example, freeways, railway lines, rivers).	☐	☐	☐	☐

D. Streets in my neighbourhood



Please circle the answer that best applies to you and your neighbourhood.

Statements	1	2	3	4
	Strongly disagree	Somewhat disagree	Somewhat agree	Strongly agree
1. The streets in my neighbourhood do not have many cul-de-sacs (dead-end streets).	☐	☐	☐	☐
2. The length of blocks in my neighbourhood is usually short (300 feet or less; the length of a football field or less).	☐	☐	☐	☐
3. There are many alternative routes for getting from place to place in my neighbourhood. (I don't have to go the same way every time.)	☐	☐	☐	☐

E. Places for walking and cycling

Please circle the answer that best applies to you and your neighbourhood.

Statements	1	2	3	4
	Strongly disagree	Somewhat disagree	Somewhat agree	Strongly agree
1. There are sidewalks on most of the streets in my neighbourhood.	☐	☐	☐	☐
2. Sidewalks are separated from the road/traffic in my	☐	☐	☐	☐

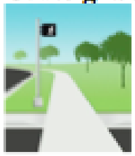
Statements	1	2	3	4
neighbourhood by parked cars.				
3. There is a grass/dirt strip that separates the streets from the sidewalks in my neighbourhood.	☐	☐	☐	☐

F. Neighbourhood surroundings

Please circle the answer that best applies to you and your neighbourhood.

Statements	1	2	3	4
	Strongly disagree	**Somewhat disagree**	**Somewhat agree**	**Strongly agree**
1. There are trees along the streets in my neighbourhood.	☐	☐	☐	☐
2. There are many interesting things to look at while walking in my neighbourhood.	☐	☐	☐	☐
3. There are many attractive natural sights in my neighbourhood (such as landscaping, views).	☐	☐	☐	☐
4. There are attractive buildings/homes in my neighbourhood.	☐	☐	☐	☐

G. Neighbourhood Safety



Please check the box that best applies to you and your neighbourhood.

Statements				
	Strongly disagree	**Somewhat disagree**	**Somewhat agree**	**Strongly agree**
1. There is so much traffic along nearby streets that it makes it difficult or unpleasant to walk in my neighbourhood.	☐	☐	☐	☐
2. The speed of traffic on most nearby streets is usually slow (30 km/hr less).	☐	☐	☐	☐
3. Most drivers exceed the posted speed limits while driving in my neighbourhood.	☐	☐	☐	☐
4. My neighbourhood streets are well lit at night.	☐	☐	☐	☐
5. Walkers and cyclists on the streets in my neighbourhood are visible to people in their homes.	☐	☐	☐	☐
6. There are crosswalks and pedestrian signals to help walkers cross busy streets in my neighbourhood.	☐	☐	☐	☐
7. There is a high crime rate in my neighbourhood.	☐	☐	☐	☐
8. The crime rate in my neighbourhood makes it unsafe to go on walks during the day.	☐	☐	☐	☐
9. The crime rate in my neighbourhood makes it unsafe to go on walks at night.	☐	☐	☐	☐

H. Physical Activity

Considering a 7-Day period (a week), how many times on average do you do the following kinds of exercise for more than 15 minutes during your free time (write on each line the appropriate number)?

Times Per Week

1. **STRENUOUS PHYSICAL ACTIVITY**
(heart beats rapidly, sweating)

____

(e.g., running, jogging, hockey, soccer, squash, cross country skiing, judo, roller skating, vigorous swimming, rigorous long distance bicycling, vigorous aerobic dance classes, heavy weight training)

2. **MODERATE PHYSICAL ACTIVITY**
(not exhausting, light perspiration)

____

(e.g., fast walking, baseball, tennis, easy bicycling, volleyball, badminton, easy swimming, alpine skiing, popular and folk dancing)

3. **MILD PHYSICAL ACTIVITY**
(minimal effort, no perspiration)

____

(e.g., easy walking, yoga, archery, fishing, bowling, lawn bowling, shuffleboard, horseshoes, golf, snowmobiling)

I. Transportation

These questions are about how you travel from place to place, including to places like stores, movies and so on.

1. During the last seven days, did you:

Did you engage in any of these travel activities during the last 7days?	Did you do this?	**Monday - Friday**		**Saturday and Sunday**	
		How many times Mon - Fri?	Average minutes each time Mon - Fri?	How many times Sat and Sun?	Average minutes each time Sat and Sun?
Example: Bike riding	**No** [✓ **Yes**]	**2**	**40 minutes**	**1**	**15 minutes**
Travel by LRT	**No** **Yes**				
Travel by bus	**No** **Yes**				
Travel by car	**No** **Yes**				
Cycle for at least 10 minutes at a time to go from place to place	**No** **Yes**				
Walk for at least 10 minutes at a time to go from place to place	**No** **Yes**				

J. Demographics

These questions are about you and your household.

1. What is your gender?

☐ Male

☐ Female

2. What is your relation to the child we are testing today?

☐ Mother

☐ Father

☐ Grandmother

☐ Grandfather

☐ Other (please describe) ____________________

3. What is the highest level of education that **you** have attained?

☐ Some high school ☐ Completed high school

☐ Some university or college ☐ Completed university/ college

☐ Some graduate school (e.g., master's degree or PhD) ☐ Completed graduate school

4. What is your annual **household** income before taxes?

☐ <$20,000 ☐ $20-39,999 ☐ $40-59,999

☐ $60-79,999 ☐ $80-99,999 ☐ >$100,000

5. What is your height and weight?

Height: ____________ feet, or ____________cm

Weight: ____________ pounds, or ___________kg

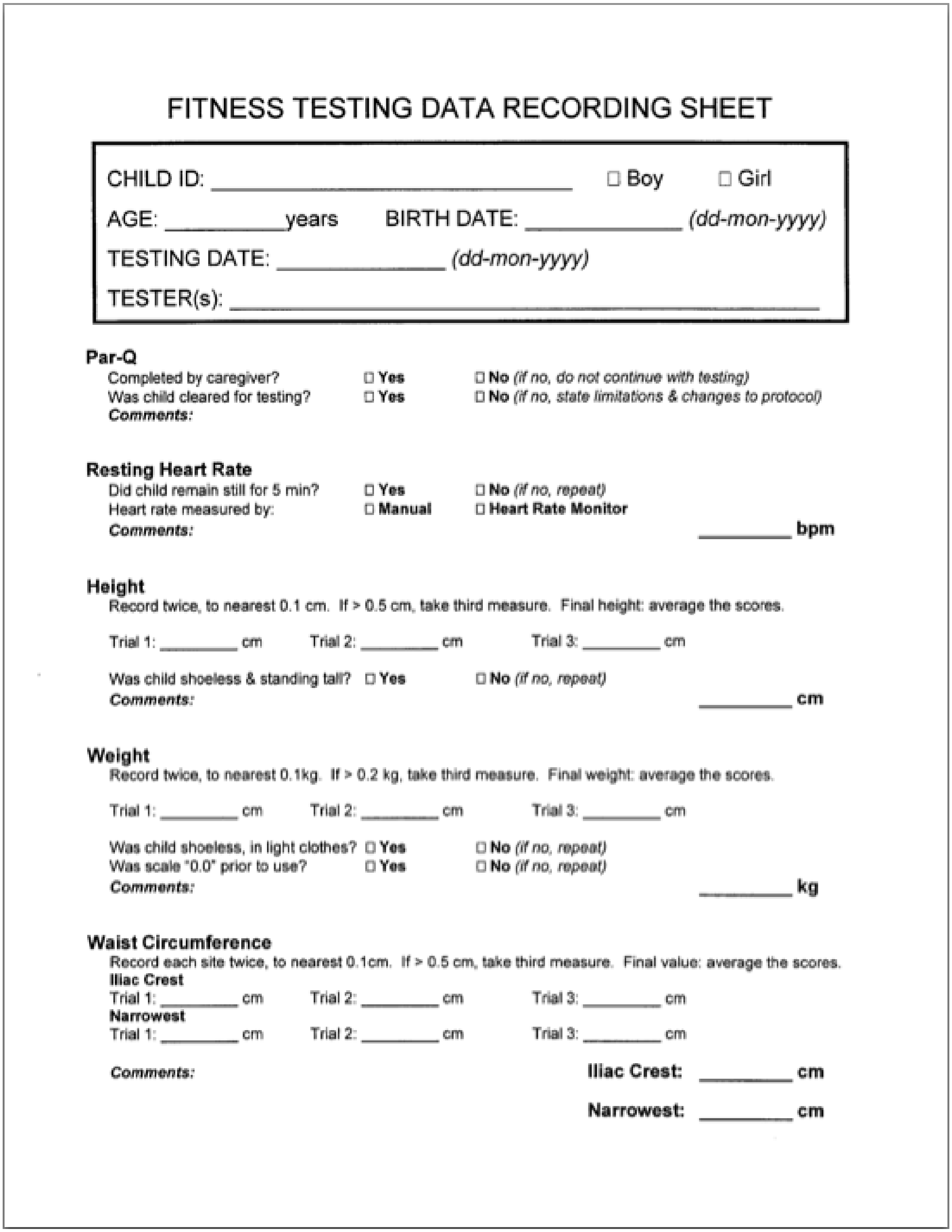
6. Do you own a dog?

☐ Yes

☐ No

THANK YOU VERY MUCH!

Appendix G: Fitness Testing Data Recording Sheet (Follow-up)



FITNESS TESTING DATA RECORDING SHEET

CHILD ID: ______________________________ ☐ Boy ☐ Girl
AGE: __________years BIRTH DATE: ____________ *(dd-mon-yyyy)*
TESTING DATE: ______________ *(dd-mon-yyyy)*
TESTER(s): ____

Par-Q
Completed by caregiver? ☐ **Yes** ☐ **No** *(if no, do not continue with testing)*
Was child cleared for testing? ☐ **Yes** ☐ **No** *(if no, state limitations & changes to protocol)*
Comments:

Resting Heart Rate
Did child remain still for 5 min? ☐ **Yes** ☐ **No** *(if no, repeat)*
Heart rate measured by: ☐ **Manual** ☐ **Heart Rate Monitor**
Comments: __________ **bpm**

Height
Record twice, to nearest 0.1 cm. If > 0.5 cm, take third measure. Final height: average the scores.

Trial 1: _________ cm Trial 2: _________ cm Trial 3: _________ cm

Was child shoeless & standing tall? ☐ **Yes** ☐ **No** *(if no, repeat)*
Comments: __________ **cm**

Weight
Record twice, to nearest 0.1kg. If > 0.2 kg, take third measure. Final weight: average the scores.

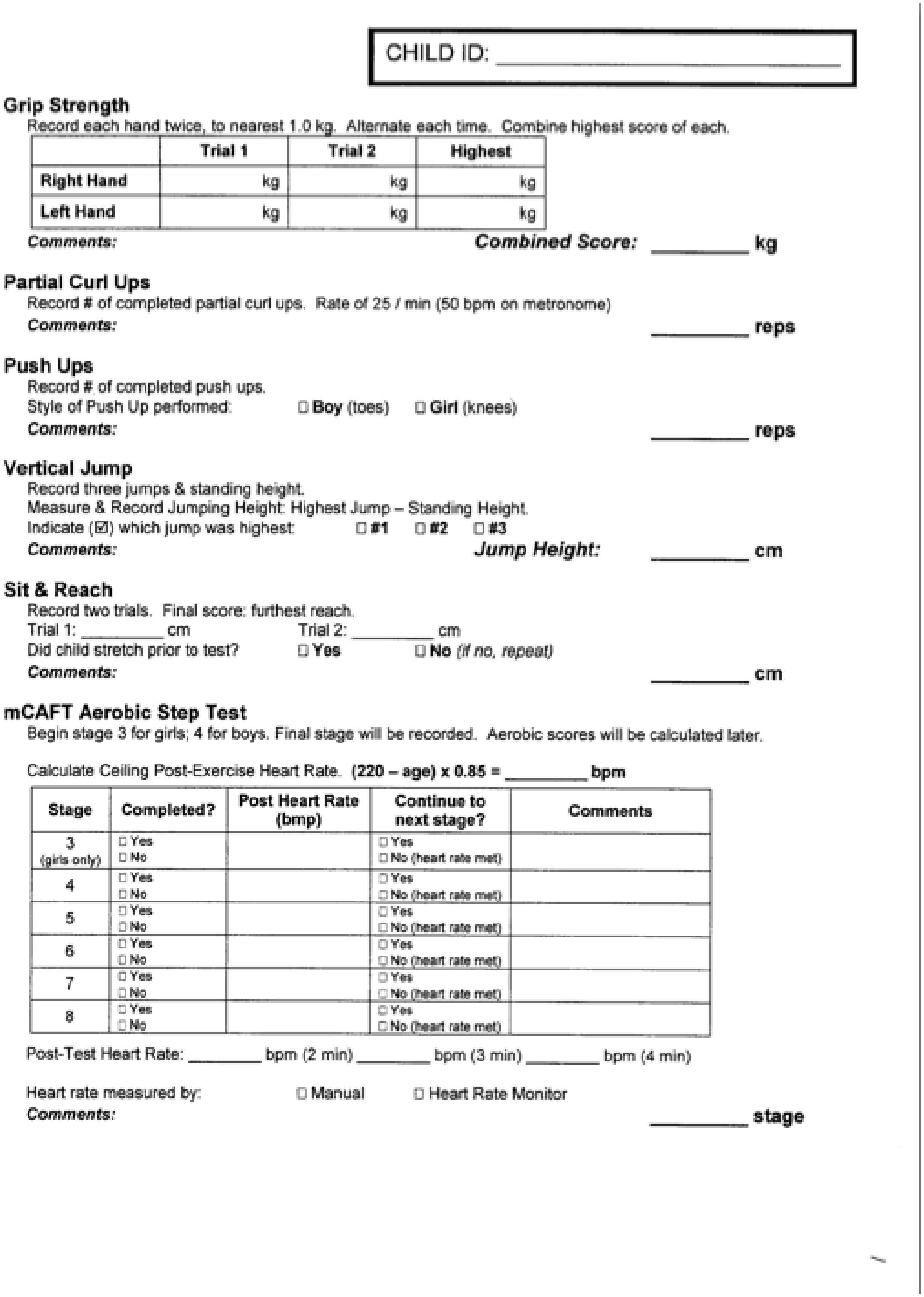
Trial 1: _________ cm Trial 2: _________ cm Trial 3: _________ cm

Was child shoeless, in light clothes? ☐ **Yes** ☐ **No** *(if no, repeat)*
Was scale "0.0" prior to use? ☐ **Yes** ☐ **No** *(if no, repeat)*
Comments: __________ **kg**

Waist Circumference
Record each site twice, to nearest 0.1cm. If > 0.5 cm, take third measure. Final value: average the scores.
Iliac Crest
Trial 1: _________ cm Trial 2: _________ cm Trial 3: _________ cm
Narrowest
Trial 1: _________ cm Trial 2: _________ cm Trial 3: _________ cm

Comments: **Iliac Crest:** __________ **cm**

Narrowest: __________ **cm**



CHILD ID: ______________________________

Grip Strength

Record each hand twice, to nearest 1.0 kg. Alternate each time. Combine highest score of each.

	Trial 1	Trial 2	Highest
Right Hand	kg	kg	kg
Left Hand	kg	kg	kg

Comments: ***Combined Score:*** _________ **kg**

Partial Curl Ups

Record # of completed partial curl ups. Rate of 25 / min (50 bpm on metronome)

Comments: _________ **reps**

Push Ups

Record # of completed push ups.

Style of Push Up performed: ☐ **Boy** (toes) ☐ **Girl** (knees)

Comments: _________ **reps**

Vertical Jump

Record three jumps & standing height.

Measure & Record Jumping Height: Highest Jump – Standing Height.

Indicate (☑) which jump was highest: ☐ **#1** ☐ **#2** ☐ **#3**

Comments: ***Jump Height:*** _________ **cm**

Sit & Reach

Record two trials. Final score: furthest reach.

Trial 1: _________ cm Trial 2: _________ cm

Did child stretch prior to test? ☐ **Yes** ☐ **No** *(if no, repeat)*

Comments: _________ **cm**

mCAFT Aerobic Step Test

Begin stage 3 for girls; 4 for boys. Final stage will be recorded. Aerobic scores will be calculated later.

Calculate Ceiling Post-Exercise Heart Rate. **(220 – age) x 0.85 =** _________ **bpm**

Stage	Completed?	Post Heart Rate (bmp)	Continue to next stage?	Comments
3 (girls only)	☐ Yes ☐ No		☐ Yes ☐ No (heart rate met)	
4	☐ Yes ☐ No		☐ Yes ☐ No (heart rate met)	
5	☐ Yes ☐ No		☐ Yes ☐ No (heart rate met)	
6	☐ Yes ☐ No		☐ Yes ☐ No (heart rate met)	
7	☐ Yes ☐ No		☐ Yes ☐ No (heart rate met)	
8	☐ Yes ☐ No		☐ Yes ☐ No (heart rate met)	

Post-Test Heart Rate: ________ bpm (2 min) ________ bpm (3 min) ________ bpm (4 min)

Heart rate measured by: ☐ Manual ☐ Heart Rate Monitor

Comments: _________ **stage**

Appendix H: Physical Activity Readiness Questionnaire (Follow-up)

Physical Activity Readiness
Questionnaire - PAR-Q
(revised 2002)

PAR-Q & YOU

(A Questionnaire for People Aged 15 to 69)

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly: check YES or NO.

YES	NO		
☐	☐	1.	**Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?**
☐	☐	2.	**Do you feel pain in your chest when you do physical activity?**
☐	☐	3.	**In the past month, have you had chest pain when you were not doing physical activity?**
☐	☐	4.	**Do you lose your balance because of dizziness or do you ever lose consciousness?**
☐	☐	5.	**Do you have a bone or joint problem (for example, back, knee or hip) that could be made worse by a change in your physical activity?**
☐	☐	6.	**Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?**
☐	☐	7.	**Do you know of any other reason why you should not do physical activity?**

If you answered

YES to one or more questions

Talk with your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.

- You may be able to do any activity you want — as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.
- Find out which community programs are safe and helpful for you.

NO to all questions

If you answered NO honestly to all PAR-Q questions, you can be reasonably sure that you can:

- start becoming much more physically active – begin slowly and build up gradually. This is the safest and easiest way to go.
- take part in a fitness appraisal – this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively. It is also highly recommended that you have your blood pressure evaluated. If your reading is over 144/94, talk with your doctor before you start becoming much more physically active.

DELAY BECOMING MUCH MORE ACTIVE:

- if you are not feeling well because of a temporary illness such as a cold or a fever – wait until you feel better; or
- if you are or may be pregnant – talk to your doctor before you start becoming more active.

PLEASE NOTE: If your health changes so that you then answer YES to any of the above questions, tell your fitness or health professional. Ask whether you should change your physical activity plan.

Informed Use of the PAR-Q: The Canadian Society for Exercise Physiology, Health Canada, and their agents assume no liability for persons who undertake physical activity, and if in doubt after completing this questionnaire, consult your doctor prior to physical activity.

No changes permitted. You are encouraged to photocopy the PAR-Q but only if you use the entire form.

NOTE: If the PAR-Q is being given to a person before he or she participates in a physical activity program or a fitness appraisal, this section may be used for legal or administrative purposes.

"I have read, understood and completed this questionnaire. Any questions I had were answered to my full satisfaction."

NAME ______________________________

SIGNATURE ______________________________ DATE____________________

SIGNATURE OF PARENT ______________________________ WITNESS ____________________
or GUARDIAN (for participants under the age of majority)

Note: This physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if your condition changes so that you would answer YES to any of the seven questions.

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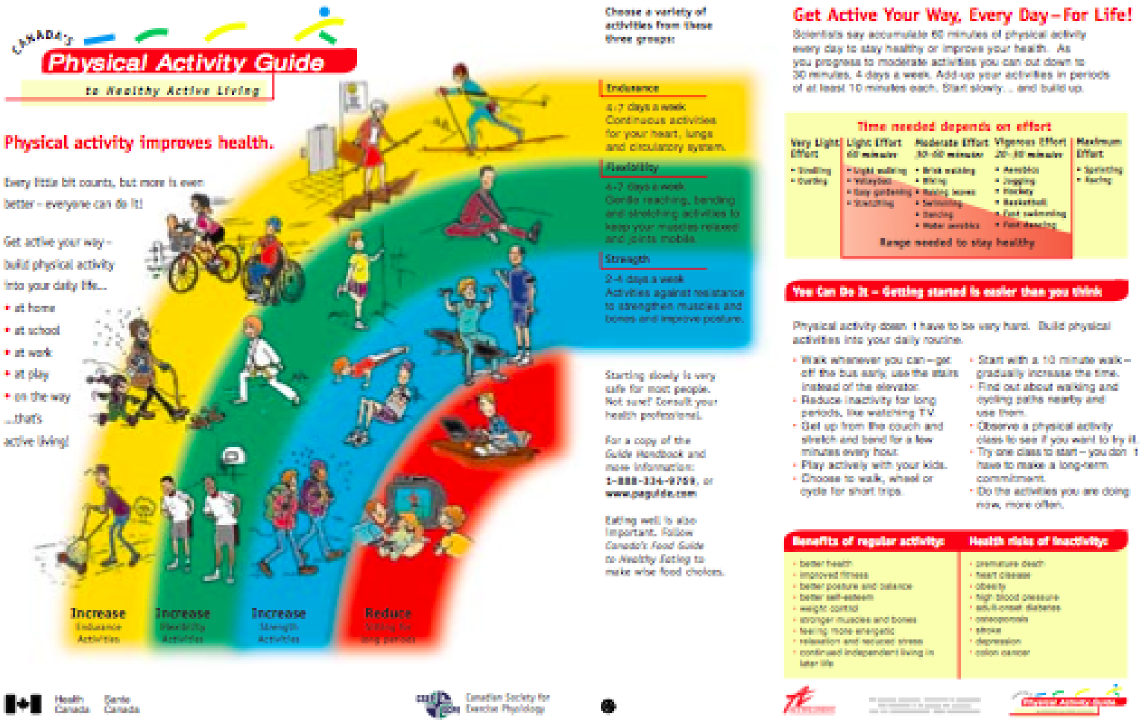
PAR-Q & YOU

Physical Activity Readiness
Questionnaire - PAR-Q
(revised 2002)



CANADA'S **Physical Activity Guide** to Healthy Active Living

Physical activity improves health.

Every little bit counts, but more is even better – everyone can do it!

Get active your way – build physical activity into your daily life...

- at home
- at school
- at work
- at play
- on the way

...that's active living!

Choose a variety of activities from these three groups:

Endurance
4-7 days a week
Continuous activities for your heart, lungs and circulatory system.

Flexibility
4-7 days a week
Gentle reaching, bending and stretching activities to keep your muscles relaxed and joints mobile.

Strength
2-4 days a week
Activities against resistance to strengthen muscles and bones and improve posture.

Increase Endurance Activities
Increase Flexibility Activities
Increase Strength Activities
Reduce Sitting for long periods

Starting slowly is very safe for most people. Not sure? Consult your health professional.

For a copy of the *Guide Handbook* and more information: **1-888-334-9769**, or **www.paguide.com**

Eating well is also important. Follow *Canada's Food Guide to Healthy Eating* to make wise food choices.

Get Active Your Way, Every Day–For Life!

Scientists say accumulate 60 minutes of physical activity every day to stay healthy or improve your health. As you progress to moderate activities you can cut down to 30 minutes, 4 days a week. Add-up your activities in periods of at least 10 minutes each. Start slowly... and build up.

Time needed depends on effort

Very Light Effort	Light Effort 60 minutes	Moderate Effort 30-60 minutes	Vigorous Effort 20-30 minutes	Maximum Effort
• Strolling • Dusting	• Light walking • Volleyball • Easy gardening • Stretching	• Brisk walking • Biking • Raking leaves • Swimming • Dancing • Water aerobics	• Aerobics • Jogging • Hockey • Basketball • Fast swimming • Fast dancing	• Sprinting • Racing

Range needed to stay healthy

You Can Do It – Getting started is easier than you think

Physical activity doesn't have to be very hard. Build physical activities into your daily routine.

- Walk whenever you can – get off the bus early, use the stairs instead of the elevator.
- Reduce inactivity for long periods, like watching TV.
- Get up from the couch and stretch and bend for a few minutes every hour.
- Play actively with your kids.
- Choose to walk, wheel or cycle for short trips.
- Start with a 10 minute walk – gradually increase the time.
- Find out about walking and cycling paths nearby and use them.
- Observe a physical activity class to see if you want to try it.
- Try one class to start – you don't have to make a long-term commitment.
- Do the activities you are doing now, more often.

Benefits of regular activity:

- better health
- improved fitness
- better posture and balance
- better self-esteem
- weight control
- stronger muscles and bones
- feeling more energetic
- relaxation and reduced stress
- continued independent living in later life

Health risks of inactivity:

- premature death
- heart disease
- obesity
- high blood pressure
- adult-onset diabetes
- osteoporosis
- stroke
- depression
- colon cancer

Health Canada Santé Canada

Canadian Society for Exercise Physiology

Source: Canada's Physical Activity Guide to Healthy Active Living, Health Canada, 1998 http://www.hc-sc.gc.ca/hppb/paguide/pdf/guideEng.pdf

FITNESS AND HEALTH PROFESSIONALS MAY BE INTERESTED IN THE INFORMATION BELOW:

The following companion forms are available for doctors' use by contacting the Canadian Society for Exercise Physiology (address below):

The **Physical Activity Readiness Medical Examination (PARmed-X)** – to be used by doctors with people who answer YES to one or more questions on the PAR-Q.

The **Physical Activity Readiness Medical Examination for Pregnancy (PARmed-X for Pregnancy)** – to be used by doctors with pregnant patients who wish to become more active.

References:
Arraix, G.A., Wigle, D.T., Mao, Y. (1992). Risk Assessment of Physical Activity and Physical Fitness in the Canada Health Survey Follow-Up Study. **J. Clin. Epidemiol.** 45:4 419-428.
Mottola, M., Wolfe, L.A. (1994). Active Living and Pregnancy, In: A. Quinney, L. Gauvin, T. Wall (eds.), **Toward Active Living: Proceedings of the International Conference on Physical Activity, Fitness and Health.** Champaign, IL: Human Kinetics.
PAR-Q Validation Report, British Columbia Ministry of Health, 1978.
Thomas, S., Reading, J., Shephard, R.J. (1992). Revision of the Physical Activity Readiness Questionnaire (PAR-Q). **Can. J. Spt. Sci.** 17:4 338-345.

For more information, please contact the:

Canadian Society for Exercise Physiology
202-185 Somerset Street West
Ottawa, ON K2P 0J2
Tel. 1-877-651-3755 • FAX (613) 234-3565
Online: www.csep.ca

The original PAR-Q was developed by the British Columbia Ministry of Health. It has been revised by an Expert Advisory Committee of the Canadian Society for Exercise Physiology chaired by Dr. N. Gledhill (2002).

Disponible en français sous le titre «Questionnaire sur l'aptitude à l'activité physique - Q-AAP (revisé 2002)».

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