Physical fitness, body composition and pedometer measured physical activity in children in a rural Manitoba community.

By

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ABSTRACT

A child's level of physical activity is an important component of that child's health. Our understanding of physical activity patterns in children is limited in rural settings, and virtually absent for climates with snow cover. Opportunities for physical activity intervention need to be identified. PURPOSE: Investigation of the relationships between pedometer-measured physical activity, body composition and aerobic performance in rural children in the winter and examination of within-day variation in stepping behavior using interval pedometry. METHODS: Aerobic performance (20 m shuttle run) with "talk test" validation and body composition (BMI, BF) were measured during mid-winter during the school year in 8 to 10 year old children. Pedometer step counts were recorded at 6 intervals throughout the day for 7 days. RESULTS: Fifty-six subjects (22 males and 34 females, mean age 9.09 (0.49), had the following measurements; BMI 17.9 (3.3), BF% 24.3 (9.5) (tricep/calf), 10,465 (±2506) steps/day, VO2 45.12 ml/kg/min (±2.87), shuttle run stage 3.0 (±1.34). Weekday steps/day (11,422 ±2573) were greater than weekend (8,112, ±3499) steps/day for both boys and girls ($p<0.01$). Town children recorded 1800 more steps/day than out of town children ($p<0.01$). All measures of body composition were found to be significantly related to aerobic power ($p<0.01$). Weekday steps were related to aerobic performance. The fittest (upper 1/3) children were leaner and had more afternoon school steps, and higher afternoon school step rates. CONCLUSION: Daily step counts were 2000-4000 steps lower than other studies and may be an impact of winter in Manitoba or the rural setting. This was consistent with overall low aerobic performance and higher adiposity of the children. Interval pedometry was capable of identifying differences in activity patterns between most and least fit children in rural Manitoba providing for targeted intervention strategies.

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Introduction

The importance of physical activity (PA) for the reduction of health risks has been well documented (Cieslak, Frost et al. 2003; Andersen, Harro et al. 2006; Basaran, Guler-Uysal et al. 2006). Children are not active enough to prevent childhood obesity and other chronic health diseases including Type II diabetes and cardiovascular disease (Tell and Vellar 1988; Tremblay and Willms 2003; Janssen, Katzmarzyk et al. 2004). The cost of managing such life-style related diseases continues to rise. In Canada, the economic burden of physical inactivity is estimated to be 5.3 billion and the cost of obesity is estimated to be 4.3 billion (Janssen, Katzmarzyk et al. 2004). Low activity levels during childhood tend to persist into adulthood (Telama, Yang et al. 2005). In order to protect future generations from the impact of such diseases it is important to start and maintain high physical activity levels from a very early age in life, as well as control over-consumption of food. One factor that can influence childhood PA that has been overlooked in the research literature is the impact of Canadian winter conditions (snow cover and cold weather). In addition, most studies examine children in urban areas (Rowlands, Eston et al. 1999; Tremblay and Willms 2003; Tudor-Locke, Pangrazi et al. 2004; Cox, Schofield et al. 2006) and few examine rural children (Loucaides, Chedzoy et al. 2004; Ozdirenc, Ozcan et al. 2005). Transportation to and from school, access to activity programming, access to television programming and internet use, and rural lifestyle all are expected to have an impact on the physical activity level of rural children. Understanding the levels and patterns of PA is an important point for design and implementation of PA promotion programs, and establishing secular trends in the PA levels. Further, there is absence of information which identifies the within day variation in PA levels which can be used to identify windows of opportunity for lifestyle modification using PA promotion.

The physical activity guides for youth and children produced by Health Canada recommend that children perform at least 90 minutes of moderate (brisk walking, skating, bike riding) to high (running, playing soccer) intensity physical activity per day. Television and computer use have contributed to a significant reduction in the amount of moderate to high level intensity activity children take part in (Janssen, Katzmarzyk et al. 2004). Physical activity of children has been examined indirectly using various self-report questionnaires (Ozdirenc, Ozcan et al. 2005) and less frequently, directly, using observation (Scruggs, Beveridge et al. 2003) or objective measures such as heart rate and activity monitors (Rowlands, Eston et al. 1999; Sirard and Pate 2001). When answering questionnaires, however, people (parents and children) tend to overestimate their activity levels and intensity of their activity (Bender, Brownson et al. 2005). Direct measurement of PA can reveal many aspects of physical activity (magnitude and pattern), Physical activity monitors including accelerometers, heart rate monitors and pedometers are used to objectively record the activity levels of adults and children (Ridgers, Stratton et al. 2005; Rowlands, Eston et al. 1999). Of these, pedometers are the most cost effective for a large sample size and are easy to use. Pedometers are valid and reliable measures of activity in children (Beets, Patton et al. 2005). Current pedometry methodology limits the ability to determine within day variation in activity, as well as the inability to evaluate intensity of activity.

Only one study was found to examine the physical activity levels between urban and rural children using pedometry. Loucaides et al examined 256 Greek-Cypriot children, aged 11 to 12, from two urban schools and three rural schools (Loucaides, Chedzoy et al. 2004). Students recorded their steps in two intervals during the day, at the end of the school day (about 1 pm) and before bedtime. Pedometers were worn for a total of 4 days in the summer and for 4 days in the winter. Subjects in this study in the winter (Jan/Feb) tallied 13,583(urban) and 12,436 (rural) steps/day and in summer (May/June) had 14,531 (urban) and 16,450 (rural) steps/day. The researchers found that urban school children were significantly more active in the Cyprus winter (average of +12°C with no snow cover), averaging about 1000 steps/day more than rural children, and that rural children were significantly more active in the summer, averaging about 2000 more steps/day than urban children. The study did not examine the difference in steps taken between the two recorded intervals nor did it examine any male/female difference in average steps taken. Comparison of physical activity level to aerobic fitness was not examined. Through questionnaire these researchers determined that rural children had larger and safer outdoor environments for physical activity and that this may have accounted for the greater steps recorded in rural children in the summer. Urban children, on the other hand, tended to attend a wide variety of sports clubs through both winter and summer, but did not have the same outdoor play opportunity as rural children. Loucaides and coworkers concluded that effective physical activity intervention programs should consider geographical location, in addition to seasonal variables.

Decline of aerobic fitness of children is correlated to the rise in childhood obesity. Obese children tend to be less physically active than non-obese children (Trost, Kerr et al. 2001; Tremblay and Willms 2003). The inter-relationship between childhood physical activity, aerobic fitness and body composition has not been well elucidated (Livingstone, Robson et al. 2003) and is completely lacking for rural children. Two studies were found in the literature that examined physical activity using a pedometer and the relationship of step counts to cardiovascular fitness in children.

Rowlands et al, examined the relationship between physical activity, aerobic fitness and fatness in 34 children aged 8 – 10 years old in Bangor, Wales (Rowlands, Eston et al. 1999). Physical activity was measured using an accelerometer, (Tritrac-R3D), a pedometer (Yamax Digiwalker DW-200,) and heart rate telemetry (Sport Tester PE4000). Pedometer steps were recorded for 6 days, only once a day, by the child's parents at bedtime. Boys averaged 16,035 (5,998) daily steps and girls averaged 12,728 (4,026) daily steps. A strong correlation between the accelerometer derived activity counts and pedometer step counts was found ($r=0.85$, $p<0.001$, $n=15$ for boys and $r=0.88$, $p<0.001$, $n=14$ for girls). This confirms the validity of daily step counts as a PA assessment tool. Body composition was assessed using BMI and body fat using the sum of 7 skin fold sites. Aerobic fitness was measured using the Bruce maximal treadmill test. Maximal heart rate was used to confirm a maximal effort. This study demonstrated that PA measures from the accelerometer and the pedometer were significantly positively correlated with aerobic fitness ($p<0.01$) and significantly negatively correlated with fatness ($p<0.05$). The researchers concluded that the accelerometer and pedometer counts predicted fitness and fatness better than heart rate. In addition, weekend accelerometer activity levels were found to be significantly lower than weekday activity levels. Rowlands et al noted the predictive value of pedometer activity counts to body fatness Body fatness in turn, was predictive of cardiovascular fitness.

Michaud et al assessed physical activity using a pedometer (Pedoboy) and compared it to cardiovascular fitness in 233 Swiss adolescents aged 11 – 15 during the school year (Michaud, Cauderay et al. 2002). Cardiovascular fitness was assessed using a 20 metre shuttle run test (Tomkinson, Leger et al. 2003). Pedometer step counts were recorded daily at bedtime. Physical activity was found not to vary from day to day (p<0.05), was higher in boys than in girls (p<0.001), and was higher in younger adolescents than older adolescents (p<0.001). A low correlation (r=0.30, p<0.01) between physical activity and cardiovascular fitness was observed.

Obese children have been observed to have low activity levels at home and outside the home when compared to normal weight siblings with about 80% of the time spent in sedentary activity (Hughes, Henderson et al. 2006). Average activity level of children during free play time at a playground has not been well examined, however boys have been found to be more active than girls using accelerometry during recess (Ridgers, Stratton et al. 2005). It is unknown, however, exactly what factors (body composition, fitness level, environmental factors, etc) influence a child's activity level during a recess or 'free play' session (Ridgers, Stratton et al. 2006). Accelerometer measured daily physical activity patterns in adolescents have been noted to differ between sex, time of day and day of week (Jago, Baranowski et al. 2005). Within day variations of physical activity levels among early years school children has not been examined.

One study was found that examined children with more than one measurement period per day using pedometers. Cox et al examined pedometer steps in school and out of school in early years school (levels 1-6) children in Auckland, New Zealand (Cox, Schofield et al. 2006). Subjects wore a Yamax pedometer for 3 days and recorded steps twice per day, immediately after school and at bedtime. Overall mean daily steps were 14,333 and boys (n=45) were significantly (p<0.01) more active than girls (n=46) with 15,606 and 13,031 steps/day for boys and girls respectively. In this study, 52.4% of steps occurred outside of school. Moreover, the most active third of subjects took 55.1% of their daily steps outside of school than did the least active third of subjects who took only 46.7% of daily steps outside of school. The climate in Auckland is very temperate with summer mean temperatures ranging from 16 to 24 degrees Celsius, and winter mean temperatures ranging from lows of 8 to highs of 15 degrees Celsius.

One study was found that used pedometer derived step rate in children as an indicator of exercise intensity. The purpose of this study was to determine a valid criterion referenced pedometer step rate that would identify the amount of time children spent in moderate-vigorous physical activity (MVPA) during Physical Education (PE) class (Scruggs, Beveridge et al. 2003). Data was collected from 45 PE classes from 6 schools from 369 students. Systematic observation (System for Observing Fitness Instruction Time: C-SOFIT) was used to identify time spent in MVPA and was highly correlated to step rate (r=0.85, p<0.01). A step rate of 60-62 steps/min

(1800-1890 steps/PE class) was identified as equivalent to 10 minutes of MVPA in the 30 min PE class.,Nador, also showed that children may only receive a total of about 25 min/*week* of moderate to vigorous activity from school PE classes (children averaged 2.1 PE lessons per week of 33 minutes each) also using the SOFIT observation method (Nader 2003). In addition, boys are noted to make use of about 33% of the time spent in recess for moderate to vigorous physical activity (measured by accelerometry),and girls only 23% (Ridgers, Stratton et al. 2005).

Tudor-Locke et al (Tudor-Locke, Pangrazi et al. 2004), calculated BMI referenced standards for recommended pedometer-determined steps per day for children. This study examined a data set of previously collected data from 1,954 children aged 6-12, where physical activity was measured using a pedometer (MLS-2000Yamax, My Life Stepper) in the USA, Sweden and Australia. BMI cut points were determined to classify the children as normal weight or overweight/obese. Mean steps per day per BMI classification were gathered from each age group for boys and for girls. They determined that the median cut point for optimal BMI in terms of daily step count for 6-12 year old children as 12,000 steps/day for girls, and 15,000 steps/day for boys. Beyond the optimal cut point for BMI, it would be important to establish cut points using more direct measures of body fat, and to establish cut points for cardiovascular fitness. A child who has a higher aerobic performance may take many more steps than these recommended levels. In addition, the difference in stride length between 6 and 12 year olds would be different as a result of growth resulting in higher daily step counts for younger (shorter) children. This would need to be considered in the interpretation and use of the recommended step count thresholds.

Secular changes in the fitness levels of children have also been measured over the past several years (Wedderkopp, Froberg et al. 2004). Wedderkopp et al examined two representative populations of age 9 Danish children measured 12 years apart. Physical fitness was examined using a maximal cycle test. Boys were found to have a significantly ($p<0.001$) lower physical fitness level in 1997 than in 1985. In addition, boys and girls with the poorest fitness level in 1997-98 had a significantly ($p<0.001$) lower fitness level than the poorest fitness levels of boys and girls in 1985-86. No significant difference was found for girls between the test years. Increased polarization was also found, with an increase in the difference between the most and least fit for both boys and girls

($p<0.001$). Chatrath and coworkers also examined physical fitness in urban American children aged 4-18 in 2002 using a Bruce's treadmill test (Chatrath, Shenoy et al. 2002). Results were compared to a widely used 1978 standard reference of normal for exercise treadmill testing in children. They found that mean endurance times were significantly shorter (from about 12.5 min to about 10 min for 9 year olds) compared to the 1978 reference standards ($p<0.03$).

Documentation of fitness performance of rural children in Manitoba needs to be performed, as it is unknown if in fact, this decrease in fitness performance is also occurring in rural Manitoba children. A useful comparative measure is the 20 meter shuttle run test normative scores obtained from 7000 Quebec children during the validation of that test in 1984 (Leger, Mercier et al 1988).

Ozdirenc et al examined physical fitness in rural vs urban grade 3 and 4 children in Turkey using the EUROFIT test battery (Ozdirenc, Ozcan et al. 2005). The EUROFIT test battery uses the 20 m shuttle run test to measure the cardiopulmonary fitness component of the test. They found differences in flexibility and muscle endurance but not in cardiopulmonary fitness between the urban and rural children. Rural children, however, were more physically active than urban children (measured by questionnaire), had lower mean BMI, and spent less time watching television.

Purpose and Hypotheses

This study examined rural children during winter to 1) characterize physical activity levels by identification of within day variations in step counts using interval pedometry, 2) assess body composition and aerobic performance, and 4) examine the inter-relationship between physical activity, body composition and aerobic performance.

Hypotheses

1. Weekday steps will be greater than weekend steps based upon findings of previous literature.
2. Children with an out of town residence will have a lower daily step count than rural children who live in a town due to restricted activity levels after-school from non-active transport.
3. Aerobic performance will be correlated to step counts and step rate (previous literature is equivocal however lack of correlation may have been to study design).
4. Aerobic performance will be correlated with body composition (consistent with literature).

Comparisons to other studies and secular trends

5. Daily step counts for winter would be substantially less than the recommended values from climates with warm temperatures and non-snow covered environments (Rowlands, Eston et al. 1999; Loucaides, Chedzoy et al. 2004; Cox, Schofield et al. 2006)
6. Higher adiposity levels and BMI values than previous assessments on children in other studies.
7. Lower 20m shuttle run test scores relative to the 1984 data reported by Leger and co-workers (Leger, Mercier et al 1988; Tomkinson, Leger et al. 2003)

Methodology

Subjects

Children ages 8 to 10 of both sexes, in grades 3 and 4 in a rural Manitoba school took part in the study. Subjects were excluded from participation in the study if they had a physical or mental handicap, severe asthma, ADHD, diabetes, or other health ailment that precluded them from cardiovascular testing. School board permission was obtained to collect the data within the school. Written, informed consent was obtained from parents/guardians and written, informed assent was obtained from the children. See Appendixes A, B and C for consent/assent/parental information forms.

A minimum sample size for correlation was established using the pedometer data and variance collected by Tudor-Locke, and an alpha level of 0.05, with a Beta level of 0.2. The minimum number of 30 is considered as a medium power (Eston and Rowlands 2000).

Anthropometric Assessment

Each child's height, body mass and skin-fold thickness was measured and recorded (Appendix G) at the school on the day of fitness testing. Body mass was measured using a digital scale (BWB 800, Tanita, UK) and height was measured using a measuring tape posted on a wall. Body mass index was calculated using height (m) and mass (kg). Body mass index is not the most accurate measure of individual levels of fatness (Rennie, Livingstone et al. 2005) and thus skin fold measurements were taken to calculate body fat. Skin fold measurements (Harpinden calipers, 0.2 mm resolution) were taken in triplicate, rotating between sites and were obtained from the following sites; triceps, biceps, sub-scapular, supra-iliac, abdominal, anterior thigh and medial calf (Slaughter, Lohman et al. 1988). The mean of each site was then calculated. Sum of 7 skin folds was calculated and used as a measure of total body fat (Rowlands, Eston et al. 1999). Percent body fat was also calculated using Slaughter's (Slaughter, Lohman et al. 1988) formulae using the triceps and calf sites (BF1) and tricep and subscapular sites (BF2) skin-fold sites for children age 8-18 as follows:

BF1:

Males: 0.735(triceps + calf) + 1.0

Females: 0.610(tricep + calf) +5.1

BF2:

Males: 1.21(tricep + subscapular) – 0.008(triceps + subscapular)^2 -1.7

Females: 1.33(triceps + subscapular) – 0.13(tricep + subscapular)^2-2.5

Pedometry

Pedometers are valid and reliable measures of activity in children (Beets, Patton et al. 2005; Rowlands, Eston et al. 1999).Pedometers record step counts by detection of step induced acceleration at the waist. A spring levered mechanism senses a step when the acceleration threshold of 0.35g is surpassed. The pedometer used in this study was a SCT01 (Steps Count, Canada) which is identical to the WalkforLife brand in the US. The SCT01 is pedometer which has very good overall step count accuracy (Beets, Patton et al. 2005). This pedometer also accumulates total daily activity time when the step rate exceeds an unspecified threshold. The optimal position for step count accuracy is at the hip along the right mid-axillary line (Kriellaars, D., Human Performance Lab, University of Manitoba, unpublished data).

Subjects were instructed to put the pedometer on first thing in the morning and to wear the pedometer at all times, except when sleeping, bathing or swimming. Subjects were shown how to attach the pedometer and how to record the steps on the pedometer log sheet, on the first day of the study. The pedometer was affixed to the subject’s pants at the waist along the right axillary line. Each subject conducted a accuracy test by walking 50 steps. If the recorded steps were between 48 and 52, then this was deemed as acceptable accuracy. If the step count deviated greater than this, the subject was requested to move the pedometer laterally along the pants waist band and retest.

Daily and interval (before school, morning school, lunch, afternoon school, after school, after 6pm) step counts were tallied over a 7 day period. This included 5 weekdays (school days) and 2 weekend days. Pedometers were reset to zero after each recording. The study investigators were available to parents/teachers if assistance was required. See Appendixes D, E, and F for data collection sheets.

Aerobic Performance: 20m Shuttle Run

Aerobic performance was assessed using the 20m shuttle run test (20mSRT) also known as the "beep" test. This test is a maximal exertion, aerobic test. This test has been found to be a reliable measure for prediction of VO2 in both children (r=0.89) and in adults (r=0.95) (Tomkinson, Leger et al. 2003).

In the 20mSRT, subjects run back and forth on a 20 m course and must touch the 20m line at the same time a sound signal is emitted from a prerecorded audio. The speed of running is increased by 0.5 km/hr each minute by providing a shorter time interval between beeps. The starting speed of the test is 8.5 km/hr. When the subject can no longer keep the pace, the last stage completed is recorded. A "talk test" was used at the conclusion of the shuttle run to confirm maximal exertion. If the subject had difficulty in talking upon completion of the stage, the test was deemed valid. If the subject could speak without difficulty, or if audible breath sounds were not heard/observed the subject was required to take the 20mSRT again after a minimum 1 hour rest. Respiration is known to dramatically increase after "anaerobic threshold" and has been shown to be a valid indicator of exercise intensity in children (Ng, 2004).

Predicted VO2 Maximum (MAXV02) is calculated with the following equation:

$$MAXVO2(ml/kg/min) = 31.025+3.238\ SPEED-3.248AGE+0.1536AGE*SPEED)$$

using the speed in the final full stage completed (Tomkinson, Leger et al. 2003).

Weather Data

Weather data was obtained corresponding to the days when the pedometer data was recorded. The following weather information was obtained for each day: mid-day temperature, wind chill, and precipitation from databases from the Environment Canada website (www.msc.ec.gc.ca) specific to the rural region. Wind chill is a value that is calculated from the combined effect of wind speed and temperature. It is expressed in temperature like values to represent the feeling of cold felt on the skin (www.msc.ec.gc.ca). Since wind chill is not a real temperature value, it is given without the degree sign. See Appendix G for the daily weather data.

Statistical Analysis

Mean values were calculated for each of a subject's anthropometric measurements, body composition values, 20mSRT scores, and daily and interval steps. Correlations were calculated for all of the above measurements. Repeated measures ANOVA and t-tests were used to compare between days of the week, intervals, weekday vs weekend, sex, and location of residence. Subjects were then divided into tertiles based on level of aerobic performance and repeated measures ANOVA was conducted between the parameters of aerobic performance, body composition, and interval steps and step rates.

Correlation, regression, repeated measures ANOVA and t-tests were employed in this study (SPSS version 11). An alpha level of 0.05 was used. A sample repeated measures ANOVA output for daily step counts is provided in Appendix H.

Results

The results of this thesis are presented in two manuscripts entitled "*Body composition, aerobic performance and physical activity of children in a rural community in Manitoba during winter*" and "*Interval pedometry for the assessment of physical activity patterns in children in rural Manitoba*".

The first manuscript addresses the need to characterize the physical activity, body composition and cardiovascular fitness of rural children in Manitoba.

The second manuscript addresses the assessment of physical activity patterns in children by examining pedometer interval step records. Body composition and cardiovascular fitness are also examined to explore their relationships with the interval step records.

Body composition, aerobic performance, and physical activity of children in a rural community in Manitoba during winter.

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Keywords –pedometer, BMI, climate, child, shuttle run test

Introduction

Despite the known benefits of physical activity and its ability to prevent disease, low physical activity levels have been documented in children in many developed countries (Michaud, Cauderay et al. 2002; Trost, Pate et al. 2002). Aerobic fitness of children is also declining in correlation to the rise in childhood obesity and obese children tend to be less physically active than non-obese children (Trost, Kerr et al. 2001; Tremblay and Willms 2003) Low activity levels during childhood tend to persist into adulthood (Telama, Yang et al. 2005). Intervening in this vicious cycle is a key mandate of Health Canada as the costs of diseases that are related to sedentary lifestyles are staggering (Katzmarzyk et al. 2004).

Winter in warmer climates has been observed to have an impact on the physical activity levels of children (Loucaides, Chedzoy et al. 2004). Winters in Canada are well known for cold temperatures, extreme wind chill values and snow covered surfaces limiting use of play structures and playgrounds. The impact of this type of winter season on the physical activity levels in children has not been examined. Further, differences have also been noted in the physical activity levels between rural and urban children (Loucaides, Chedzoy et al. 2004). In rural settings, access to programming opportunities for physical activity is limited and similar to sub-urban environments, the ability to walk to recreation facilities is limited (Ewing, Schmid et al. 2003). The winter weather and the rural setting may combine to restrict physical activity leading to decreased aerobic performance and increased adiposity ultimately leading to increased risk for disease. It is important to understand the impact of these factors on physical activity, body composition and aerobic performance.

Physical activity monitors such as pedometers have become increasingly popular tools in which the physical activity of children can be measured. Pedometers are valid and reliable measures of physical activity in children (Rowlands, Eston et al. 1999; Tudor-Locke, Williams et al. 2002; Tudor-Locke, Williams et al. 2004). There are guidelines and daily step counts for children (Tudor-Locke, Pangrazi et al. 2004) however, these have been established in warm climates. With the increase in use of pedometers in interventions, it is important to establish the impact of weather and rural living on the number of steps taken per day.

The purpose of this study was to characterize physical activity levels in rural children during a Canadian winter using pedometry and examine the relationship of the step counts to body composition and aerobic performance.

Methods

Subjects

Fifty-six boys and girls, ages 8 to 10, in grades 3 and 4 in a rural Manitoba school were recruited. Subjects were excluded from participation if they had a physical or mental handicap, severe asthma, ADHD, diabetes, or other health ailment that precluded them from aerobic testing. One subject provided body composition and step data however was excluded from the fitness testing due to a cardiac condition. Subjects were also classified into rural residence sub categories of in-town and out of town.

School board permission was obtained to collect the data within the school. Written, informed consent was obtained from parents/guardians and written, informed assent was obtained from the children. This study was approved by the Health Research Ethics Board of the Faculty of Medicine, University of Manitoba.

Body Composition

Each child's height (m), body mass (kg) and skin-fold thickness was measured at the school on the day of fitness testing. Skin fold measurements (Harpinden calipers) were taken in triplicate, rotating between sites and were obtained from the following sites; triceps, biceps, sub-scapular, supra-iliac, abdominal, anterior thigh and medial calf (Slaughter, Lohman et al. 1988). The mean of each site was then calculated. For comparison to related research by Rolands and coworkers (Rowlands, Eston et al. 1999), the sum of 7 skin folds (SUM7) was calculated. Body fat (%) was calculated using Slaughter's formulae using tricep/calf (BF1) and tricep/subscapular (BF2) skin-fold sites (Slaughter, Lohman et al. 1988). Body mass index (BMI) was derived from height and mass.

Pedometry

Subjects were instructed to put the pedometer (SC, Stepscount, Canada) on first thing in the morning and to wear the pedometer at all times, except when sleeping, bathing or swimming. Subjects were shown how to attach the pedometer and how to record the steps on the pedometer log sheet, on the first day of the study. The pedometer was affixed to the subject's pants at the waist along the right axillary line. Daily step counts were tallied over a 7 day period from the interval records collected in another study. The seventh day was only a partial day of recording due to completion of the study at dismissal of school. This included 5 weekdays (school days) and 2 weekend days. Pedometers were reset to zero each morning. This pedometer has been shown to have very good accuracy (Beets, Patton et al. 2005). Unpublished work has shown the optimal location for accuracy to be the right hip position along the mid-axillary line.

Aerobic Performance

Aerobic performance was assessed using the 20m shuttle run test (20mSRT). This test is a maximal exertion test that was designed for use in school children. This test has been found to be a reliable measure in both children (r=0.89) and in adults (r=0.95) (Tomkinson, Leger et al. 2003). In the 20mSRT, subjects run back and forth on a 20 m course and must touch the 20m line at the same time a sound signal is emitted from a prerecorded tape. The frequency of the sound signal is increased 0.5 km/hr each minute. The starting speed of the test is 8.5 km/hr. When the subject can no longer keep the pace, the last stage completed is recorded for computation of maximal oxygen consumption using a regression equation (Tomkinson, Leger et al. 2003). A "talk test" was used at the conclusion of the shuttle run to confirm maximal exertion. If the subject had difficulty in talking upon completion of the stage, the test was deemed valid. If the subject was able to talk with out audible breath sounds, they were identified as having not put in a full effort and were required to take the 20mSRT again after a minimum 1 hour rest. Respiration is known to dramatically increase after "anaerobic threshold" and can be used to indicate a high level of exertion in children (Ng 2004).

Weather Data

Daily mid-day temperature, wind chill, and precipitation information was garnered from the Environment Canada database specific to the location of the school in the rural region. Wind chill is a value that is calculated from the combined effect of wind speed and temperature. It is expressed in temperature like values to represent the feeling of cold felt on the skin. Since wind chill is not a real temperature value, it is given without the degree sign. The data was collected in the 2nd week of January, 2006.

Statistical Analysis

Repeated measures ANOVA was performed to examine differences in step counts between days. Pearson's correlation was performed to identify relationships between body composition and aerobic performance, body composition and pedometer data, and aerobic performance and pedometer data. Statistical analysis was performed using SPSS (v11.0 for Windows). An alpha level of 0.05 was used.

Results

Physical characteristics and body composition

A total of 56 children (22M:34F) were assessed with a mean age of 9.09 (0.49) years, mean height was 1.38 (0.05) m boys and 1.37 (0.06) m for girls. Mean mass for boys and girls was 35.9 (8.89) kg and 32.9 (0.07) kg, respectively. There were no significant differences between boys and girls for height or body mass.

Body composition of the children is presented in Table 1a. The average BMI for the boys and girls lies just below the internationally accepted cut-off point (19.2) for overweight classification for age 9 children. Twenty-nine percent of the group was considered overweight or obese. Using BF1 a total of 60% of the children had a body fat of greater than 20%, using BF2 a total of 50% of children had a body fat of greater than 20%. Figure 1a shows the percentage of children at each of 3 levels of body fat.

Table 1a: Mean (SD) body composition of male and female children.
No significant differences were found between males and females.

	n	BMI	SUM7 (mm)	BF1 (%)	BF2 (%)
Boys	22	18.7 (3.8)	100.4 (53.5)	24.4 (11.4)	22.4 (10.1)
Girls	34	17.4 (2.8)	100.7 (45.5)	24.2 (8.1)	20.9 (7.0)

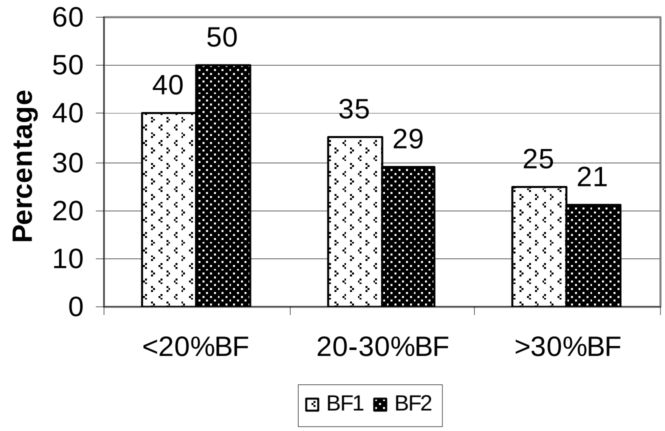

Figure 1a: Distribution of children based upon body fat (BF1=triceps/calf, BF2= triceps/subscapular).

Aerobic Performance

The results of the 20mSRT are shown in Table 2a. One subject was excluded from the test due to a cardiac condition and 2 other subjects were absent from school on the day of testing. The stage in the shuttle run was recorded using two methods: the last lap completed for a stage (partial stage) and the last total stage completed with all laps (completed stage). VO2 Max was computed with the completed stage for a valid test. Subjects who failed the talk test (n=15, 28% of group) at the end of the initial shuttle run test were required to perform the test again. Table 3a shows the results of the retest on the subjects that did not put in a full effort on the initial 20mSRT. Significant improvement of the partial stage (12.1%), completed stage (19%) and the predicted VO2 Max (2.8%) scores were obtained through the repeated 20mSRT.

Table 2a: Mean (SD) of stage level and predicted VO2 Max for the 20mSRT

	n	Partial Stage	Completed Stage	VO2 Max (ml/kg/min)
Males	21	3.12 (1.42)	2.71 (1.42)	44.75 (3.71)
Females	32	3.56 (1.27)	3.18 (1.26)	45.96 (2.88)
Significance		ns	ns	ns

Table 3a: Mean (SD) scores for the retest of the initial invalid 20mSRT

	Partial Stage	Completed Stage	VO2 Max (ml/kg/min)
First Test	3.14 (1.05)	2.6 (1.12)	44.43 (2.41)
Re-test	3.52 (1.21)	3.1 (1.19)	45.67 (2.58)
Significance	p<0.02	p<0.01	p<0.01

Daily Step Counts

Mean daily step counts are illustrated in Figure 2a. No significant difference was found between step counts between each weekday. A significant difference (p<0.01) was found between mean weekday (11,319 ±2760, n=38) and mean weekend steps (8,084 ±3596, n=32). The overall mean daily step count was 10,465 (±2506) steps/day (n=46). Twenty percent of children did not record their daily steps correctly on one or more intervals, and had to be excluded from total daily step calculations. Mean weekday steps was calculated from 4 weekdays instead of 5 as Monday's pedometer records did not include the full day. Mean total daily steps was 9,733 (±2634) for boys and 10,855 (±2388) for girls. Mean weekday steps for boys were 10,700 (±3012) and weekend steps were 8,082 (±3419). Mean weekday steps for girls were 11,773 (±2305) and 8,132 (±3632) for the weekend. There were no significant differences between boys/girls for mean total daily steps, mean weekday steps or mean weekend steps.

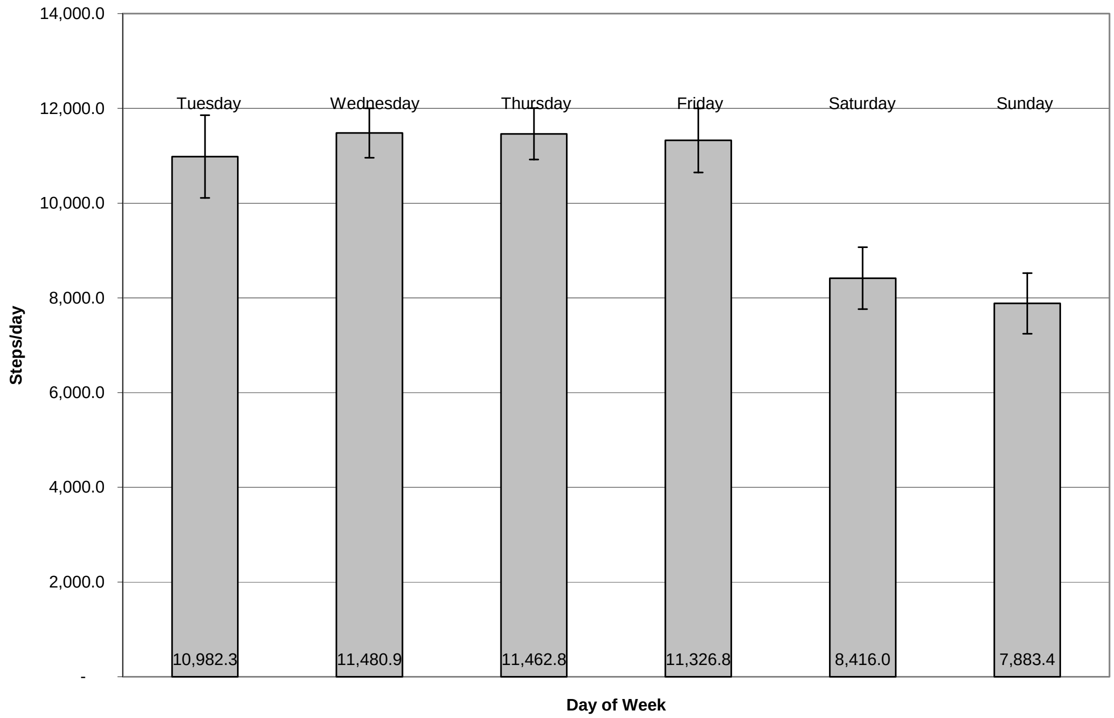

Figure 2a: Mean (SE) daily step counts.

Daily Step Count of Town and Out of Town Children

Subjects who lived in town had significantly ($p<0.01$) greater overall mean daily steps (11,506±2,564, n=20) than out of town children (9,665±2,185, n=25), with a mean difference of 1840 steps. Based upon mean weekday step counts, town children were significantly ($p<0.05$) more active than out of town children by 1654 steps. No significant difference was found using weekend steps. On weekdays, town children had an average of 12,394 (±2519) steps/day and 9,333 (±3261) steps/day on the weekend. Out of town children had an average of 10,740 (±2428) steps/day on weekdays and 7,369 (±3497) steps/day on the weekend. There were no differences between in and out of town subjects in terms of body composition or aerobic performance.

Body composition and daily steps

During the weekdays, a significantly lower ($p<0.01$) daily step count was observed for children with body fat greater than 20% than subjects with body fat less than 20% (BF2), with a mean difference of 1811 steps. For the weekend, significantly

($p<0.03$) lower number of steps (2406 steps/day less) was recorded for children with higher body fat (>20%) than lower body fat (<20%). No significant differences were noted for BMI using a 19.2 cutoff or using BF1.

Weather

The range of daily temperature for the weekdays was from -1.2 to -11.2°C. The range of weekend temperatures was from -4.7 to -7.3°C Wind chill values also varied during the week from -6 to -20. Daily mean temperature (8am-8pm) for the weekday period was -6.6°C, and daily mean weekend temperature was -6°C. The snow cover was continuous with snow depth variable – the school's outdoor play structure was partially useable due to the depth of snow.

Relationship between aerobic performance, daily step count and body composition

All measures of body composition (BMI, SUM7, BF1, BF2) were found to be inversely related to aerobic performance (Predicted VO2 Max) ($p<0.01$). The relationships between body composition and Predicted VO2 Max are as follows; BMI $r=-0.383$, BF1 $r= -0.337$, BF2 $r= -0.482$, and SUM7 $r= - 0.422$. Central fat indicators (BF2) and total body fat (SUM7) had a slightly stronger relationship to aerobic performance than peripheral indicators of fat (BF1) and BMI. Similarly, shuttle run stage completed was also significantly related to BF2 (-0.414 $p<0.01$), SUM7 (-0.367, $p<0.01$), and BMI (-0.365, $p<0.01$), and to BF1 (-0.272, $p<0.02$).

A relationship between aerobic performance using shuttle run stage completed ($r=0.271$, $p<0.03$), and using predicted VO2 Max ($r=0.258$, $p<0.05$) and mean weekday steps was found. No relationship with mean weekend steps to VO2Max or stage was found. A significant relationship between Tuesday's total daily steps and predicted VO2 Max was found (0.420, $p<0.05$). Tuesday was the first day of the study and other factors may have produced this significant result.

A significant weak inverse relationship between BMI and mean weekday steps (r= -0.246, p<0.05) was found but not for BF1, BF2 or for SUM7. No relationship was found between any of the body composition measures and mean weekend steps.

Discussion

This study has provided the first information related to physical activity levels, body composition, and cardiovascular fitness of children in a rural setting in Canada during winter. The principal findings are that the average daily step counts are low consistent with a low level of cardiovascular fitness and a substantial degree of adiposity.

Only 7% of children in this study met the minimum recommended the Tudor-Locke steps per day of 12,000 and 15,000 steps/day for girls and boys respectively (Tudor-Locke, Pangrazi et al. 2004). Other studies have documented substantially higher step rates in children 14,333 (Cox, Schofield et al. 2006) and 14,439 (Rowlands, Eston et al. 1999), compared to 10,465 in the present study. These low daily step values may be an impact of winter in Central Canada. In Southern Manitoba, Canada, average temperatures range from -12 to -22°C in January and from 12 to 26°C in July. There is snow cover in Southern Manitoba from November to March and in January, 50% (13-15/31) of the days of the month can expect precipitation in the form of snow fall (www.viarail.ca, www.climate-zone.com). Other studies examining step counts in children have been performed in warmer climates and these studies report higher daily step values overall. For example, a recent study reported 3868 more steps/day (14,333 vs 10,465) in early years school children in Auckland, New Zealand children (Cox, Schofield et al. 2006) than in this study. These investigators observed that boys were significantly more active than girls with 15,606 and 13,031 steps for boys and girls respectively. The climate in Auckland is very temperate with summer mean temperatures ranging from 16 to 24°C, and winter mean temperatures ranging from lows of 8 to highs of 15°C and no snow cover. In another study examining children in Bangor, North Wales (Rowlands, Eston et al. 1999) mean temperatures range from 7°C in January to 16°C in July. Precipitation is solely in the form of rain. These investigators also found substantially greater daily mean steps (14,439 vs 10,465) for 34 boys and girls aged 8-10 than found in the present study.

In Cyprus, (Loucaides, Chedzoy et al. 2004) mean temperatures range from 12°C in January to 32°C in July. Subjects aged 11 to 12 tallied 13,583 (urban) and 12,436 (rural) steps in the winter (Jan/Feb) steps and tallied 14,531 (urban) and 16,450 (rural) steps in summer (May/June).The rural children in Cyprus which had lower daily steps than their urban counterparts, still had substantially more steps, by 1971, than the rural children in Manitoba. The temperature difference between Manitoba winter (-15°C) and winter in Cyprus (+12°C) would be approximately 27°C! Michaud and coworkers (Michaud, Cauderay et al. 2002) studied children aged 11-15 in southwestern Switzerland. In January, temperatures range from -2 to 3°C and in July from 12 to 23°C. There are nine days in average of precipitation in the form of rain (6 days) or snow (3 days) in January. In this study, boys averaged 13,000 steps while girls averaged 10,800 steps. Although not directly comparable in age to this study, the apparent average number of steps is still greater than in this study and this despite the fact that average daily step counts reduce with age.

Vincent et al (Vincent, Pangrazi et al. 2003), also noted differences ($p<0.001$) in total daily steps accumulated between urban children 6-12 years old in Sweden, Australia and the USA (southwest), with American children having the lowest step counts and highest BMI values. They attributed the differences in step counts to SES, access to PA programming and urban/neighborhood environment differences and they did not examine climate.

The reduction in steps may be due to temperature or the effect of snow cover (surface and play structure effects). An interesting issue is the reduction in time available to play due to the requirement to don and doff substantial winter clothing and footwear in Manitoba. Further study is required to examine the effects of snow cover, temperature and clothing on physical activity in children.

In the present study, girls were more active than boys (not significantly) where as in most other studies the reverse has been found (Rowlands, Eston et al. 1999; Michaud, Cauderay et al. 2002; Cox, Schofield et al. 2006). However, boys were also slightly more obese than girls in the present study, and this may be why girls were found to be more active than boys as physical activity has been shown to be inversely related to BMI, (Ekelund, Sardinha et al. 2004).

A low negative correlation between BMI and weekday steps was found (r=-.246, p<0.05), in the present study. A stronger relationship was found by (Abbott and Davies 2004), in age 8 children, with body fat (r=-0.43, p<0.002) and BMI (r=-0.45, p<0.001) to physical activity level (measured by accelerometry). Vincent et al (Vincent, Pangrazi et al. 2003) found similar correlations between pedometer PA and BMI in age 11 American boys to be -0.389, p<0.01), and age 8 girls to be -0.276. The lower overall daily steps in the present study may have contributed to the lower correlation. This would be consistent with the indication that the majority of children were sedentary in this sample.. This is a significant finding because if children are already sedentary at this age group (age 8-10), the obesity findings and inactivity levels observed later in early adolescence are not surprising. Vincent et al (Vincent, Pangrazi et al. 2003) found that children with the lowest daily steps were the heaviest and over time had the largest rate of BMI increase.

Weekday steps were found to be greater than weekend steps in both boys and girls. This is also a finding that has been found in other studies; Rowlands et al (1999) found weekend activity levels to be lower than weekday activity levels (p<0.05). Michaud et al (2002) also found that weekend steps were lower in adolescents aged 11 – 15. Boys had 13,400 steps on weekdays and 11,200 steps on weekend days, while girls had 11,200 steps on weekdays and 9,000 steps on weekend days (p<0.01). Oliver et al (Oliver, Schofield et al. 2006) also found that New Zealand children aged 8-10 were less active on the weekend than during the weekday. Data was collected in the spring. Baseline week day pedometer step counts were high, 16,305 for the group and 18,055 for boys and 14,719 for girls. The physical activity intervention steps were recorded over 4 weeks over both weekday and weekends. Weekend steps were a total of Friday, Saturday and Sunday steps. Using accelerometry, Page et al (Page, Cooper et al. 2005), found boys to be more active than girls during the week than on weekends (p<0.01).

With 29% of the subjects in the present study considered overweight or obese using BMI cut off points, these values closely reflect the status of Canadian children as measured in the ‘National longitudinal survey of children and youth: childhood obesity’. According to this survey conducted in 1998/99, examining BMI values, greater than one third of children aged 2 – 11 years are considered to be overweight with half of these considered obese. BMI values recorded in Nova Scotia (Thompson, Campagna et al.

2005) had higher values than this, where 19% of boys (n=289) and 20% of girls (n=286) were classified as having a BMI of greater than the 95th percentile. In a recent publication, (Page, Cooper et al. 2005) children with a mean age of 10.5 (n=133), classified using BMI, boys were also more obese than girls, 16.9% of girls were obese where as 20.6% of boys were classified as obese. BMI, however, has been shown to underestimate over-weightedness, and body fat measures are a more accurate measurement of obesity and disease risk. For example, the body fat measurements in the present study revealed that 60% of subjects in the study had a body fat value of greater than 20%. This threshold has been shown to be related to cardiovascular disease markers in children. Using a 30% body fat threshold, 21-25% of subjects were considered substantially over fat (obese).

Using sum of 7 skin folds, Rowlands et al (1999) found lower body fat total values of 61.4 mm for boys and 89.2 mm in girls compared to 100.3 and 100.7 for boys and girls respectively in the present study. The difference between these values may be explained by the different climates and activity levels. Alternatively, this difference may be explained by the time frame difference of 7 or 8 years between the studies and may be indicative of the exponential increase in obesity in children. Secular trends of increased skin folds measurements (sum of 5 skin folds) have been found (Thompson, Baxter-Jones et al. 2002) in Canadian children as well. BMI (kg/m^2) values are also higher in the present study (18.7) for males but not for girls (17.4), compared to Rowlands (1999) with 16.8 and 17.7 in boys and girls respectively. The consistent shift in body fat observed between the two studies but not BMI, may be once again an indicator of the specificity of body fat measures and the limitation of BMI.

Wedderkopp et al (Wedderkopp, Froberg et al. 2004) examined secular trends in fitness and body composition in 9 year old boys and girls. This study examined two representative populations measured 12 years apart. Physical fitness was examined using a maximal cycle test and body composition by skin fold measurements. Boys were found to be fatter and have a lower physical fitness in 1997 than in 1985. The percentage of children exceeding the internationally accepted BMI cut-offs for obesity increased by 1.8%, from 2.3% to 4.1%. In our study, 8.9% of the group exceeded the BMI cut point for obesity, and 20% of the group, were in the overweight category.

Children in the present study were divided into rural sub categories of rural-town and rural-out of town. Town children were found to be significantly more active than out of town children. Such differences have also been noted in Cyprus where urban children were found to be more active than rural children in the winter (Loucaides, Chedzoy et al. 2004). The present study took place in the winter as well, and the results add weight to the conclusion that rural-out of town children may be disadvantaged in terms of opportunities for physical activity in the winter. It may also be suggested that the reliance on recreational programming is a key factor in addressing the physical activity needs of children. Children are not taking advantage of 'free time' for physically active play, and instead need opportunities for group play such as in recreational programming

A significant relationship in the present study was found between physical activity depicted by mean weekday steps and predicted VO2Max Rowlands et al (1999) found that all accelerometer and the pedometer measures in a group of children of the same age group as the present study were significantly positively correlated with aerobic fitness ($p<0.01$). Michaud et al (2002) also found a correlation between physical activity in early adolescents (age 11-15) and cardiovascular fitness (20mSRT) to be 0.30 ($p<0.01$) for the weekday and 0.29 ($p<0.01$) for the weekend. All body composition measures in the present study were found to be a significant predictor of cardiovascular fitness. This corresponds with findings in a number of other studies. Rowlands et al (1999) reported that levels of body fat in children were a strong predictor of aerobic fitness and that higher body fat corresponded with lower aerobic fitness.

Lower fitness levels were also observed in the present study and are consistent with secular trends noted in other studies. The mean shuttle run stage completed was 2.6 and 3.1 for boys and girls respectively and reflects a decline of about 2 stages in fitness when compared to the 1984 values obtained by Leger (Leger, Mercier et al 1988; Tomkinson, Leger et al. 2003). Mean VO2 Max values are also lower by 9% for both boys and girls, than the Leger 1984 reference values of 51.54 ml/kg/min, and 49.2 ml/kg/min for age 9 boys and girls respectively. Ozdirenc et al also found lower shuttle run test values (mean stage 2.6) in 172 children of the same age group in Turkey in 2003, with no significant differences found between urban and rural children (Ozdirenc, Ozcan et al. 2005). Wedderkopp et al also found a significant decline in physical fitness in age

9 boys between 1985 and 1997 using a cycle test, as well as increased polarization between the most and least fit subjects (Wedderkopp, Froberg et al. 2004). A significant difference in mean endurance time was also found between Bruce's treadmill testing done with 525 children in 2002 and the 1978 reference treadmill test values for children (Chatrath, Shenoy et al. 2002).

The significant difference shown between the test and retest values in the subjects identified as not putting in full effort by the talk test has shown the talk test to be a useful method of obtaining a valid 20mSRT score.

In conclusion, rural Manitoba children have unacceptably low aerobic performance, poor mean body composition values and lower steps rates than the recommended standards for children. There has been a two stage erosion in aerobic performance compared the 1984 Leger values. Mean body composition data is equal to national values in terms of BMI, but worse in terms of body fat. Daily step counts are far lower than other published studies likely due to climate. The expected BMI to aerobic performance relationship and physical activity and aerobic performance were also observed.

Interval pedometry for the assessment of physical activity patterns in children in rural Manitoba.

Tanya R. Kozera and Dean J. Kriellaars

Keywords –child, activity level, fitness, body composition, step-rate,

Introduction

Lifestyle promotion and intervention programs require the identification of 'windows of opportunity' for increasing physical activity. The identification of activity specific activity patterns in relationship to children of varying body composition or aerobic performance is also important. Interval pedometry has the potential of being a useful cost effective technique to identify when children are active.

Cox et al used pedometry to examine within day variation in stepping behavior in and out of school in early years (levels 1-6) school children in Auckland, New Zealand (Cox, Schofield et al. 2006). Subjects wore a Yamax pedometer for 3 days and recorded steps twice per day, immediately after school and at bedtime. They found that students had more steps out of school than in school. This study however, was limited in the number of intervals used and it would be useful to partition a child's day further in order identify key areas of activity or inactivity.

The use of interval pedometry also has the potential to derive step rate – an intensity measure of pedometer steps. One study was found that used pedometer derived step rate in children as an indicator of exercise intensity. Scruggs et al compared pedometer steps during physical education classes to time identified as containing moderate to vigorous physical activity by the C-SOFIT system (Scruggs, Beveridge et al. 2003). A step rate of 60-62 steps/min (1800-1890 steps) was identified as equivalent to 10 minutes of MVPA in the 30 min PE class.

The purpose of this study was to fill a gap in the literature and to identify physical activity patterns using interval pedometry, and to relate interval step counts to body composition and aerobic performance in rural children aged 8-10 during winter.

Methods

Subjects

Male and female subjects between the ages of 8 and 10 (grade 3 or 4) were recruited. Subjects were excluded from participation in the study if they had a physical or mental handicap, severe asthma, ADHD, diabetes, or other health ailment that precluded them from cardiovascular testing or recording the data. School board permission was obtained to collect the data within the school. Written, informed consent was obtained from parents/guardians and written, informed assent was obtained from the children. This study was approved by the Health Research Ethics Board of the Faculty of Medicine, University of Manitoba.

Body Composition

Each child's height (m), body mass (kg) was used to derive BMI. Skin fold measurements (Harpinden calipers) were taken in triplicate, rotating between sites and were obtained from the following sites; triceps, biceps, sub-scapular, supra-iliac, abdominal, anterior thigh and medial calf (Slaughter, Lohman et al. 1988). Body fat was calculated using the triceps and calf sites (BF1) and the triceps and subscapular (BF2) skin-fold sites (Slaughter 1988). Sum of 7 skin folds (SUM7) was calculated and used as a measure of total body fat and for comparison to Rowland (Rowlands, Eston et al. 1999).

Aerobic Performance

Aerobic performance was assessed using the 20m shuttle run test (20mSRT). A talk test was used at the conclusion of the shuttle run to confirm near maximal exertion. The subject is asked to read/say a sentence. If they are too out of breath to do so, this confirms exertion above anaerobic threshold (Ng, 2004). Partial stage and completed stage level was recorded. Maximum VO2 was derived using a regression equation using the last completed stage (Tomkinson, Leger et al. 2003).

Pedometry

Subjects were instructed to wear the pedometer (SCT01, Steps Count, Canada) at all times, except when sleeping, bathing or swimming. Subjects were shown how to attach the pedometer and how to record the steps on the pedometer log sheet, on the first day of the study. The pedometer was affixed to the subject's pants at the waist along the right axillary line. Teachers were also shown how to affix the pedometer and how to record the steps and were asked to assist the subjects while at school. Parents were provided with written instructions of the same information and were asked to assist the subjects with the recordings at home.

Daily interval step counts were tallied over a 7 day period (5 weekdays that were school days and 2 weekend days). The pedometer was reset to zero after each recording, and the children were required to record what time they removed the pedometer at bedtime and when it was affixed to their pants in the morning. For children who affixed or removed his/her pedometer significantly later (after 11pm) than was indicated on the recording sheet, the data for that interval was excluded from the mean interval calculations, but was still used for the daily tally of steps. Weekend step intervals were to be recorded in the same manner as a week day, however not all children were able to keep the same frequency of recording steps on the weekend. The afternoon school interval had the scheduled physical activity period and the physical education classes.

Step counts were logged for six time intervals.

1. Interval one (before school) was from waking in the morning, 7:00 am until 9:00 am (120 minutes),
2. interval two (morning school) was morning school session from 9:00 am to 11:45 am (165 minutes),
3. interval three (lunch) was lunch/recess from 11:45 am to 12:45 pm (60 minutes),
4. interval four (afternoon school) was afternoon school session from 12:45 pm to 3:20 pm (155 minutes),
5. interval five (after school) was after school to early evening, 3:20 pm to 6:00 pm (160 minutes), and
6. interval six (after 6 pm) was the remaining time until bedtime, 6:00 pm until 9:00 pm (180 minutes).

One class of grade three students (n=18) recorded three additional intervals. Morning recess (15 min) and afternoon recess (15 min) were recorded for two school days. A scheduled 15 minute daily activity break was recorded for three days.

Step rate (steps/min) for each interval was computed by dividing the interval's steps by the total minutes in each interval. Total daily steps was computed as the sum of the steps recorded during each intervals (for complete interval records only).

Results

Physical characteristics, body composition, and aerobic performance of the subjects are shown in Table 1b.

Table 1b: Mean (SD) physical characteristics, body composition, and aerobic performance.

	n	Age (years)	Height (cm)	Mass (kg)	BMI	SUM7 (mm)	BF 1 %	BF 2 %	Predicted VO2 Max (ml/kg/min)
Male	22	9.13 (0.47)	137.95 (4.95)	35.90 (8.89)	18.7 (3.8)	100.4 (53.5)	24.4 (11.4)	22.4 (10.1)	44.53 (3.24)
Female	34	9.07 (0.51)	137.07 (5.85)	32.92 (6.59)	17.4 (2.8)	100.7 (45.5)	24.2 (8.1)	20.9 (7.0)	45.74 (2.5)
Total Subjects	56	9.09 (0.49)	ns	ns	ns	ns	ns	ns	ns

Interval Pedometry

Step count and step rate: The mean steps accumulated for each interval during weekdays is shown in Figure 1b. No significant differences in steps were noted between males and females or between grades in any of the intervals. The afternoon school interval included a scheduled 15 minute daily physical activity session and Physical Education classes. Figure 2b shows the percentage of total daily steps that takes place in each interval. Mean step rate for each interval is shown in Figure 3b. All subjects had the highest step rate during the lunch interval followed by the afternoon school interval.

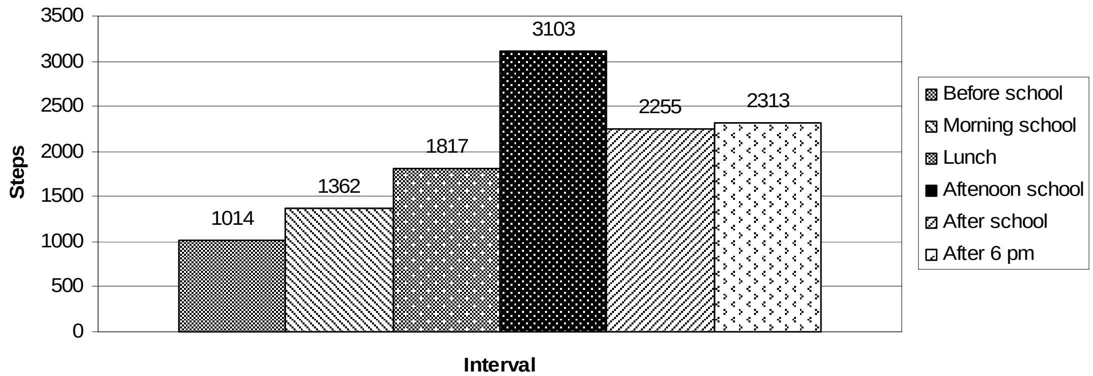

Figure 1b: Mean steps accumulated during each interval.

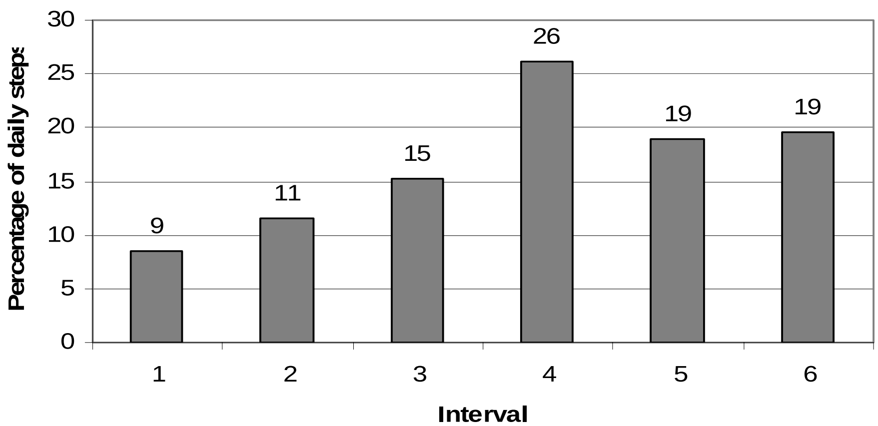

Figure 2b: Percentage of total daily steps occurring in each interval.

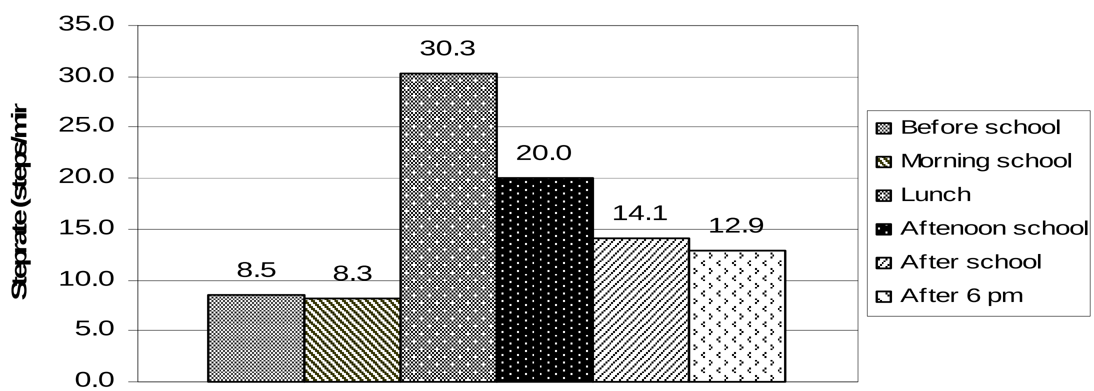

Figure 3b: **Mean step rate (steps/min) for each interval.**

School vs Non-school Steps

Out of school steps (4294 ±2150steps) comprise 38% of a child's total mean daily weekday steps (11,313 ±1574steps), School steps however, comprise 53% (6028 steps) of total mean daily weekday steps. Interestingly, the total time in school (380 minutes) was less than the total non-school time (460 minutes). Accordingly, the average step rate in school was 15.9 steps/min and 9.3 steps/min out of school. In addition, it was observed that some children were delivered to school up to 20 minutes prior to school starting, and often played outdoors. Based upon the protocol, these steps prior to school were allocated to interval 1 (before school) instead of to 'school time' in interval 2 (morning school).

On weekdays, girls were significantly more active than boys outside of school, ($p<0.004$) with 4841 and 3390 mean steps respectively. No other differences between boys and girls were found in any other interval.

Body Composition and School/Non-School Steps

Children classified with a body fat (using BF2) of greater than 20% had significantly ($p<0.04$) less steps within school (5612 (±1621)) than the steps (6385 (±1171)) taken by children with an acceptable level of body fat (< 20%) Outside of school, children greater than 20% had significantly less steps ($p<0.02$) than children with an acceptable level of body fat. Using BF1, children with BF1 greater than 20% had significantly ($p<0.01$) less school steps (5579 (±1602)) than children with a body fat of 20% or less (6588 (±966)). No significant differences were observed for non school steps using BF1. No significant differences were found for the school and non-school intervals based on BMI classification of the children (acceptable < 19.2, not acceptable >19.2) based upon the international age dependent BMI cutoff for overweight (Cole, 1988)
A significant inverse relationship ($r=-0.255$, $p<0.05$) was present between BMI and school steps. Interval 4 (afternoon school period) also presented with a significant relationship between BMI and mean steps ($r=-0.289$, $p<0.05$).

Afternoon school interval

Children with less than 20% BF1 (and BF2), had significantly ($p<0.02$) greater steps in the afternoon school interval than children with body fat greater than 20%. A significant positive relationship was found for children with body fat less than 20% and lunch step rate (0.276, $p<0.02$) and afternoon school (0.274, $p<0.02$) intervals.

Lunch Interval

A significant positive relationship (r=0.726, Pearson's correlation, $p < 0.01$) was present between lunch steps and total school steps. Lunch steps therefore were highly predictive of the steps the subject took in school. Thirty percent of total school steps took place over the 60 minute lunch interval.

Relationship of School and Non-school Intervals and Daily Step Count

School intervals were all predictive ($p<0.05$) of each other, but not to the after school interval or the after 6 pm interval. The interval prior to school is significantly related to the school intervals but not to the after school intervals (0.328, $p<0.05$ to morning school, 0.419, $p<0.01$ to lunch, and 0.280, $p<0.05$ to afternoon school).

Non school steps (0.753, $p<0.01$), were also significantly predictive of daily mean steps, and were more predictive than school steps (0.504, $p<0.01$). The after 6 pm interval of the non school intervals was, however, found to be most predictive of daily mean steps (0.536, $p<0.01$) over all of the other intervals.

Location of Residence and Interval Steps

Subjects living in town had significantly ($p<0.01$) higher average daily steps (11,506 steps/day) compared to out of town children (9,665 steps/day). A significant inverse relationship (r=-0.427, $p<0.01$, n=47) between type of residence and the after school interval (3:20 pm to 6 pm) was also found. Subjects who lived outside of town (1,846 steps in interval) had significantly ($p<0.001$) fewer steps (960 steps) in this interval than students who identified themselves as living in town (2,806 steps in interval). Step rates were also significantly different between town and out of town subjects ($p<0.01$) in the after school interval with step rates of 17.5 (6.6) and 11.5 (4.8) respectively.

Aerobic performance and Step Rate

A significant relationship between the mean interval steps (0.348) and the step rate (0.359) of the afternoon school interval and predicted VO2Max was identified ($p<0.01$). The afternoon school interval had the scheduled physical activity period and the physical education classes. The after school ($r=0.253$) and evening interval ($r=0.248$) step rates and mean interval steps (same correlation values) were also significantly related to aerobic performance ($p<0.05$).

Body Composition and Step Rate

A significant inverse relationship between all body composition measures (BMI, BF1, BF2, & SUM7) and the afternoon school step rate was found; BMI $r=-0.290$, BF1: $r=-0.412$, BF2: $r=-0.345$, , and SUM7: $r= -0.335$, ($p<0.03$,).

Aerobic performance, Body Composition and Interval Steps

Subjects were divided into tertiles on the basis of aerobic performance. There was a significant difference in VO2 Max ($p<0.001$), between each group. There was a significant difference in BF1 ($p<0.04$), BF2 ($p<0.002$), and BMI ($p< 0.005$) between the subject who had the best performance on the 20mSRT and the lowest scores on the 20mSRT, but not between the best and the middle and the lowest and the middle. See Table 2b for the characteristics (mean (SD)) of each group.

Table 2b: Characteristics of children using aerobic performance
(Aerobic performance divided into upper, middle and lower thirds) Significance: One way ANOVA between Highest and Lowest scores on the 20mSRT.

	Highest 20mSRT scores (n=17)	Middle (n = 19)	Lowest 20mSRT scores (n=17)	Significance p value
VO2Max (ml/kg/min)	49.20 (2.20)	45.08 (1.23)	42.21 (1.27)	.001
BF1 (%)	21.66 (6.26)	23.68 (11.80)	27.42 (8.99)	.038
BF2 (%)	18.24 (5.21)	20.43 (9.49)	25.90 (8.02)	.002
BMI	17.06 (1.93)	17.87 (4.48)	19.35 (2.43)	.005
Afternoon school steps	3,408 (695)	3,338 (733)	2,660 (839)	.01
Afternoon step rate (steps/min)	22.0 (4.5)	21.5 (4.7)	17.2 (5.4)	.01

A significant difference was found between steps in the afternoon school interval between the subjects with the highest 20mSRT scores and the subjects with the lowest 20mSRT scores, ($p<0.01$), with a mean difference of 678 steps and between the middle and the lowest ($p<0.01$) with a mean difference of 677 steps. No significant difference in steps was found between the middle and the subjects with the highest 20mSRT scores. No other step intervals had significant differences between levels of aerobic performance.

Step rate also varied significantly between the subjects with the highest 20mSRT scores and the subjects with the lowest 20mSRT scores in the afternoon school interval, $p<0.01$, and between the middle and the subjects with the highest 20mSRT scores ($p<0.02$), but not between the middle and the subjects with the highest scores. No other interval step rate differences were found to be significantly different.

Active subjects

Subjects were also divided into tertiles based on mean activity level (average daily step count) and analyzed using a one way ANOVA. While there were no significant differences between the three groups in terms of body composition and aerobic performance, the most active subjects were significantly more active than the least active subjects in all the intervals ($p<0.05$, Figure 4b). The most active subjects had 4836 steps/day more than the least active subjects on weekdays and 5123 more steps/day on the weekend ($p<0.05$). The greatest difference in steps occurred in the after 6pm interval where the least active subjects had 44% less steps than the most active subjects. During lunch break at school, the least active subjects took 25% less steps.

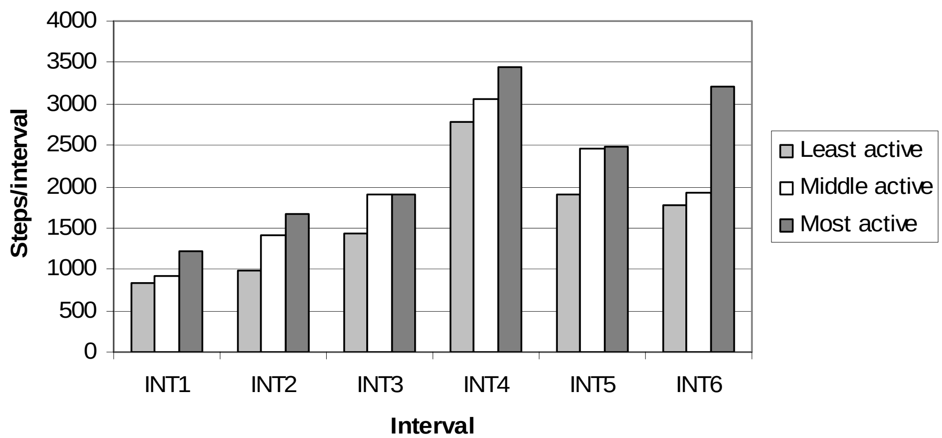

Figure 4b. The step count per interval for the tertiles based upon average daily step count (least active – lowest tertile)

Adiposity and Interval Steps

When subjects were divided into body fat tertiles (BF1), a significant difference in steps/interval was found between the fattest (mean 35.4% BF1, (±5.6)) and the least fat (mean 14.3% BF1, (±2.4)) subjects during the afternoon school interval ($p<0.03$) with a mean difference of 672 steps/interval.

Weekday steps/day also showed a significant difference ($p<0.05$) between subjects with highest fat and those with lowest body fat (BF2). Using BF1, school steps approached a significant difference with a p value of 0.057. No other significant differences were found with any other step intervals. No differences were found using the top one third, middle one third and bottom one third of subjects using BMI.

Special Intervals

One of the grade 3 classes (n=18) recorded steps for two days during morning and afternoon recess and for 3 days of the daily physical activity session.

Recess

Step rates for recess and daily physical activity session for two days are found in Figure 4b, each of these sessions lasted 15 minutes. The mean step rate during the daily PA session (79 steps/min) was much higher than either AM or PM recess (35 steps/min), and illustrates intensity of activity. Mean step rates for school ‘free time’ (AM recess, Lunch and PM recess) are all comparable; 35, 30 and 35 steps/min for each time frame, respectively.

A significant relationship between mean steps from all recesses combined and predicted VO2Max was found; 0.632, $p<0.002$ (n=18).

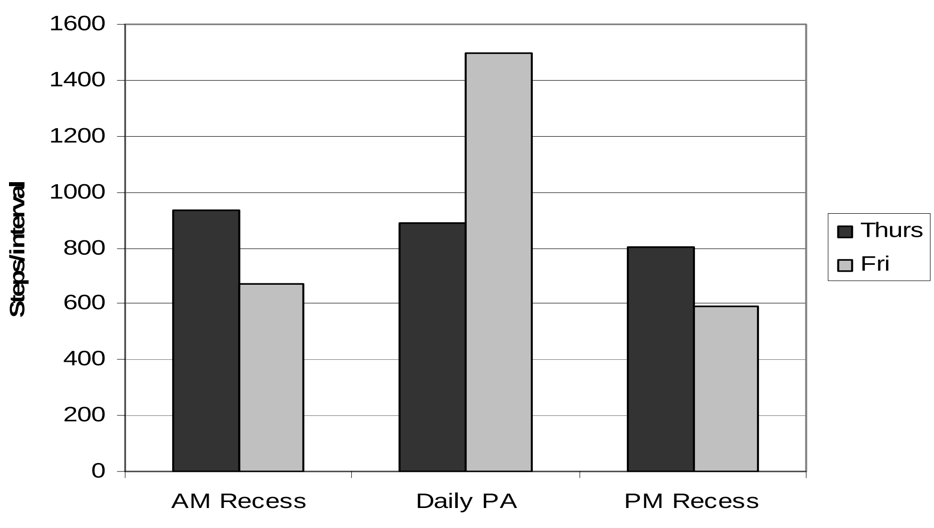

Figure 5b: Steps/interval in AM, PM, Recesses and Daily PA

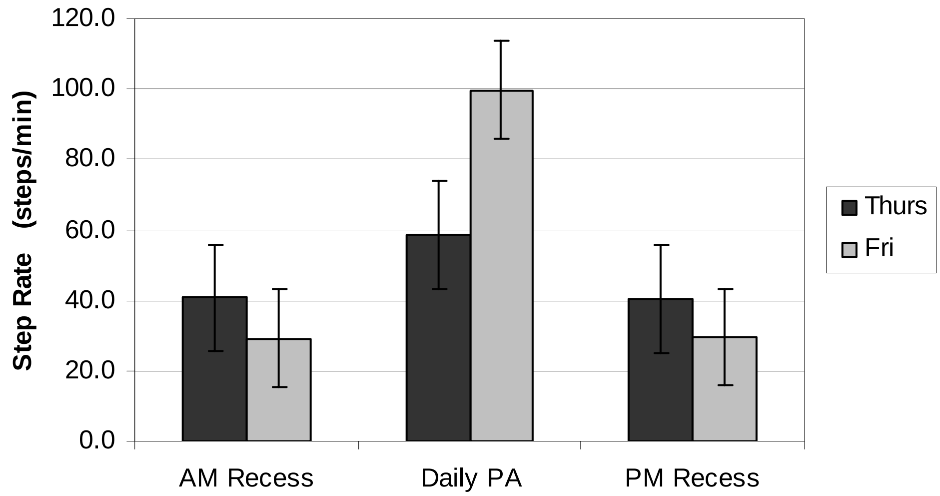

Figure 6b: Step rates for recess and daily physical activity session (mean and SD).

Daily physical activity session

A significant negative correlation between BMI and Thursday Daily Physical Activity period was found (-0.64, $p<0.01$, two tailed Pearson's correlation, n=17). A similar relationship between body fat and Thursday Daily PA was also found, BF1 -0.561 ($p<0.05$), BF2 -0.601 ($p<0.05$). No significant relationship between step-rates of Friday or Monday Daily PA was found to body fat or BMI. It should be noted that Friday's Daily PA period consisted of continuous walking in the school hallways whereas Thursday and Monday consisted of two different programs of aerobics type movements in the gym.

A significant positive relationship also was noted between Predicted VO2 Max and the step rate of Thursday Daily PA session, 0.633 ($p<0.01$) but not for Friday's or Monday's daily PA sessions alone. No relationship was found between aerobic performace and mean steps of all 3 PA sessions combined.

A significant relationship between sex and Daily PA period also noted on Monday (-0.50, alpha level 0.05, two tailed Pearson's correlation). Girls were more inclined to participate in the Monday's chosen activity than boys.

Discussion

This study has shown the feasibility and utility of interval pedometry as a method to assess physical activity patterns of children. This assessment provides for individual and group based identification of windows of opportunity for physical activity interventions. Interval pedometry assessment provided objective information about the activity levels through step counts and step rate regarding recess, programmed physical activity period and other time periods. Based upon the interval pedometry data this study revealed in rural Manitoban children in the winter that

1. more steps occur in a school setting than during non-school time,
2. town children had greater steps than out of town subjects in the afterschool interval,
3. the lunch time steps was highly predictive of school steps,
4. there is a significant relationship between body composition and school steps.
5. there is a relationship between steps and step rate during the afternoon interval and recess and aerobic performance level (VO2Max)
6. the subjects with the best aerobic performance scores had higher steps and step rate and better body composition than those with the lowest aerobic performance scores
7. the most active subjects were significantly more active than the least active subjects in all intervals, most notably in the after 6pm interval
8. Dedicated PA time resulted in greater steps and step rates than within school leisure time (recess)

Fifty-three percent of steps subjects recorded during the week in the present study took place within the school setting. Cox et al (Cox, Schofield et al. 2006) however found the opposite; that children in grades 1-6 took 52.4% of steps outside of a school setting. A significant difference was found between the most active third and least active third both in ($p<0.01$) and out ($p<0.01$) of school. In addition, the most active third of subjects took 55.1% of their daily steps outside of the school setting than did the least active third of subjects who took only 46.7% of daily steps outside of the school setting. The home environment was identified as a key time frame for PA intervention programming. The length of time spent in school vs non school may be different between the present study and Cox (2006) and this may account for the differences between the two studies. However, another study using accelerometry to measure PA found that both obese and non-obese children had higher levels of activity during school than in the evening or on weekends (Page, Cooper et al. 2005), suggesting the home environment was associated with lower levels of PA. The home/out of school environment, in the present study, was found to be a key contributor to a child's daily steps, and the lower steps recorded after school therefore significantly contributed to the lower total daily steps recorded.

The present study found that girls were more active than boys outside of school hours. Jago et al found the reverse to be true, that accelerometer measured physical activity levels varied by sex and time of day in 100 adolescents in 8^{th} grade in Texas, USA (Jago, Baranowski et al. 2005). Boys were more active than girls overall and were more active in the 3:00 to 7:00 pm afternoon interval than girls.

No relationship was found between body composition, and aerobic performance and 'free playtime' during the lunch interval in the present study. This corresponds with other findings that there is no difference observed (measured by observation) between children with different BMI's at school (Waxman and Stunkard 1980). Lunch steps, in the present study however, significantly predicted school steps that a child took, and when examining step rate, this time period provides the one of the more intense activity sessions that a child takes part in while at school, along with the dedicated physical activity sessions, and then by morning and afternoon recesses. When intensity of activity is higher as in the daily PA session the relationship of body composition and aerobic performance to steps is shown. It is interesting to note that it took structured activity sessions rather than free play sessions to produce the highest step-rates.Mean lunch steps and step-rate did not show any relationship to predicted VO2 Max. Recess, however, did show a strong significant correlation between mean step rate during recess and predicted VO2 Max. It is possible that the time spent eating lunch (approximately 20 minutes) during the lunch interval reduced the likelihood of achieving a significant relationship. This study did not record the 'eating lunch' activity vs actual 'free play' time activity during this interval. Nonetheless, children with better aerobic performance scores were significantly more active during recess than children who had poorer aerobic performance scores.

In a study using accelerometry determined PA patterns (Mota, Santos et al. 2003), no difference was noted between girls and boys in total daily activity, however during recess, girls spent more time in MVPA than boys ($p<0.05$) and that recess contributed 6-8% of total daily MVPA for boys and girls respectively. However, 15-19 % of total recommended MVPA (by health related PA guidelines) occurred during recess for boys and girls respectively. These researchers suggest that school recess time is an important setting to promote MVPA.

Interval 4 (afternoon school interval) produced the greatest contribution to total daily steps (26%). This interval (155 min) however, consists of the most obligatory steps than any of the other intervals. Children were obliged to step as a result of scheduling of daily PA session and Physical Education classes in this interval. The after-school and evening intervals, however, have comparable or more time; 160 min and 180 min respectively, yet only contribute 19% each to total daily steps. Of note, the shortest time frame, lunch (60 min), produced 15% of the total daily steps. Overall, this identifies the 'out of school' or 'home environment' as an inactive time that should be targeted for intervention programs. Much opportunity for physical activity exists in these two intervals. In addition, the present study found that the most active children were 44% more active than the least active children in the evening. For children with lower aerobic performance scores and higher fat, the within school intervals may be targeted for intervention as these children had about 750 steps less than in the afternoon period than fitter and lean children.

Hourly patterns of obese children (BMI defined) aged 9-11 yrs measured by accelerometry indicated a tendency of obese children to be less active when activity was determined by free choice, such as at lunch and outside school hours (Page, Cooper et al. 2005). These children were also found to spend less time in moderate or greater levels of physical activity (9.9 min/hr vs 12.9 min/hr, $p<0.002$) than non obese children. These findings are consistent with that observed in the present study, and shows that this is true for obligatory activity periods (re: afternoon session with PA and PE classes).

When intensity of activity is assessed using step rate, in the afternoon interval and during the daily physical activity session significant relationships between all body composition measures and activity levels are observed. The more obese the child is the lower the step-rate. In addition, a significant relationship between the step rate of the afternoon interval and during recess and predicted VO2Max was identified. The group of subjects with the best aerobic performance scores had the highest step rate in these step intervals. The step rate during the daily PA session ranged from 60 -100 steps/min, and this exceeds the step rate suggested to be representative of MVPA by Scruggs (Scruggs, Beveridge et al. 2003). The time over which to steps/min is measured is different; 15 min in the present study vs 30 min in Scrugs (2003). However since the time intervals were different, these are not directly comparable as step rates are likely to be skewed to lower values in the longer time periods. Regardless, the step rate indicates that the children are attaining MVPA during the daily PA session. This type of PA intervention program appears to achieve its goal of increasing activity in children, however care must be taken to ensure children of all fitness and body composition levels benefit equally.

There was no significant difference noted however, between the correlations observed in steps/interval and step/rate of the intervals. Therefore either method of measuring activity in children can be used.

In consideration of the above discussion, the opportune time for physical activity intervention programming appears to be during school free play time, such as at recess and at lunch. When children are given free choice of activity, they tend to choose to be less active; however, the step rate of the daily PA session shows that with programming, significantly higher step rates can be achieved in all children. The other time frame identified as having a significant opportunity for PA is the evening interval. The most active children make use of this time frame, while the least active do not. It is unknown why this difference exists, but it can be presumed that access to programming, the home environment and SES may be important variables that need to be evaluated.

In conclusion, pedometer step interval analysis is a useful method of assessing childhood activity.Key differences in activity level between children of different body composition and sex in terms of time of day, has been shown. Understanding when these differences in physical activity take place provides valuable input to intervention strategies.

Overall Discussion

This study has provided valuable information on the current health status of rural children. High adiposity, low aerobic performance scores and low activity levels have been documented. Below is a summary of aggregate results from both manuscripts.

Summary of Results

1. No significant differences in body composition between 22 males and 34 females aged 8-10. Other studies have found females to be more obese than males. Using BMI, 29% of study subjects were classified as overweight or obese, which corresponds closely to the status of Canadian children as measured in the 'National longitudinal survey of children and youth: childhood obesity'. Using %Body Fat, however, 50-60% of study subjects had values indicating overweight or obese, and 21-25% indicating obesity alone (>30%BF).
2. Low aerobic performance scores on the 20mSRT indicating a decline in fitness performance since the 1984 Leger normal values.
3. Overall mean daily steps totaling 10,465, with weekday steps significantly higher than weekend steps. Out of town subjects had fewer steps than town steps..
4. Significant relationships between all measures of body composition, daily steps and predicted VO2Max.
5. Interval step and step rate analysis can be performed to identify opportunities for intervention;
    a. School steps greater than non school steps
    b. Fattest kids have lower steps in school and out of school
    c. Lunch interval most predictive of school steps (r^2=0.52) and containing 15% of total daily steps.
    d. After school interval identified as a key lost opportunity for PA for out of town subjects due to bus ride home.

e. Significant differences in afternoon steps and step rate identified between the subjects when divided into top and bottom thirds based on aerobic performance scores
f. Most active subjects more active all day, most notably at lunch and in the evening.
g. Description of special intervals; recess and daily PA session.

6. Opportunities for PA intervention identified to be during recess and lunch breaks as well as in the evening.

Only 7% of children in this study met the minimum recommended the Tudor-Locke steps per day of 12,000 – 15,000 steps for day for girls and boys respectively (Tudor-Locke, 2004). Other studies have noted higher mean daily step counts. These low daily step values may be an impact of winter in Central Canada. In light of the differences between studies in terms of climate, comparison of step count normative data from other climates (Tudor-Locke step recommendations) must be re-assessed and step count norms for snow covered and colder climates must be established and considered.

The overall level of physical inactivity revealed in the present study is also likely an indication of family inactivity levels, as after school pedometer step counts were the most predictive of total daily step counts. As well, the evening interval also showed a significant difference in activity levels between subjects with acceptable and unacceptable body fat levels. This is a significant finding because if children are already sedentary at this age group (age 8-10), the obesity findings and inactivity levels in early adolescence are not surprising. It is necessary to identify if this level of inactivity is present in even younger age groups. Age 6 – 7 has been identified as a critical age where physical activity and television viewing has a negative impact on BMI (Jago, Baranowski et al. 2005).

With 29% of the subjects in the present study considered overweight or obese using BMI cut off points, these values closely reflect the status of Canadian children as measured in the 'National longitudinal survey of children and youth: childhood obesity'. However, using body fat measures of body composition 50-60% of subjects in the study had a body fat value of greater than 20%. This is an alarming level of body fat in young children, and may be considered a more accurate method of body composition than BMI.

All body composition measures in the present study were found to be a significant predictor of aerobic performance. Mean VO2 Max values were lower than the Leger 1984 reference values, and this was correlated to weekday step counts.

Interval pedometer step records are a useful way of examining a child's daily physical activity. Relationships between activity level, body composition and cardiovascular fitness can be identified for physical activity intervention programming.

Step count analysis is an intensity defined aspect of pedometer step counts and a positive relationship was shown between step rate and Predicted VO2 Max in the afternoon school time interval and during recess. This is a new method of examining pedometer step count data, and promises to be a useful way of understanding when children are active. More research must be done to validate this type of pedometer analysis.

Subjects of this age group have shown that they are capable of recording data on a regular basis with the assistance of parents/teachers/study investigators. The Steps Count pedometers with the lids were well tolerated by the children.

The cardiovascular fitness test chosen for this study was a running test. Some children may have been disadvantaged due to their levels of body fat. Higher levels of body fat are known to produce lower fitness scores in locomotive fitness tests, (Cunningham 1981). However, since the physical activity measure (pedometer) was a product of locomotion, the fitness test used in this study could be considered a functional test as it is also a product of locomotion. The ability to locomote is essential to the well being of children.

The key limitation of the study was weekend step records were required to be recorded in the same manner as during the week. However, many subjects were unable to record weekend steps in this way, and several weekend step records were not completed and had to be discarded. Total daily weekend steps would have been a simpler way for the children of this age group to gather weekend steps.

Conclusions

Children in rural Manitoba are at risk for the same lifestyle diseases identified among children in urban areas in Canada and in other countries. Low daily step values across all children in this study indicate that these children are sedentary at the ages of 8-10. These low daily step values may be the result of the harsh Canadian winter, and if so, intervention programs must take this into account, as a prairie winter is long, lasting for several months. The body composition and aerobic performance of these children were consistent with the substantially lower step counts in comparison to children in warmer climates. Rural children should not be treated uniformly, as significant differences were observed in stepping behavior between town and out of town children. Step rate analysis is a method that yields an intensity derived component of pedometer steps. This, along with interval analysis provides a useful new way of examining pedometer step data.

Each of the four hypotheses were supported in this study showing that 1) weekday steps were greater than weekend steps 2) Children with an out of town residence will had lower daily step counts than rural children who live in town as a result of decreased stepping during the after-school time period, 3) aerobic performance was correlated to specific step counts and interval step rates, and 4) cardiovascular fitness was correlated with body composition.

Future Directions

1. Examination of the same age group in the same manner in the summer in order to compare summer and winter step counts in children in rural Manitoba.
2. Examination of younger age group, age 6-7, is also recommended, as this is an age suggested to be a key age for instilling physical activity into the lifestyle of a child (Jago, Baranowski et al 2005).
3. A study that examines intervention programming in the lunch interval, which was identified as a key predictor of a child's daily school steps is also suggested.
4. A study that devises the usefulness of an intervention program for parents to administer pre/post school to increase the 'out of school' steps.
5. Further step-rate studies should also be conducted to examine the validity and utility of step rate analysis.

APPENDIX A: PARENT CONSENT FORM

PARENT/GUARDIAN RESEARCH INFORMATION AND CONSENT FORM

Title of Study: The relationship between physical activity, body composition and cardiovascular fitness in grade 3 and 4 children in rural Manitoba.

Principal Investigator: Tanya Kozera, RR359 Health Sciences Centre Rehabilitation Hospital, 810 Sherbrook Street, 787-4720, xxx-xxxx
Co-Investigator: Dr. Dean Kriellaars, RR303 Health Sciences Centre Rehabilitation Hospital, 810 Sherbrook Street, 787-3505

Your child is being asked to participate in a research study. Please take your time to review this consent form and discuss any questions you may have with the study staff. You may take your time to make your decision about your child participating in this study and you may discuss it with your friends, family or (if applicable) your doctor before you make your decision. This consent form may contain words that you do not understand. Please ask the study staff to explain any words or information that you do not clearly understand.

Purpose of Study
It has been demonstrated that Canadian children are becoming less physically active, more overweight and less fit. This places children at risk for health problems. It is unknown what the activity levels of rural children are and what impact these activity levels have on their physical fitness. The purpose of this study is to examine the relationship between physical activity, body composition and cardiovascular fitness in rural children.

A maximum total of 80 participants will participate in this study

Study procedures
If your child takes part in this study, he/she will have the following procedures:

He/she will be asked to specify age, date of birth, and gender. Height will be measured using a mechanical scale and mass will be measured using a digital scale. Percent body fat will be calculated by measuring 7 skinfold sites. In this method a skin fold caliper will be used. Your child’s skin will be gently pinched with this device and the skin fold will be measured.

Your child will be asked to complete a daily log of physical activity for a period of 7 days. On this log, they will be asked to record the date, time, time spent, activity, and an estimate of the activity's intensity.

Your child will be asked to wear a pedometer for a one week period. He/she will record the total steps taken at several intervals throughout the day; such as first thing in the morning, before lunch, after lunch, after school, and at supper. Do not reset the pedometer, just keep recording the new total. The pedometer is to be worn on the left hip along the pants seam. Please wear the pedometer all day long. Your child may remove the pedometer while having a bath/shower, while swimming and while sleeping.

Your child will also take part in a cardiovascular fitness test called the 20 meter shuttle run, or the 'beep test'. In this test he/she will run between 20 meter pylons at the sound of a beep. Your child will be asked to run this distance until he/she is unable to run any further. Level of ability will then be recorded. To validate that your child has run to his/her maximal ability, they will be tested using a talking test. The talking test determines how out of breath you are.

The height, mass and skin fold measurements will take place at your child's school as will the fitness test. The researchers will take these measurements.

Your child will need to take recordings from the pedometer and for the activity logs at school and at home. Teacher and/or parents may assist.

The researchers may decide to take your child off this study if they are unable to complete the fitness test safely.

Your child can stop participating at any time. However, if he/she decides to stop participating in the study, we encourage you and your child to talk to the study staff first.

There are no serious consequences of sudden withdrawal from the study.

Individual and aggregate results may be provided to the participants upon request immediately following completion of the analysis of data.

<u>Risks and Discomforts</u>
The risks of this study are minimal and limited to physical injury, which may result from accidental fall while running in the cardiovascular fitness test. An out of breath sensation immediately following the fitness test may also occur, but this is a temporary effect.

Benefits
There may or may not be direct benefit to your child from participating in this study. We hope the information learned from this study will benefit a wide variety of people in the future.

Costs
All the procedures, which will be performed as part of this study, are provided at no cost to you or your child.

Payment for participation
Your child will receive no payment or reimbursement for any expenses related to taking part in this study.

Confidentiality
Information gathered in this research study may be published or presented in public forums, however your child's name and other identifying information will not be used or revealed. Despite efforts to keep your child's personal information confidential, absolute confidentiality cannot be guaranteed. Your child's personal information may be disclosed if required by law.

The University of Manitoba Health Research Ethics Board may review records related to the study for quality assurance purposes.

All records will be kept in a locked secure area and only those persons identified will have access to these records. If any of your child's medical/research record need to be copied to any of the above, your child's name, and all identifying information, will be removed. No information revealing any personal information such as your child's name, address or telephone number will leave the University of Manitoba Human Performance Laboratory, RR359 Rehabilitation Hospital, Health Sciences Centre.

Voluntary Participation/Withdrawal from the Study
Your decision for your child to take part in this study is voluntary. You and your child may refuse to participate or you and your child may withdraw from the study at any time. If the study staff feel that it is in the best interest of your child to withdraw from the study, they will remove your child without your consent.

We will tell you about any new information that may affect your child's health, welfare, or willingness to stay in this study.

Medical Care for Injury Related to the Study

You are not waiving any of your legal rights by signing this consent form nor releasing the investigator(s) or the sponsor(s) from their legal and professional responsibilities.

Questions

You are free to ask any questions that you may have about your child's rights as a research participant. If any questions come up during or after the study or if your child has a research-related injury, contact the study doctor and the study staff: Dr. Dean Kriellaars, Tanya Kozera, at (204) 787-4720.

For questions about your child's rights as a research participant, you may contact The University of Manitoba, Bannatyne Campus Research Ethics Board Office at (204) 789-3389

Do not sign this consent form unless you have had a chance to ask questions and have received satisfactory answers to all of your questions.

Statement of Consent

I have read this consent form. I have had the opportunity to discuss this research study with the study staff. I have had my questions answered by them in language I understand. The risks and benefits have been explained to me. I believe that I have not been unduly influenced by any study team member to participate in the research study by any statements or implied statements. Any relationship (such as employer, supervisor or family member) I may have with the study team has not affected my decision to allow my child to participate. I understand that I will be given a copy of this consent form after signing it. I understand that my child's participation in this study is voluntary and that I may choose to withdraw my child at any time. I freely agree to allow my child to participate in this research study.

I hearby give consent to the study investigators to present information regarding this study to my child. I understand that if my child does not want to participate in this study, even though I have already given consent, my child's decision is binding.

I understand that information regarding my child's personal identity will be kept confidential, but that confidentiality is not guaranteed. I authorize the inspection of any of my child's records that relate to this study by The University of Manitoba Research Ethics Board for quality assurance purposes.

By signing this consent form, I have not waived any of the legal rights that I have as a parent/guardian of my child's participation in a research study.

Parent/legal guardian's signature______________________

Date _______________

day/month/year)

Parent/legal guardian's printed name: ______________________

Child's printed name: ________________________________
Date _______________
(day/month/year)

To be completed by investigator:

I, the undersigned, have fully explained the relevant details of this research study to the parent/guardian named above and believe that the parent/guardian has understood and has knowingly given their consent for their child to participate in the study. I understand that assent from the child must be obtained prior to his/her participation in the study.

Printed Name: __________________________
Date _________________
(day/month/year)

Signature: _____________________________

Role in the study: _____________________________

Relationship (if any) to study team members:_______________________

APPENDIX B: COVERING LETTER

Dear Parent/Guardian of a child in grade 3 or 4.

RE: Participation in a research study

A research study will be taking place in Sigurbjorg Stefansson School conducted by a Master of Science candidate from the University of Manitoba. The study investigators are Tanya Kozera and Dr. Dean Kriellaars from the Faculty of Medical Rehabilitation. The Evergreen School Division Board has given permission for this study to take place within the school.

The study is entitled '***The relationship between physical activity, body composition and cardiovascular fitness in grade 3 and 4 children in rural Manitoba***'. This study is a very low risk study measuring physical activity in children using pedometer step counts and physical activity logs. Cardiovascular fitness will be measured using a 20 metre shuttle run test where children run back and forth between two lines in a gymnasium. Body composition will be assessed using height, mass and skin fold measurements.

You will find information regarding this study attached to this letter in the form of a parental consent form. **You are invited to attend an informational session that will be held on _____________ at the school,** please bring the consent form with you to the meeting. All parents/guardians of grade 3 and 4 students are encouraged to attend this session to ask questions regarding the study. If you are unable to attend this session, an appointment can be made by calling Tanya Kozera at xxx-xxxx.

Parental consent to present this study to your child must be obtained prior to obtaining assent from your child to take part in this study. We will meet with you and your child individually at the information session.

We look forward to meeting with you and your child on _______________.

Regards,
Tanya Kozera, BMR-PT
Dr Dean Kriellaars, PhD

APPENDIX C: CHILD'S ASSENT FORM

Study title: 'The relationship between physical activity, body composition and cardiovascular fitness in grade 3 and 4 children in rural Manitoba'

Investigators: Tanya Kozera
Dean Kriellaars

Why you are here?

The study investigators would like to tell you about a study about physical activity, body composition and fitness in children in rural Manitoba. They want to see if you would like to be in this study. This form tells you about the study. If there is anything you do not understand, please ask your parent, your guardian or the study staff.

Why are they doing this study?

The study investigators want to learn more about how physically active children are compared to how fit they are and what their body composition is.

What will happen to you?

If you want to be in the study these things will happen:

The study will last about 1 month. You will be asked to collect information about your daily activity for 1 week. Sometime during the other 2 - 3 weeks you will be asked to take part in a fitness test and see the study investigators at the school for up to 2 visits.

The following are the main study procedures:

You will record the number of steps you take each day using a pedometer. (A pedometer is a tool that measures how many steps you take.)

You will need to record the steps taken several times throughout the day on the form provided to you. Your teacher, parent and study staff may assist you.

You will need to record the steps for 7 days.

During the same 7 days that you record your steps, you will be asked to write down your activities for that day and how long you spent in each activity.

The study staff will collect body composition information. These include how tall you are, what you weigh, and skin fold thickness. Skin fold thickness is measured using an instrument that gently pinches your skin and measures the amount. Seven skin fold sites will be measured from your arm, back, abdomen, and leg.

You will be asked to take part in a fitness test called the ‘20 meter shuttle run’ also known as the ‘beep test’. In this test you will run back and forth in the gymnasium keeping time to a beep sound. When you can no longer keep up with the beep sound, the number of runs completed will be recorded.

Will the study hurt?

You should feel out of breath when you complete the ‘beep test’. This is only for a short period of time and should pass quickly. You must tell the study staff or your teacher if you do not catch you breath quickly or feel sick after the ‘beep test’.

It will not hurt when they measure your height or weight.

You will feel a gentle pinch when they measure your skin fold thickness.

Will you get better if you are in the study?

This study may not make you feel better or get well. But the study staff might find out something that will help other children like you later.

What if you have any questions?

You can ask questions any time, now or later. You can talk to the study staff, your family or someone else.

Who will know what I did in the study?

Any information you give to the study staff will be kept private (or secret). Your name will not be on any study paper and no one but the study staff will know that it was you who was in the study.

Do you have to be in the study?

You do not have to be in the study. No one will be mad at you if you don’t want to do this.

If you don’t want to be in this study, just say so. We will also ask your parents if they would like you to be in the study. Even if your parents want you to be in the study you can still say no.

Even if you say yes now you can change your mind later. It’s up to you.

Do you have any questions?
What questions do you have?

Assent

I want to take part in this study. I know I can change my mind at any time.

___________________________ Verbal assent given Yes □
Print name of child
[If verbal assent obtained the process must be clearly documented in the research or medical file]

Written assent if the child chooses to sign the assent.

________________________ ___________ ________________
Signature of Child Age Date
[The following statement and signature is required]:
I confirm that I have explained the study to the participant to the extent compatible with the participants understanding, and that the participant has agreed to be in the study.

_____________________ ________________ _____________
Printed name of Person obtaining assent — Signature of Person obtaining assent — Date

APPENDIX D: PEDOMETER STEP COLLECTION SHEET

Name:____________________ **DATE: ________________**

Classroom #:

Time pedometer put on:	**Pedometer Steps**	**Activity Time Recorded on pedometer**	**Physical Activity Log –** indicate what you did, with estimates of minutes and intensity during the time frame.
9:00am Record time if different:			**(morning -9am)**
11:45am			**(9am – 11:40)**
12:45pm			**(11:40-12:45)**
3:15pm			**(12:45-3:15)**

Name: ______________________ **DATE:__________________**

Classroom #:

DATE:	**Pedometer Steps**	**Activity Time Recorded on pedometer**	**Physical Activity Log –** indicate what you did, with estimates of minutes and intensity during the time frame.
6:00pm (Record time if different)			**(3:15-6:00)**
Bedtime 9:00 (record time pedometer removed):			**(6:00-Bedtime)**

APPENDIX E: SUBJECT INSTRUCTION SHEET

Instructions For Recording Pedometer Steps and Physical Activity

The entire recording process should take no longer than 5 minutes at a time.
Pedometer steps and activity time need to be recorded at several intervals throughout the day. (Step count data sheets need to be turned in to your teacher every day)

Clip the pedometer to the waist of your pants on your right side between the middle of your leg and your hip. Put the pedometer on as soon as you wake in the morning. Record the time you put the pedometer on. Attach the safety cord to your pocket or along your waist band. Reset the pedometer to zero by pressing and holding the reset button for 3 seconds. Close the cover. (The pedometer only records while the cover is closed and in the upright position). Record your steps and the activity time at the following times: (Reset the pedometer to zero after each recording)

- 9am
- Before lunch break (11:45 am)
- After lunch break (12:45 pm)
- At school dismissal (3:15 pm)
- At 6 pm
- At bedtime (record time)

Activity time can be found by pressing the mode button, record the numbers exactly as you see them.
Step and activity recording are recommended to be done as a group while at school.
Next, record what activity you did during that interval. For example, sitting, class time, at recess played on snow hill, played video games, time on computer: homework, computer games, surfing on internet, in a chat room, MSN, on phone, gymnastics, hockey practice etc. An estimate of intensity should be included. See chart below.

Under **INTENSITY** record as best you can the level of intensity using the following guidelines;
High –Unable to talk during the activity
Moderately High –Can talk during the activity, breathing heavy
Moderately Low – Breathing slightly heavier than normal
Low – Normal breathing and talking

The pedometer should be worn all day long, except when bathing, swimming or sleeping. The pedometer should be worn at the front of the right hip. Do not open the pedometer except at the time of recording. If the buttons are accidentally hit, just record what data you have in that interval, indicate that the button was accidentally hit, and continue recording as usual in the next interval.

Quick test: walk 50 steps (count them!) after resetting pedometer to zero, check the steps recorded – it should be between 48 and 52. If significantly different, move the pedometer slightly along your waist band and retest.

Please do not hesitate to call Tanya Kozera, principal investigator, at xxx-xxxx or xxx-xxxx if you have any questions. Thank you for your assistance and participation in this study

APPENDIX F: SPECIAL INTERVAL STEP RECORD SHEET

Name: ____________________ **DATE:** ________________

Classroom #:

Time pedometer put on:	**Pedometer Steps**	**Activity Time Recorded on pedometer**	**Physical Activity Log –** indicate what you did, with estimates of minutes and intensity during the time frame.(See instruction sheet)
9:00am **Record time if different:**			**(morning -9am)**
Before morning recess Record Time:			
After morning recess Record Time:			
11:40am			**(9am – 11:40)**
12:45pm			**(11:40-12:45)**
Before afternoon recess - Record Time:			
After afternoon recess - Record time:			
3:15pm			**(12:45-3:15)**

Turn in to your teacher at the end of the school day.

Appendix G: Subject Data Sheet

Name ________________________

Area of residence:
____ rural-town (reside within a town)
____ rural-country (reside in the country, but not on a working farm)
____ rural-farm (reside on a working farm)

Date of Birth __________________

Height ___________m

Body Mass ___________kg

Skin-fold Measurements (triplicate)

Triceps	_____/ _____/ _____
Biceps	_____/ _____/ _____
Sub-scapular	_____/ _____/ _____
Supra-iliac	_____/ _____/ _____
Abdominal	_____/ _____/ _____
Medial calf	_____/ _____/ _____

Shuttle Run Test Stage _______ Retest Stage (if necessary) _______

Date measurements taken ________________________

Name of Investigator taking measurements ________________________

Appendix H Sample Weather Data

The chart below is a sample chart obtained from the Environment Canada website for the rural region specific to the location of the school where the study took place. Temperature, precipitation, and wind chill values were used for the weather descriptions in the study. Wind chill is a value that is calculated from the combined effect of wind speed and temperature. It is expressed in temperature like values to represent the feeling of cold felt on the skin. Since wind chill is not a real temperature value, it is given without the degree sign. The data was collected in the 2nd week of January, 2006.

This item has been removed due to copyright issues. To view it, refer to its source.

http://www.weatheroffice.ec.gc.ca/

Appendix I: Sample Statistical Analysis of Daily Step Counts

The following statistical analysis is a sample of a repeated measures ANOVA that was produced from the statistical program SPSS 11. This analysis examined the difference in daily step counts (repeated measures) over 6 days (Days 1-6). Post-hoc comparisons are also shown based upon the significant within subjects ANOVA (F=3.6, p=0.007).

Within-Subjects Factors

Measure: MEASURE_1

DAYS	Dependent Variable
1	VAR00001
2	VAR00002
3	VAR00003
4	VAR00004
5	VAR00005
6	VAR00006

Multivariate Tests[b]

Effect		Value	F	Hypothesis df	Error df	Sig.
DAYS	Pillai's Trace	.741	3.441[a]	5.000	6.000	.082
	Wilks' Lambda	.259	3.441[a]	5.000	6.000	.082
	Hotelling's Trace	2.868	3.441[a]	5.000	6.000	.082
	Roy's Largest Root	2.868	3.441[a]	5.000	6.000	.082

a. Exact statistic

b.

Design: Intercept
Within Subjects Design: DAYS

Mauchly's Test of Sphericity[b]

Measure: MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[a] Greenhouse-Geisser	Huynh-Feldt	Lower-bound
DAYS	.218	12.348	14	.597	.563	.805	.200

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

b.

Design: Intercept
Within Subjects Design: DAYS

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
DAYS	Sphericity Assumed	164464638	5	32892927.56	3.648	.007
	Greenhouse-Geisser	164464638	2.813	58468490.46	3.648	.026
	Huynh-Feldt	164464638	4.027	40841764.82	3.648	.012
	Lower-bound	164464638	1.000	164464637.8	3.648	.085
Error(DAYS)	Sphericity Assumed	450777870	50	9015557.390		
	Greenhouse-Geisser	450777870	28.129	16025512.79		
	Huynh-Feldt	450777870	40.269	11194238.46		
	Lower-bound	450777870	10.000	45077786.95		

Tests of Within-Subjects Contrasts

Measure: MEASURE_1

Source	DAYS	Type III Sum of Squares	df	Mean Square	F	Sig.
DAYS	Linear	122265778	1	122265777.8	11.310	.007
	Quadratic	20034687.8	1	20034687.75	3.839	.079
	Cubic	3126933.952	1	3126933.952	.382	.550
	Order 4	18095354.0	1	18095353.98	2.135	.175
	Order 5	941884.347	1	941884.347	.076	.788
Error(DAYS)	Linear	108105070	10	10810506.99		
	Quadratic	52182977.0	10	5218297.698		
	Cubic	81859063.3	10	8185906.328		
	Order 4	84772781.6	10	8477278.163		
	Order 5	123857978	10	12385797.78		

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	7166667614	1	7166667614	183.586	.000
Error	390371829	10	39037182.90		

Estimated Marginal Means

1. Grand Mean

Measure: MEASURE_1

Mean	Std. Error	95% Confidence Interval	
		Lower Bound	Upper Bound
10420.455	769.072	8706.854	12134.055

2. DAYS

Estimates

Measure: MEASURE_1

DAYS	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	11738.727	1265.945	8918.025	14559.429
2	11222.000	1135.205	8692.606	13751.394
3	12236.000	1223.775	9509.258	14962.742
4	10752.455	1040.666	8433.705	13071.204
5	8459.091	835.029	6598.531	10319.651
6	8114.455	1215.575	5405.985	10822.924

Pairwise Comparisons

Measure: MEASURE_1

(I) DAYS	(J) DAYS	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
1	2	516.727	899.297	.578	-1487.031	2520.486
	3	-497.273	1747.322	.782	-4390.549	3396.003
	4	986.273	891.527	.295	-1000.174	2972.719
	5	3279.636*	1176.850	.019	657.451	5901.822
	6	3624.273*	1527.178	.039	221.507	7027.038
2	1	-516.727	899.297	.578	-2520.486	1487.031
	3	-1014.000	1718.758	.568	-4843.631	2815.631
	4	469.545	1023.279	.656	-1810.461	2749.552
	5	2762.909*	1020.564	.022	488.951	5036.867
	6	3107.545*	1303.586	.038	202.975	6012.116
3	1	497.273	1747.322	.782	-3396.003	4390.549
	2	1014.000	1718.758	.568	-2815.631	4843.631
	4	1483.545	1527.099	.354	-1919.044	4886.135
	5	3776.909*	1352.415	.019	763.540	6790.279
	6	4121.545*	1105.987	.004	1657.253	6585.838
4	1	-986.273	891.527	.295	-2972.719	1000.174
	2	-469.545	1023.279	.656	-2749.552	1810.461
	3	-1483.545	1527.099	.354	-4886.135	1919.044
	5	2293.364*	1028.329	.050	2.103	4584.625
	6	2638.000	1366.788	.082	-407.393	5683.393
5	1	-3279.636*	1176.850	.019	-5901.822	-657.451
	2	-2762.909*	1020.564	.022	-5036.867	-488.951
	3	-3776.909*	1352.415	.019	-6790.279	-763.540
	4	-2293.364*	1028.329	.050	-4584.625	-2.103
	6	344.636	1077.958	.756	-2057.203	2746.476
6	1	-3624.273*	1527.178	.039	-7027.038	-221.507
	2	-3107.545*	1303.586	.038	-6012.116	-202.975
	3	-4121.545*	1105.987	.004	-6585.838	-1657.253
	4	-2638.000	1366.788	.082	-5683.393	407.393
	5	-344.636	1077.958	.756	-2746.476	2057.203

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

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