Physical activity during recess and physical education class in children.

By

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Abstract

As children are not acquiring adequate amounts of physical activity (PA), it is important to identify opportunities in which PA can be increased. The purpose of this thesis is to characterize PA during recess periods within the elementary school day, as well as to determine the effectiveness of a short term recess PA intervention. Children from two schools (N=75, ages 7-10, BMI =17.96±3.16, BF = 21.67%±9.12) wore pedometers for five consecutive days. A subset of subjects (N=17) also wore accelerometers. Step counts were recorded 9-10 times per day to obtain PA information for five daytime periods; morning (AM) recess, lunch recess, afternoon (PM) recess, physical education (PE), and out of school. Males were more active than females (P<0.001, 12.331 and 9439 steps per day respectively). Recess contributed to 30.6% of daily step counts, with PE contributing another 17.2%. The highest step rates occurred during PM recess (71 steps/minute (s/m), versus 57 s/m AM recess, 48 s/m lunch recess, and 52 s/m PE). A subject's sex, the period duration, weather and location of PA period all had an effect on PA levels. There was no relationship of steps or step rate to body composition. The intervention was effective in increasing PA by a mean 985 (±1808) steps per day (P<0.05). Those subjects who were least active at baseline were most likely to have a positive reaction to intervention. Recess is an area which can significantly contribute to overall PA. Children are receptive to intervention in this area and pedometers can be used to increase PA.

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Introduction

Health Canada and the Canadian Society for Exercise Physiology has recommended that in order to receive heath benefits, children need to engage in a minimum of 90 minutes of physical activity (PA) on a daily basis (www.csep.ca, www.hc-sc.gc.ca). Of this time, there is a further suggestion that 60 minutes comes from moderate activity and 30 from intense activity. Canadian children are not meeting the recommended PA guidelines. (Tremblay and Willms 2003; Wittmeier, Mollard et al. 2007) In Manitoba, only 13.2% of females and 31.5% of males are achieving a threshold of 60 minutes of moderate PA (PA) (Tremblay and Willms 2003; Wittmeier, Mollard et al. 2007). As a consequence of inactivity and over-consumption of food, in Manitoba 25.4% of males and 35.0% of females aged 7-11 are overweight while 8% of males and 13.1% of females are obese (Wittmeier, Mollard et al. 2007). This is similar to national data on the rates of overweight and obesity, which indicate that 26% of males, and 33% of females are overweight and 9% of males and 10% of females are obese (Tremblay, Katzmarzyk et al. 2002).

Physical inactivity and being overweight or obese is associated with health risks later in life including, but not limited to cardiovascular disease and Type 2 Type 2 Diabetes, cancer, osteoporosis, and respiratory disease (Sothern, Loftin et al. 1999; Geiss, Parhofer et al. 2001; Ball and McCargar 2003; Reilly, Methven et al. 2003), (Katzmarzyk and Ardern 2004). There is also evidence indicating that these diseases and disease risk factors are now appearing earlier in life, and are in fact appearing in childhood. (Silverstein and Rosenbloom 2001; Vainio, Kaaks et al. 2002; Woo, Chook et al. 2004).

Children from Kindergarten to Grade 12 spend a substantial portion of waking time in the school setting (approximately 200 school days per year in Manitoba). In addition to the educational characteristics, the time spent in school has made it an important institution in promoting healthy lifestyle choices in childhood and youth (Bar-Or 2005; Booth and Okely 2005; Story, Kaphingst et al. 2006). Due to the documented increase in childhood obesity and inactivity, many schools are considering shifting the goal from promotion to actual provision of PA for children and youth. Schools have several strengths in promoting and provision of PA in youth, in that most children and adolescents attend school and view teachers as credible sources of information (Booth and Okely 2005). Schools also provide access to the facilities, infrastructure and support required for PA (Booth and Okely 2005). Traditionally the school's impact on PA is typically viewed in the narrow context of physical education (PE), particularly in providing daily PE to all students in all grades (www.healthypeople.gov). A report to the Manitoba government (Report on Quality Daily PE, 2001) compared the amount of PA and body composition of children in daily PE programs with children in every other day PE programs. This report demonstrated in four schools (two daily and two with every other day PE) that daily PE classes are not associated with increased PA within or out of school, or with improved body composition in children in Grades 3, 4 and 5. This is not surprising as PE is largely a skills-based program and there are currently no guidelines regarding engaging in regular exercise/activity or specific intensity levels (www.edu.gov.mb.ca). The recent updated health and PE curriculum of Manitoba does not directly address the inclusion of PA programming for children (www.edu.gov.mb.ca). So even with an increase to daily PE for children, the current curriculum for K-12 would not be suitable for addressing the inactivity and over-consumption of food in our children. Recent reintroduction of mandatory physical education for Grade 11 and 12 has added mandatory physical activity element to the curriculum. At face value, this is an important component in the battle but only a small piece. Further, the effectiveness of this approach needs to be assessed.

In elementary years (K-6) an over-looked opportunity for enhancement of PA is the recess period. In Manitoba, recess is a part of the school day for children from kindergarten to grade 6. Children (5 to 13 years of age) spend nearly a fifth of the school day in recess, totaling approximately 1 hour per school day (generally 15 min morning, 30 minutes lunch, and 15 minutes afternoon). Currently recess has the potential to contribute a maximum of 60 minutes of the 90 minutes recommended in the Canadian PA guidelines. Options to enhance PA can occur through 1) semi-structured facilitation of PA during recess, 2) extended recess duration, 3) conversion of recess into a PA period, 4) the addition of PA periods and 5) the conversion of PE class to a PA class. All of these options need to be explored as opportunities to address the childhood inactivity problem.

There is very little information on the PA levels during recess and the potential role that recess can have in PA enhancement. Even though there has been some recent work the objective documentation of recess as a PA opportunity is still largely unexplored (Dale, Corbin et al. 2000; Stratton 2000; Zask, van et al. 2001; Mota, Silva et al. 2005; Ridgers, Stratton et al. 2005; Beighle, Morgan et al. 2006; Ridgers, Stratton et al. 2006; Tudor-Locke, Lee et al. 2006; Verstraete, Cardon et al. 2006).

Literature Review

In 2004, Biddle, Gorley et al. published a review on health enhancing PA in children and adolescents (Biddle, Gorely et al. 2004). The relationships between PA, sedentary behavior, health and obesity were discussed. The authors of this report recognized the importance of providing youth with PA enhancing interventions, and discussed school-based, family, and community interventions. Biddle and coworkers suggested that one avenue for school based lifestyle intervention that has not been adequately examined is recess, as PE class alone is unlikely to contribute sufficiently to daily PA either directly or indirectly.

Recess is a unique opportunity for children to engage in leisure activities as it is generally unstructured, similar to adult PA (Biddle, Gorely et al. 2004). There are often barriers identified that limit participation in PA including; expense, inadequate skill level, time commitment, and safety. Recess is a setting that the vast majority of children have an opportunity to be active, regardless of sex, skill level, socioeconomic class, or family lifestyle. Recess provides the majority of able bodied students with access to equipment such as play structures and marked fields as well as peers to engage in activities with. Recess is also adult supervised and play structures are constructed to meet high safety standards that comply with CSA voluntary standard (CAN/CSA-Z614-03 Children's Play spaces (www.csa.ca), making the environment generally free from major hazards for PA. However, recess supervisors are not trained as PA facilitators and generally serve as limiters to inappropriate behavior. Over the past decade, schools and parent advisory councils have undertaken the role of updating play structures to the new standard. However as PA levels are still inadequate, simply having the safe facilities is clearly not sufficient to address the problem.

Within the last five years, assessment of PA levels at recess has begun to appear in the literature (Dale, Corbin et al. 2000; Zask, van et al. 2001; Mota, Silva et al. 2005; Ridgers, Stratton et al. 2005; Beighle, Morgan et al. 2006; Ridgers, Stratton et al. 2006; Tudor-Locke, Lee et al. 2006; Verstraete, Cardon et al. 2006). Even though these investigations have commenced, our understanding of recess PA is still incomplete. These same researchers have repeatedly identified recess as an ideal area for PA intervention. Although objective forms of PA assessment (accelerometry, indirect calorimetry, pedometry) are generally considered to be valid in assessing children's PA and activity patterns (Welk, Blair et al. 2000; Trost 2001), there are a limited number of studies that have used such measures to describe PA at recess (Dale, Corbin et al. 2000; Mota, Silva et al. 2005; Ridgers, Stratton et al. 2005; Stratton and Mullan 2005; Beighle, Morgan et al. 2006; Ridgers, Stratton et al. 2006; Tudor-Locke, Lee et al. 2006; Verstraete, Cardon et al. 2006; Stratton, Ridgers et al. 2007).

The contribution of recess and school day PA has been demonstrated by the removal of recess with the subsequent observation of substantially reduced PA (Dale, Corbin et al. 2000). These authors hypothesized that children seek out activity, and if are not active for a period of time, they will compensate for this by seeking PA opportunities later to make up for a lack of central nervous system stimulation. Grade 3 and 4 students (n=78) participated in this study which involved two days of data collection on "active" or normal days, and two days of data collection on restricted days where no PE was offered, and recess was spent indoors on computers. PA was measured with a CSA uniaxial accelerometer. Contrary to their hypothesis, the authors found that children were actually less active in the evening period when PA was restricted at school. This demonstrates the school's important role in providing PA opportunities during the school day; as this has direct impact on their total daily PA accumulated. If children do not receive these opportunities at school, they do not replace them.

Recent work from our lab is also in agreement with that of Dale et al. 2000 (Kozera 2006). Kozera also found that children, who are not active during the school day, do not compensate by becoming more active in the evening. The data demonstrated that those children, who are most active during the school day, are also more active after school as well. Conversely, the least active children during the school day are also the least active children at night. Further, those children that were bused to school had substantively less steps per day reflecting that these children, also, do not make up physical activity if it is restricted. The correlation that was observed by these studies, supports the proposition of the hypothesis that increasing children's PA levels at school will increase children's after school PA.

The American initiative of Healthy People 2010 (www.healthypeople.gov) suggested the arbitrary goal that by the year 2010, children should engage in moderate to vigorous PA (MVPA) for 50% of their PE class. In essence, shifting the focus of PE from skills based class to a PA or fitness class. Of note, there is no corresponding goal, or an actual curriculum based PA goal, within the current PE curriculum in Manitoba (www.edu.gov.mb.ca). Ridgers et al. (2005) determined that a 50% active PE class goal was too lofty to be applied to recess (Ridgers, Stratton et al. 2005). Primary school children (N=228, age 5-10 years) participated in this study which used Actigraph accelerometers to characterize recess PA. Because the amount of PA at recess recorded in this study was noticeably lower than the hypothesized 50% threshold**,** the researchers decided that 40% of recess spent in MVPA was a more appropriate goal for this period. They observed that males were more active than females (32.9% or 28 min of recess in MVPA compared to 25.3% or 21.5 min for females). In pre-pubescent children, this sex difference is not fully understood but may be related to sex based socialization differences on the playground. The sex based differences in recess PA has been echoed throughout the literature, with males consistently being more active than females (Ridgers, Stratton et al. 2005; Beighle, Morgan et al. 2006; Tudor-Locke, Lee et al. 2006; Stratton, Ridgers et al. 2007). However, in the study of Ridgers and coworkers, the researchers noted that two males who participated in this study accumulated 60 minutes of MVPA through all combined recesses. This demonstrated that it is possible to exceed a 60 minute daily PA threshold through recess alone. This encouraged the researchers to conclude that recess is an area that should be further investigated as well a key opportunity for PA interventions.

Recess PA has shown little day to day variability or seasonal variability in the temperate climate of North West England (Ridgers, Stratton et al. 2005). Thus, it has been recommended that only one day of monitoring may be sufficient when examining recess PA. However, the setting of this study is quite different from Canadian climate, as the temperature was mild, with little variation seasonally. In Canadian climates, and specifically in the prairies of Manitoba, there is extreme variation in weather conditions and temperatures from season to season and even day to day. It is imprudent to believe that Canadian weather is not a primary factor in influencing PA patterns of children and that one day of measurement is adequate to represent recess PA.

Another important aspect of understanding recess PA is to understand which children capitalize on recess opportunities. 420 children (aged 6–10) participated in a study designed to examine the sex and body composition specific PA habits (Stratton, Ridgers et al. 2007). PA (measured by heart rate telemetry) was monitored over AM, lunch and PM recess on one day. Although no effect on PA was observed for BMI (continuous data), there was an effect when subjects were collapsed into BMI groups (overweight versus normal weight). The authors did not use skin folds or other more direct measures of adiposity such as DEXA. In males, normal weight males achieved more MVPA than overweight males. Interestingly, overweight females were more active (higher heart rates) than normal weight females possibly due to the added energy expenditure of carrying fat mass for the same number of steps. Both male groups were more active than either female group. The difference between sexes was attributed to potential social or behavioral aspects on the playground. It is possible that because heart rate telemetry was used to quantify PA, that physical fitness may have impacted the recorded PA levels. The authors did not perform fitness testing and used simple HR thresholds (i.e. did not use individual resting HR or actual HR maximum) to determine activity levels. If one assumes that an overweight child is less physically fit than a normal weight child, then higher heart rates would be observed at any given task with the same workload. This study also aimed to determine how many students meet the purposed guidelines of 40% (Ridgers, Stratton et al. 2005) and 50% (Stratton and Mullan 2005) of recess spent in MVPA. As expected from previous literature, a higher percentage of males generally met either guideline. A higher percentage of normal weight males and females met either guideline when compared to overweight males and females, although there was not a drastic difference between groups (65% and 63.8% respectively for the 40% guideline, and 32.5% and 25% for the 50% guideline).

Pedometers have frequently been used to measure PA in children, and two forms of daily step count guidelines have been produced (Tudor-Locke, Pangrazi et al. 2004; Duncan, Schofield et al. 2007). However, only very recently have step counts been published for recess (Beighle, Morgan et al. 2006; Tudor-Locke, Lee et al. 2006). In Beighle and coworker's study, students in grades 3, 4 and 5 (n=270 subjects) from the Southwest USA participated. One 15 minute recess period and the after school period were monitored on 4 consecutive days. Research staff was present to ensure that each class received a full 15 minutes for recess. Based on the un-validated activity time feature (not step count) of the Walk4Life pedometer, researchers found that children were engaged in PA for 60% of the recess period. This is higher than PA levels reported in other studies, we believe was as a result of employing the "activity time" feature of the pedometer. This feature accumulates time using a very low intensity threshold of PA (corresponding to a sustained step rate at approximately 1.8 mph), where as the other studies report only MVPA (walking at a brisk walk). Also, in this study playground game rules were altered to promote PA, which may be viewed as a form of PA intervention. Consistent with other studies, males were more active than females based on steps and activity times. Males took a mean of 1262 steps at recess and females a mean of 968. Out of school, males took a mean of 7000 steps and females a mean of 5750. This study also included a subjective description of recess which described the sex specific, preferred activities engaged in at recess. Males tended to use the fields for soccer and football, females who did participate tended to be more sedentary or watch. As mentioned above, soccer and football rules were changed to maximize PA and decrease waiting time, for example by using two balls in soccer. These rules were learnt in PE class. In contrast females preferred to play handball, which was associated with longer waiting periods. As such, these activities and step counts represent an intervention model (due to altered playground rules and equipment access) and may over-estimate normal recess behaviors.

The use of segmented or interval pedometry (the recording of step counts over specific periods of time within the day) is emerging as a method to quantify recess PA (Beighle, Morgan et al. 2006; Tudor-Locke, Lee et al. 2006). Since the proposal of the current study, Tudor-Locke 2006 has reported segmented pedometry to look not only at recess, but also PE, class time, and after school activity. Although there are similarities to the current study, it involves only one measure of PA (pedometry) and does not provide a comprehensive characterization of recess and school day PA.

In Tudor-Locke's study (Tudor-Locke, Lee et al. 2006), total of 88 Grade 6 students from Mesa, AZ participated in this study using a pedometer (Walk4Life LS2500). Data was collected over six days and examined PE class (every other day, 30 minutes), lunch time (40 minute period in which children ate lunch and then were allowed to play indoors or outdoors –actual PA time was not measured), and one afternoon (PM) recess (15 minutes). PM recess was the only recess period where steps counts and actual duration were measured. Step counts were recorded 8 times throughout the day (beginning of class in the morning, before and after each recess and PE class, and at the end of the class day). Males were more active than females in this study. Males took significantly more steps than females during recess, but there was no difference between sexes during structured PE time. Step rates were highest for the 15 minute recess period (78 steps/minute) compared to PE (47 steps/minute) or lunch time (53 steps/minute). Although recess was 15 minutes shorter than PE, males took the same number of steps during both periods. Females took 400 fewer steps at recess compared to PE (28 % fewer steps, but in half the time). Males were found to be considerably more active on PE days than days that PE was not offered. For females there was no significant difference and in fact, females were more active at other times during the school day on non-PE days. After school steps accounted for almost half of total daily steps for both sexes. There was no relationship between segmented step counts and BMI. The average steps/day was 16,421 for males, and 12,332 for females. This is significantly higher than daily step counts recorded in Canadian schools. Kozera found Canadian children took an average of 11,319 steps/day (Kozera 2006). This difference is likely a result of climate differences between the studies (warm temperatures of the southern USA compared to cold temperatures and snow cover in Manitoba). Tudor-Locke found that 54.7% of males and 53.6% of females met the BMI referenced, sex specific, daily step count goals (15,000 males, 12,000 females, Tudor-Locke et al 2004).

Researchers concluded that lunch time was the school period that contributed the most to daily PA, as it had the highest steps counts; however it actually had the lowest step rate – which may be due to the unstructured nature of this period (children may eat then play, or play then eat, or eat and play). Contrary to the school reported in this study, Manitoba schools usually have the lunch hour segmented to two parts – one part devoted to eating and the other part to recess which may alter PA patterns from Tudor-Locke's study.

Recent literature has some evidence to indicate that recess PA interventions are effective. Stratton et al. in 2005 investigated the effect of painting multi-coloured markings on playgrounds in respect to children's recess PA (Stratton and Mullan 2005). Subjects (N=99, ages 4-11) from 8 schools (4 intervention schools and 4 control schools) participated in this study. PA was measured using heart rate monitoring. Baseline data was collected over 4 weeks in June. The playground markings were painted over the summer break and included such things as mazes, trails, hopscotch, and tennis. Data was collected again over 4 weeks in September and October. Interestingly not only did MVPA increase in the intervention group, it actually decreased in the control group. While the increase in MVPA (36.7% to 50.3% of recess spent in MVPA) in the intervention group was attributed to the positive effect of playground markings, the authors provided no explanation as to what caused the decrease in MVPA in the control group (39.9% to 33.4% of recess spent in MVPA). Over a long term follow up of this intervention, at 6 weeks and 6 months, a positive intervention effect was still demonstrated, with the intervention school engaging in 4.5% and 2.3% more MVPA and vigorous PA respectively (Ridgers, Stratton et al. 2007).

The use of game equipment at recess has also been investigated (Verstraete, Cardon et al. 2006). This Belgian study investigated the effect of providing students with game equipment on their recess PA levels. The game equipment provided included sets of jump ropes, scoop sets, flying discs, balls, hoops, etc. There were different sets of equipment and the sets were circulated through out the classes to aid in the prevention of boredom with the equipment. An MTI accelerometer was used to measure PA on 122 subjects (mean age 10.8 ± 0.6 years). During the baseline data collection these subjects were found to be more active than others reported in recess PA literature. MVPA was characterized based on (Trost, Way et al. 2006) calibration equation in which moderate intensity PA was 3.0 – 5.9 METS and vigorous intensity was > 6.0 METS. These thresholds have recently come under scrutiny as they may be appropriate for adults but may over-represent activity levels in children. That is, 3 METS corresponds to regular paced walking which is not normally a moderate activity level (Wittmeier, Mollard et al. 2007). On average these subjects engaged in MVPA for 56% of recess and 51% at lunch. This study also found that males are more active than females. During the intervention, recess moderate PA increased from 41% to 45%. At lunch, moderate PA increased from 38% to 50% and vigorous PA increased from 10% to 11%. During the intervention, subjects engaged in MVPA for a total of 61% of the lunch period.

Further evidence to suggest the merit of PA intervention is provided by from our lab. (Kozera 2006) found that when comparing step rate of structured activity periods (15 minute teacher led activity break) to unstructured PA periods (15 minute recess) of similar duration, the structured periods on average had double the step rate of unstructured periods. The daily PA break (not a recess) was lead by the PE teacher and took place either in the gymnasium or outdoors. It included gross motor activities such as aerobics or an organized walk. The PA levels of this period were significantly higher when compared to either morning (AM) recess or PM recess. Recess being an unstructured play time, and although it is supervised by an adult, interference with the child's chosen activities generally only takes place when there is behavior or safety concerns. By providing structure in a 15 minute period, PA was significantly increased and children achieved step rates of 100 steps/minute. This suggests that semi-structured recess interventions can provide increased PA or that additional PA specific periods can be added to enhance total activity. The intensity of activity needs to be considered, as we know that the best body compositions are associated with children that engage in vigorous activity Wittmeier, Mollard et al. 2007).

Thus far it has been identified that both providing equipment (Verstraete, Cardon et al. 2006) and using playground markings (Stratton and Mullan 2005) can be effective in increasing recess PA. Further more, having a trained supervisor leading a PA period also appears to provide increased PA levels (Kozera 2006). Kozera also identified that specific “PA periods” provide more PA than recess does. This leads to the question of whether recess should be converted into a PA period or whether recess can be manipulated as it is into providing additional PA. Additionally, having sex specific interventions may be indicated as many studies show that there is a difference in magnitude of PA between the sexes as well as different play types (Beighle, Morgan et al. 2006).

There is a further need to characterize PA of children during recess. While accelerometers and pedometers are widely used in assessing PA in children, there is currently very limited published data with regards to energy expenditure, step counts, or the time, duration, and patterns (durations of bouts) of PA specific to the recess period. There is currently very little published data that relates PA at recess to body composition or compares recess PA to PE PA. While pedometers are becoming increasingly more common in elementary schools, they are not currently used to measure intensity of PA. If steps were recorded over a period of time (recess for example), a step rate or intensity could be calculated, which may provide more detailed information in regards to PA Segmented pedometry is an effective way to describe patterns and could be used to gauge intensity of PA (Tudor-Locke, Sisson et al. 2005; Tudor-Locke, Lee et al. 2006)}. Further validation of this method is required using an objective energy expenditure measurement tool such as an accelerometer. There is also a further need to assess the short term PA interventions as possible candidates for sustainable interventions. As many schools now own pedometer sets, it must also be determined if pedometer based interventions are effective in increasing PA at recess, Pedometer based interventions are not only objectively measured, but also realistic and simple for schools to independently implement as a way of increasing PA in all students. Pedometer interventions also allow for the maintenance of unstructured activity time at recess with the goal of PA addition.

Purpose

The purpose of this study twofold; (1) to characterize PA levels and patterns of children during recess, PE and the school day and (2) to examine the effect of a short term PA intervention during recess.

Objectives & Hypotheses

Recess and PE Characterization

1. *Objective:* Examine day to day variation in step counts. *Hypothesis:* There will be no differences in step counts between days.

2. *Objective:* To examine the impact of weather on step counts. *Hypothesis*: Decreased temperature will be associated with decreased steps.

3. *Objective:* Compare morning, lunch and afternoon recess PA levels (steps, step rate). *Hypotheses*: There will be no difference in morning, lunch, and afternoon recesses in step rate. The step count will be proportional to duration.

4. *Objective:* Compare recess to PE. *Hypothesis:* Recesses will have higher step rates and higher step counts than PE.

5. *Objective:* Examine the influence of body composition on PA. *Hypothesis:* There will be an inverse relationship between PA and body fat or BMI.

6. *Objective*: Correlate steps and step rate to accelerometer energy expenditure to determine if step rate is a valid measure of the intensity of PA in free playing children. *Hypothesis*: There will be a linear relationship between pedometer step rate and accelerometer energy expenditure level.

7. *Objective*: Examine the differences between sexes in PA during recess, PE and school day. *Hypothesis*: Males will have greater PA then females in all activity periods.

Pedometer Intervention

6. *Objective:* To examine the effect of a short-term PA intervention during recess/PE. *Hypothesis:* PA will be greater during recess as a result of intervention. No effect will be demonstrated for PE.

Methods

Design: Repeated measures assessment of PA and a one time PA promotion intervention during recess.

Subjects: Subjects were recruited from Grade 3, 4 and 5 classes from two Manitoba schools. A power analysis ensures there is adequate ability to show a difference if there really is a difference. A conservative approach to the power analysis was performed. In order to determine the minimum number of subjects required to assess a change in PA (energy expenditure and step count) as a result of the recess PA promotion in comparison to the baseline PA levels, an alpha level of 0.01 and a power level of 0.9 were used. Sigma was determined by referencing recent literature in the area. The standard deviation associated with energy expenditure measurements has been previously evaluated in this age group of children to be 0.8 kilocalories (kcal)/kg/day (Wittmeier 2005). The standard deviation associated with step count data during the school day has recently been assessed (Tudor-Locke, Williams et al. 2002; Tudor-Locke, Williams et al. 2004; Bjornson 2005)). We expect an increase of 20% in energy levels (3.0 to 5 kcals/kg/day) and step counts (8600 to 10070 steps), there for the delta level was set at 0.2. A sample size of 12 subjects is required per grade. A total of 15 subjects per grade are required for adequate power accounting for attrition and data loss.

In total 75 subjects were recruited from 2 schools. All students in Grades 3, 4, and 5 were invited to participate in this study. An exclusion criterion for this study was for subjects that were unable to participate in regular recess activity on regular basis. There were no subjects excluded on this basis. All subjects completed and returned a parental consent and subject informed assent prior to the commencement of data collection.

This study has been approved by the HREB of the Faculty Medicine (H2006:086).

Measurements

PA will be measured using two methods; 1) pedometry and 2) accelerometry. Direct observation will be used to verify time period of class/recess intervals, weather effects, and any extraordinary events that may affect recess PA.

Pedometry

Pedometry involves the recording of step counts via a device called a pedometer. Pedometry has previously been validated in children (Tudor-Locke, Williams et al. 2002; Tudor-Locke, Williams et al. 2004; Bjornson 2005). Interval pedometry requires the children to record the steps counts at various time intervals. For example they will record step counts prior to and after specific events (such as recess) through out the day. Using the direct observation to record actual times for recess and PE classes, the step rate (steps/min) can be computed and used as a PA intensity measure.

The position of the pedometer will be tested for accuracy by having the subjects perform a 50 step count test. The pedometer will be placed on the left hip in line with the anterior superior iliac spine. The subjects were asked to walk 50 steps, counting the 50 steps in their head. At 50 steps exactly they were be asked to open their pedometers. If the pedometer reads a step count between 48 and 52, the pedometer placement was considered accurate in that position. If it was inaccurate, the pedometer position was adjusted and the procedure was repeated. Once an accurate position was found for the pedometer, the subjects were instructed to apply the pedometer at that placement for the duration of the study.

Step counts were recorded at the following nine or ten periods (depending when PE is scheduled) through out the day; roll call (beginning of school day), before morning recess, after morning recess, before lunch recess, after lunch recess, before afternoon recess, after afternoon recess, before PE, after PE, and at dismissal. Step counts were recorded on a cumulative basis through out the day and were reset every morning after recording the number for the roll call period. This allowed for the calculation of daily step counts, school day step counts, out of school step counts, as well as step counts for each of the intervals. Although pedometry can be a measure of total daily PA, it does not provide information regarding the intensity of PA in which the steps were accumulated. By recording step counts over a set period of time, step rate was calculated, which may be indicative intensity. For example, if a person accumulates 10,000 steps in a day, you can not be sure if they were low active for long periods are highly active for a short period and sedentary elsewhere. However, if you know that 5,000 of those steps were recorded over an hour time frame, you know that a higher PA intensity was reached in that time frame. Using step rate also normalizes step counts for time, which is important in this study as not all PA periods were of equal duration. Recent unpublished data from the Human Performance Lab has indicated the preliminary success of interval step counts derived from pedometry in children (Kozera 2006). Tudor-Locke (2005) has also had preliminary success with developing step rate cut offs to indicate moderate intensity activity in adult populations (Tudor-Locke, Sisson et al. 2005). An accelerometer is capable of identifying intensities of PA; there for interval pedometry may be validated for predicting intensity if compared to accelerometer data. Recent work from our lab has compared Biotrainer accelerometer data with interval step counts expressed as steps per minute. There is a very high correlation ($r>0.95$) between the measures during treadmill walking.

Each interval count was converted into steps/minute based on the actual time of the interval as recorded by the investigator or teacher. A time frame for each class was used, as it was not possible to identify an exact time for each child. Each child was provided with a step count log that will have all intervals listed for each day and will require them to record the number in the appropriate box. During the baseline data collection children were asked to record their step counts only. Both school staff and researchers were present to assist subjects in step recording, as well as to cue timing for recordings. Teachers were asked not to use the step count numbers in any ways, except to record them. For example, children will not be using subtraction skills to determine number of steps taken at recess. Children will be instructed to engage in typical recess/daytime activities. Any comparison of step rates between children was discouraged due to the potential for competitive behavior which may artificially increase PA.

Accelerometry

Accelerometry is a reliable, validated, objective measure of PA (Rowlands, Ingledew et al. 2000; Trost, Pate et al. 2002). Objective measures are superior to self reported activity analysis in children and adults, which results in over-estimation of activity participation (Janz, Witt et al. 1995; Epstein, Paluch et al. 1996; Buchowski, Townsend et al. 1999; McKenzie, Marshall et al. 2000). Although accelerometry has limitations in monitoring all forms of activity, it is currently the best tool for assessment of free living PA. (Eston, Rowlands et al. 1998; Rowlands, Thomas et al. 2004). Accelerometry has been validated in the measurement of PA in children (Rowlands, Eston et al. 1997; Eston, Rowlands et al. 1998; Eisenmann and Wickel 2005) and involves wearing a pager sized device (Biotrainer Pro) on the hip for the duration of the school day. The Biotrainer Pro is considered a uniaxial bidirectional accelerometer as it picks up movement in two planes. The Biotrainer Pro is in fact a uniaxial accelerometer that is oriented on a 45 degree angle from vertical, therefore is considered a bidirectional accelerometer as it picks up movement in two planes; horizontal and vertical. Data was recorded on the following settings; 20X gain, 30 second epoch length). Available literature reports that due to the intermittent nature of children's play, a shorter epoch length is desirable in order to reflect the short bursts of activity. From preliminary testing of the Biotrainer accelerometer in our lab, 20X sensitivity is the most accurate for a 30 second epoch. 20X gain at 15 second epoch does not demonstrate a "capping off" effect for higher intensity of PA as shown with other settings of the Biotrainer accelerometer (Unpublished data, Wittmeier, Mollard, Kriellaars). This setting is also sensitive enough to pick up lower levels of activity. The Biotrainer can record 11 days of data at the 30 second epoch setting.

The accelerometer will be donned and doffed by the investigator or teacher. The accelerometer was worn from beginning to end of each school day. After removing the accelerometer from the subject at the end of the day, the data was downloaded onto a computer via accelerometer software. The accelerometer data can be displayed as PA (activity counts) or energy expenditure (kcals/min). Accelerometer data will allow us to precisely characterize PA during recess periods based upon intensity of activity, and duration of bouts of PA.

Direct Observation

Direct observation involved a researcher on the playground to record the timing of recess and PE classes. In addition, the researcher recorded the environmental conditions including precipitation and storm conditions. When possible, the researcher also recorded special factors that may impact recess PA, such as Halloween activities and Remembrance Day services. Although it was not possible to record activities for each child, by having the researcher present, it was possible to monitor which areas of the playground were being used during each observed period. This provided a further subjective understanding of what types of activities are commonly engaged in, as well as being able to note any gross differences in amounts or types of PA between males and females. Being present at the schools during data collection also led to the understanding that although all subjects participated in recess, the actual opportunity for PA varied somewhat between schools and classes. For example, in one school it was common practice that if a child did not finish their homework from the night before, the result was an activity restriction during recess the following day. Also, one of the teachers would not allow children to leave for recess until they had their work from the preceding class checked over. This sometimes limited the children's recess to less than five minutes as there was often a line up to have the work checked. The investigator was present for the direct observation of approximately half of the data collection period. During the remainder of the time the teacher recorded the time intervals of recess, or any events that may have shifted the time of recess. Approximately half of the teachers involved were also able to record any circumstances that may have affected individual children's PA levels (example: child was not feeling well).

Body Composition

Mass (kg) and height (m) were collected to calculate BMI. Mass and height were measured with the children in school clothing with no shoes. Skin folds (mm) were measured at the calf and triceps area (HSK-BI, Harpenden). Skin fold measurements were taken on bare skin, and children were given the opportunity to change their clothing prior to the measurements if needed. The Slaughter regression equations were used to estimate percentage of body fat (BF) (Slaughter, Lohman et al. 1988). Skin folds were measured in triplicate.

The following equations were used;

Males: Percent Fat = 0.735 (triceps + calf) +1.0

Females: Percent Fat = 0.610 (triceps + calf) + 5.1

Predicted body fat using the Slaughter equation has a high correlation (r = 0.82) with body fat measured by dual energy x-ray absorptiometry (Nicholson, McDuffie et al. 2001).

Timeline

<u>Baseline:</u> For each group of subjects (1 class per group) baseline data was collected over 4 days/week (See Table 1) in a one week period (Monday-Thursday). Baseline data collection consisted of students participating in their regular school day and participating in recess as they normally would. Baseline data collection included body composition measurement, accelerometry, interval step counts (including recess step counts and PE step counts), and direct observation at recess and/or PE.

<u>Intervention:</u> Intervention data was collected once all baseline data collection had been completed for each group (Friday). The short term intervention took place over one day, with the purpose of determining if children are receptive to recess interventions.

Intervention data collection included accelerometry, school day step counts, recess step counts, PE step counts, and direct observation at recess.

Table 1. Data collection timeline.

September 13, 2006	Day 1	Advertisement letters and consent/assent packages sent home to parents
September 25, 2006	Day 2	Info presented to students at School 1 Q & A with parents Collection of consents
September 27, 2006	Day 3	Info presented to students at School 2 Q & A with parents Collection of consents
October 2-5, 2006	Day 4-7	Group 1 baseline PA data collection Body composition data collection
October 6, 2006	Day 8	Group 1 PA Intervention
October 16-19,2006	Day 9-12	Group 2 baseline PA data collection Body composition data collection
October 20	Day 13	Group 2 PA intervention
October 23-26, 2006	Day 14-17	Group 3 baseline PA data collection Body composition data collection
October 27, 2006	Day 18	Group 3 PA intervention
October 30-November 2, 2006	Day 19-22	Group 4 baseline PA data collection Body composition data collection
November 3, 2006	Day23	Group 4 PA intervention
November 6-9, 2006	Day 24-27	Group 5 baseline PA data collection Body composition data collection
November 10, 2006	Day 28	Group 5 PA intervention
September 2007	Day 29 & 30	Follow up sessions at each school

Intervention

The intervention period began with an education session that was presented to all children in the participating classes. The presentation focused on importance of PA, PA guidelines and energy balance. The PA intervention consisted of one day of recess data collected. The subjects were given the instructions to accumulate as many steps as possible. Activity goal setting were discussed and students were asked to set personal goals. A class goal was also set for accumulated step counts. Children were instructed to encourage each other to be active. Those children who were not participating in the study were told to also be active, thus potentially motivating the subjects to increase their PA. The same measures were used to assess PA for the intervention period; pedometry, accelerometer, and direct observation, as described above. Subjects were encouraged to be as active as possible over all recess periods. Both the investigator and the teachers were involved in encouraging children to be active on the intervention day. At this point children were encouraged to look at their recess step counts, calculate how many steps they took at different periods through out the school day, etc. Individual and class step goals were evaluated for success. At this time, teachers were also encouraged to use the step counts in the curriculum, such as using math skills to work with step count numbers.

There were a few potential phrasing issues involved in the intervention presentation. As not everyone in the class was participating in the study, they were not all wearing pedometers on the day of intervention. During the discussion, it was suggested to all children to encourage each other to be active and to lead by example by being active themselves. This was designed to encourage the children not wearing pedometers to buy in to the intervention and to help create more excitement around it for the whole class. However, this may have led to the more active children in the class lowering their activity levels in order to help encourage the less active children. The words “help each other to be active” were intended to raise activity levels on whole; however some children may have literally stopped to help other children to be active.

Results

The Results section is divided into three sections. The first section provides a description of the setting and the subjects. The subsequent section is a characterization of recess and PE, and the third section describes the effects of a single day pedometer intervention.

Description of Setting and Subjects

School Environment

The school environment was assessed by direct observation. Two schools participated in this study and the qualitative aspects of each school are described below. The researcher was present at each school during the majority of the data collection and was able to observe the school environments. Recess literature has suggested that there is an influence of psychosocial and environmental factors that affect recess PA that is not yet fully understood (Ridgers, Stratton et al. 2005). The addition of subjective description to this study may add to the further understanding of qualitative factors that may affect recess PA and provide an enhanced ability to interpret the quantitative data.

<u>School 1:</u> Located in a small rural town with a largely agricultural economy located in southwestern Manitoba. The school draws students from a population of approximately 1400 in the town and surrounding rural municipality. It is a largely Caucasian population. It is a kindergarten to Grade 12 school with 11.5 teachers on staff. This school has daily PE in the elementary grades, and all classes participating in this study were instructed by qualified PE teachers. Recess periods were held outside except when weather conditions prevented this. If recess was held indoors, generally students stayed in their classroom playing games that did not involved substantial physical activity. Occasionally students were allowed access to play in the hallways or gymnasium during indoor recess. Kindergarten to grade 6 classes participated in recess together at the same time. The playground consisted of the following play areas; pavement pad with game markings (example: four square), soccer/football field, basketball courts, open grassy fields, large play structure, 2 smaller play structures, swing sets, tire swings, monkey bars, and a sand

box. All recess periods were supervised by school staff. Children wore their regular school clothes for recess, plus or minus outdoor clothes (weather dependent). Children were encouraged to change their shoes to "outdoor shoes" but this was not strictly enforced.

School 2: This was a private school located in an urban area of Winnipeg. It's enrollment in Kindergarten – Grade 12 is nearly 600 students. Generally, there are 2-3 classes per grade. There is a multicultural population at this school. Because of lack of gym space for the student population, PE occurs approximately 2-3 times per week, is usually held indoors, and occasionally two classes shared the gym. PE was instructed by qualified PE teachers. Because of lack of space on the playground, recess times were divided so that grades 1-3 had scheduled recess together and grades 4-6 had recess scheduled together at another time. One group had lunch recess after having their eating break; the other group had recess prior to eating their lunch. The playground consisted of the following play areas; paved basketball courts, paved playing area, 1 large play structure, grassy soccer field; (however most of the grass was worn through and it became very muddy, so this area was off limits when it was wet), and picnic tables under the trees. Recess was held outdoors whenever weather permitted. If recess was held indoors, children played games in the classroom, such as board games, colouring, etc. Students wore school uniforms (pants/shorts for males and skirts/tunics for females). Females were permitted to wear shorts/pants under their skirts/tunics for recess. Students changed their shoes in order to go outside. Occasionally at this school, if children did not finish their homework from the night before, the result was a physical activity restriction during recess.

Schools were selected based on opportunity. There was no significant source of bias noted between the two schools. Both school had approximately 50-75% of subjects in each class participating in the study. One potential bias in PA studies is that those that are less active or have poor body composition may not choose to participate as to avoid embarrassment. However this was not felt to occur in this study. As both the parent and child had to agree to the study prior to participation, it is felt that we captured a representative sample of the whole population. The research staff had parents comment on both wanting to help their sedentary child as well as parents wanting to compare their highly active child to other children. A visual scan of the subjects allowed us to conclude there was no bias of the subjects to either body composition or PA levels. Of note, both the body composition and PA levels reported in this study were comparable to other studies in Manitoba and Canada.

Data Collection

Data was collected over a five week period at the two schools. Two weeks were spent at School 1 and three weeks were spent at School 2. Overall, seventy-five subjects participated. Each of the classes participating in this study generally had three recess periods each day; morning, lunch, and afternoon recess. Occasionally due to exceptional events occurring during the school time, such as Remembrance Day Services, recess periods were missed or time shifted. Also, at times individual subjects would miss a period due to leaving school early or being ill. Table 2 represents the total number of measured periods for each of the four sampled periods.

Table 2. Sampling of recess and PE.

Period	# of measurements
AM Recess	259
Lunch Recess	257
PM Recess	253
PE Class	140

Recess and PE Class Durations

The durations of PE and recess were determined from school timetables and bell schedules. PA duration refers to the time allotted for each period in the time table. At both schools a bell would ring to signify the commencement of the PA period and again at the end of the period. Thus durations correspond to the maximum time for each period, and actual durations of activity would be necessarily less than the allotted time.

Due to the number of measurement periods, it was not possible to have an exact, measurement for the actual duration for each period. However, since the periods were observed it was possible to note specific variances. Durations for each period were homogenous within schools; however there were differences between schools with school 1 having significantly more time allotted to PA periods. Table 3 displays the duration of each of the four periods for each school, and the sum of periods per week.

Table 3: Durations (min) of scheduled PA time by school.

School	AM Recess	Lunch Recess	PM Recess	PE Class	Daily Total	Total/Week
School 1	15	35	15	40 (x 5 days / week)	105	525
School 2	15	25	15	30 (x 2 days / cycle)	55-85	335

Due to the differences in total daily durations of PA periods, an opportunity to access the effect of differences in durations was provided. Over four days of baseline data collection, School 1 had a total of 140 minutes extra of scheduled PA time when compared to School 2. This was due to three things. First, School 1 had daily PE (four PE classes during baseline data collection), whereas School 2 only had up to two PE classes during the four baseline days. At 40 minutes a class, these two extra PE's added 80 minutes of PA time for School 1 over the four day baseline measurement period. Secondly, School 1's scheduled PE classes that was 10 minutes longer than those of School 2. Thus, further adding 20 minutes more PA time for School 1 (as School 2 only had 2 PE classes per week). Thirdly, School 1 had a 10 minute longer recess break at lunch, thus adding another 40 minutes of PA over four days.

Variables which effect duration of recess and PE

Although time frames are set for each PA period (which varies somewhat school to school), realistically there are a number of factors that influence the actual time available for PA. Although it was not possible to record exact recess PA times, as each subject varied somewhat and research staffing did not allow for one on one monitoring, having the researcher on site for data collection did allow for real time estimates, as well as recording of factors that influence or reduce PA time. For example AM and PM recess were scheduled for 15 minutes, however actual PA time was approximately 10 to12 minutes. Delays in recess PA included bathroom breaks before recess, donning outdoor clothes, foot wear change, and finishing up schoolwork given precedence (school dependent). At lunch time there was also a delay if students did not finish their lunch in the time provided and was highly dependent on the supervising teacher's motivation to get the students outside. During PE class, the main factor delaying PA was the changing of clothing. Other delays included the teachers not being set up for activities when the students arrived, class overlap; not being dismissed on time, disorderly commuting time to gym, having the children involved in setup, and of course the required verbal instruction that generally requires children to be still and listen.

Weather

Data collection occurred during the fall season in Manitoba, a province characterized by warm summers and cold, bright winters. It is not abnormal to have a 70°C temperature range throughout the year (from -35°C in the winter, to 35°C in the summer). The weather conditions during the fall season (in which data collection occurred) can be variable. During data collection, there was a range in temperatures from -11.6 °C to 18.7 °C, with the average daytime temperature of 5.03 °C. Wind chill uses the combined effect of temperature and wind speed to demonstrate perceived temperature on bare skin. When there is no effect of wind, the wind chill is recorded as 0 or not reported. Many schools have guidelines in place stating that recess be held indoors if wind chill surpasses -35°. The maximum wind chill during data collection was -19° with an average of -1.9°. Another distinguishing factor of Manitoba's climate is snowfall during the fall, winter, and occasionally spring months overlapping substantially with the school year. Overall, 52% of the data collection days were under snowfall or with snow on the ground. Table 4 describes the weather conditions over the five week data collection period.

Table 4. Weather characteristics during data collection weeks.

	Week 1 (Oct 2-6)	Week 2 (Oct 15-20)	Week 3 (Oct 24-27)	Week 4 (Oct 30-Nov 3)	Week 5 (Nov 6-10)
Average Daytime Temperature	13.3 °C	2.5 °C	6.8 °C	-3.1 °C	-3.5 °C
Minimum Temperature	8 °C	-0.1° C	2 °C	-6.2 °C	-11.6 °C
Maximum Temperature	18.7 °C	7.2 °C	12.5 °C	-1.2 °C	1 °C
Average Wind Chill	0	0	0	-6	-8.8
Minimum Wind Chill	0	0	0	-9	-19
Days with Snow Cover	0	3	0	5	5

Subject Characteristics

A total of 75 subjects participated from Grades 3, 4, and 5 classes (Table 5).

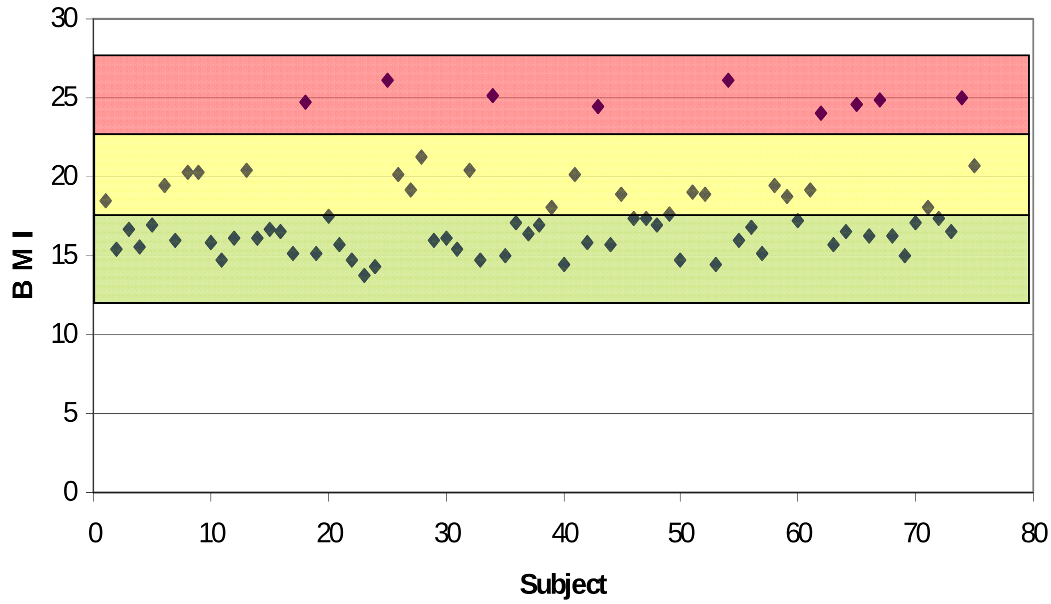
Table 5. Subject characteristics with mean and SD. Differences between sexes assessed using independent t –test.

	Combined	Male	Female	p Value
N	75	30	45	
Age (yr)	8.7 (0.86)	8.7 (0.97)	8.7 (0.80)	1
Mass (kg)	34.2 (8.73)	32.7 (7.68)	35.2 (9.37)	0.12
Height (m)	1.37 (0.08)	1.36 (0.06)	1.38 (0.09)	0.12
BMI	17.96 (3.16)	17.58 (3.01)	18.21 (3.27)	0.21
BF (%)	21.7 (9.12)	18.1 (9.38)	24.1 (8.20)	**<0.01**
FM (kg)	8.0 (5.67)	6.5 (5.67)	9.1 (5.51)	**0.03**
FFM (kg)	26.2 (4.06)	26.2 (2.73)	26.1 (4.78)	0.47

Body Composition (Body fat and BMI)

BMI and BF thresholds have been published which can be used to classify children. The BMI thresholds which are age and sex specific an be used to (Cole, Bellizzi et al. 2000) classify children with acceptable body composition, those that are overweight and those that are obese. The BMI distribution of children in these categories is illustrated in Figure 1. Colors (stop light) were used to delineate between body compositions categories and a single mean threshold value was used to separate categories. However, because there was a range in age and the two sexes, there was also a range in actual threshold values. For males the actual overweight threshold for BMI ranged from 18.16 to 20.2 and the obese threshold ranged from 21.09 to 24.57 in this age group. For females, the overweight threshold ranged from 18.03 to 20.29 and the obese threshold ranged from 21.01 to 24.77.

The bottom panel of Figure 1 illustrates the distribution of body fat as determined by four thresholds (<20, 20-25, 25-30 and 30+). In comparison of the two figures, body fat identifies a higher number of subjects that are in the in the "red zone" or are considered obese.



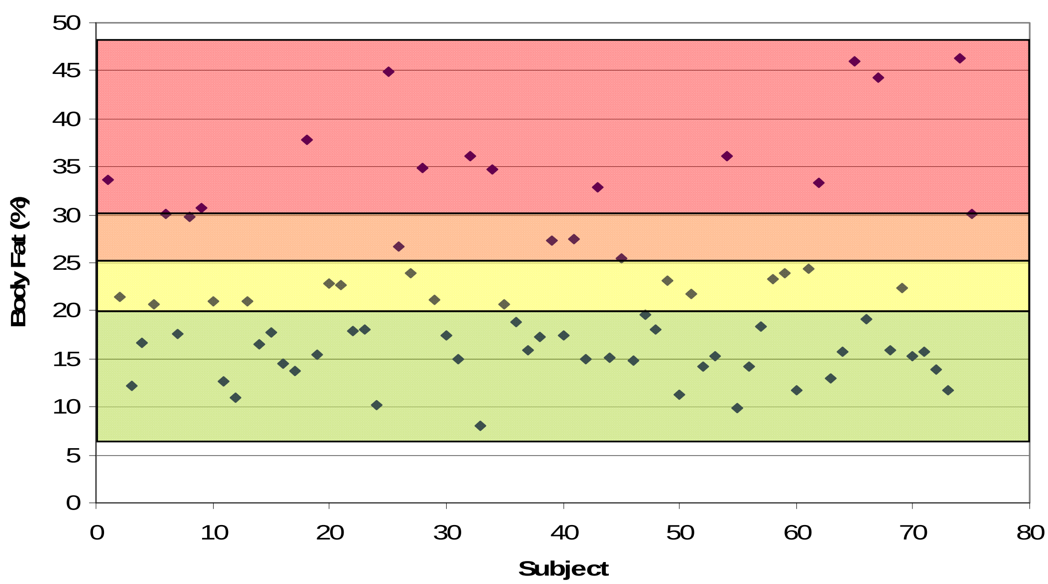


Figure 1: Body composition distributions shown in "Stop Light" format. Top panel showing BMI using Cole BMI thresholds for not overweight, overweight and obsese. Bottom panel showing body fat distribution using <20, 20-25, 25-30 and 30+thresholds. Green represents acceptable body composition, yellow and orange represents overweight/over fat, and red represents obese/over fat.

Table 6 provides a summary of the categorization of subjects into each category of BMI and BF. For BMI classification, subjects were individually characterized using the specific age and sex cutoff values.

Table 6. Body composition categorization.

BMI	% of Subjects
Acceptable body composition	70.7
Overweight	18.7
Obese	10.7
Overweight and Obese	29.3
Body Fat	
< 20%	53.3
20-25%	20
25-30%	6.7
>30%	20

The relationship between the two measures of body composition was also examined. As expected there was a strong linear relationship (Figure 2, $R^2=0.76$, $p<0.01$) between the two measures. When performing a partial correlation and controlling for sex, the correlation between BMI and BF slight increased to $r^2=0.79$ ($p<0.001$).

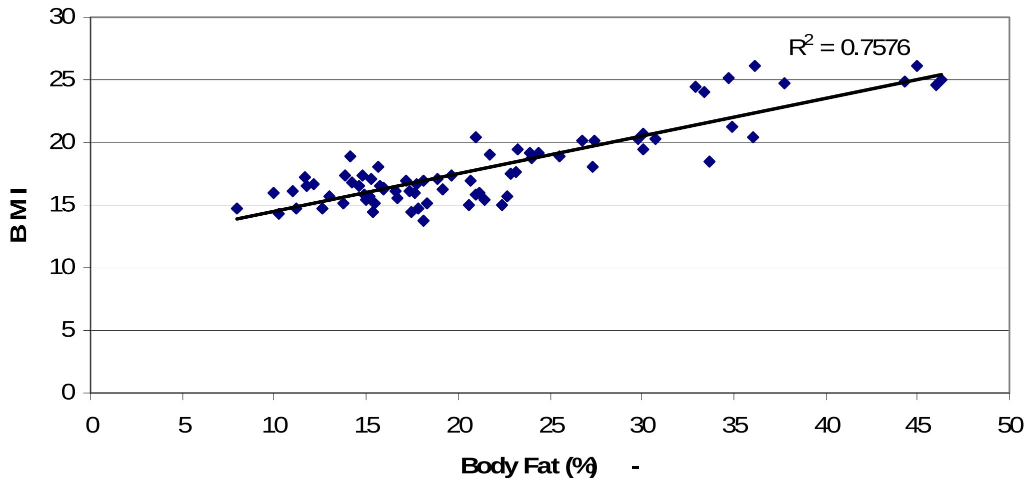


Figure 2. Relationship between BF and BMI. Best fit line shown (R^2 = 0.76, p<0.01).

Baseline PA

Daily Steps

Average daily step counts were recorded for each of the four baseline days. In order to evaluate the day to day variability in daily step count, a repeated measures ANOVA was performed. As expected, there was no significant difference between days (p=>0.103). As there was no significant difference between baseline days, this permitted us to use average daily step count. The group average daily step count was 10,713 steps per day. The average daily step counts for the group are less than even the lowest of recommended daily step count guidelines in the literature being 12,000 steps per day (Tudor-Locke and Bassett 2004). When classified based on BMI referenced step count guidelines set forth by Tudor-Locke (2004), only 37% of subjects met these guidelines. Figure 3 illustrates the daily step counts across baseline days, as well as the mean daily step count.

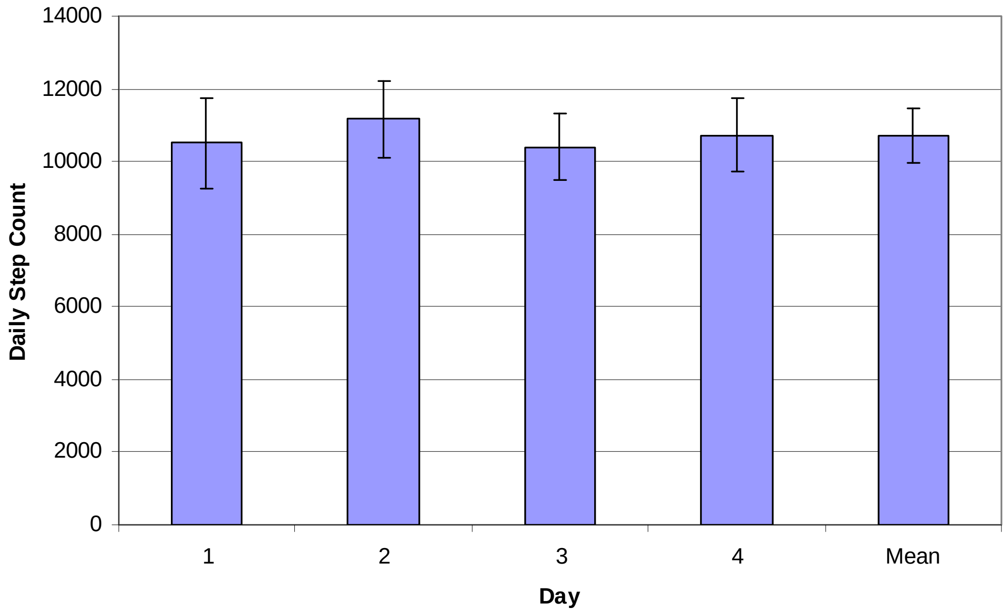


Figure 3. Daily step counts (SD), including the mean of four baseline days (not significantly different between days, p=>0.103).

The ratio of the average daily steps taken within the school and out of school was computed (Figure 4). Out of school steps included all steps taken in the evening after school as well as the morning before the next day of school, as pedometers were not reset for the day until after the recording was taken at the beginning of the school day (this measurement technique improves upon techniques used in other studies). School day steps were the largest contributor to average daily steps (Figure 4 top panel). School day steps contributed to an average of 887 more steps per day. School day steps were significantly higher than out of school steps (p=0.008). The bottom panel of Figure 4 demonstrates that this is true of both sexes. For both males (p=0.01) and females (p=0.03) in school steps were greater than out of school steps. It is also identified that males accumulated more steps than females, both in school (p=<0.01) and out of school (p=0.01).

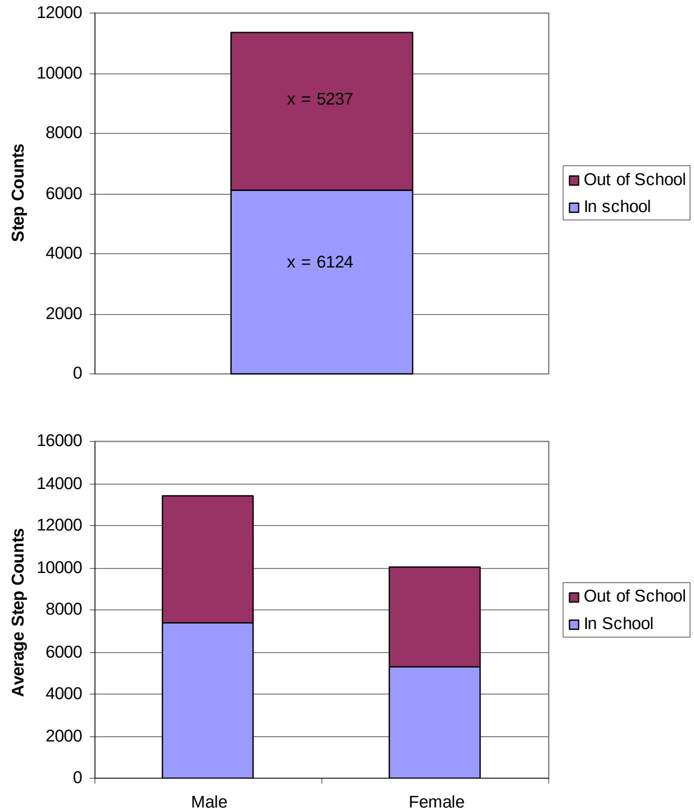


Figure 4. Steps within and outside of school day. Top panel displays both sexes combined. Bottom panel displays the sex specific means. Males had an average of 7403 in school steps and 6028 out of school steps ($p<0.05$). Females had an average of 5281 in school steps and 4734 out of school steps ($p<0.05$). Males greater than females ($p<0.01$)

Daily Step Counts and Overall School PA Duration

As described above there was a substantial difference in the time allotted for PA between the two schools. School 1 had between 20 and 60 minutes more PA than school 2 on any given day. This provided an opportunity to assess the impact of the this difference on total daily steps, leading us to postulate that we expected a greater daily step count for School 1 due to the increased time available to take steps. Indeed, there was a significant difference with an average of 2027 more daily steps for School 1 ($p= 0.005$) (Figure 5, top panel).

To ensure that the difference in step counts between schools could be attributed to the differences in durations of PA periods within the school day, school day and out of school steps were compared for each school. There was no difference in the number of out of school steps ($p = 0.346$). There was, as expected, a difference of 1940 in school steps favoring School 1 ($p < 0.001$) (Figure 5, bottom panel).

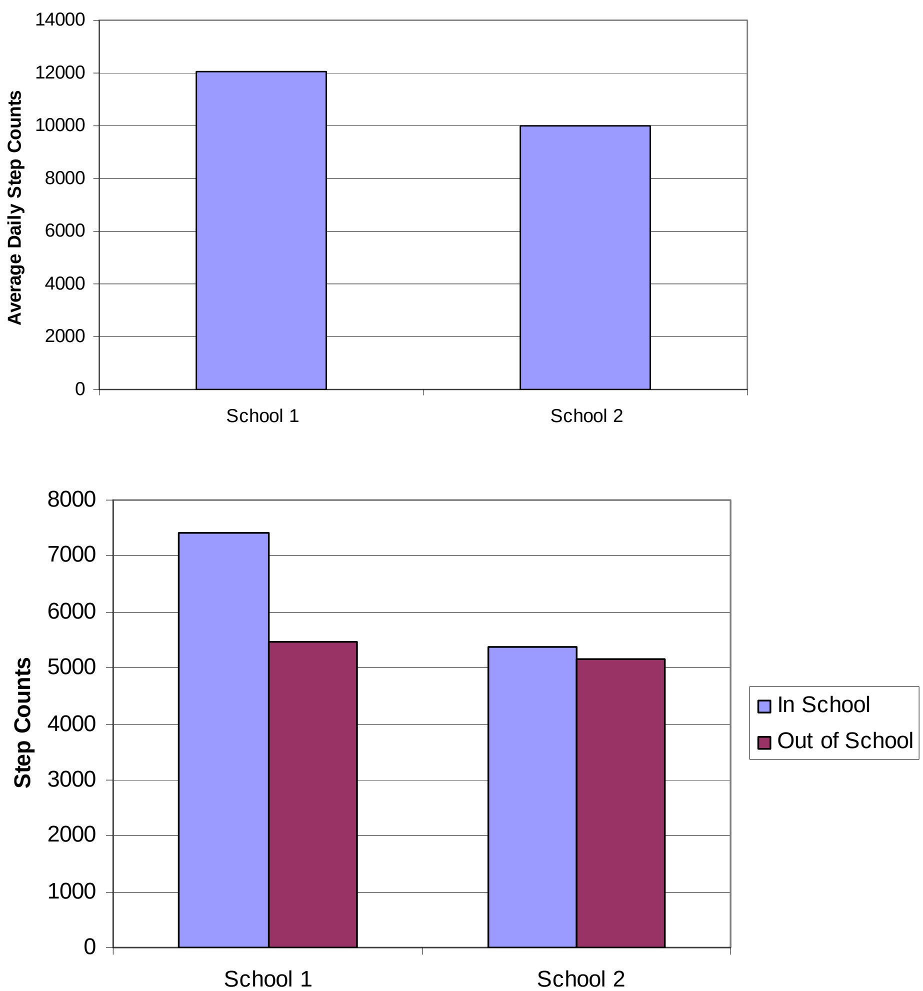


Figure 5. School differences in daily step counts. The top panel illustrates the average total daily steps of each school, and the bottom panel shows a break down of "in school" steps and "out of school" steps for each school.

In order to examine which of the three duration differences between schools contributed to the increase in step counts for School 1, we performed a linear stepwise regression. In this regression, step counts for each period were used to develop a model to predict the number of minutes of PA time during the day for each school. The following periods were used to predicted total PA duration; AM step counts, Lunch step counts, PM step counts, and PE step counts. The model that was most predictive of total daily minutes of PA was PE step counts (adjusted $R^2 = 0.417$, $p < 0.001$). However because the number of minutes of PA was really only two levels (School 1 or School 2), the minutes per day were coded as 0 and 1, and the more conservative approach of a binary logistic regression was completed. The same four models were included. The model that was most predictive was again PE step counts ($R^2 = 0.534$, $p < 0.001$). Due to this difference, it was possible to use total daily steps in a logistic prediction of which school children attended. Daily step counts were 83.3% correct in predicting that children were from School 1, and 92.3% correct that children were from School 2.

Figure 6 compares pedometer data between schools at each PA period. The top panel displays step count which displays School 1 has higher steps at both AM and lunch recess as well as PE class. We also know that lunch recess and PE class are the periods that School 1 has a longer duration of period. To determine whether this difference was due to duration alone, we also compared step rates between schools for all of the periods (Figure 6, bottom panel), which normalizes the step counts by duration. We find that there is a difference in step rates for AM recess and PE class. From this, we gather that School 1 was more active than School 2 during AM recess for a reason other than duration, as durations were the same between schools. As there is no difference between lunch step rates, we know that School 1 had higher step counts due to the longer duration of that period. PM recess there was no difference for either step count or step rate. PE class had a higher step count and higher step rate for School 1. This means that some, but not all of the higher step count for School 1 is explained by the longer duration. School 1 also was more active than School 2 during PE even when the duration effect was eliminated.

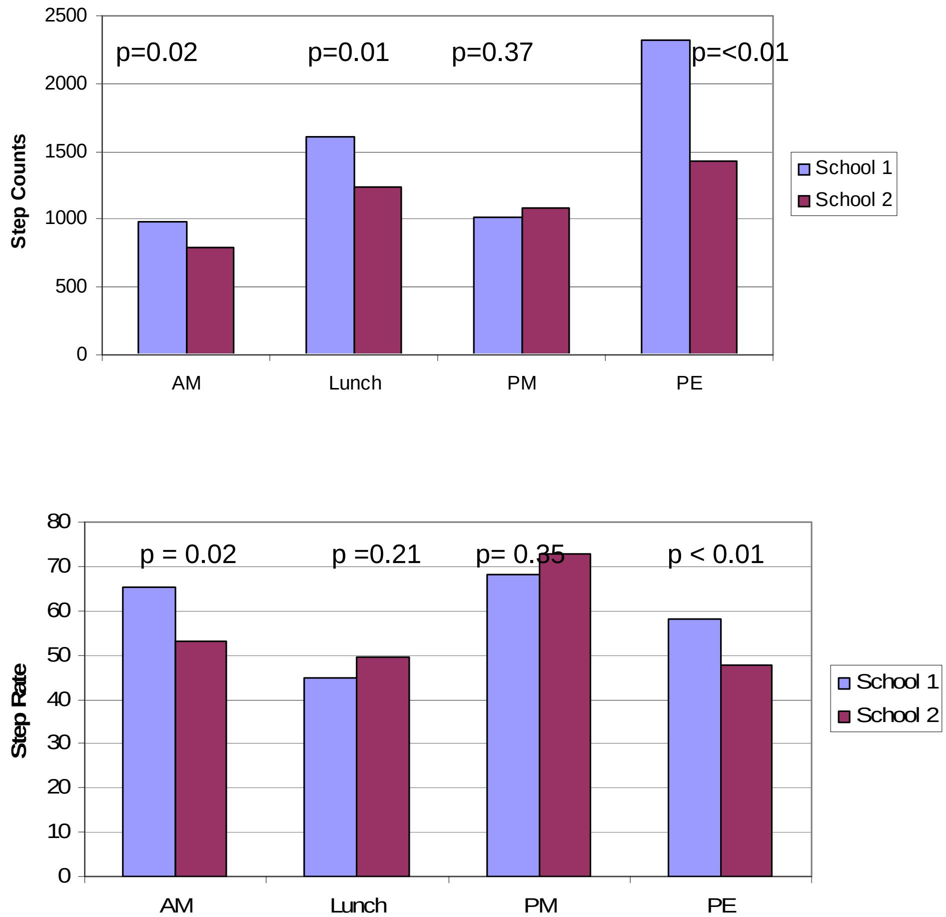


Figure 6: Comparison of pedometer data between schools. Top panel displays step count and bottom panel displaying step rate (steps / minute). P values (t-test) indicated above comparisons.

Although there was a difference in duration and PA between schools, there was no difference in body composition between schools. However, the school which had longer durations and higher PA levels (School 1) also had lower average BMI and BF (17.6 versus 18.7 BMI and 21.4 versus 22.2 BF). This difference between schools was not significant.

Step Counts and Body Composition

Another aim was to determine whether daily PA determined by step counts was related to body composition. It was predicted that there would be a significant negative relationship. There was a negative relationship (R^2 = -0.005), but not significant (p=0.967) relationship between BMI and daily step counts. When body composition was represented as BF, there was a stronger negative relationship (R^2 = -0.142) although also not significant (p = 0.234). When the correlation between body composition and step counts was redone controlling for sex, there was still no significant correlation between either BMI (p=0.457) or BF (p=0.768) and PA (step counts).

Recess and PE

A primary aim of this study was to characterize recess and PE PA using pedometer data. Step counts were calculated for each period (Figure 7, top panel). PE was greater than all other periods ($p<0.01$). Lunch recess was greater than both AM and PM recess ($p<0.01$), and PM recess was greater than AM recess (p=0.03). Of note, PE and lunch were respectively the longest duration periods; hence the greatest numbers of steps were accumulated in these time periods. However, when all three recess periods were combined, recesses accumulated approximately twice what PE achieved alone (Figure 7, bottom panel). Step rates for each period were also calculated as using steps per minute versus steps alone partially controlled for the duration differences between periods. For this reason, ANOVA was used to compare step rates between periods. PM recess was greater than AM recess (p=0.029), lunch recess ($p<0.001$), and PE (p=0.013). AM recess was greater than lunch recess ($p<0.001$). There was no significant difference in PE and lunch (p=0.179) or PE and AM recess (p=0.102). The top panel of Figure 8 illustrates the differences in step rate between periods.

Of note, the two periods with the shortest durations (AM and PM recess) had the highest step rates, which may indicate a higher intensity of PA in these periods. Also, PE which is the only structured PA period of the day has one of the lower step rates. The combined step rate for all recesses is higher than the step rate of PE. Similar to the relationship between PE and recess step counts, the average step rate of recess is nearly double that of PE (Figure 8, bottom panel).

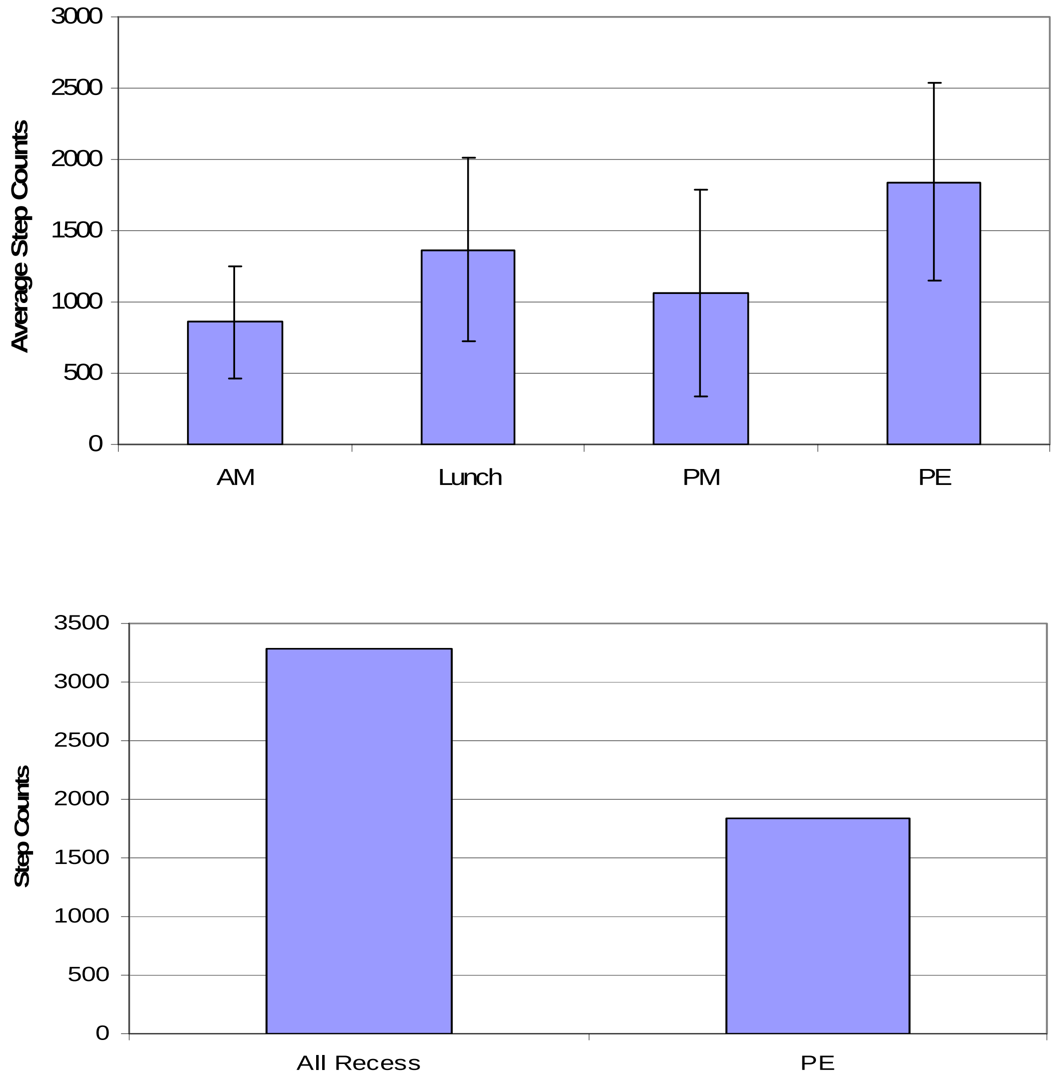


Figure 7. Step counts for recess and PE. The top panel displays average step counts (SD) for each period and the bottom panel displays the sum of all of recess combined versus PE (p<0.01).

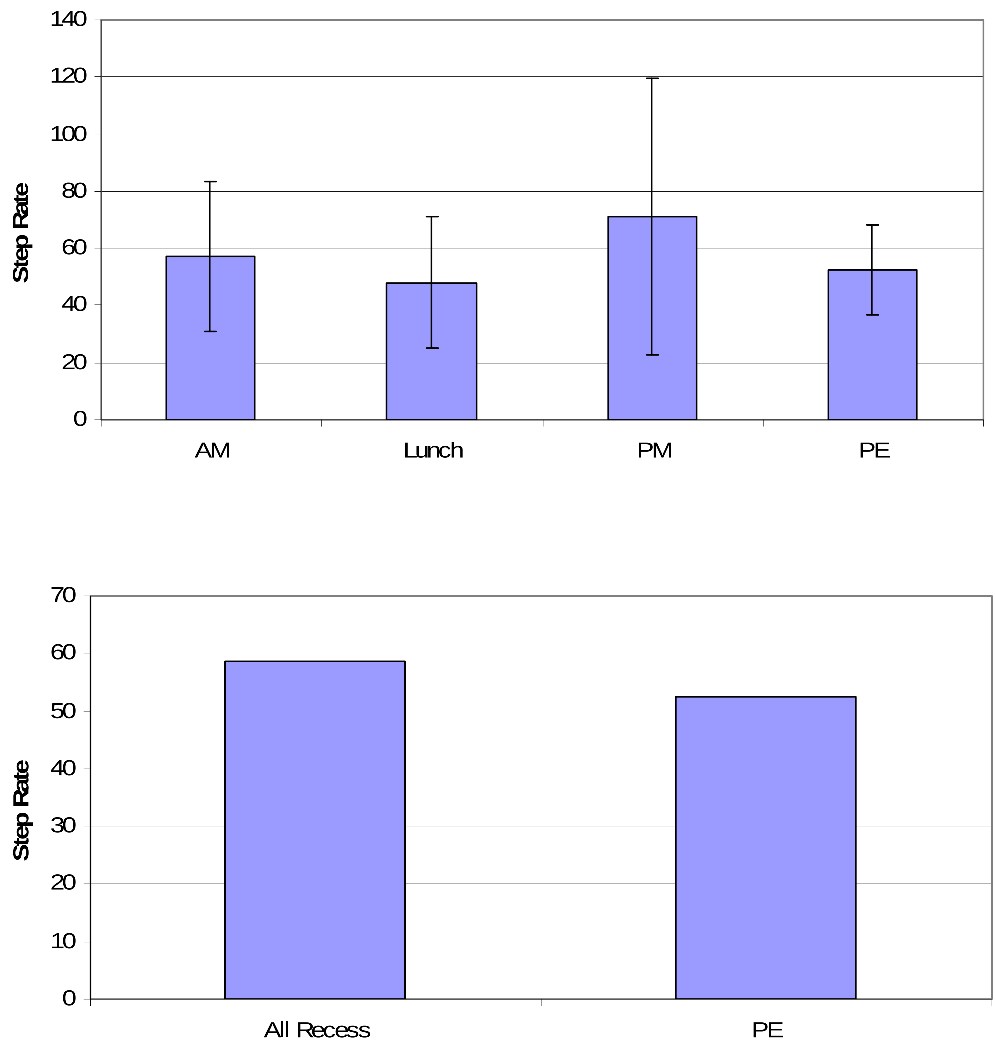


Figure 8. Step rates for recess and PE. The top panel displays average (SD) step rates for each period and the bottom panel displays all of recess combined versus PE (p=0.048).

In order to understand the overall contribution of recess and PE PA levels, step counts for each period were expressed as a percentage of total daily step counts (Figure 9, top panel). Again PE had the highest contribution as this was based on step counts, and there for was affected by duration. When all three recess periods were combined, we find that recess contributes to over 30% of total daily step counts, nearly double that which PE contributes (Figure 9, bottom panel).

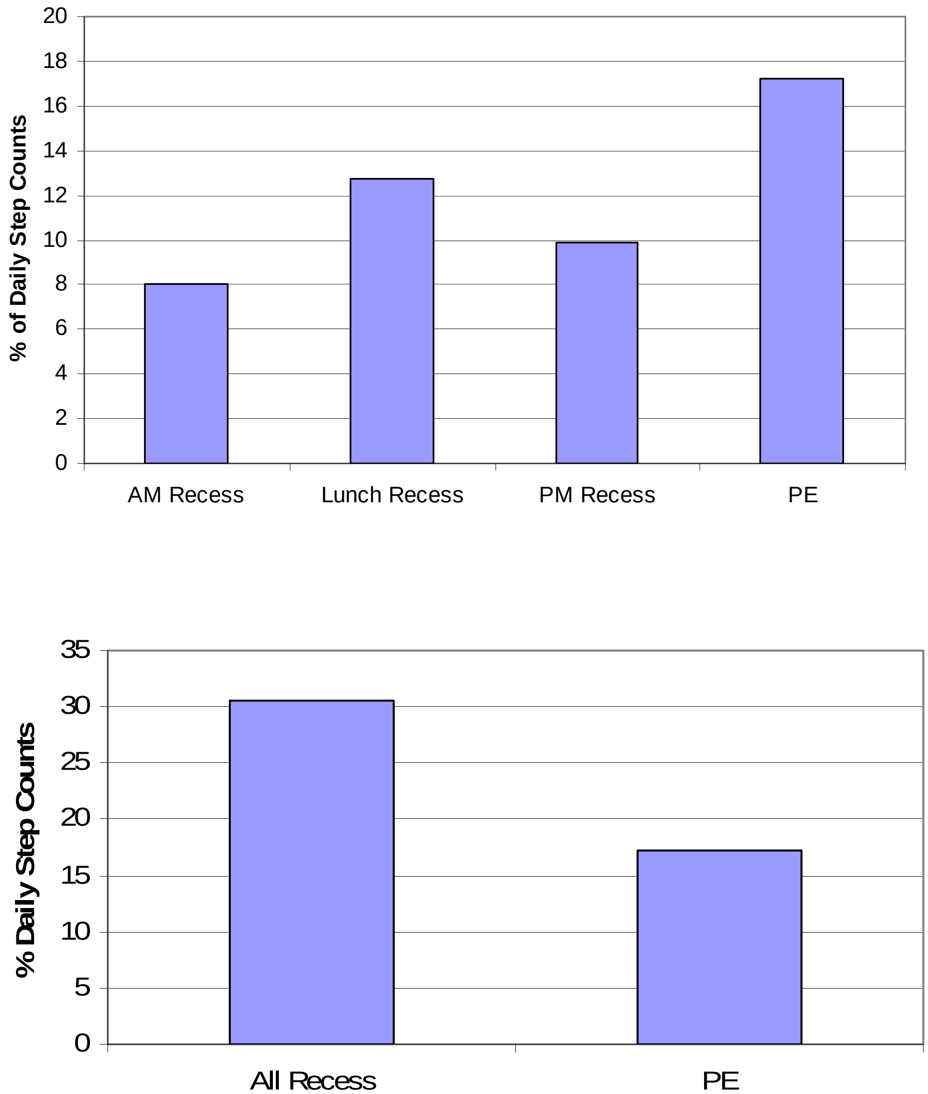


Figure 9. Percentage of total daily steps for recess and PE. Top panel; contribution of each recess period and PE to total daily steps. Bottom panel; all recess combined versus PE.

Sex differences in Step Counts and Rates

Males had higher average daily step counts ($p < 0.001$). Figure 10, top panel illustrates daily step count by sex. Of note, males' average daily step counts of 12331 steps per day was higher than the group mean and females were lower than the mean with 9439 steps per day. On average, males took 2648 more steps per day that their females counter parts.

When PA differences between sexes are compared further, the same relationship was found for different periods throughout the day. Males were consistently more active than females. Not only were males more active than females both inside and outside of school ($p<0.001$, $p=0.01$ respectively), the same was true for each PA period also. Males were more active than females at AM recess ($p<0.001$), lunch recess ($p<0.001$), PM recess ($p=0.049$) and PE ($p=0.039$). Figure 10, middle panel illustrates the average step counts for males and females at each PA period. Little is known regarding at what time of day this sex difference exists. Over the four periods, males took on average 1588 more steps than females. This data demonstrates that over half of the sex dependent differences in PA occur during school time PA opportunities. As females are less active than males regardless of period of day, this demonstrates that they do not compensate for lower levels of recess activity elsewhere in their day. The importance of maximizing females' PA levels during the school day is highlighted by these results.

Step count quartiles based on average daily step counts (described further below) were derived for both sexes (Figure 10, bottom panel). The male subjects are clearly right shifted, demonstrating that the highest percentages of males are in the top or fourth quartile. The females were left shifted with the highest percentage of females being in the bottom or first quartile.

BMI referenced step count guidelines have been recommended by Tudor-Locke et al. 2004 (15,000 steps/day for males and 12,000 steps per day for females) (Tudor-Locke and Bassett 2004). Of note, the recommendation for females is lower than that of males. Sex based PA differences were also compared in this light. Interestingly, although accumulating fewer steps, a higher percentage of females met the sex specific step count guidelines (22.7% compared to 14.3% of males). Duncan et al 2007 also have made body fat referenced step count guidelines (16,000 steps/day for males and 13,000 for females) (Duncan, Schofield et al. 2007). As these guidelines are higher, fewer subjects met them. However a higher percentage of females still met the guidelines with 20% of females meeting the guidelines, and only 10% of males meeting the guideline.

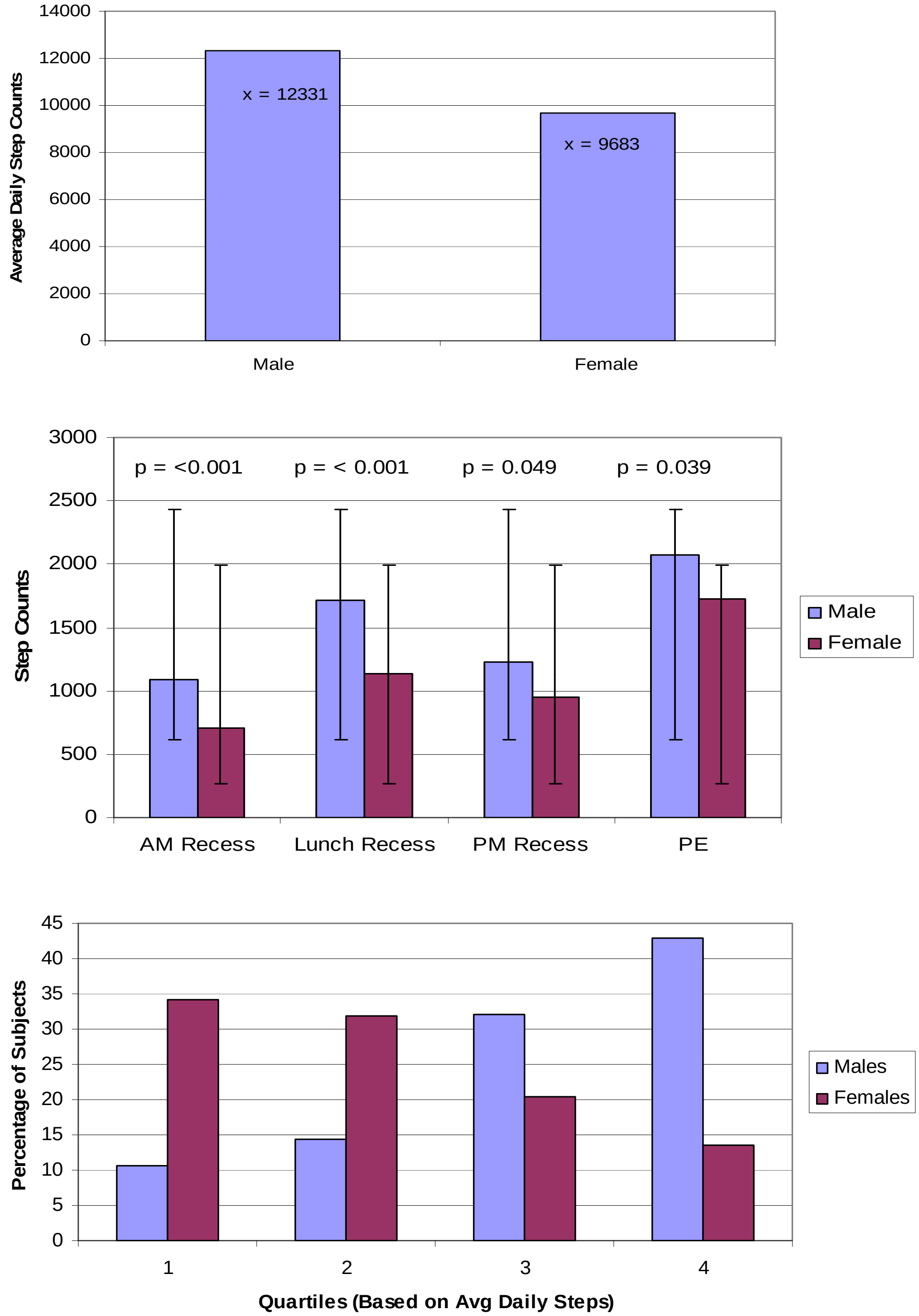


Figure 10. Male and female differences in step counts. Top panel illustrates average total differences in sexes (p=<0.001). Middle panel illustrates the mean (SD) step count differences between sexes at each period. The bottom panel illustrates the distribution of males and females in PA quartiles.

Weather Effect

As Manitoba weather conditions can be extreme, the relationship between recess PA (which is usually outdoors) and weather conditions was examined. This is especially important to consider, as all other data published on recess PA has been collected in more temperate climates. Little is known on the effect Manitoba weather conditions can have on PA levels. There was a diverse range of weather conditions during the data collection. This ranged from sunny warm days to snow and ice storms, and slushy wet weather. Approximately half of the days were under snow cover and there were a number of recesses held indoors due to adverse weather outdoors. Table 7 reports the number of periods held indoors throughout data collection.

Table 7. Indoor/outdoor distribution of recess and PE periods

Period	Indoor (%)
Overall	15.3
AM Recess	13.7
Lunch Recess	8.7
PM Recess	4.8
PE	51.9

Correlations between weather characteristics and recess and PE step counts were completed. Overall, whether or not recess was indoor or outdoor was the most significant predictor of recess step counts ($p < 0.001$).

When step counts between indoor and outdoor recess were compared, there was a significant difference. For example, Day 1 PA levels were compared for indoor to outdoor recess step count and step rate averages (Figure 11). If all activity periods are held indoors, this could result in an average loss of 3701 steps per school day. As reported above, the average school day step counts were 6124, there for indoor PA could effectively cut school day PA in half. There was a similar relationship with step rates. The average indoor recess step rate was only 19.4 steps/minute compared to 68.3 steps/minute for outdoor recess. Interestingly however, there was not as large of difference for indoor and outdoor PE classes. The average indoor PE class was 47.0 steps/minute compared to the average of 63.7 steps/minute during outdoor PE.

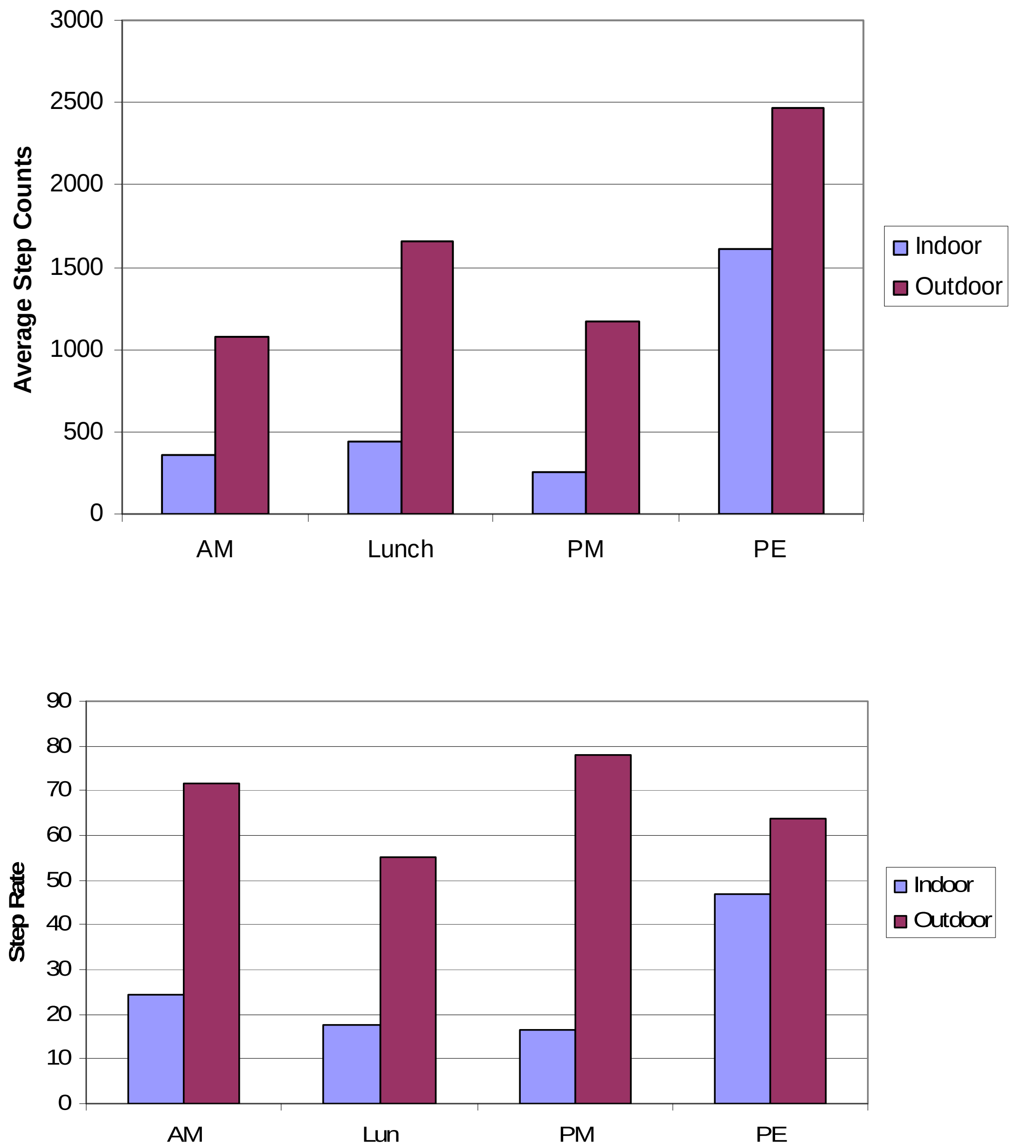


Figure 11. Example of indoor and outdoor step counts and step rates for each period (Day 1 data only). The top panel of this figure displays the step counts, and the bottom panel of this figure displays step rates.

Regression demonstrated that both AM and lunch recess step counts or rates are predicted by wind chill and snow cover (p = 0.001). There was no significant weather predictor of

PM step counts. Average school day steps were also predicted by wind chill, as well as average temperature ($p < 0.001$). It is important to remember that the range of temperatures and wind chills was still relatively small compared to full winter conditions.

Of note, there were fewer PM recesses held indoors in comparison to the other recess periods. PM recess was also associated with the highest step rates in comparison to the other periods. This higher mean step rate during PM recess may have been attributed to the fact that a higher percentage of PM recess was held outdoors (which are known to have higher PA rates). However, the subjective direct observation component of this study provided further insight into this increased PA level. Direct observation noted that children were generally more active during the PM recess period. There were fewer sedentary children and more children engaging in large gross motor activities during this period. This led us to conclude that the increased rate of PA during PM recess was not attributed to a greater number of outdoor recesses.

Direct observation also provided us with the information that School 1 had a greater number of PE classes outdoors as compared to School 2. School 1also had higher step rates at PE (58.1 steps/minute) compared to School 2 (47.7 steps/minute). In this instance, it is probable that the discrepancy in step rate is due to indoor PE versus outdoor PE classes, as we know that indoor PE classes had lower step counts and step rates than outdoor PE classes.

Accelerometry

A subset of subjects (N = 17) also wore accelerometers during data collection. This was undertaken as a partial validity check to the use of pedometers, and to provide further insight into the recess and PE PA. Accelerometers have the capacity to measure the intensity as well as the quantity of PA.

Accelerometer data can be expressed as either activity counts or energy expenditure. Each different brand/model of accelerometer has a slightly different method of calculating activity counts there for activity. Each different brand/model of accelerometer has a slightly different method of calculating activity counts there for

activity counts data from different models can not be directly compared to each other. Although the accelerometer does not directly measure energy expenditure, most models have developed a conversion equation (the primary element of the conversion being body mass) which allows activity counts to be expressed as energy expenditure. For this data set, activity counts and energy expenditure were compared. Across the four PA periods there was a high correlation between energy expenditure and activity counts (R^2 = >0.84) largely due the small range of body masses observed in the sample.

The relationship between pedometer and accelerometer data was examined with correlation. There was a moderate correlation between step counts and activity counts. This study is one of the first to assess the relationship between pedometry and accelerometry in "free living" physical activity settings. Table 8 displays the correlation coefficient between the accelerometer and pedometer step counts. Figure 12 illustrates the relationship between pedometer step count and accelerometer data. The relationships between accelerometer and pedometer did not change when accelerometer data was correlated with pedometer step rate data.

Table 8. Correlation between step counts and energy expenditure. Correlation coefficient shown. All correlations were significant (p<0.05)

	AM Recess	Lunch Recess	PM Recess
Day 1	0.557	0.648	0.151
Day 2	0.745	0.641	0.745
Day 3	0.040	0.392	0.582
Day 4	0.425	0.479	0.259
Day 5	0.575	0.552	0.122
Mean	0.469	0.542	0.372
Total Mean (all periods)	0.485		

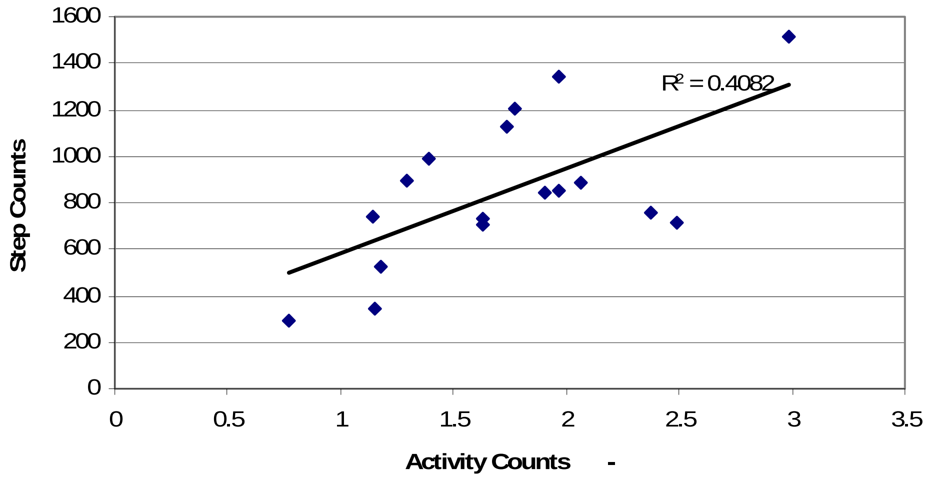


Figure 12. Example relationship between step counts and activity counts; average PM recess correlation, all data points. Best fit line shown ($R^2 = 0.41$, $p<0.05$).

What was noted during this comparison is that there were consistently a few outliers in each PA period that greatly affected the R value. Upon closer examination, it was typically the step count value that was creating the outlier. Reviewing the data offered three explanations as to why this may occur. Primarily, a pedometer has been validated as a measure of children's PA for loco motor activities (Tudor-Locke, Williams et al. 2004). However through the direct observation component of this study, it is known that non-loco motor activities were not uncommon in the schools researched. These activities included swinging, playing on the monkey bars, and cable rides. During these activities accelerations could be high and as such the accelerometer would register high levels of PA. However few to no step counts would be recorded as there is no contact with the ground providing the upward acceleration at the hip. Therefore, the step count mechanism of the pedometer may not be activated. If a child were to spend the majority of his or her recess period engaged in one of these activities, their step counts may be limited to the number of steps it took to carry them from the classroom to the playground equipment. This would not correlate well with the high level of accelerations recorded by the accelerometer, which are necessary to partake in these activities. As observed, playing on the monkey bars has the potential to be a moderate to high intensity exercise that is more accurately measured by the accelerometer. The pedometer has limitations in this area.

Another source of error in the pedometer data is human error. The design of this study required 7-10 year olds to accurately record their step counts 9-10 times per day. This is an age where the practice of place value as well as addition and subtraction of large numbers is a challenge for some or most children. Although teaching and research staff were present to assist with step count recordings, time wise it was not always possible to ensure accurate recordings. Often teaching staff only allowed a few minutes of class interruption for the recordings. Therefore, more emphasis was put on ensuring all children had a recording and the correctness of that recording was not always checked.

In the cases where the accelerometer data was the cause of the outlier, it is possible that the accelerometer's position was altered during recess play, and there for not accurately recording. Although accelerometer position was checked by the researcher frequently through out the day, at times the subjects clothing and or play habits could affect the recording position. If the child were wearing loose clothing or aggressively changing positions, the accelerometer could become detached and be left hanging from the safety strap only. This would significantly change the accuracy of the recordings. Typically these situations were identified quickly and rectified, however there are likely a few occasions were this was not identified by the research staff.

Once the source of the discrepancy was identified, removal of the few outliers in each data set, the R^2 values substantially and significantly improved. However, these outliers were retained in the data set as we had no bona fid means to drop them. Further study of these factors affecting the interrelationship of pedometer and accelerometer data is warranted.

Figure 13, top panel compares the average activity counts at each period (N=17). Of note, PE was underpowered as it was not daily for all 17 subjects, where as recess was. For sake of comparison between accelerometer and pedometer data, figures of step counts (Figure 13, middle panel) and step rate (Figure 13, bottom panel) were also generated for only the 17 subjects who had accelerometer data as well. With the exception of PE (which was underpowered) the relationship between periods was generally the same, regardless of method used to express PA. Also note that step counts are affected by duration of period as well, where as step rate and activity counts are normalized for duration. What is known from this comparison of data is that regardless of method used to express PA, when comparing two periods of equal duration (AM and PM recess), the same relationship was identified (PM>AM).

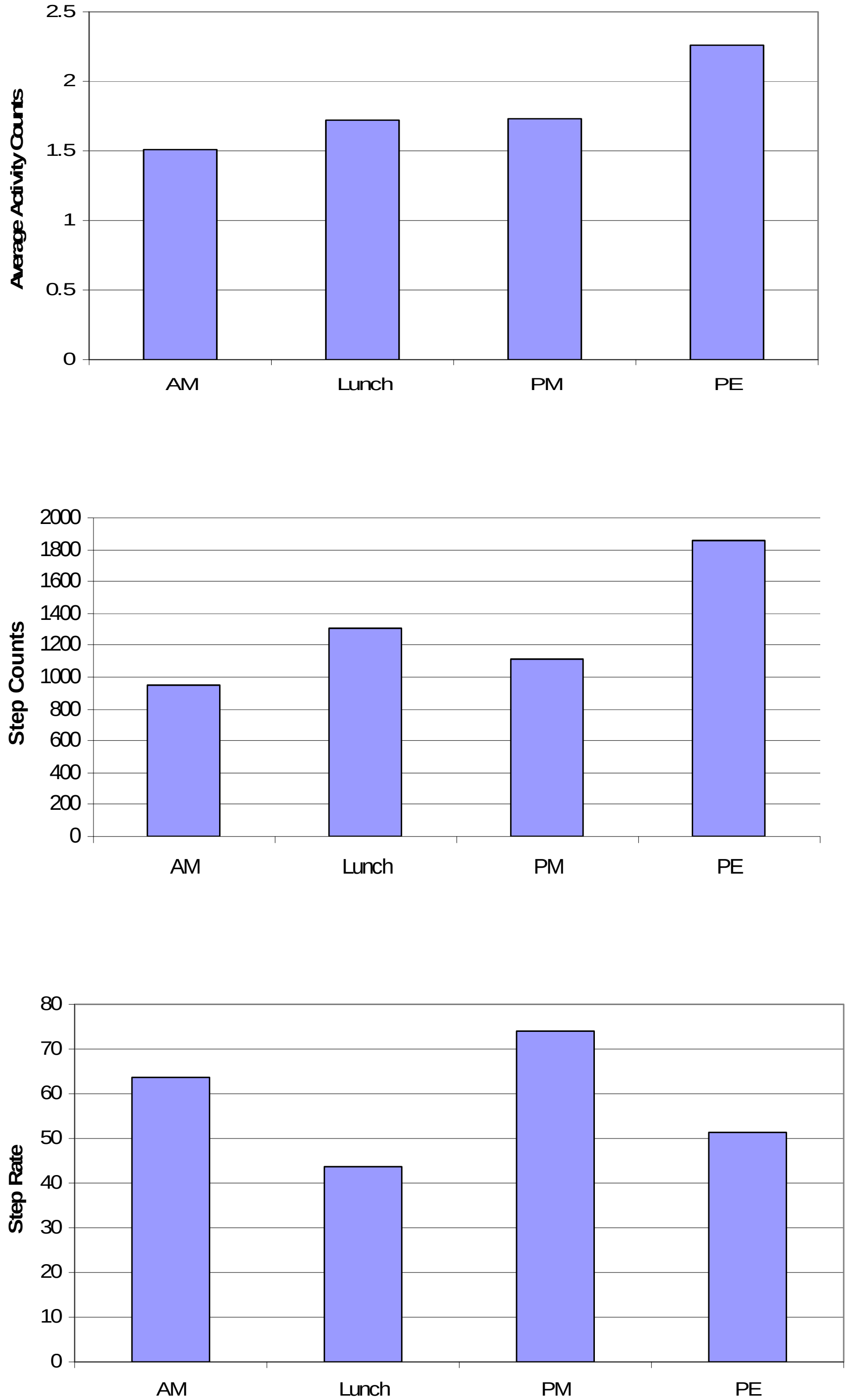


Figure 13. Accelerometer data as compared to pedometer data of the 17 subjects who had accelerometer data. Top panel displays average activity counts at each recess period, middle panel displays average step counts per period and bottom panel is average step rate (steps/minute) per period.

Potential for Intervention

Quartiles: In order to assess recess as an area of opportunity for PA intervention, it was important to determine the potential for PA in this setting. Daily step count quartiles were derived for each of the four periods based upon average daily steps for each child. The mean daily step counts for each quartile were as follows; Quartile 1: 6887 (SD 1834), Quartile 2: 9464 (SD 529), Quartile 3: 11524 (SD 907), and Quartile 4: 14975 (SD 1562). Figure 14, top panel illustrates the average step counts in each period, and the average steps for the bottom and top PA quartiles. The top quartile is the only class of subjects (N=18) that on average meets even the lowest daily step count guideline. By identifying the step count levels of the top quartile (i.e. the most active 25% of subjects) upper limits can be established for step count guidelines for unstructured recess.

PA Break: Previous research from our lab (Kozera 2006) looked at a Grade 3 class who had a daily 10 minute PA breaks built into their school day (on top of recess and PE). This break was measured by pedometry. When children spent the entire 10 minutes walking in the hallways or outdoors the average step rate was 100 steps/minute. This is almost 30 steps / minute higher than even the highest average step rate for a PA period collected in this study (PM recess averaged 71 steps / minute). This is striking as even in the most active PA period, PA levels at recess are still less than that of a 10 minute continuous walk. This may indicate that PA could be increased if children were to spend their recess periods continuously walking. For the purpose of comparison, the average time (in minutes) for each PA period was multiplied by the 100 steps/minute guideline to determine the number of steps a child might take by walking though the PA period. By having a scheduled walking program, the average PA levels could be higher than even those of the most active children (top 25%) without a walking program. Figure 14, bottom panel demonstrates the effect that scheduling a continuous walk at recess could potentially have on step counts. This shows that having a walking club or a scheduled, adult led group walk at recess could be an effective intervention. However this would take away from the free play aspect of recess, and would not promote high intensity activities. Of course, the intensity of activity is important to consider and it is overly simplistic to simply add a regular pace walking program as a means to address the physical activity requirements of children. Certainly, the limit set by the directed walking program provides additional insight into establishing step count guidelines and recess PA recommendations.

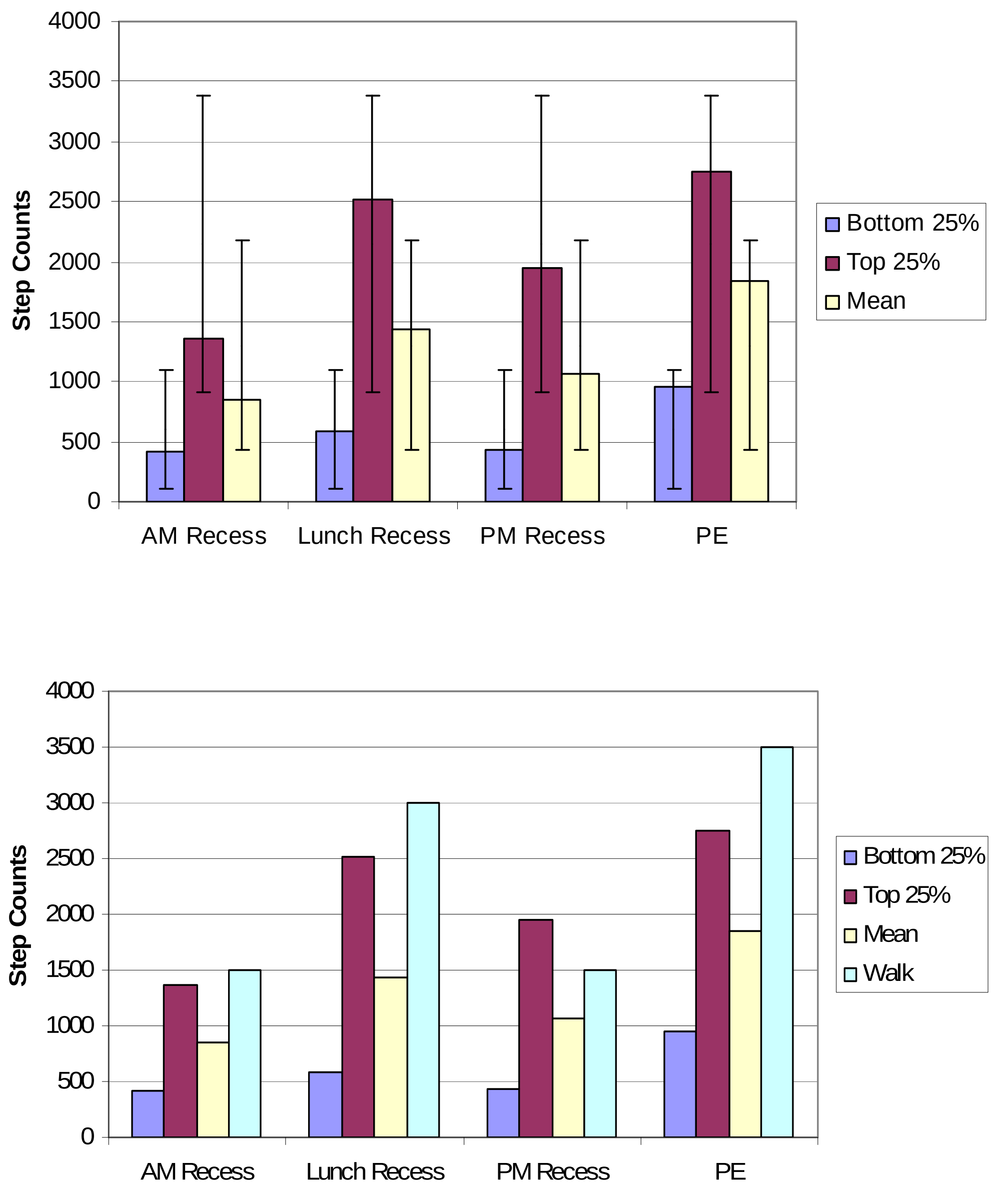


Figure 14. Upper limits of step counts during recess and PE. Top panel: Step counts (SD) for mean, upper and lower quartiles. Lower panel: same data as top panel but with the addition of bar reflecting a PA directed walking program at 100 steps/min.

Intervention

Baseline data collection clearly identified recess as an area in which PA intervention is not only plausible, but necessary. This data set revealed PA levels were lower than those required to provide optimal health (based on activity guidelines). Based on the top quartile of children by recess PA levels, there is also room to improve PA levels in this time constrained setting. The average daily step count for the bottom quartile was 6887, while the top quartile more than doubled this step count with 14975 average daily steps. Increasing recess PA can have a significant effect on increasing overall, daily PA.

Reaction to Intervention – Pedometry Data

The intervention was successful in increasing PA levels. The goal of the intervention was to increase step count goals by approximately 1400 steps per school day. Although the average change with intervention did not quite meet this goal, the intervention was effective in increasing PA levels at recess. There was an average increase of 985 steps throughout the PA periods with the recess PA intervention (total change during AM, Lunch, PM, and PE periods). The reaction to intervention ranged between a <u>decrease</u> of 4213 steps to an increase of 7772 steps per school day. Figure 15, top panel demonstrates the overall affect of the intervention, measured by school day step counts. The average change of school day step counts was an addition of 865 steps, which is slightly lower than the total reaction during recess and PE specifically (which indicates children were less active in the academic parts of the school day during the intervention day).

In order to understand how the intervention was effective, specific recess periods were examined. All recess periods had a positive change with intervention, meaning that PA was increased over all recess periods. When the effect of the intervention was further broken down, there was an average positive reaction to intervention at each of the three recess periods ($p < 0.016$). The largest change in step counts occurred during morning and lunch recess. This could demonstrate a "wash out" effect where the intervention was most effective earlier in the day and gradually decreased in effectiveness as the day progressed. More likely however, AM and lunch recess had lower PA levels at baseline, thus there was more room for improvement. PM recess was already the most active period at baseline, thus we see smaller increases with intervention. The same relationship between baseline and intervention are true regardless of whether step counts or step rates are represented. There was no carry over to PE, as there was no change from baseline PA levels ($p > 0.343$).

Figure 15 illustrates the difference between baseline and intervention step counts at each period (middle panel). Figure 15 illustrates the same graph but using step rate to represent PA (bottom panel).

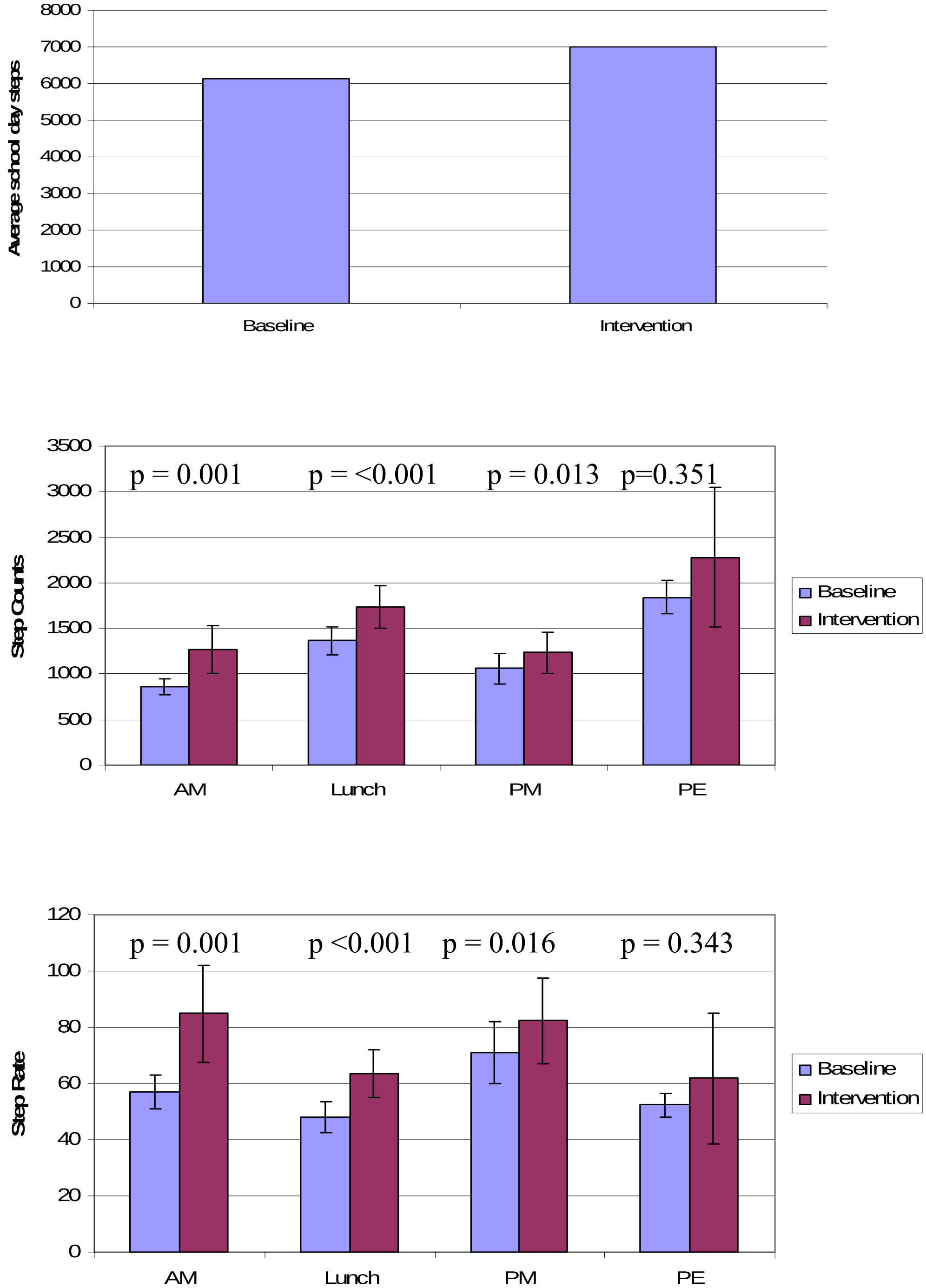


Figure 15. The effect of the intervention. Top panel displays the overall effect of school day step counts (p=0.02). The middle panel and bottom panel display the step counts and step rate (respectively) for each period.

Reaction to Intervention – Accelerometry Data

As noted in the methods, a subset of subjects wore accelerometers in addition to pedometers through out data collection. The accelerometer data with regards to the intervention effect echoes that of the pedometer data. The acceleration data also demonstrates an increase in PA at each of the three recess periods (Figure 16). PE was left out of this analysis as it was under powered for two reasons; small sample size (n = 17) and fewer periods measured. Unlike recess, PE was not a daily occurrence and therefore there were fewer periods to compare. Of the 17 subjects that had accelerometer data, not all of them had PE on the intervention day, therefore had no PE intervention day data.

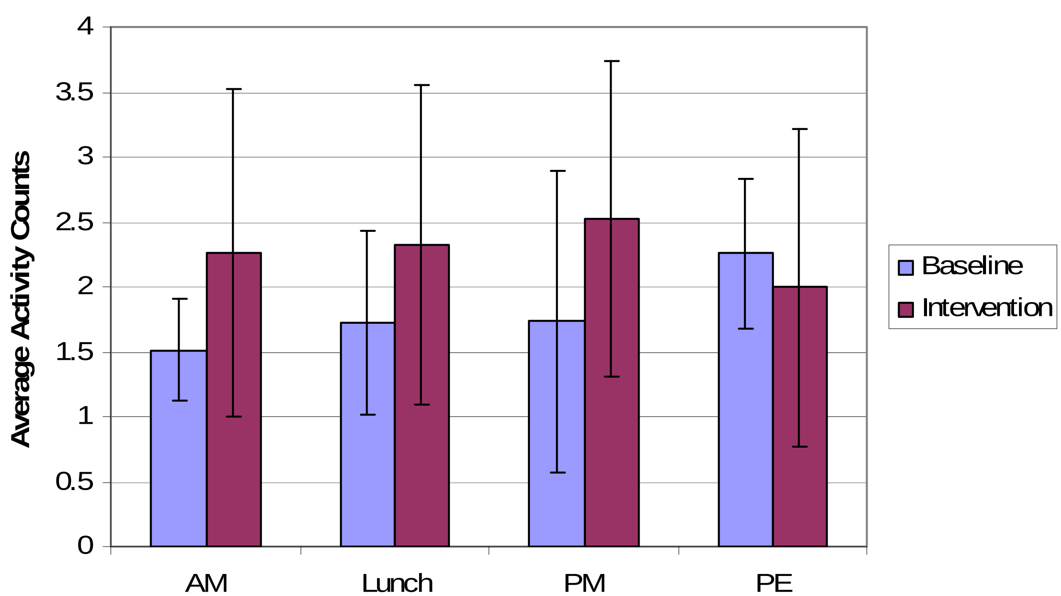


Figure 16. The change in activity counts with intervention (p= 0.018 (AM recess), 0.034 (lunch recess), 0.010 (PM recess), and 0.038 (PE)).

One advantage to using accelerometry is the capacity to measure intensity of PA. Regardless of using step count, step rate, activity count, or energy expenditure, there is a positive intervention effect. Thus the quantity of PA increased. As intensity has been suggested to be an important qualifier to the health benefits of PA, by looking at intensity of activity we can also examine the quality of the PA. By breaking down the PA into different intensities, we can examine how the intervention affected the intensity of PA. During intervention there was a shift towards higher intensity PA (> 3 kcal/minute). As recess is a time constrained period, there was a trade off where low intensity PA was exchanged for higher intensity PA. Thus, low intensity PA decrease and higher intensity PA increased. Figure 17 shows an example that during AM recess lower intensity PA

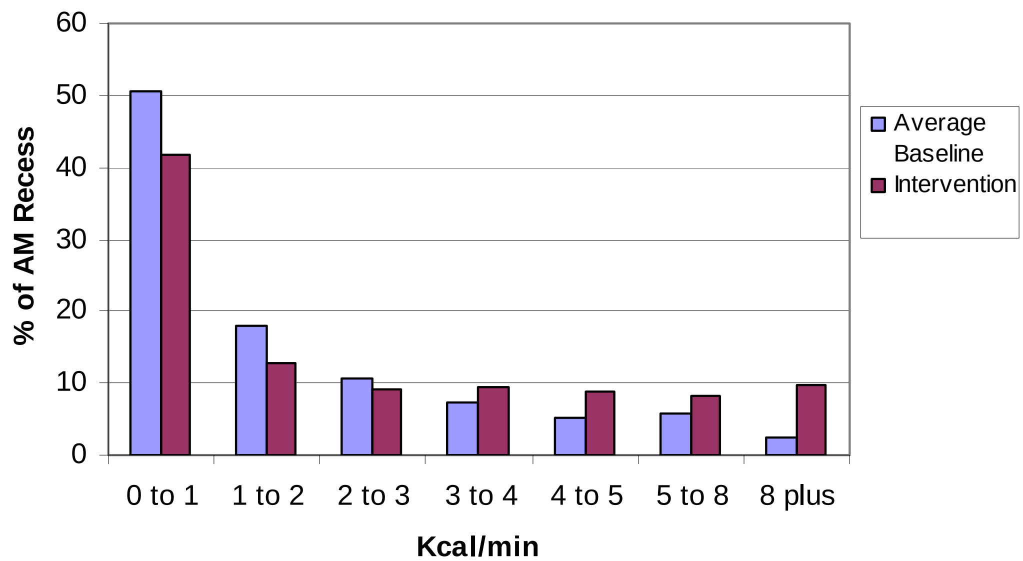


Figure 17. The shift of intensity of PA with intervention during AM recess; After intervention activities <3kcal/minute decreased concomitantly with an increase of activities ≥3kcal/minute.

Characteristics of the Reaction to Intervention

Although the average reaction to intervention was positive, there were subjects who did not react to the intervention (no change from baseline PA) and subjects that reacted negatively to the intervention (decrease from baseline PA). There was no significant difference between step counts on baseline days; however there was variation day to day in average school day step counts. Therefore a change from baseline of an increase of over 500 steps was considered a positive reaction. A decrease from baseline of over 500 steps was considered a negative reaction. A reaction that was not different from baseline steps by at least 500, was considered a neutral or no reaction. 52% of subjects reacted positively to reaction (gained 500 steps), 33% of subjects had no reaction to intervention (±500 steps), and 15% of subjects reacted negatively to the intervention (lost 500 steps). Figure 18 illustrates the break down of reactions to intervention.

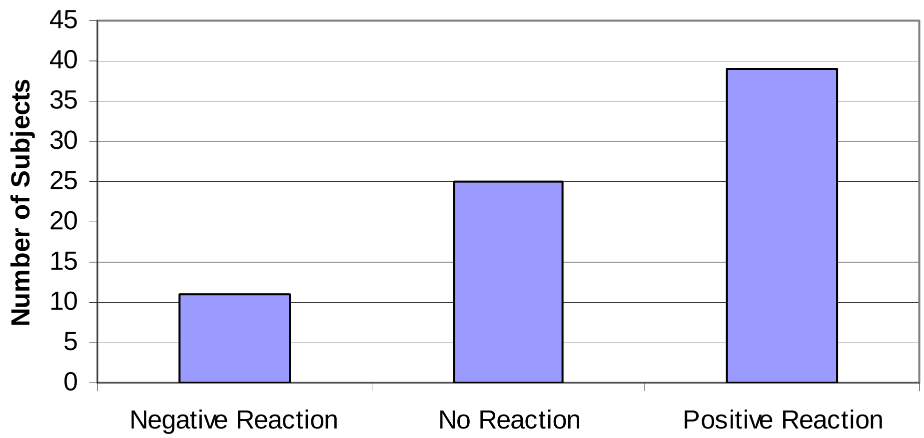


Figure 18. Distribution of the reactions (negative, < 500 steps; none, ±500 steps; positive, > 500 steps) to pedometer intervention.

In order to examine who reacted in which way, subjects were broken into several characteristic groups. To begin with subjects were broken into quartiles based on average daily steps at baseline (as described above). Thus the bottom (1^{st}) quartile were the least active children at baseline and the top (4^{th}) quartile were the most active children at baseline. The bottom quartile had the largest reaction to intervention when compared to the top quartile. Thus, because the top quartile was already active at baseline, there was less room for improvement during the intervention. Of note, the average change, even for the most active group at baseline is still positive. Figure 19 illustrates how the top and bottom quartile reacted to intervention.

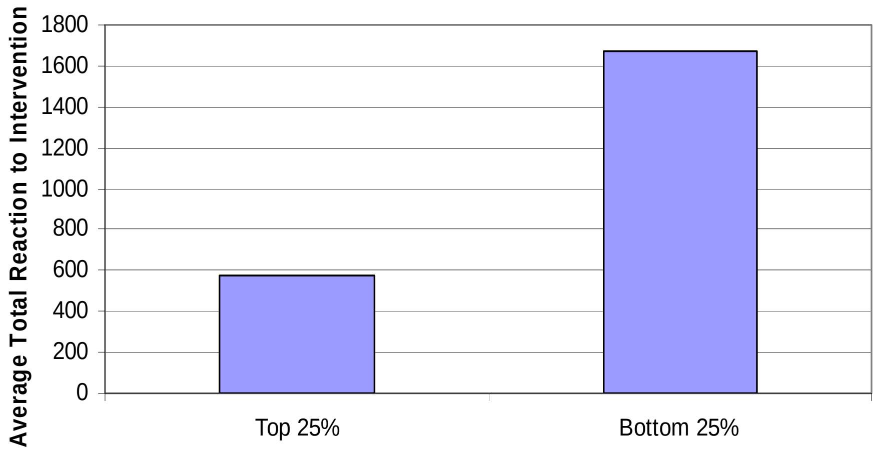


Figure 19. Comparison of reactions between top and bottom activity quartiles. Quartiles based on average daily steps at baseline.

As discussed previously, females are less active than males, both on a daily basis and on an individual PA period basis. As demonstrated, the pedometer PA intervention was most effective in circumstances where PA levels were low at baseline (i.e.: AM and lunch recess for all subjects and for those subjects with the lowest baseline activity levels). It was hypothesized during data analysis that because females were less active at baseline, they would also have a higher reaction to intervention than males, as there was more room for improvement. Subjects were divided into reaction quartiles, based on their total reaction to intervention. The lowest (1st) quartile had an average negative reaction to intervention (Mean: -928 steps). The second quartile, although a positive reaction, essentially had a neutral or no reaction to intervention when allowing for some day to day variability (Mean: +164). The top two quartiles had a positive reaction to intervention (Mean: +1280 and + 3324, respectively). These quartiles were further broken down into males and females and percentage of each sex in each quartile was represented. With the exception of the fourth quartile, females were right shifted, demonstrating that a higher percentage of females had higher positive reactions and a smaller percentage of females had neutral or negative reactions. Also with the exception of the fourth quartile, males meanwhile were generally left shifted, demonstrating that males were more likely to have reacted negatively or neutrally to the intervention. Interestingly, the fourth quartile was the opposite relationship, where there were a higher percentage of males than females.

Thus, although females had a greater tendency to react positively to intervention, their reactions were in the lower range of positive and did not make really large increases in PA. Males were able to achieve that large increase in PA. Figure 20 demonstrates the break down of reaction quartiles and sex differences.

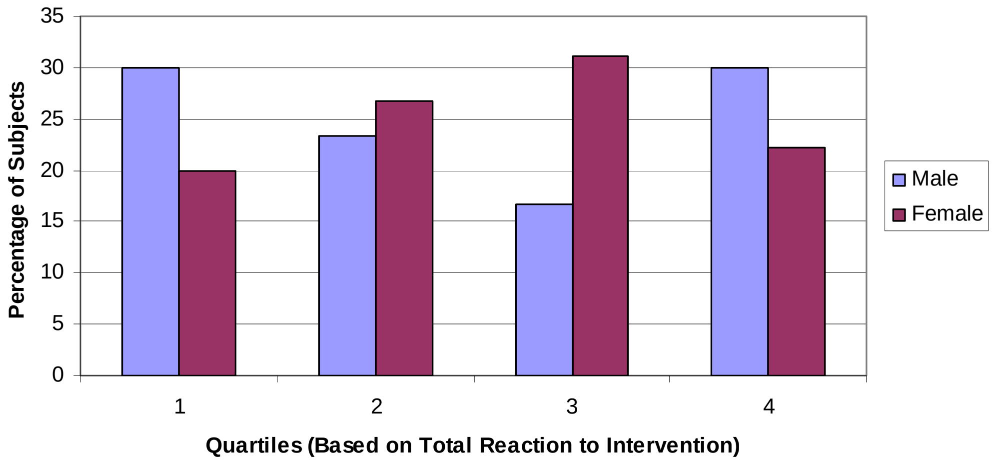


Figure 20. Distribution of males and females in reaction quartiles (quartiles based on total reaction to intervention). Average reaction of each quartile; Quartile 1: -928 steps, Quartile 2: +164 steps, Quartile 3: +1280 steps, and Quartile 4: +3324 steps.

Although there was not a strong relationship between body composition and baseline PA levels, further comparison was done to investigate whether body composition was a factor in how subjects reacted to the intervention. In order to determine whether the intervention targeted either overweight or healthy weight children, the reaction quartiles were further stratified by BMI and BF. The top quartile (highest positive reaction) and bottom quartile (average negative reaction) were used and average BMI and BF were compared. There was no difference in either BMI or BF between groups ($P = >0.234$). There for a subject's body composition did not determine whether they reacted positively or negatively to the intervention.

Although the intervention was successful at increasing recess PA, it was not to the same magnitude as hypothesized. To determine if a larger intervention effect was possible at recess, reaction to intervention was compared to the top quartile of children at baseline (quartiles based on average daily steps). The top quartile of children was still more active at baseline than the mean of the entire group during the intervention. This demonstrates what is possible for recess PA, and that there is still more room for improvement with intervention strategies. Recess PA can be increased further, beyond the scope of the intervention involved in this study.

Discussion

The primary aim of this study was to characterize recess and school based PA in Manitoba schools. As of late, much attention has been drawn to the growing need to increase physical activity in our society. The school system has been identified as an area where such interventions are required. However, the need to understand what physical activity exists, as well as the factors affecting PA in the school system precedes the goal of intervention and increasing PA levels. There is very limited PA data at recess that adequately describe recess PA and use methods to represent PA that are comparable to other or new studies. Thus far only two such studies exist for pedometer data and both were published in the warmer climates of the southern USA. Currently there is no Canadian data published that specifically describes recess, PE class and school PA.

The school day time frame is the most significant contribution to total daily PA (57.2% of total daily steps). The school day in Manitoba typically consists of four activity periods throughout the day; three recess periods and most often a PE class. Recess is the most important school day contributor to daily PA with over 30% of total daily steps occurring at recess. Although less than half of what recess contributes, PE class also contributes another 17% of total daily PA. Logically, the periods that have the longest durations (PE and lunch recess) have the highest step counts (1843 and 1364 respectively versus 1059 and 856 for PM and AM recess). However, even though PM and AM recess are the shortest duration periods, they also have the highest step rates (step count adjusted for time; 71 steps/minute and 57 steps/minute respectively, compared to 52 and 48 steps/minute for PE and lunch recess) indicating that the intensity of PA at during these periods are greater. The school day is the most important contribution to overall PA. Further more, recess is the most important part of the school day in providing PA to children.

A concerning fact revealed in this study is that only 37% of children in Manitoba met American based, warm climate step count guidelines. In comparison to other similar studies, Manitoban children are significantly less active than those from warmer climates where those studies were published. Although recess currently provides the most significant fraction of PA for children, it can be identified as an area of opportunity for intervention based upon comparisons to 1); most active kids, and 2); the short term pedometer intervention, 3); other studies, as well as comparisons to structured PA periods (See Figure 13 in results). Table 9 provides a summary comparing data between this study and the two other published studies recording recess pedometer data.

As noted, the one significant difference between this study and the others represented in Table 9 is climate. Both Tudor-Locke et al. 2006 and Beighle et al. 2006 published studies out of parts of the southern USA, known for its warm dry climates (Beighle, Morgan et al. 2006; Tudor-Locke, Lee et al. 2006). It is likely that weather conditions rarely, if ever interfered with recess PA. As we now know that the weather conditions experienced through much of Manitoba's school year have a detrimental effect on children's PA, Manitoban children are facing a PA opportunity disadvantage when compared to children residing in warmer climates.

As Manitoban children are consistently less active at baseline (far left column) than those from the other two studies (2 columns on far right), the need for intervention is identified. Isolating the most active (top 25%) of children, it becomes clear that substantive increases in PA are possible at recess. When effects of the intervention in this study are compared with the other studies (both are reported as baseline), it is evident that providing intervention brings Manitoban children to comparable PA levels as noted in the warmer climates. Children are not adequately active during the school day. This highlights the importance of providing recess and school based PA interventions in order to negate the detrimental effect that our climate has on school PA. As climate does play a negative role on PA for Manitoban children, we must provide them with increased opportunity and interventions to promote PA in order to narrow or eliminate the gap between them and children not facing such harsh, PA limiting weather conditions.

Table 9. Summary of Research on Recess and PE Step Data.

	Present Study Baseline N=75	**Present Study Top 25% N=18**	**Present Study Intervention N=75**	**Beighle et al. 2006 N= 270**	**Tudor-Locke et al. 2006 N= 81**
AM Recess					
Step Count	♂ 1084 ♀ 710 Average 856	♂ 1137 ♀ 1102 Average 1125	♂ 1307 ♀ 1153 Average 1271	**NM**	**NM**
Step Rate	♂ 72 ♀47 Average 57	♂ 76 ♀ 74 Average 75	♂ 99 ♀ 77 Average 85	**NM**	**NM**
Duration	15 minutes	15 minutes	15 minutes	**NM**	**NM**
Lunch					
Step Count	♂1711 ♀1135 Average 1364	♂ 2067 ♀ 1884 Average 2006	♂ 2001 ♀1594 Average 1738	**NM**	♂2521 ♀ 1913 Average 2123
Step Rate	♂ 61 ♀40 Average 48	♂ 75 ♀ 59 Average 70	♂ 74 ♀ 58 Average 64	**NM**	♂63 ♀48 Average 53
Duration	Average 30 minutes (either 25 or 35 minutes)	Average 30 minutes (either 25 or 35 minutes)	Average 30 minutes (either 25 or 35 minutes)	**NM**	40 minutes total period (includes eating) – no real PA time known
PM Recess					
Step Count	♂1231 ♀ 945 Average 1059	♂ 1456 ♀ 1060 Average 1324	♂ 1559 ♀ 1055 Average 1234	♂1262 ♀918 Average **NM**	♂ 1490 ♀ 1011 Average 1177
Step Rate	♂ 83 ♀ 63 Average 71	♂ 97 ♀ 71 Average 88	♂ 104 ♀ 70 Average 82	**NM**	♂78 ♀ 67 Average 78
Duration	15 minutes	15 minutes	15 minutes	15 minutes	15 minutes
PE					
Step Count	♂ 2078 ♀1725 Average 1843	♂ 2004 ♀ 2247 Average 2095	♂ 2802 ♀ 2015 Average 2277	**NM**	♂1429 ♀ 1410 Average 1417
Step Rate	♂ 58 ♀ 50 Average 52	♂ 58 ♀ 60 Average 59	♂ 79 ♀ 53 Average 62	**NM**	♂48 ♀ 47 Average 47
Duration	Average 35 minutes (either 30 or 40 minutes)	Average 35 minutes (either 30 or 40 minutes)	Average 35 minutes (either 30 or 40 minutes)	**NM**	30 minutes
After school Step Count	♂ 6028 ♀ 4735 Average 5237	♂ 7272 ♀ 6693 Average 7079	**NM**	♂ 7136 ♀5754 Average **NM**	♂7805 ♀ 5933 Average 6580
Total Daily Step Count	♂ 12,331 ♀ 9,439 Average 10,713	♂ 14944 ♀ 15037 Average 14975	**NM**	**NM**	♂ 16,421 ♀ 12,332 Average 13,746
Meeting Guideline Step Count	♂ 14.3% ♀ 22.7% Average 37.0%	♂ 33 % ♀ 100% Average 56%	**NM**	**NM**	♂ 54.7 % ♀ 53.6% Average

As it has now been identified that Manitoban children are not accumulating sufficient levels of PA throughout the day, but more specifically during school PA opportunities, it is imperative to determine the factors that affect PA during these periods. Some of these factors are modifiable, others are not. By understanding factors that affect recess and PE PA, it better prepares us to design effective interventions that we now know are indicated.

Sex also plays an important role on PA as males are more active that females throughout the entire day as well as each period through out the day, regardless of what is period are examined. Males are not only more active on a daily basis, both in and out of school (daily difference of 12331 steps versus 9439 steps for girls), but also during each individual PA period. The difference between sexes at recess and PE accounts for over half of the total difference (1588 steps compared to a total difference of 2648 steps through out the day). Therefore, by increasing females PA during recess and PE, the gap between sexes could be significantly reduced.

Although a higher percentage of females (22.7% versus 14.3% of males meet the BMI referenced step count guidelines (Tudor-Locke, Pangrazi et al. 2004), they also have higher BF ($p<0.01$). There was no difference in fat free mass. There was also no significant difference height between the sexes. There for the difference in adherence to guidelines between the sexes can not be attributed to a difference in stride length secondary to height differences. As this difference in body fat and PA exists, this may support the argument that sex based PA guidelines are not warranted. Arguably, females in this sample are not healthier even though on average they are more successful in meeting step count guidelines.

Although these sex specific step count guidelines have been used in the past, the results of this study suggest that they be re-examined in their applicability to generalized samples. Future studies that report on daily step counts should also report step counts based on percentage of subjects meeting these guidelines. This would assist in determining the practicality of these guidelines. There is potential for the lower guidelines for females to send an inappropriate message that females require less PA regardless of body composition or height. The results of this study suggest that a universal step count guideline should be used for both males and females. All subjects should be given the target of 15,000 steps/day, regardless of sex. Although this study is underpowered to determine that these sex specific guidelines are inappropriate, this is an area that warrants further research.

Although sex appears to have an affect on both body composition and PA in which females have higher body composition and lower PA levels, PA levels themselves are not related to body composition. This means that in this sample, PA levels do not predict body composition or visa versa. This may indicate that PA does not yet have an impact on body composition in this age group. Further investigation is warranted in examining the relationship of body composition and PA in pre-pubescent boys and girls.

It has already been suggested that the climate of Manitoba also had a significant impact on overall PA. Inhospitable weather conditions often prevented outdoor play at recess and this was associated with a significant decrease in PA. In this sample of subjects, recess was held indoors when it was deemed that the weather was too wet or cold to be outside. Also in the winter months, recess is held indoors if the wind chill is greater than -35°. PA during indoor recess was very low. Both wind chill and snow cover also had a negative impact on PA. Never before has the impact that weather conditions in Canada have on recess PA been examined. As a significant number of days during data collection were under snow cover (52%), this is a real explanation to why Manitoban children are less active than their cohorts in warm climates. Both step counts and step rates were significantly lower during indoor recess compared to outdoor recess. Of note, although indoor PE classes were less active than outdoor PE classes, a much smaller difference was observed when compared to in and outdoor recess. This speaks to the fact that the structured nature of PE class ensures higher levels of PA, regardless of whether it is held indoors or outdoors. This may also indicate that use of the gym facilities during indoor periods may also increase PA.

Although previous research has suggested that there are no seasonal differences in recess PA (Ridgers, Stratton et al. 2006), this has never been investigated in a climate such as Manitoba's where there is a wide range in seasons. Unlike other published data, Manitoba experiences weather that makes outdoor play a challenge and even prevents it at times. Having indoor recess significantly decreased the amount of PA, as children were generally confined to quiet activities in the classroom. Indoor versus outdoor recess was highly predictive of recess step counts. Further more, wind chill and snow cover was also predictive of recess step counts. Therefore this study demonstrates that Manitoba's climate does have a detrimental impact on PA.

Consistent with other pedometer literature, there was no variation between school days (p >0.103). However, the subjects participating in this study appear to be less active than comparable samples reported in other studies. When comparing average weekday step counts between studies, several studies report higher step counts. Duncan et al 2007, Duncan et al 2006, and Tudor-Locke et al 2006 all report higher daily step counts of 13,827, 15,085, and 13,746 respectively (Duncan, Schofield et al. 2006; Tudor-Locke, Lee et al. 2006; Duncan, Schofield et al. 2007). These step counts are significantly higher than the average step count of 10,713 reported in this study. On a whole, only 37% of subjects in this study met the BMI referenced step count guideline, compared to over 50% of subjects reported by Tudor-Locke et al 2006. As suggested above, the low PA levels of the subjects in the current study may be explained by weather characteristics.

Weekday PA levels are higher in comparison to weekend PA (Duncan, Schofield et al. 2006; Duncan, Schofield et al. 2007). This may lead us to believe that school day PA contributes significantly to total daily PA, as for children that is the primary difference between weekdays and weekends. Consistent with this thinking, school day steps overall do contribute significantly more to daily PA than out of school steps (6214 steps and 5237 steps respectively, p = 0.008). This confirms the important role school plays to children's PA levels. Although weekend PA has consistently be shown to be low, thus making a prime window of opportunity for intervention, there are also more barriers associated with weekend PA interventions. Typical barriers to PA such as socioeconomic class, parental or family attitudes towards PA and access to facilities need to be considered during weekend PA interventions. These barriers however are not such a factor for recess interventions, thus making recess interventions easier to facilitate.

We also must describe PA based on period of PA opportunity. In this sample there was a discrepancy between durations of PA periods between the two schools involved. School 1 had approximately 140 minutes more PA time over the four days of baseline data collection. As one may predict, this resulted in more PA for School 1 (1940 more steps per day). Although there may be other differences between students of the two schools, this discrepancy in PA can be further examined, revealing that this difference occurs during school hours. Within the school day, there are several differences between schools; lunch recess duration, PE duration, and frequency of PE. The most significant difference in PA between schools can be attributed to PE classes, specifically daily PE, as it provided approximately 120 minutes per week more PA for one school. Thus this study has shown that having daily PE provides significantly more PA. Providing sufficient PA opportunities on a daily basis is rewarded with an associated increase in PA levels.

As one school had longer durations of PA throughout the day, which was associated with increased PA, an improved body composition might be expected for students of that school. Although the difference between schools was not significant, there was a trend in the right direction; in that the school with longer durations also had lower average BMI and BF. This suggests a slow gain; that increasing duration of PA periods may potentially improve body composition over time. However, as the majority of subjects in this study could be expected to have attended the same school for at least one to six years, duration alone is not enough to significantly improve body composition in Manitoban children. This displays the importance of intensity of PA in providing interventions. Duration alone is not enough to make a significant difference in PA; intensity must also be increased in order to see real change.

The importance of durations of PA periods through out the school day is however a crucial piece of information for school boards and programmers. As of late, recess and PA times have been decreased in favor of more academic teaching time. This data suggests that restricting PA time during the school day can have a detrimental effect on overall PA. Children do not compensate by increasing PA later if it is restricted during the school day (Dale, Corbin et al. 2000; Kozera 2006). Therefore if children are not provided adequate opportunities to be active during school, they will not accumulate adequate levels of PA.

The comparison of PA during different school day periods is difficult as their durations vary between periods and between schools. However, using step rates (steps/minute) controls for time differences and allow for direct comparison in order to determine the most and least active periods. PM recess had the highest step rate 71 (steps/minute), followed by AM recess (57 steps/minute), PE (52 steps/minute) and finally lunch recess (48 steps/minute). In the discussion of duration above, duration has been used to describe overall minutes of PA in a day, achieved both through longer periods and added periods. Essentially, adding more minutes of PA opportunity results in more PA. However through the comparison of PA periods, we can see that shorter duration periods (PM and AM recess, both 15 minutes in duration); actually have the highest volume of steps. Children are most active during short periods. There for the most effective way to add more PA during the school day may be to add another short period (approximately 15 minutes), rather than extending existing periods as this would involve higher intensities of PA.

Much emphasis has been put on the goal of offering daily PE in Manitoban schools. This study has demonstrated a positive effect that daily PE has on overall PA, however this increase in PA is not sufficient to provide adequate levels of PA; the effect is positive but not large enough. Daily PE is effective in increasing PA levels, however recess has been largely overlooked as an area either for existing PA or adding extra PA. Little is known in the comparison of recess and PE. Tudor-Locke found that children took more steps during a lunch recess (2133) compared to PE class (1417) (Tudor-Locke, Lee et al. 2006). In this study, PE was a 30 minute period and lunch recess did not have a specific duration of PA time (varied between subjects). In the current study, we found children took more steps at PE than at lunch recess (1843 compared to 1364 at lunch). The difference was attributed to duration (as PE was typically 10 minutes longer than lunch recess), although this does not explain the different findings of Tudor-Locke. However, when the whole of recess (AM, Lunch, and PM) is compared to PE, we find that recess contributes twice as much daily PA than PE does (31% versus 17% of total daily PA). This identifies recess as an important provider of daily PA, and it is in fact, the period of the school day that contributes most to daily PA.

Another important aspect of this study was the ability to compare two objective measures of PA measurement in children; accelerometry and pedometry. There was only a moderate correlation between pedometer data and accelerometer data. This highlights the difficulties in objectively measuring PA in free living children. Both accelerometers and pedometers have limitations in free living and the results of this study confirm the need to use more than one measure of PA in such situations. As of yet, there is no practical, affordable gold standard of measurement tools in measuring free living PA in children. There for using two forms of PA assessment may assist in eliminating some error in one measurement device alone. These devices specifically lack capabilities of accurately assessing non-loco motor activities which do occur at recess (Welk, Corbin et al. 2000).

Thus far, this is the only study to compare to objective measures of PA in truly free range PA in children. There are no other studies that compare pedometer to accelerometer data in children in complete free play settings. The only moderate correlation between these two data sets is expected as this is only the beginning of this research area. This correlation should improve with further research as techniques are perfected.

Although it was beyond the scope of this study to validate segmented pedometry as a measure of intensity, it is evident segmented pedometry and step rate adds to the understanding of activity patterns and allows for comparisons of PA periods. Accelerometer data did provide specific information regarding intensity of PA in that the majority of recess PA is spent in low intensity PA. This data shows that there is room for improvement in recess PA, specifically in the addition of higher intensity PA.

The secondary aim of this study was to determine the effect that a one time pedometer based intervention had on recess PA. Overall the intervention was successful with an average increase of 985 steps over the four PA periods. Although the mean reaction was positive, not all of the subjects reacted positively to the intervention. There was a range of reactions from a decrease of 7772 steps to an increase of 4213 steps. Overall, 52% of subjects reacted positively (gained more than 500 steps), 33% did not react to intervention (± 500 steps), and 15% of subjects reacted negatively (lost 500 or more steps). The accelerometer data demonstrated that the intensity of PA was increased during the intervention. This is logical as recess is time constrained. The addition of more PA is only possible when sedentary activities took place (replace sedentary time with active time). Otherwise, subjects were forced to change their low intensity PA into higher intensity PA. One must increase intensity as duration is not possible when time is fixed.

Average PA increased at each of the 3 recess periods. The least increase was at PM recess which could indicate a wash out effect or perhaps as PM recess had the highest PA levels at recess, there was less room for improvement. As AM and lunch recess had lower PA levels at baseline, it was easier for subjects to add activity in these periods. The sex based differences also fits with the argument that the intervention was most effective in areas that PA was low at baseline. A higher percentage of females reacted positively to intervention compared to males. Generally females were less active at baseline. Males were more likely to react negatively or not at all. In general, there was a negative relationship between baseline PA and reaction to intervention. The subjects who were least active at baseline were more likely to have a strong positive reaction to intervention than those already active at baseline. This indicates that the intervention was most effective at increasing areas of low activity; either by period or by subject. Perhaps it is more difficult for those who were already active at recess to add more activity with this form of intervention.

The intervention was primarily recess focused. The goal that was portrayed to the subjects was to increase recess step counts. Interestingly, there was no change in PE step counts. This may indicate that the intervention was specific to the targeted period and there was no carry over to other periods. However, because PE is a structured and instructed period, it is also possible that the regiment of the class did not allow enough flexibility for children to increase their PA. When the effect of intervention was examined for just the PA periods, there was an increase of 985 steps. When the effect of intervention was examined for the whole school day, there was an average increase of only 865 steps. This indicates that although children were more active at each PA period, they actually decreased PA at other points of the school day, primarily class time. This may support the train of thought that children are able to concentrate and function more effectively during the school day when they receive adequate PA.

The accelerometer data demonstrated that there was an increase in intensity of PA with the intervention. Lower intensity activities were replaced with higher intensity activities. This trade off occurred at approximately 3 kcal/minute. Of note, in studying a directed walking program reported by Kozera in 2006, the walking program would demonstrate an increase of activity at 3-4 kcal/minute, but activity would be capped off at this point. There would not be any activity above this intensity. Although with this intervention, the average intensity is lower than this, we are seeing spikes of activity up to 8 kcal/minute. Although these spikes of intensity are not maintained, it is encouraging as it is possible that as PA increased over time with this intervention we would potentially see a greater percentage of recess engaged in MVPA. This would not be possible with a directed walking program, even though at present the average intensity may be higher for the walking program – it is not capable of achieving high intensity PA.

There are several practical limitations to providing recess PA interventions based on school policy. Primarily safety concerns have had a large impact on recess PA as it is now influenced by strict safety regulations. There are many guidelines for safe equipment and any play that may potentially result in injuries are often discouraged. This limits the number of activities available to children even though the relative risk for injury is low. Many schools also have regulations that at least part of the playground be wheelchair accessible. This often limits MVPA in these areas for able bodied students (for example large platforms on play structures on which children often congregate). Secondarily is the strong anti-bullying role of playground supervisors that limits the impact these supervisors may have in promoting PA. And lastly, it is not uncommon for schools to have strong inclusion and non-competitive imperatives. Schools are beginning to ban competitive activities such as tag and competitive sports to avoid children having to lose. Schools often dislike incentive programs, unless the incentive is offered to the class on whole to avoid children being left out. All of these aspects of the modern school not only hinder existing PA but can potentially be limiting factors to recess PA interventions.

Although the intervention was successful, it did not exceed the example set by the most active children at baseline. The top 25% of children at baseline were still more active than the entire group during the intervention. This demonstrates that there is still room for improvement and that this intervention while successful did succeed in tapping the full potential of the recess period. This solidifies the importance of recess intervention as the majority of children appear to require motivation to capitalize on the recess opportunity.

Objectives & Hypotheses - Answered

Recess and PE Characterization

1. *Objective:* Examine day to day variation in step counts. *Hypothesis:* There will be no differences in step counts between days.

- This was answered by ANOVA comparison between daily step counts. There was no difference in baseline days. Refer to Figure 3.

2. *Objective:* To examine the impact of weather on step counts. *Hypothesis*: Decreased temperature will be associated with decreased steps.

- This was answered by correlation between indoor and outdoor recess and weather characteristics to step counts. Indoor recess, wind chill and snow cover were associated with decreased step counts. Refer to Table 7 and Figure 10.

3. *Objective:* Compare morning, lunch and afternoon recess PA levels (steps, step rate). *Hypotheses*: There will be no difference in morning, lunch, and afternoon recesses in step rate. The step count will be proportional to duration.

- This was answered by computing and comparing average step counts and step rates of each period. Step counts were proportional to the duration of the period. Step rates were not equal between periods, and shorter duration periods (AM and PM recess) were associated with higher step rates, there for PA intensity was higher for shorter duration periods. Refer to Figures 6, 7, and 8.

4. *Objective:* Compare recess to PE. *Hypothesis:* Recesses will have higher step rates, higher step counts than PE.

- This was answered by computing and comparing average step counts and step rates of each period. Step rates were higher at recess than PE and step counts were proportional to duration of period. Recess contributed twice as much daily PA when compared to PE. Refer to Figures 6, 7, and 8.

5. *Objective:* Examine the influence of body composition on PA. *Hypothesis:* There will be an inverse relationship between PA and body fat or BMI.

- This was answered by correlation between body composition (BMI and BF) and average daily step counts. There was no relationship between body composition and PA.

6. Objective: Correlate steps and step rate to accelerometer energy expenditure to determine if step rate is a valid measure of the intensity of PA in free playing children. *Hypothesis*: There will be a linear relationship between pedometer step rate and accelerometer energy expenditure level.

- This was answered by correlation of pedometer data to accelerometer data. There was moderate linear relationship between pedometer data and accelerometer data with outliers mostly explained by the equipment's limitation in quantifying non-loco motor activity. Using step rates is useful in comparing PA periods and relative intensity of PA. Refer to Table 8 and Figure 11.

Pedometer Intervention

6. *Objective:* To examine the effect of a short-term PA intervention during recess/PE. *Hypothesis:* PA will be greater during recess as a result of intervention. No effect will be demonstrated for PE.

- This was measured by paired T test of average baseline PA data and intervention PA data as well as repeated measures ANOVA. The intervention was effective in increasing recess PA by an average of 985 steps. The intervention was effective for each recess period and there was no effect for PE. PA intensity increased with intervention. Refer to Figures14, 15, and 16.

Conclusions

As Manitoban children are now known to be considerably less active than their cohorts from other climates, it is evident that interventions are needed. This study has confirmed the need to increase PA during school time and recess. When recess is left unaltered and unstructured, children are not adequately active. There for is necessary to intervene in order to provide sufficient PA.

Recess is a significant part of daily PA in children. Currently Manitoban children are not adequately active during recess of the rest of the day. This is potentially due to the harsh climate we experience for the majority of the school year as children from warmer climates are significantly more active. Although PE also contributes to a significant amount of PA, it is less than half of recess' impact. One possible method of increasing children's PA is to change PE to a PA class where the focus is put on providing actual PA and intensity of PA during the class. However, PE is also important as a skill based class in order to provide children with the skills and confidence to pursue lifelong PA. By providing interventions at recess, PE can retain the instructional component without pressure to change it to a PA class in order to increase daily PA. Although overall Manitoban children's PA levels are disappointing in comparison to their cohorts in other parts of the world, there are children who do capitalize on recess PA opportunities and are comparable or even exceed children from warmer climates. These children should act as a benchmark to what is possible and necessary to achieve in Manitoban recess.

This study has demonstrated that recess based PA interventions are effective and warranted in this population. Recess is a "window of opportunity" for PA in children. Currently it does provide a significant amount of daily PA for children, however it needs to be further explored for intervention as Manitoban children's PA is not adequate. Recess equivocates to approximately one hour of unaltered, untapped activity time for children. By providing PA opportunities and shifting the focus of recess from a "break from class time" to a "PA break", significant improvement in overall PA can be made. Recess is a unique PA prospect as it one of the only "free play" opportunities children have in which they are surrounded by their peers. Children are typically left to choose their own peer group and activities and the adult supervision role is limited to ensuring safety and playground manners. However, it is now evident that most children appear to require motivation to take advantage of these PA opportunities at recess. We now know that PA interventions that do not take away from the "free play" aspect of recess are also possible, and pedometers can be effective motivating devices.

Increasing overall PA through recess can lead to positive effects on the health of Manitoban children and reduce their risk for disease. There is also evidence that their function during the academic portion of the school day improves when recess PA is improved. Although this intervention had a positive effect, there is still room for further improvement, and the long term effectiveness of intervention needs to be determined.

Recommendations

There are several purposed options of providing this additional PA. Providing game equipment and using multi-coloured playground markings have already been shown to increase recess PA (Stratton and Mullan 2005; Verstraete, Cardon et al. 2006). Kozera's data has also suggested that having a facilitated PA period is also an effective way of increasing PA. This may be achieved by either adding an extra PA period or by converting a recess into a PA period. Further more, this study has demonstrated that pedometer based interventions are also effective at recess. With several options for interventions available now in literature, school boards, schools, or individual teachers have the opportunity to choose their route of intervention. However, the results of this study may provide further information into the most effective route of intervention for PA.

1. Pedometer based recess PA interventions.
    a. Step count goals.
    b. Activity intensity substitutions.
    c. Incorporate in class / academic portions of school day (ex; geography lessons, math skills etc.)

2. The addition of a facilitated, semi-structured PA period.
    a. Adding an extra short duration period (as the highest intensity of PA occurs at short duration periods).
    b. Converting a recess or part of recess into a PA period.
    c. Converting a portion of PE into a PA period (having a mandatory short duration (10 minutes) MVPA period during PE class).
3. Employing a trained recess facilitator to promote PA during recess.
    a. Balance the role of behavior modifier (anti-bullying) and PA enhancement or promotion).
    b. Balance the non-competitive initiative employed by many schools with PA enhancement.
    c. Maintain the sex based differences in preferred play, while increasing PA for both sexes.
4. PA programming or provision for indoor recess.
    a. Access to gymnasium and other PA facilities.
    b. Structured / semi-structured activities in the classrooms.
    c. Indoor walking programs.
    d. Having older students facilitate activities indoors.
5. Enforcing proper outdoor clothing as to not limit opportunities to play outdoors.
    a. Warm and/or water proof outerwear.
    b. Proper footwear that does not inhibit play, specifically for females.

Limitations

A limitation of this study is that it may not be appropriate to generalize to other age groups or geographical regions, specifically with different weather characteristics. As school based PA appears to be somewhat specific to each individual school depending on schedules, equipment, rules, etc specifics of this data may not translate to other schools. There is also the possibility that having the research staff present during data collection, PA may have been artificially increased. Further more, due to equipment limitations; the accelerometer data is somewhat underpowered as only 17 subjects wore accelerometers. The accelerometry data in this study serves as a good check for the pedometer data, however in order to derive specific accelerometry parameters for recess, more subjects are required.

Future Studies

Future studies in this area should investigate the effect of Manitoba winters have on recess PA. This study demonstrated the negative effect weather has on recess activity levels, however the weather conditions in this study were relatively mild compared to what is possible in this Manitoban climate. The long term effect of adverse weather conditions and indoor recess should be characterized. Implementing an indoor recess PA intervention would be also be worthy as this study has demonstrated the significant decrease of PA when students are kept indoors.

The long term sustainability of a pedometer based recess intervention needs to be determined prior to its promotion for widespread use. As it is a relatively simple and cost effective intervention technique, it is possible for schools to use pedometers as a long term intervention to promote and increase school based PA.

Further more a study that combines objective measures of PA with direct observation would be helpful in determining what types of play and activities children engage in at recess. This information would be useful in the design of future recess interventions as well as for schools when selecting playground equipment.

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