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ORIGINAL RESEARCH

Physical Activity Among Canadian Children on School Days and Nonschool Days

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Background: Schools are frequently cited as a favorable venue to promote physical activity (PA), however little data exist describing times when students are least active. Our objective was to overcome this limitation and describe time periods when students are least active. ***Methods:*** We used a cross-sectional design to assess patterns of PA in 923 grade 5 students [mean age: 10.9 (± 0.4) years] from 30 schools in Alberta, Canada. Students wore time-stamped pedometers for 9 consecutive days, providing 7 full days of data. We compared step counts adjusted for nonwear time between school days and nonschool days as well as during school hours and after school hours. ***Results:*** 689 (75%) students provided complete data. The average daily step count was higher on school days (boys 13,476 ± 4123 step/day; girls 11,436 ± 3158 steps/day) than nonschool days (boys 11,009 ± 5542 steps/day; girls 10,256 ± 5206 steps/day). More steps were also taken during school hours than nonschool hours (boys +206 ± 420 steps/hour, $P < .001$; girls 210 ± 347, $P < .001$ steps/hour). ***Conclusions:*** PA levels of children are below Canadian recommended levels for optimal growth and health. Health promotion should emphasize PA particularly among girls, outside school hours, and weekends.

Keywords: pedometer, childhood obesity, public health

Regular physical activity (PA) has beneficial effects on reducing obesity and improving health.[1–3] Despite these benefits, the majority of Canadian children do not meet the recommended[4] 60 minutes of moderate-to-vigorous PA or 13,500 steps daily.[3,5,6] Population-based studies show that 26%–29% of Canadian children and youth are overweight or obese.[7,8] Because overweight in childhood often persists into adulthood, a rising number of children are at increased risk of obesity and consequent chronic disease.[9,10] Increasing PA levels among children is therefore a public health priority.

Schools provide children multiple opportunities for PA throughout the day. As children spend substantial time at schools, they are considered an ideal environment to implement interventions to increase PA. Although schools provide guaranteed opportunities for PA through physical education and recess, its remains unclear if the majority of children's PA is achieved during school hours. While some studies have noted significantly higher levels of PA after school hours,[11–14] others have not.[15–17] Discrepancies between studies can be explained by several factors, including study design, duration of observation, climate, and method used to assess PA. Several of these limitations can be overcome by recording hourly records of PA on both weekdays and weekends in robust samples of children during seasons in which weather is less of a barrier to PA participation.

The purpose of our study was to resolve previous studies by assessing PA objectively using time-stamped pedometers over the course of a typical week with measurements in a population-based sample of youth during the spring months of the school year. We hypothesized that PA would be lowest during the windows of time that students were at school.

Methods

Study Design

The Raising healthy Eating and Active Living (REAL) Kids Alberta is a population-based study of grade 5 students age 10–11 in Alberta, their parents, and their school principals.[8] In 2008, the REAL Kids Alberta survey included 148 randomly selected schools from across the Canadian Province of Alberta. In 2009, we selected and invited 20 of these 148 schools, located in the city of Edmonton and surrounding areas, to participate in an additional survey. In addition, we invited grade 5 students from 10 schools participating in the Alberta Program Promoting active Living and healthy Eating Schools (APPLE Schools).[18] In this survey, we objectively measured hourly step counts using time-stamped pedometers. Details of the projects and survey tools are accessible through www.realkidsalberta.ca and www.APPLESchools.ca. The current study, including data

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collection and parental informed consent forms, was approved by the Human Research Ethics Board at the University of Alberta.

Participants

We invited 1271 parents of grade 5 students to provide their informed consent for their children to participate in this survey. A total of 984 (77%) requests were returned, with 975 (99%) granting consent. Of the students whose parents provided consent, 973 (99%) students assented to participate (Figure 1).

Outcome Variable: Physical Activity

We used Omron HJ-720ITC (Ontario, Canada) pedometers to measure PA objectively in the form of hourly step counts recorded over a period of 7 days. Hourly step counts allows for more precise evaluation of patterns of PA throughout the day. The Omron pedometer also features a 41-day storable memory and is automatically reset at midnight; thereby eliminating the need for participants to record their step counts at the end of each day. In addition to recording steps, this pedometer has a sensitive motion detector, which indicates through a binary variable whether it was worn. This feature allowed us to distinguish periods of sedentary behavior from nonwear time providing a more objective record of student compliance with wearing the pedometer. The accuracy and validity of the Omron pedometer has been demonstrated under various conditions.[19–21]

We instructed students to wear the pedometers for 9 consecutive days. We chose not to include records from the first and last day in our analysis due to differing administration and collection times, along with any potential reactivity to wearing the pedometers.[22] We asked children to wear the pedometer during all waking hours unless showering, swimming, or taking part in activities in which an adult deemed unsafe to wear. We directed students to wear the pedometer on their right hip directly in line with their right knee. Students were also asked to keep a log of their daily activities including the duration and whether the pedometer was worn in an activity log (available at www.realkidsalberta.ca).

The evaluation assistants returned to schools on the third day of data collection to encourage students to wear the pedometers and to complete their activity logs. On the ninth day, research staff returned to the schools to collect pedometers and download the data to computers. Nine hundred and twenty-three (95%) pedometers were returned, providing crude hourly step counts; 50 (5%) pedometers were lost or malfunctioned.

We considered a pedometer recording to be complete when a pedometer was worn for a minimum of 8 consecutive hours per day.[23] To be included in our analysis we required students to provide valid pedometer recordings on at least 2 school days and 1 nonschool day (weekend and/or holiday).[24] Based on these criteria, we included 689 (75%) students in our analysis (Figure 1).

Confounding Variables

Evaluation assistants measured standing height to the nearest 0.1 cm using stadiometers (Seca Stadiometer, Germany) and body weight to the nearest 0.1 kg on calibrated digital scales (Health o meter, model 320KL, IL, USA). Students removed their shoes for both measurements. With parent consent and student ascent, evaluation assistants visited the participating schools to administer a background survey on lifestyle behavior.

Data Processing

Although pedometers measure ambulatory activity, they do not accurately capture energy expenditure from activities such as biking, skating, and skiing. Because Canadian children and youth report similar participation rates between both ambulatory activities and nonambulatory

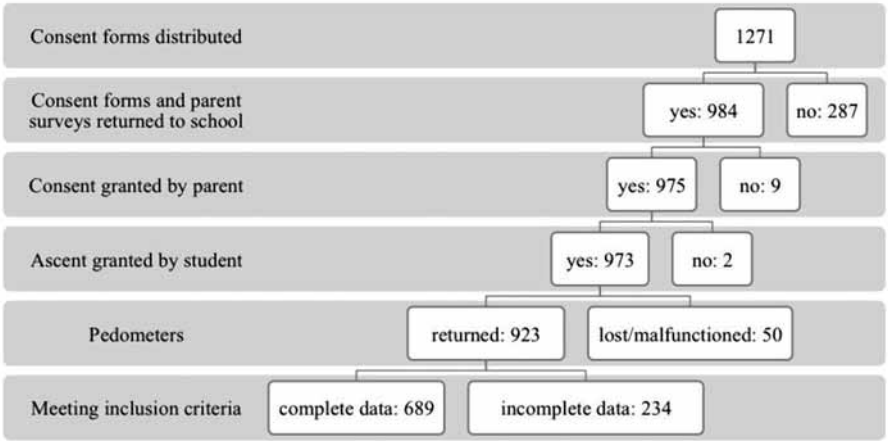

Figure 1 — Description of enrollment of grade 5 students in the study and their pedometer usage.

activities,[25] relying on crude step counts may underestimate their actual activity level. To overcome this, we complemented crude step counts with step counts estimated from activities recorded by students in their daily activity logs (referred to as 'log-adjusted steps'). To adjust crude step counts first, we assigned each activity a youth-specific metabolic equivalent task (MET) unit.[26] When youth specific values were not available we used Adult MET units.[27] Next, we categorized activities into moderate (0–3 MET), moderate to vigorous (3.1–5.9 MET), and vigorous (6.0–8.9 MET) intensities[27,28] and assigned a step per minute value to each category.[29] Finally, we were able to estimate step counts for each activity a student described by multiplying the step-per-minute value for each respective category by two-thirds of the duration of the activity recorded in their activity log as per the NASPE[30] guideline that 15 minutes of children's activity is made up of 10 minutes of activity interspersed with 5 minutes of rest. This procedure was used to estimate the steps that would have been achieved during activities in which students could not wear their pedometer (ie, swimming). When students forgot to wear their pedometer and complete their activity log, we imputed information from other randomly selected valid days. For example, if a student forgot to wear his/her pedometer between 7:00 PM and 8:00 PM on a school day, their pedometer or log-adjusted steps during this period on another randomly selected school day were imputed to this missing hour. When possible, we imputed steps for all missing hours of complete days. We imputed steps only within an individual, within school days between 7:00 AM and 9:00 PM, and within nonschool days between 9:00 AM and 9:00 PM. Differing patterns of behavior observed from weekdays to weekend days dictated the time periods for imputation.

We considered activities gained through travel to and from school as activities during 'school hours' because these activities are characteristic of behaviors on school days.

Statistical Analyses

Body mass index (BMI) was calculated as kg/m^2. Overweight and obesity were defined using the International Obesity Task Force BMI cut-off points established for children and youth.[31] These cut-off points are based on health-related adult definitions of overweight (BMI ≥ 25) and obesity (BMI ≥ 30), but are adjusted to specific age and sex categories for children.[31] Descriptive statistics are presented as means ± SD or frequencies. We used independent *t* tests to analyze sex-specific differences on school days, on nonschool days, and during a typical week of 5 school days and 2 nonschool days. We used paired *t* tests stratified by sex to analyze differences in total steps per day on school days and nonschool days and differences in total steps per hour during school hours and nonschool hours. We considered the proportion of boys and girls who achieved 13,500 steps per day to have met the Canadian recommendation for PA. To analyze sex differences in the proportion of boys and girls who met the Canadian recommendation of 13,500 steps per day we used Chi-square (χ^2) tests.

Results

Six hundred and eighty-nine students (318 boys and 371 girls) wore a pedometer for a minimum of 8 consecutive hours on at least 2 school days and 1 weekend day. Descriptive statistics are reported in Table 1. There were no sex-based differences in age, BMI, or weight status (normal weight, overweight, or obese).

The average crude daily step count for a typical week in the entire cohort was 9221 ± 3027 steps per day. However, when information provided through the activity logs was considered the average daily step count increased to 11,189 ± 3561 steps per day, a mean difference of 1968 steps per day ($P < .001$). Lastly, with imputations for the time that students forgot to or could not wear their pedometers we observed an average daily step count of 11,871 ± 3680 steps per day, a mean difference of 682 steps per day from the activity log adjusted step count ($P < .001$). Figure 2 shows how the adjustments affect step counts by activity level.

Table 2 depicts activity during various windows of time for boys and girls. Boys achieved significantly more steps per day than girls on school days (+ 2040 steps/day,

Table 1 Descriptive Statistics of Grade 5 Student Sample

	Boys (n = 318)	Girls (n = 371)	Total (n = 689)
Age (yr)	10.9 ± 0.4	10.9 ± 0.4	10.9 ± 0.4
BMI (kg·m^{-2})	19.7 ± 4.0	19.3 ± 3.5	19.5 ± 3.7
Normal weight	63% (199)	67% (250)	65% (449)
Overweight	25% (80)	22% (80)	23% (160)
Obese	10% (33)	8% (28)	9% (61)

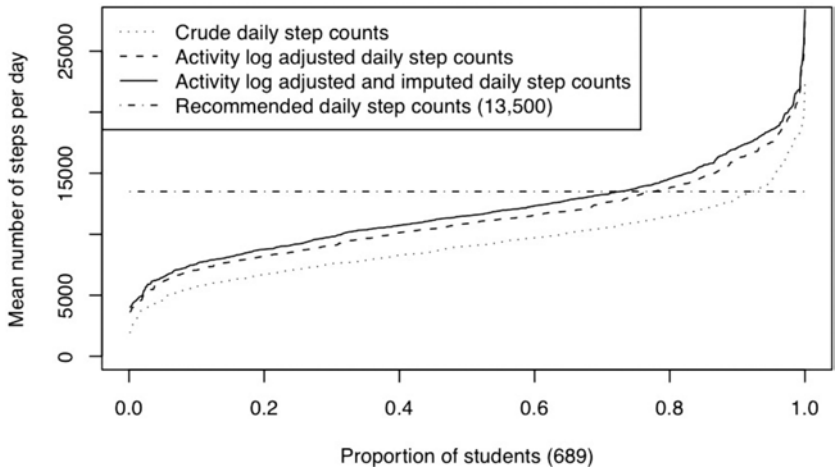

Figure 2 — Mean number of daily steps among grade 5 students.

Table 2 Average Number of Steps (Standard Deviation) of 689 Students on School Days, During School Hours, Before and After School Hours, on Nonschool Days, During a Typical Week of 5 School Days and 2 Nonschool Days

Steps per day	Boys (n = 318)	Girls (n = 371)	Total (n = 689)
School day	13,476 ± 4123	11,436 ± 3158**	12,377 ± 3773
During school (steps/hour)	1,024 ±290	883 ± 226**	948 ± 267
Before & after school (steps/hour)	818 ± 419	673 ± 332**	740 ± 382
Nonschool day	11,009 ± 5542	10,256 ± 5206*	10,604 ± 5373
Typical week	12,771 ± 3907	11,099 ± 3288**	11,871 ± 3680

* $P < .05$; ** $P < .001$.

$P < .001$), on nonschool days (+ 753 steps/day, $P = .03$), and during a typical week (+ 1672 steps/day, $P < .001$). What is more, during school hours as well as outside of school hours, boys took significantly more steps per hour than girls during the school day (+ 141 steps/hour, $P < .001$; + 145 steps/hour, $P < .001$), respectively.

Table 2 also shows that the daily step-count was significantly higher during school days compared with nonschool days (boys + 2467 ± 5262 steps/day, $P < .001$; girls + 1180 ± 4459 steps/day, $P < .001$). In addition, both boys and girls took significantly more steps per hour during school hours than during before and after school hours (boys + 206 ± 420, $P < .001$; girls +210 ±347, $P < .001$). The differences between weekday and weekend PA are further illustrated in Figure 3. Figure 3 shows that the differences in activity levels between school days and nonschool days occurred primarily during the following windows: the 8:00–9:00 AM, 10:00–11:00 AM, 12:00–1:00 PM, and 3:00–4:00 PM. These windows of time seem to coincide with travel to and from school, lunch hour, and recess times. Apart from these times, there is relatively little variation in steps achieved on school days and weekend days. However, the decline in activity from school days to weekends was more pronounced for boys (–2467 steps/day) than for girls (–1180 steps/day) (Table 2).

Calculation of the average step count on school days for each participant revealed that 43% of boys and 21% of girls met the recommendation of 13,500 daily steps or more ($P < .001$). For nonschool days, this was 30% for boys and 22% for girls ($P = .01$). And for a typical week, this was 37% for boys and 19% for girls ($P < .001$). The proportion of students who achieved less than half of the recommended steps was higher on nonschool days (23% of boys and 27% of girls) than on school days (3% of boys and 3% girls).

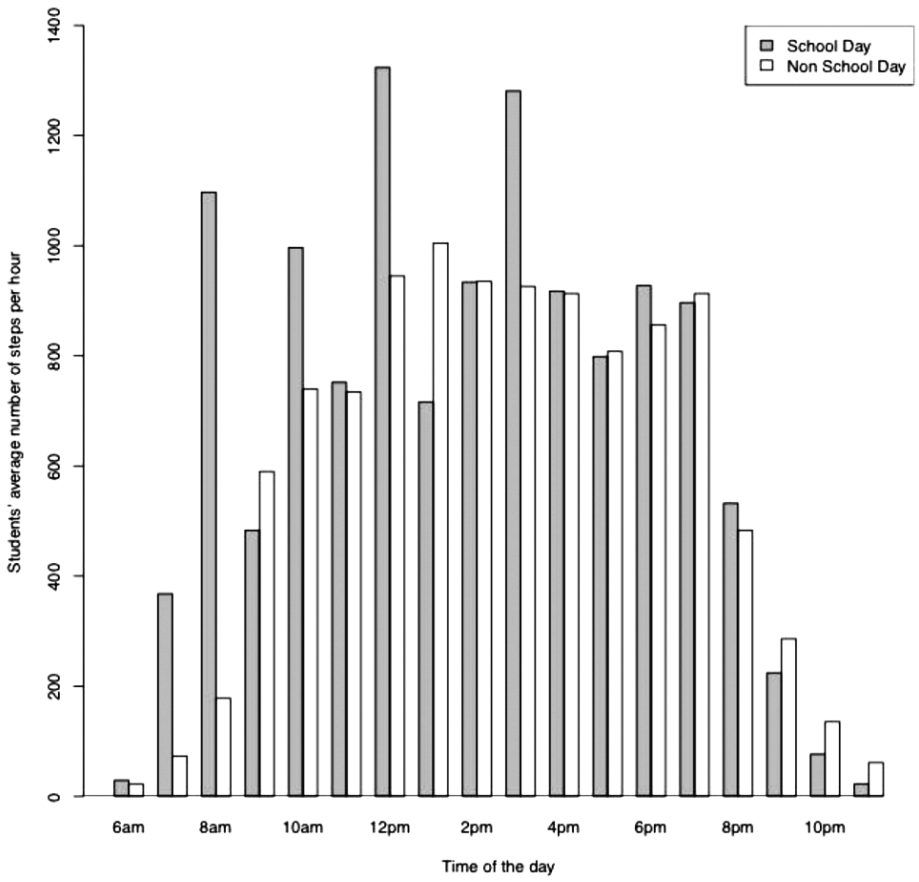

Figure 3 — Average number of daily steps among 689 students from 30 schools in Alberta, Canada on school days and nonschool days.

Discussion

Two novel findings emerged from this cross sectional study of PA patterns in grade 5 students, primarily 10–11 years of age. First, we found that PA outside of school hours and on weekend days is significantly lower than PA during school hours and on school days, particularly among boys. Second, excess PA comes primarily from a set number of hours.

The current study shows that 27% of the surveyed students are meeting the recommended 13,500 steps/day required for optimal growth and development. This proportion is slightly lower than the Canadian national rate of approximately 31% from 2007–2009.[4] The proportion of children who achieve 13,500 daily steps in Alberta is unknown due to recent changes in the Canadian recommendation for daily physical activity. However, Alberta and national percentages were close based on the old recommendation of 16,500 steps/day.[32,33] Over a typical 5-day school week, the daily average step count (11,871 ± 3680 steps/day) was slightly higher than the provincial (11,600 steps/day)[32] and national (boy 12,100 steps/day, girls 10,300 steps/day) averages.[4]

In support of previous literature,[4,16,34,35] boys were found to be more active than girls with a mean step difference of 2040 steps per day ($P < .001$) during a typical week. There was, however, a greater decline in PA levels between weekdays and weekends for boys compared with girls. This is different from previous studies[14,16] where girls were more susceptible to a drop in activity levels on weekend days. The school environment provides structured opportunity for children to engage in regular PA throughout the week (eg, active transportation, active play before and after school, during recess, and lunch time, physical education classes). Health promotion strategies should target girls such that their PA benefits from these opportunities as it does for boys.

We observed children to be more active on school days relative to nonschool days. This finding is consistent with some,[15,16,22,36,37] but not others.[11,13,14,28] It is believed that the variability in PA between weekdays and weekends relates to a number of factors that are not well understood (eg, age, culture, involvement in sports).[17] Despite the observation that youth are more active on school days than weekend days, their daily step counts on weekdays remain below the current recommendation. This indicates

that opportunities for PA provided at school alone are not sufficient for children to accumulate adequate PA to gain both current and future health benefits. Health promotion strategies should therefore extend to after school hours and weekends.

We also observed PA levels to be higher during school hours than nonschool hours. Again, there is variability in the literature between activity levels during school hours and nonschool hours; some studies report higher levels during school[36,37] and others report higher levels outside of school.[13,14,22] The inconsistencies between results reported here and results in the literature may be attributed to the fact that Hardman et al,[14] Betlon et al,[13] and Cox et al[11] recorded school time activity only during the time students were at school. We had considered active transport as PA related to the school routine. From Figure 3 it is evident that a large proportion of children's daily activity was gained during periods when children would be traveling to and from school.

Despite the observation that PA is higher during school hours, excess PA was primarily achieved during discretionary periods including recess, lunch breaks, and active transportation to and from school. It is widely known that while at school, children are seated for a large percentage of the day and opportunities for PA are limited to recess, lunch breaks, and physical education classes. Targeted interventions maximizing activity during these periods have been suggested to increase levels of PA.[38] Currently, only 38% of Alberta children report using active transport to and from school.[39] Activity levels, therefore, can be expected to increase substantially if all students would engage in active transport.

The increasingly widespread use of pedometers in both research and practice reinforces the importance of providing PA estimates truly reflective of the population. The current study showed that it is important to consider nonambulatory activities that are not recorded well with pedometers, as these constitute a substantial proportion of all activities. We have included steps estimated from activities recorded in daily logs for those activities in which the pedometer could not be worn (eg, swimming), for those in which the pedometer could not accurately measure (eg, biking, gymnastics, and karate), and for those when students forgot to wear the pedometer. As a result, we are able to provide an average daily step count that more accurately reflects the actual PA behavior of children. Adjusting for the above also allows us to maintain a larger sample from which estimates of daily activity are drawn. Accordingly, we provide an estimate of children's physical activity that is more representative of the population.

Estimates of daily PA using objective measures are affected by the number of hours per day pedometers are worn. When pedometers are removed for prolonged periods physical activity levels may be underestimated because the actual behavior is not captured. To overcome this potential bias, wear time criterion has been established. Some pedometers studies eliminate data from participants who report removing their pedometer for more than 1 hour,[15,40,41] more than 2 hours,[14] or longer[13] during the monitored day. Others required that the pedometer be worn for a minimum of 10 hours for a monitored day to be included in the final analysis.[42] The application of the above criterion resulted in the exclusion of 5–11%,[18,26] 24%,[17] and 37%[42] of participants, respectively. Penpraze et al[23] showed that reliability increases as the number of days and hours of monitoring increased, but only to 10 hours per day. Penpraze et al[23] also showed that reliability was more dependent on the number of days than the number of hours. In the current study, 8 hours was selected as the minimum daily wear criterion. By reducing the amount of time per day that students were expected to wear their pedometers we maintain a larger sample size and maintain estimates from less active children who under more conservative requirements may have otherwise been excluded. This is an important consideration when generating population-based estimates of physical activity.

Study Limitations and Strengths

Strengths of our study include the use of time-stamped pedometers. Another strength of our study is the adjustments made to raw pedometer recorded steps from activities described in daily activity logs, as this has not been recorded in the literature. This study shows that consideration should be given to activities that are not captured by pedometers, as ignoring these nonambulatory activities may lead to a substantial underestimation of the actual activity level. We used MET values specific to youth when possible. However, when youth values were not available, we used adult values instead. Although selected from a population-based sample, the sample of students in this study is not representative of the Alberta population. Caution is warranted when generalizing the present results.

Conclusion

A significant portion of youth 10 to 11 yrs in the province of Alberta are not achieving current recommendations for PA, especially on weekend days. Children were significantly more active during school days and school-hours than compared with nonschool days and after school hours. The Physical activity interventions and policies should recognize these trends and consider strategies that target these windows of time.

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References

1. Tremblay MS, Willms JD. Is the Canadian childhood obesity epidemic related to physical inactivity? *Int J Obes*. 2003;27:1100–1105. PubMed doi:10.1038/sj.ijo.0802376
2. Must A, Tybor Dj. Physical activity and sedentary behaviour: a review of longitudinal studies of weight and adiposity in youth. *Int J Obes*. 2005;29:S84–S96. doi:10.1038/sj.ijo.0803064
3. Janssen I, LeBlanc AG. Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *Int J Behav Nutr Phys Act*. 2010;7:40. PubMed doi:10.1186/1479-5868-7-40
4. Colley RC, Garriguet D, Janssen I, Craig CL, Clarke J, Tremblay MS. Physical activity of Canadian children and youth: accelerometer results from the 2007 to 2009 Canadian Health Measures Survey. *Health Rep*. 2011;22(1):1–9. PubMed
5. Tremblay MS, Kho ME, Tricco AC, Duggan M. Process description and evaluation of Canadian physical activity guidelines development. *Int J Behav Nutr Phys Act*. 2010;7:42. PubMed doi:10.1186/1479-5868-7-42
6. Canadian Society for Exercise Physiology, ParticipACTION. Canadian Society for Exercise Physiology and ParticipACTION share new research to inform Canadians of physical activity levels required. Press Release; May 12, 2010. Available at: www.csep.ca; www.participaction.com.
7. Shields M. Overweight Canadian children and adolescents. *Health Rep*. 2006;17:27–42. PubMed
8. Simen-Kapeu A, Veugelers P. Should public health interventions aimed at reducing childhood overweight and obesity be gender-focused? *BMC Public Health*. 2010;10:340–346. PubMed doi:10.1186/1471-2458-10-340
9. Manson JE, Bassuk SS. Obesity in the United States. A fresh look at its high toll. *JAMA*. 2003;289:229–230. PubMed doi:10.1001/jama.289.2.229
10. Dietz WH. Overweight in childhood and adolescence. *N Engl J Med*. 2004;350:855–857. PubMed doi:10.1056/NEJMp048008
11. Cox M, Schofield G, Greasley N, Kolt GS. Pedometer steps in primary school-aged children: a comparison of school-based and out-of-school activity. *J Sci Med Sport*. 2006;9:91–97. PubMed doi:10.1016/j.jsams.2005.11.003
12. Tudor-Locke C, Lee SM, Morgan CF, Beighle A, Pangrazi RP. Children's pedometer-determined physical activity during the segmented school day. *Med Sci Sports Exerc*. 2006;38(10):1732–1738. PubMed doi:10.1249/01.mss.0000230212.55119.98
13. Belton S, Brady P, Megan S, Woods C. Pedometer step count and BMI of Irish primary school children aged 6-9 years. *Prev Med*. 2010;50(4):189–192. PubMed doi:10.1016/j.ypmed.2010.01.009
14. Hardman CA, Horne PJ, Rowlands AV. Children's pedometer-determined physical activity during school-time and leisure-time. *J Exerc Sci Fitness*. 2009;7:129–134. doi:10.1016/S1728-869X(09)60016-2
15. Duncan MJ, Al-Nakeeb Y, Woodfield L, Lyons M. Pedometer determined physical activity levels in primary school children from central England. *Prev Med*. 2007;44:416–420. PubMed doi:10.1016/j.ypmed.2006.11.019
16. Rowlands AV, Pilgrim EL, Eston RG. Patterns of habitual activity across weekdays and weekend days in 9-11-year-old children. *Prev Med*. 2008;46:317–324. PubMed doi:10.1016/j.ypmed.2007.11.004
17. Tudor-Locke C, McClain JJ, Hart TL, Sisson SB, Washington TL. Expected values for pedometer-determined physical activity in youth. *Res Q Exerc Sport*. 2009;80:164–174. PubMed
18. Schwartz M, Karunamuni ND, Veugelers PJ. Tailoring and implementing comprehensive school health: The Alberta Project promoting active living and healthy eating in schools. *Phys Health Educ J*. 2010;2:1–15.
19. Hasson RE, Haller J, Pober DM, Staudenmayer J, Freedson PS. Validity of the Omron HJ-112 pedometer during treadmill walking. *Med Sci Sports Exerc*. 2009;41(4):805–809. PubMed doi:10.1249/MSS.0b013e31818d9fc2
20. Holbrook EA, Barreira TV, Kang M. Validity and reliability of Omron pedometers for prescribed and self-paced walking. *Med Sci Sports Exerc*. 2009;41(3):670–674. PubMed doi:10.1249/MSS.0b013e3181886095
21. Zhu W, Lee M. Invariance of wearing location of Omron-BI pedometers: a validation study. *J Phys Act Health*. 2010;7(6):706–717. PubMed
22. Rowe DA, Mahar MT, Raedeke TD, Lore J. Measuring physical activity in children with pedometers: Reliability, reactivity, and replacement of missing data. *Pediatr Exerc Sci*. 2004;16:343–354.
23. Penpraze V, Reilly JJ, MacLean CM, et al. Monitoring of physical activity in young children: how much is enough? *Pediatr Exerc Sci*. 2006;18:483–491.
24. Craig C, Tudor-Locke C, Cragg S, Cameron C. Process and treatment of pedometer data collection for youth: The Canadian Physical Activity Levels Among Youth study. *Med Sci Sports Exerc*. 2010;42(3):430–435. PubMed doi:10.1249/MSS.0b013e3181b67544
25. Institute Canadian Fitness and Lifestyle Research Institute. Physical activity among Canadians: the current situation.
26. Ridley K, Ainsworth BE, Olds TS. Development of a compendium of energy expenditures for youth. *Int J Behav Nutr Phys Act*. 2008;5:45. PubMed doi:10.1186/1479-5868-5-45
27. Ainsworth BE, Haskell WL, Whitt MC, et al. Compendium of physical activities: an update of activity codes and MET intensities. *Med Sci Sports Exerc*. 2000;32:S498–S504. PubMed doi:10.1097/00005768-200009001-00009
28. Trost SG, Pate RR, Freedson PS, Sallis JF, Taylor WC. Using objective physical activity measures with youth: how many days of monitoring are needed? *Med Sci Sports Exerc*. 2000;32:426. PubMed doi:10.1097/00005768-200002000-00025
29. Jago R, Watson K, Baranowski T, et al. Pedometer reliability, validity and daily activity targets among 10- to 15-year-old boys. *J Sports Sci*. 2006;24(3):241–251. PubMed doi:10.1080/02640410500141661

30. National Association for Sport and Physical Education (NASPE). *Physical activity for children: a statement of guidelines for children ages 5-12*. Reston, WA: NASPE; 2004.
31. Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: international survey. *BMJ*. 2000;320:1240. PubMed doi:10.1136/bmj.320.7244.1240
32. Institute Canadian Fitness and Lifestyle Research Institute. Bulletin 1.9: Physical activity levels of children and youth in Alberta. 2010;1–3. Accessed from http://www.cflri.ca/node/105.
33. Institute Canadian Fitness and Lifestyle Research Institute. Bulletin 1: Activity levels of Canadian children and youth. 2009;1–6. Accessed from http://www.cflri.ca/node/105.
34. Trost SG, Pate RR, Sallis JF, et al. Age and gender differences in objectively measured physical activity in youth. *Med Sci Sports Exerc*. 2002;34:350. PubMed doi:10.1097/00005768-200205001-01563
35. Vincent SD, Pangrazi RP. An examination of the activity patterns of elementary school children. *Pediatr Exerc Sci*. 2002;14:432–441.
36. McGall SE, McGuigan MR, Nottle C. Contribution of free play towards physical activity guidelines for New Zealand primary school children aged 7-9 years. *Br J Sports Med*. 2009;45(2):120–4. PubMed
37. Nyberg GA, Nordenfelt AM, Ekelund U, Marcus C. Physical activity patterns measured by accelerometry in 6- to 10-yr-old children. *Med Sci Sports Exerc*. 2009;41(10):1842–8. PubMed
38. Beighle A, Morgan CF, Le Masurier G, Pangrazi RP. Children's physical activity during recess and outside of school. *J Sch Health*. 2006;75:516–520. doi:10.1111/j.1746-1561.2006.00151.x
39. Carson V, Kuhle S, Spence J, Veugelers P. Parents' perception of neighbourhood environment as determinants of screen time, physical activity, and active transport. *Can J Public Health*. 2010;101(2):124–127. PubMed
40. Bourdeaudhuij ID, Cardon G. A pilot study comparing pedometer counts with reported physical activity in elementary schoolchildren. *Pediatr Exerc Sci*. 2004;16(4):355–367.
41. Tudor-Locke C, Pangrazi RP, Corbin CB, et al. BMI-referenced standards for recommended pedometer-determined steps/day in children. *Prev Med*. 2004;38:857–864. PubMed doi:10.1016/j.ypmed.2003.12.018
42. Eisenmann JC, Laurson KR, Wickel EE, Gentile D, Walsh D. Utility of pedometer step recommendations for predicting overweight in children. *Int J Obes*. 2007;31:1179–1182. PubMed doi:10.1038/sj.ijo.0803553